Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AC1-054

Eatons Ferry – Kerr Dam 115kV
65 MW Capacity / 44.5 MW Energy

April / 2019

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 Hawtree Creek Farm Solar, LLC, (Interconnection Customer (IC)) and PJM Interconnection, LLC (Transmission Provider (TP)). IC has proposed a solar generating facility located on Peete Farm Road, north of the Town of Macon in Warren County, NC. The installed facilities will have a total capability of 65 MW with 44.5 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 12/15/2020. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AC1-054 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects onto the Kerr Dam – Eatons Ferry - Carolina 115kV line # 22.

Cost Summary

The AC1-054 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 543,191
Direct Connection Network Upgrades	$ 5,281,084
Non Direct Connection Network Upgrades	$ 1,099,010
Allocation for New System Upgrades	$
Contribution for Previously Identified Upgrades	$ 0
Total Costs	**$ 6,936,043**

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A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue AC1-054 is a request to interconnect a 65 MW new solar generating facility to be located in Warren County, North Carolina. The proposed generating facility will interconnect with the ITO's new AC1-054 115kV Switching Station via a new three breaker ring-bus switching station. The requested in-service date is December 15, 2020. 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

Generator step-up transformer specifications:

- 115kV Grd Wye / 22.68 Grd Wye
- 42/56/70 MVA AM/AF/AF
- 9.5% Z X1/R1 = 27
- R1 = 0.0034 pu X1 = 0.0916 pu
- 42MVA base

3. Interconnection Customer's Submitted Milestone Schedule

- Plan to break ground December 15, 2019
- Permits – state level Permit By Rule and county level Final Site Plan approval complete September 15, 2019
- Substantial site work completed June 15, 2020
- Delivery of major electrical equipment March 15, 2020
- Back Feed Power September 15, 2020
- Commercial Operation December 15, 2020

4. Scope of Customer's Work

IC will build a solar generating facility in Warren County, North Carolina. The generating facility (Hawtree Creek Solar) will be comprised of solar arrays. AC1-054 consists of 32 x 2.2 MVA SMA SC2200 EV inverters. The 32 x 22.86/0.385 kV grounded wye delta 2.2 MVA generator step up (GSU) transformers will connect to the solar inverters to the 22.86 kV collector system. The collector bus will also have 4 x 5.4 MVar Capacitor Banks. The generating facility will connect to the Point of Interconnection (POI) via a 115/22.86 kV wye ground/wye ground main power transformer with a rating of 42/56/70 MVA. The AC1-054 POI will be at a tap of the Carolina – Kerr Dam 115kV line #22.

5. Description of Facilities Included in the Facilities Study

The ITO will connect the proposed generator lead via Attachment Facilities to a new AC1-054 ring bus switching station adjacent to the transmission right of way. The site is located along the ITO's 115kV Line #22 between existing Kerr Dam and Eatons Ferry substations. The switching station will be positioned in such a way that the new backbone will be between 22/2870 and 22/2871 structures with about 25 FT offset from the transmission line. The cut lines will be

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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. The demarcation point between the switching station and the collector station will be the 4-hole pads on the ITO's disconnect switch. The IC will bring its bus to the demarcation point. Metering equipment will be installed in the ITO Switching Station. The grounding systems for both stations will be tied together. The IC will provide the property and access to the switching station. All substation permitting, site preparation and grading activity will be performed by the IC. There will be transmission line protection and anti-islanding work required at the remote lines terminals in Kerr Dam and Carolina Substations. This project will require installation of transfer trip at Kerr Dam which is owned by the Army Corp. 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	$312,109	$159,331	$53,639	$18,112	$543,191
Total Attachment Facilities Cost	$312,109	$159,331	$53,639	$18,112	$543,191
AC1-054 115 kV Switching Station (n5995)	$2,366,803	$2,285,302	$389,060	$239,919	$5,281,084
Line #22 Transmission work (n5996)	$549,831	$327,119	$97,075	$37,267	$1,011,292
Remote relay (n5997)	$37,740	$31,977	$12,277	$5,724	$87,718
Clubhouse 230kV wave trap (n6051)	$6,044	$5,019	$1,658	$764	$13,485
Total Network Upgrades	$2,960,418	$2,649,417	$500,070	$283,674	$6,393,579
Total Project Costs	$3,272,527	$2,808,748	$553,709	$301,786	$6,936,770

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 September 2019.

