Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AC1-034

Heartsease – Mayo Dunbar DP 115kV
42.75 MW Capacity / 75 MW Energy

Revised August 2020

June / 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 Edgecombe Solar LLC, (Interconnection Customer (IC)) and PJM Interconnection, LLC (Transmission Provider (TP)). IC has proposed a solar generating facility located on New Hope Church Road, Edgecombe County, North Carolina. The installed facilities will have a total capability of 75 MW with 42.75 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 10/1/2022. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AC1-034 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects onto the Anaconda - Vaughan115kV line # 80.

Cost Summary

The AC1-034 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 534,716
Direct Connection Network Upgrades	$ 5,755,360
Non Direct Connection Network Upgrades	$ 1,437,383
Allocation for New System Upgrades	$ 50,487
Contribution for Previously Identified Upgrades	$ 29,316
Total Costs	**$ 7,807,262**

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue AC1-34 is a request to interconnect a 75 MW new solar generating facility to be located in Edgecombe county, North Carolina. The proposed generating facility will interconnect with the ITO's new AC1-034 115kV Switching Station via a new three breaker ring-bus switching station. The requested in-service date is December 1, 2022. Attachment Facility and Network upgrade construction is estimated to be 8 – 12 months.

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

None

3. Interconnection Customer's Submitted Milestone Schedule

- Plan to break ground January 1, 2022
- Permits – state level Permit By Rule and county level Final Site Plan approval complete December 1, 2021
- Substantial site work completed August 1, 2022
- Delivery of major electrical equipment June 1, 2022
- Back Feed Power June 1, 2022
- Commercial Operation October 1, 2022

4. Scope of Customer's Work

IC will build a solar generating facility in Edgecombe County, North Carolina. The generating facility (Edgecombe Solar) will be comprised of solar arrays. AC1-034 consists of 34 x 2.5 MVA SMA SC2500 inverters. The 34 x 34.5/0.550 kV grounded wye delta 2.5 MVA generator step up (GSU) transformers will connect to the solar inverters to the 34.5 kV collector system. The generating facility will connect to the Point of Interconnection (POI) via a 115/34.5 kV wye ground/wye ground main power transformer with a rating of 51/68/85 MVA.

5. Description of Facilities Included in the Facilities Study

Project AC1-034 provides for the construction of a new interconnect station and necessary network upgrades to tie a 75 MW solar generating facility into the ITO transmission network. The scope includes the construction, by the ITO, of a 115 kV switching station with a three breaker ring bus and the required 115 kV transmission line modifications.

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	$307,733	$155,748	$53,005	$18,230	$534,716
Total Attachment Facilities Cost	$307,733	$155,748	$53,005	$18,230	$534,716
AC1-034 115 kV Switching Station (n6644)	$2,651,244	$2,422,283	$431,404	$250,429	$5,755,360
Line #80 Transmission work (n6645)	$703,018	$423,210	$119,247	$45,656	$1,291,131
Remote relay (n6646)	$78,641	$45,483	$15,387	$6,741	$146,252
Clubhouse-Lakeview reconductor (n6052)	$13,611	$12,021	$1,945	$1,739	$29,316
Battleboro substation upgrades (n6118)	$30,440	$13,805	$4,807	$1,434	$50,487
Total Network Upgrades	$3,476,954	$2,916,802	$572,791	$305,999	$7,272,546
Total Project Costs	$3,784,687	$3,072,550	$625,796	$324,229	$7,807,262

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

Facilities are estimated to take 14 - 24 months to 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 8 to 12 months

ITO requires the site to be fully graded and permitted site so they can start construction by April 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:

1. One (1) 115 kV, 2000A, 3-phase center break gang operated switches
2. Three (3) 115 kV metering accuracy CCVT’s
3. Three (3) 115 kV metering accuracy CT’s

4. Conductors, 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 – Bus Differential C.T. M.U. Box
3. One (1), 1425 – 28" Dual SEL-735 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
7. Two (2), 4541 - Control Cable M.U. Box

