Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AC1-043

Mountain Run – Mitchell 115kV
38 MW Capacity / 100 MW Energy

November 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 Greenwood Solar I, LLC, (Interconnection Customer (IC)) and PJM Interconnection, LLC (Transmission Provider (TP)). IC has proposed a solar generating facility located in Culpeper County, VA. The installed facilities will have a total capability of 100 MW with 38 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is November, 2021. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AC1-043 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Mountain Run – Mitchell 115kV line.

Cost Summary

The AC1-043 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 499,691
Direct Connection Network Upgrades	$ 5,468,155
Non Direct Connection Network Upgrades	$ 1,602,259
Allocation for New System Upgrades	$ 0
Contribution for Previously Identified Upgrades	$ 0
Total Costs	**$ 7,570,105**

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue AC1-043 is a request to interconnect a 100 MW new solar generating facility to be located in Culpeper County, Virginia. The proposed generating facility will interconnect with the ITO's new AC1-043 115kV switching station located on the Mountain Run –Mitchell 115kV line #2. The requested in-service date is October 2, 2021. 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 July 31, 2020
- Permits – state level Permit By Rule and county level Final Site Plan approval complete by June 30, 2020
- Substantial site work completed September 30, 2020
- Delivery of major electrical equipment November 30, 2020
- Back Feed Power October 15, 2021
- Commercial Operation October 30, 2021

4. Scope of Customer's Work

IC will build a solar generating facility in c County, Virginia. The generating facility (Greenwood Solar) will be comprised of solar arrays. AC1-043 consists of 50 x 2.2 MW SMA Sunny Central inverters. The 50 x 34.5/0.39 kV delta / wye 2.2 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 grounded wye grounded main power transformer with a rating of 64/85/106 MVA. The AC1-043 POI will be at a tap of the Mountain Run –Mitchell 115kV line #2.

5. Description of Facilities Included in the Facilities Study

The ITO will connect the proposed generator lead via Attachment Facilities to a new AC1-043 115kV three breaker ring bus located between transmission structures 2/490 and 2/491 adjacent to the transmission right of way of the Oak Green - Mountain Run 115kV line #2.

The new 115kV AC1-043 three breaker ring substation will share a common foot print and fence line with Greenwood Solar I, LLC's collector station. The demarcation point between the two stations will be the 115kV breaker disconnect Switch 4-hole pad in the Greenwood Solar I, LLC'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.

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. The transmission line will be renumbered over the existing line segment between the new AC1-043 substation and the Oak Green substation. The existing line segment between the new AC1-043 substation and Mountain Run substation shall remain Line #2. Site plan (Attachment 2) was developed by the ITO. 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	$284,056	$149,157	$49,093	$17,385	$499,691
Total Attachment Facilities Cost					
New AC1-043 three breaker substation (n6235)	$2,532,827	$2,280,794	$412,540	$241,994	$5,468,155
Line #2 Transmission work (n6236)	$764,574	$475,699	$137,570	$48,603	$1,426,446
Remote relay (n6237)	$87,330	$60,638	$18,425	$9,420	$175,813
Total Network Upgrades	$3,384,731	$2,817,131	$568,535	$300,017	$7,070,414
Total Project Costs	$3,668,787	$2,966,288	$617,628	$317,402	$7,570,105

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 2020.

B. Transmission Owner Facilities Study Results

1. Attachment Facilities and Direct Connection Upgrades

Build a 115kV, 3 breaker ring bus substation to support the new AC1-043 solar facility (PJM Network Upgrade # n6235). The site is located along Dominion Energy's existing 115kV, line #2 from Oak Green substation to Mountain Run substation. The cut line will consume two of the positions in the ring bus. The third position will be for the 115kV feed from AC1-043's collector station.

The new AC1-043 substation will share a common foot print and fence line with AC1-043's collector station. The demarcation point between the two stations will be the 115kV breaker disconnect switch 4-hole pad in the 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

Note: 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 the ITO team should be informed at the earliest to adjust the project estimate.

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.