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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 Point of Interconnection with the generator will be the 4-hole pad on the ITO disconnect switch. The IC will bring its bus to the demarcation point. Metering equipment will be installed in the ITO Switching Station. The equipment associated with the Attachment Facilities includes the following. 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) 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

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 (Transmission & Generation Interconnect)
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 #n5996 - Re-arrange Line #22 to loop into and out of the new three breaker AC1-054 115 kV switching station between existing Eaton's Ferry DP and Kerr Dam 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) 115 kV SC Heavy-Duty Steel DDE Backbone structure (no switches) with foundations (Str. 22/2870A).
2. Install two (2) Galvanized Steel Static Poles with foundations (Strs. 22/2870B and 22/2870C).
3. Modify two existing H-Frame structures (Strs. 22/2870 and 22/2871). These structures are currently Suspension structures that will be changed to DDE structures. Modifications will include the following:

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I) Replace the conductor cross-arm – Both structures
II) Install conductor and OPGW deadend hardware – Both structures
III) Install (2) OPGW splices - Str. 22/2870 only
IV) Install guy wire and guy anchors – Both structures

4. Cut the existing 3-Phase conductor between Strs. 22/2870 and 22/2871 and transfer the existing 3-Phase 636 ACSR 24/7 "Rook" conductor to the new backbone structure.
5. Cut the existing two OPGW cables between Str. 22/2870 and 22/2871 (cut the OPGW close to Str. 22/2870). Transfer the OPGW to new Backbone Str. 22/2870A and install splices on the Backbone.
6. Install two (2) OPGW cables, of approximately 230' each, from modified Str. 22/2870 to new Str. 22/2871.
7. Install approximately 0.13 miles of 1-7#7 static wire from the new Backbone Structure to the new Static poles.
8. Renumber approximately 119 structures with new line numbers between AC1-054 Substation and Kerr Dam Substation.

ESTIMATE – MISCELLANEOUS:

1. Obtain additional R/W from Str. 22/2870 – 22/2871.

3. New Substation/Switchyard Facilities

PJM Network Upgrade #n5995 - Build a three breaker AC1-054 115 kV switching station. The site is located along the ITO's 115kV Line #22 from Carolina to Kerr Dam substation. The switching station will be positioned in such a way that the new backbone will be between 22/2870 and 22/2871 structures with about 25 FT offset from the transmission line, with just enough offset to maintain clearance from the second transmission line in this right of way. 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.

The work required is as follows:

Purchase and install substation material:

1. Approximately 285' X 285' site preparation and grading as required for installation of the switching station (by the IC)
2. Approximately 1100 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 (by Transmission)
5. Two (2) shield wire poles and two span of shield wires (by Transmission)
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 Trap and Line Tuner

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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. Oil Containment system for the 115 kV PVTs.
16. Two (2) 115 kV, 2000A, 2-phase Center Break Gang Operated Switches
17. Two (2), 2” conduits from structure outside the substation to the cable trough
18. Conduit Tracer Wire, 1/C #10, Green
19. 1-1/4” Orange Polyethylene conduits for fiber in the cable trough
20. Steel structures as required including switch stands, bus supports, station service transformers, CCVT and wave trap supports
21. Foundations as required including control house, equipment and bus support stands
22. Conductors, connectors, conduits, control cables, cable trough, and grounding materials

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 (Provided by IT)

4. Upgrades to Substation / Switchyard Facilities

PJM Network Upgrade #n5997 - 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:

Carolina 115 kV Substation

Project Summary
Install Islanding Transfer trip set to Line 22. The estimated cost of this scope is $55,664.

Purchase and install:

1. Install any foundations, grounding, steel pipe stands, conductor and connectors

Purchase and install relay material:

1. One (1), 1604 – Islanding Transfer Trip Panel 24”

Kerr Dam 115 kV Substation

Project Summary
Install Islanding Transfer trip set to Line 22. The estimated cost of this scope is $32,054.