2. Transmission Line – Upgrades

PJM Network Upgrade #n6645 - Re-arrange Line #80 to loop into and out of the new three breaker AC1-34 115 kV switching station between existing Anaconda and Hathaway substation. Constructed in 2015 on Dom-pole H-Frame structures, the 22 line is an existing over-insulated 115kV line that runs parallel with the 90 line from Carolina Substation to Kerr Dam Substation. The line connection will require the installation of (1) backbone structure, two (2) static pole structures, and the modification of two existing H-Frame structures. The conceptual design and estimate includes costs for the following:

ESTIMATE – FACILITIES TO BE INSTALLED:

1. Install one (1) 115kV SC steel DDE backbone structure with foundations.
2. Install two (2) steel static poles with foundations.
3. Install approximately 3.5 miles of OPGW from proposed AC1-034 substation to proposed AB1-081 substation.
4. Cut and transfer existing spans of 3-Phase conductor to the new SC backbone structure.
5. Cut and transfer existing spans of AWLD shield wire to new SC backbone structure.

ESTIMATE – FACILITIES TO BE REMOVED:

1. Remove approximately 3.5 miles of ALWD from proposed AC1-034 substation to the proposed AB1-081 substation.
2. Remove one (1) wave trap installed at the AB1-081 substation.

ESTIMATE – MISCELLANEOUS:

1. Obtain additional right of way into proposed substation.

PJM Network Upgrade #n6052 Line #2141 Lakeview – Carolina 230 kV: The existing line is approximately 1.4 miles long (1.3 miles of 795 ACSR 45/7 – "Tern" and 0.1 miles of 1033 ACSR 45/7 – "Ortolan"). The line consists of nine (9) V-Series Towers, two (2) tubular steel backbones, one (1) monopole structure, and one (1) switch tower.

Lakeview Substation scope of work includes replacement of two 2000 Amp switches with new 3000 Amp.

Lakeview substation scope:

1. Install two (2), 230 kV, 3000 Amp, center break disconnect switches

2. Install conductor, connectors, foundations, steel and grounding material as per engineering standards.

3. Remove existing 2000 Amp switches and accessories

REMOVAL:

1. Remove (1) span (*approximately 0.1 miles)* of 3 phase 1033 ACSR 45/7 – "Ortolan" conductor from Lakeview Substation (Structure 2141/1) to Structure 2141/2.
2. Remove *approximately* 1.3 miles of 3 phase 795 ACSR 45/7 – "Tern" conductor from Structure 2141/2 to Carolina Substation (Structure 2141/13).
3. Remove insulator hardware from Structure 2141/1 to Structure 2141/13 associated with the phase conductor being removed. This will consist of removing approximately:
    a. (12) suspension insulator assemblies
    b. (14) idler suspension assemblies
    c. (2) suspension training insulator assemblies
    d. (48) dead-end insulator assemblies

INSTALLATION:

1. Modify (5) existing T0415003 dead end towers to accommodate proposed conductor; modifications included in this estimate are for the installation of dead end conductor assemblies and replacement of failing angle members.
    a. Tower modifications will need to be completed on Structure 2141/2 (4V Tower + 15' Leg Extension), 2141/5 (4V Tower + 10' Leg Extension), 2141/7 (4V Tower + 15' Leg Extension), and 2141/9 (4V Tower + 15' Leg Extension).
    b. Install (2) new members on the bottom arm of the structures to reinforce angle members 4V74A.
    c. Install thirty (30) DE Insulator Assemblies:
    d. One (1) project specific DE insulator assembly (32.337B) shall be installed on structure 2141/10.
    e. Install fourteen (14) idler suspension assemblies.
2. Modify (4) existing T0412019 suspension towers to accommodate proposed conductor; modifications included in this estimate are for the installation of suspension conductor assemblies.
    a. Install twelve (12) suspension insulator assemblies.
3. Modify (2) existing backbone structures to accommodate proposed conductor; modifications included in this estimate are for the installation of suspension conductor assemblies.
    a. Three (3) dead-end insulator assemblies on structure 2141/1.
    b. Six (6) dead-end insulator assemblies on structure 2141/12.
4. Modify (1) existing monopole structure to accommodate proposed conductor; modifications included in this estimate are for the installation of dead end conductor assemblies.

    c. Install six (6) dead-end insulator assemblies.
    d. Install two (2) suspension training insulator assemblies.
5. Modify (1) existing switch tower to accommodate proposed conductor; modifications included in this estimate are for the installation of dead end conductor assemblies.
    e. Install three (3) dead-end insulator assemblies.
6. Install approximately 1.4 miles of 3-phase 768.2 ACSS/TW/HS-285 – "Maumee" from existing Lakeview Substation (Structure 2141/1) to existing Carolina Substation (Structure 2141/13).