Purchase and install:

1. Install any foundations, grounding, steel pipe stands, conductor and connectors

Purchase and install relay material:

1. One (1), CT – 51C Islanding Transfer Trip Set

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Carolina	$25,879	$17,955	$8,638	$3,192	$55,664
Kerr Dam	$11,861	$14,022	$3,639	$2,532	$32,054
Total Remote Relay Upgrades	$37,740	$31,977	$12,277	$5,724	$87,718

PJM Network Upgrade #n6051 Line #238 Clubhouse to Sapony 230 kV: Replace wave trap at Clubhouse Substation. This will increase emergency rating to 722 MVA. It is estimated to 12-16 months to engineer and construct. Estimated cost is $150,000. This cost includes the following:

Purchase and install at Clubhouse Substation:

1. One (1), 230 kV, 3000 Amp Wave Trap and Line Tuner

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.

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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 285' 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 September 2019.
    - The size of the station assumes ITO will not need a separate storm water management system for the substation. If the county rules differently then 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.

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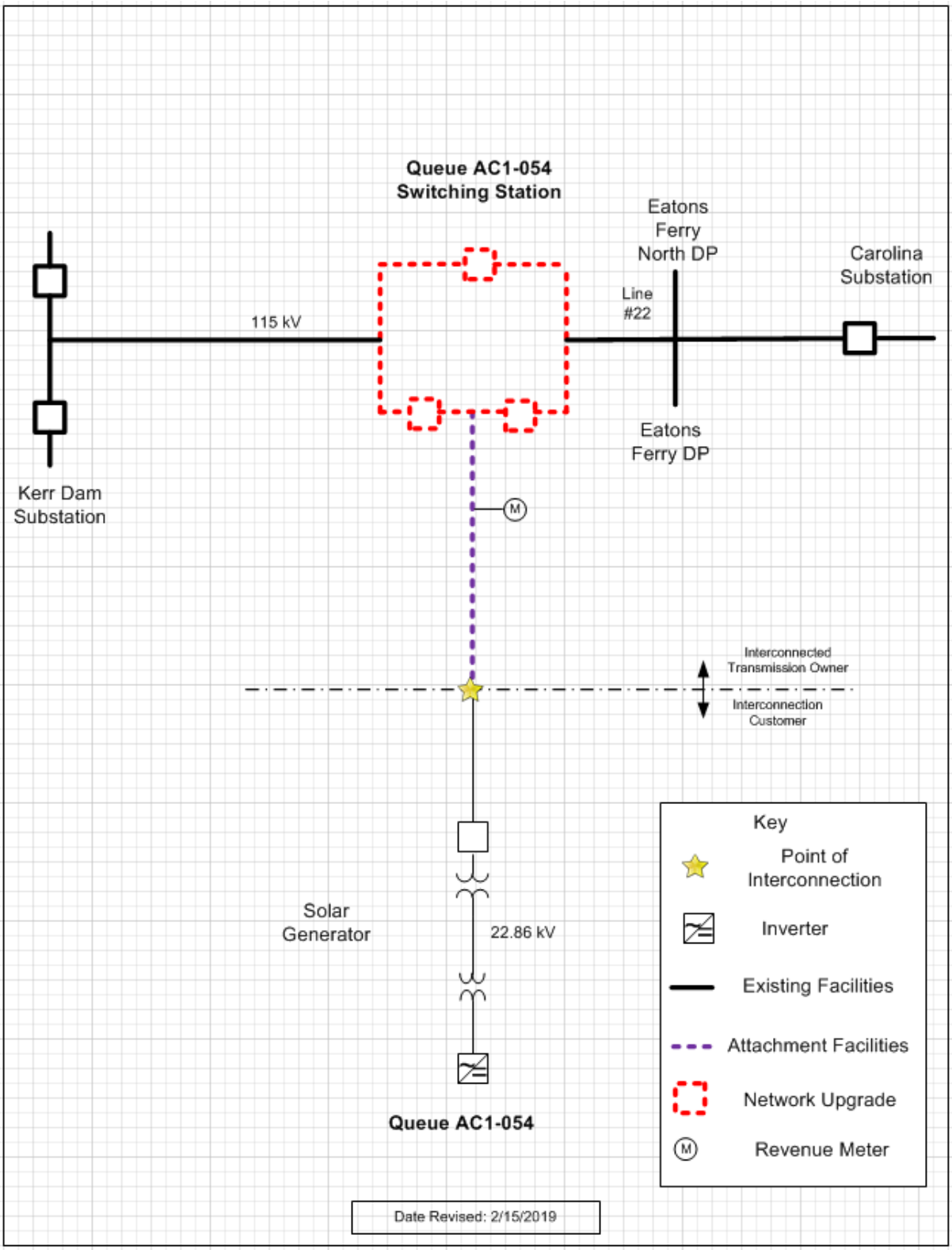
Attachment 1.
Single Line