ESTIMATE ASSUMPTIONS:

1. Line #239, the adjacent circuit on Towers 2141/2 to 2141/7, was modeled using available information to support the analysis of Line #2141 and associated towers. Line #239, other than how it affects Line #2141, is not covered under the scope of project GITAC1034.
2. The PLS-Tower models that were provided by Dominion accurately represent the existing towers. A full model check will need to be performed during detailed design to confirm.
3. The line analysis does not take into account any physical or conditional degradation of the structures.
    a. A formal conditional analysis of all structures is recommended.
4. No foundation analysis was performed as part of this estimate, and is outside the current scope of this project.
5. Station backbones will have adequate capacity based on GITAC1034 design loads.
6. Analysis results are based on NESC minimum requirements and a structure usage limit of 100%.
7. The LiDAR survey provided is accurate and governs over the structure coordinates that can be found in the SAP Line Data database. Due to the narrow tolerances in the design, it is recommended that additional survey points be taken of the structures (C/L, leg base(s), and conductor attachment points at a minimum) prior to finalization.

DESIGN NOTES:

1. Per Dominion standards, failing members are to be reinforced not replaced. However, to be conservative both methods were checked.
    a. DAE (3"x3"x0.25") angle type was used to model the reinforcement on the failing member.
    b. Failing members were replaced with 3"x3"x0.25" and analyzed; towers passed.
2. Section Usage Comparison: Due to terrain limitations within section 2141/2 – 2141/5, the sag of the phase conductor is limited by clearance requirements. Below is a chart comparing the results of the conductor at a MOT of 250°C/482°F, Max Sag and at a MOT of 210°C/410°F, Max Sag.
    a. The existing conductor (795 ACSR 45/7 – "Tern") at MOT (90°C/194°F) does not have any additional buffer over the 2017 NESC ground clearance requirement of 22.5'.
    b. The other sections though-out the line were able to be preliminarily adjusted to limit the amount of section usage, load on the tower members, and usage of insulator assemblies.

3. Crossing span clearances were checked utilizing provided LiDAR. During final design, it is recommended that the crossing spans are modeled appropriately.
4. Based on this review it has been recognized that the bottom phase connecting 2141/10 – 2141/11 has a structure clearance violation. The estimate reflects a custom insulator assembly that should be installed to mitigate the violation.

3. New Substation/Switchyard Facilities

PJM Network Upgrade #n6644 - Build a three breaker AC1-034 115 kV switching station. The solar generating facility will be located Edgecombe County, NC. The position of the switching station will be adjacent to the common right of way of the Transmission Line #80 and 229. The station will be positioned in such a way that the new backbone will be near 80/83 with about 25 foot offset from the transmission line. The cut lines will be attached to the new backbone and risers will be dropped from both sides of the backbone to the bus sections directly underneath the line. The lines will consume two of the three positions in the ring bus. The third position will be for the 115 kV feed from the collector station for the solar farm. There will be an ITO owned transmission structure outside the switching station fence and the developer will bring the 115 kV line to the structure. The demarcation point will be the 4-hole pads on the ITO disconnect switch located on the transmission structure. Metering equipment will be installed in the ITO Switching Station. The developer will provide the property and access to the switching station. All substation permitting, site preparation and grading activity will be performed by the developer.

The work required is as follows:

Purchase and install substation material:

1. Approximately 285’ X 260’ site preparation and grading as required for installation of the switching station (by the developer)
2. Approximately 1050 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. Full substation ground grid as per engineering standards
4. One (1) 115 kV, heavy duty steel backbone
5. Two (2) shield wire poles and three span of shield wires
6. Three (3) 115 kV, 3000A, 40 kA SF6 circuit breakers
7. Six (6) 115 kV, 2000A, 3-phase center break gang operated switches
8. Nine (9) 90 kV MO, 74 kV MCOV station class arresters
9. Six (6) 115 kV CCVTs, relay accuracy
10. One (1), 115 kV, 2000 amps wave traps and line tuners
11. One (1) 24’ X 40’ control enclosure
12. One (1) 125 VDC, 200 Ah station battery and 50 amp charger (size to be verified during detail engineering)
13. Approximately 240 FT of cable trough, with a 20 FT road crossing section
14. Four (4) 100 KVA power potential transformers for station service
15. Two (2) 115 kV, 2000A, 2-phase center break gang operated switches
16. Oil containment system for the 115 kV PVTs.
17. High voltage protection cabinet

18. Steel structures as required including switch stands, bus supports, station service transformers, CCVT and wave trap supports
19. Foundations as required including control house, equipment and bus support stands
20. Conductors, connectors, conduits, control cables and grounding materials as per engineering standards

Purchase and install relay material:

1. Three (3), 1510 – 28" Dual SEL-351-7 transmission breaker w/ reclosing panel
2. Three (3), 4510 - SEL-2411 breaker annunciator
3. Two (2), 1320 – 28" Dual SEL-421-5 DCB Line Panel
4. Two (2), 4506 – 3 Phase CCVT Potential M.U. Box
5. One (1), 1603 – 28" SEL-451 Islanding Control Scheme Panel
6. Two (2), 4000 – Station Service Potential M.U. Box
7. Two (2), 4018 – 500A Station Service AC Distribution Panel
8. Two (2), 4007 – 225A Outdoor Transmission Yard AC NQOD
9. Two (2), 4019 – 225A Three Phase Throwover Switch
10. Two (2), 4016 – 600A PVT Disconnect Switch
11. One (1), 4153 – Wall Mount Station Battery Monitor
12. One (1), 5612 - SEL-3530 Data Concentrator Panel
13. One (1), 1255 – Station Annunciator Panel
14. One (1), 5021 – SEL-2411 RTU Panel
15. One (1), 5609 – Fiber Optic Management Panel
16. Three (3), 4526_A – Circuit Breaker Fiber Optic M.U. Box
17. One (1), 5202 – 26" APP 601 Digital Fault Recorder
18. One (1), 5603 – Station Network Panel 1
19. One (1), 5603 – Station Network Panel 2
20. One (1), 5616 – Station Security Panel
21. One (1), Telephone Interface Box
22. One (1), High Voltage Protection (HVP) Box

4. Upgrades to Substation / Switchyard Facilities

PJM Network Upgrade #n6646 - 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 Carolina and Kerr Dam 115kV substations. These costs include the following:

Harts Mill 115 kV Substation

Project summary:
Update Line 80 transfer trip system. Also update drawings accordingly to support the new AC1-034 substation.

Substation scope:

1. Remove line #80 wavetrap and carrier blocking and transfer trip sets.

Purchase and install relay material:

1. One (1), 1340 – 28" Dual SEL-411L DCB Line Panel (fiber TT)

AB2-059 115 kV Substation

Project Summary:
Update drawings accordingly to support the new AC1-034 substation.

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
AB2-059 substation	$11,059	$0	$2,802	$0	$13,861
Harts Mill substation	$67,582	$45,483	$12,585	$6,741	$132,391
Total Remote Relay Upgrades	$78,641	$45,483	$15,387	$6,741	$146,252

PJM Network Upgrade #n6118- Battleboro – Rocky Mt 115kV: Replace Battleboro substation terminal equipment. Upgrading the breaker leads at Battleboro will bring the rating to 239/239/239 MVA.