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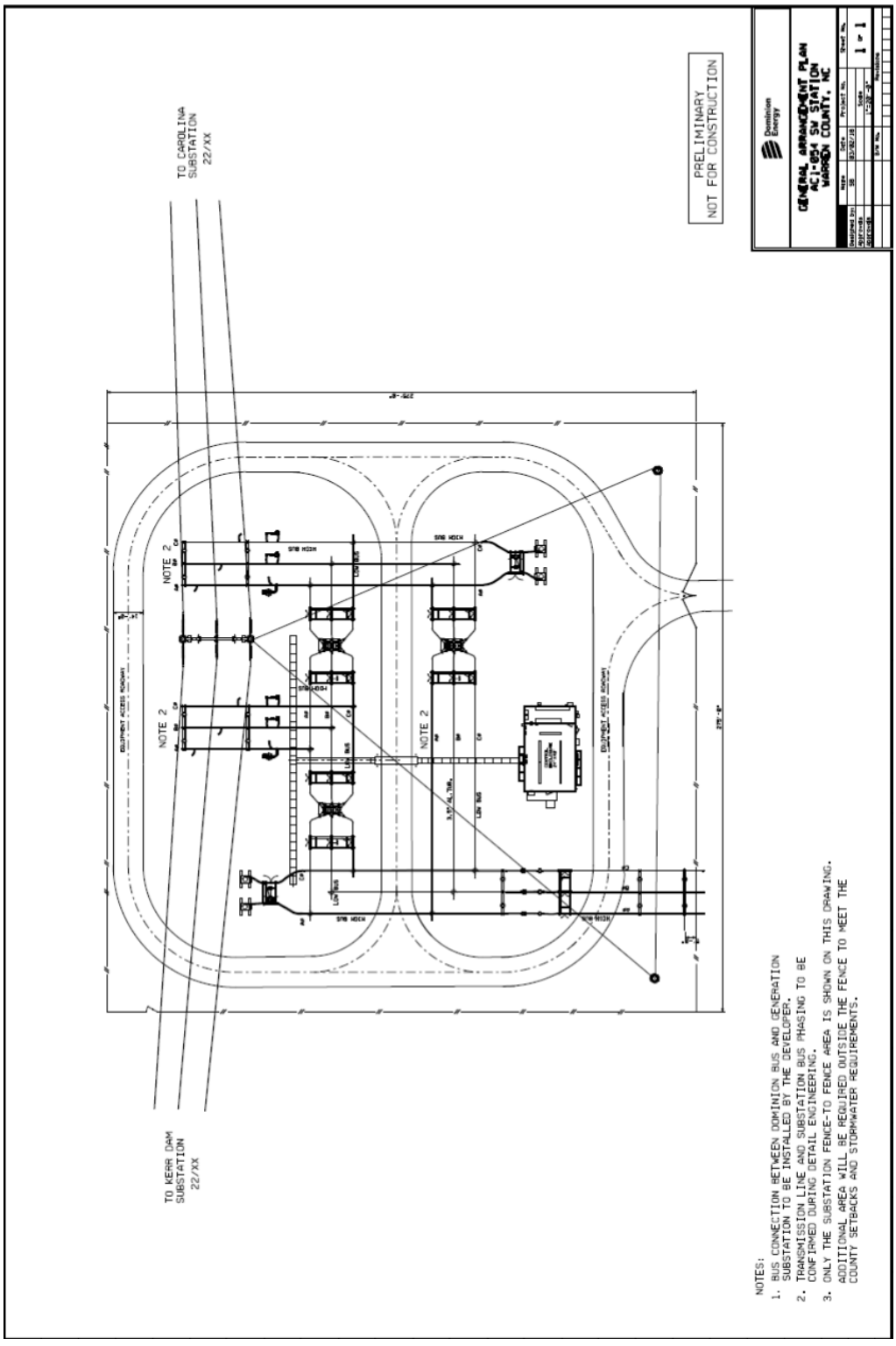
Attachment 2.
AC1-054 Switching Station General Arrangement



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AC1-054 Switching Station Plan

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