Purchase and install at Battleboro substation:

1. Install- 2-795 AAC conductors and connectors as required
2. Remove- existing 1-795 AAC conductors and connectors

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 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 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

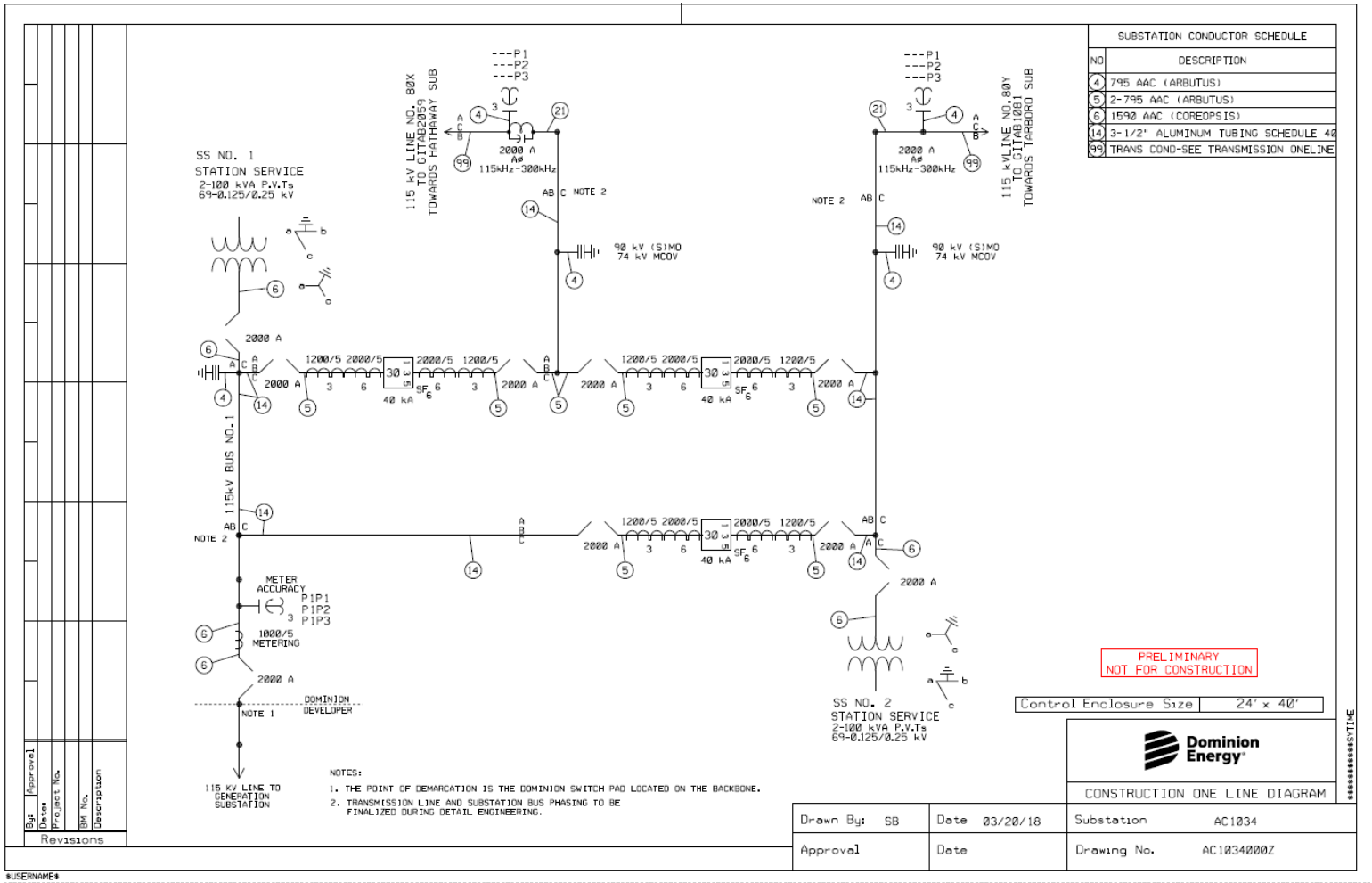
The IC would be responsible for the following expectations in the area of Environmental, Real Estate and Permitting:

- 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:

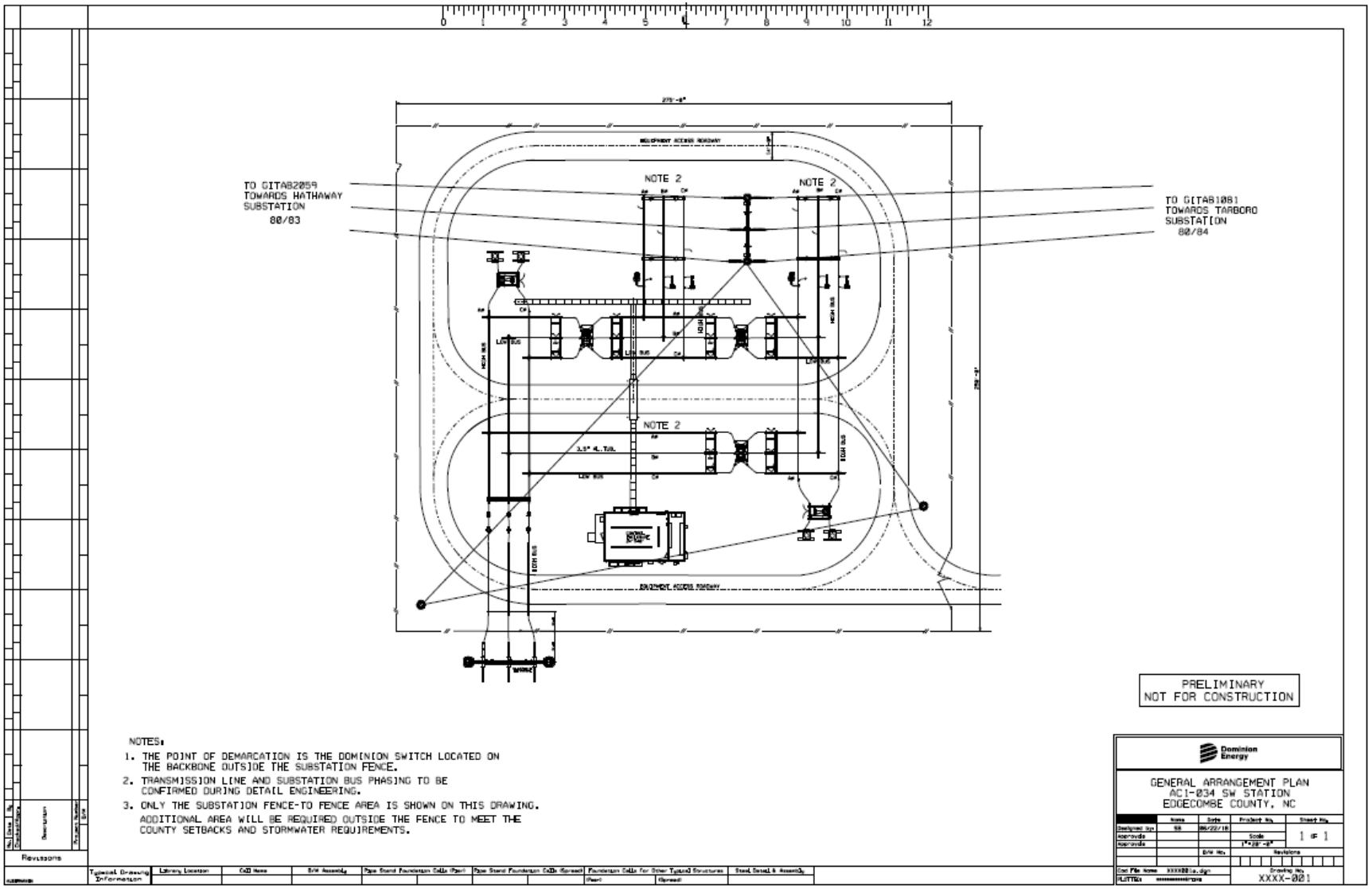
- The substation layout is complete and ITO requires a 285'x 260' piece of property (title in fee) to build the substation. The property includes the piece of property between the substation and collector station for the strain bus.
    - ITO requires ownership transfer of the substation site before they start construction. Target for the deed by April 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.

AC1-034 Switching Station General Arrangement



Attachment 3.
AC1-034 Switching Station Plan