Purchase and install substation material:

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
4. Six (6), 115kV, CCVT's relay accuracy
5. Two (2), 2000A, vertically mounted wave traps
6. Two (2), 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
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
19. Conductor, connectors, conduit, control cable, foundations and grounding material as required per engineering standards

Purchase and install substation relay material:

1. Three (3), 1510 – 28” dual SEL-351-7 transmission breaker with 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 throw-over switch
10. Two (2), 4016 – 600 A disconnect switch fused at 500A
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), 4523 – Security camera interface box
21. One (1), 5616 – Station security panel
22. One (1), High voltage protection box
23. One (1), Telephone interface box

Purchase and install Attachment Facilities material:

1. One (1), 115kV, 2000A Center Break Switch (purchased by DE)
2. Three (3), 115kV, Metering Accuracy CCVT’s (purchased by DE)
3. Three (3), 115kV,500:5 Metering Accuracy CT’s (purchased by DE)
4. Tubular bus as required
5. Steel Structures as required
6. Conductor, connectors, conduit, control cable, foundations and grounding material as required per engineering standards

Purchase and install Attachment Facilities 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 transmission and generator interconnect 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 #n6236 – Tap the Mountain Run to Oak Green 155kV line #2 between structure 2/492 and 2/494 to interconnect the new AC1-043 three breaker ring bus substation.

STRUCTURE INSTALLATIONS:

1. Install (1) 230KV Galvanized Double Circuit Steel Backbone Structure (no switches) with 38'-0" spacing with foundations.
2. Install (2) Galvanized Static Pole Structure with Foundations.

CONDUCTOR/SHIELD WIRE INSTALLATIONS:

1. Cut and transfer (4) existing spans of 3-Phase 2-636 ACSR conductor to the new double circuit backbone structures (two spans will run from Ex. Str. 2/492 – Proposed BB, the other two spans will run from Str. Proposed BB – 2/494).
2. Cut and transfer (2) existing spans of OPGW to the new backbone structures (two spans will run from Ex. Str. 2/492 – Proposed BB, the other two spans will run from Str. Proposed BB – 2/494).
3. Install approximately 0.12 miles (3 pans) of 1-7#7 static wire from the proposed backbone structure to the proposed static poles.
4. Install approximately 0.95 miles of 2-OPGW wire from the proposed backbone structures to the existing monopole, 2199/100. Include fiber splicing.
5. Renumber approximately 57 structures with the new line number between AC1-043 and Mountain Run substation.

3. Upgrades to Substation / Switchyard Facilities

PJM Network Upgrade #n6237 - 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 Oak Green, Mountain Run, and Remington 115kV substations. These costs include the following:

Oak Green 115kV Substation

Complete drawing work, relay resets, and field support necessary to change line #2 destination from Mountain Run to AC1-043 substation. Also install Line #2 islanding transfer trip scheme to work with the new AC1-043 Substation

Purchase and install relay material:

1. One (1), 1604 – 24" Transmission Transfer Trip Panel

Mountain Run 115 kV Substation

Complete drawing work, relay resets, and field support necessary to change line #2 number and destination from Oak Green to AC1-043 substation. Also install line #2 islanding transfer trip scheme to work with the new AC1-043 substation. Note that since Mountain Run only has a line tie breaker, the islanding scheme will need to extend to the next substation, Remington (line #70). Breaker positions at Remington will transmit to Mountain Run to pass through along with the breaker position at Mountain Run to AC1-043. Due to the lack of relay panel space, the islanding schemes will be installed in the existing sectionalizing panel.

Purchase and install relay material:

1. One (1), CT-51C Islanding Transfer Trip Transmit Set
2. One (1), CR-51C Islanding Transfer Trip Receive Set
3. One (1), SEL-2411 94/ITR

Remington 115 kV Substation

Install line #70 islanding transfer trip scheme to work with the new AC1-043 substation. Note that since Mountain Run substation only has a line tie breaker, the Islanding Scheme will need to extend to the next substation, Remington (line #70). Breaker positions at Remington will transmit to Mountain Run to pass through along with the breaker position at Mountain Run to AC1-043 for islanding conditions. The existing control enclosure at Remington Substation will not accommodate the additional relays.

Project 992523 at Remington will install a new Transmission control enclosure that is scheduled for a 4/2020 completion. It is assumed that the timing of this project will allow this relay addition to be installed in that new control enclosure. If not, alternative plans will be needed that will affect the cost of the project.

Purchase and install relay material:

1. One (1), 1604 – 28" Transmission Transfer Trip Panel

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Mountain Run	$28,975	$25,376	$6,510	$3,908	$64,769
Remington	$29,018	$17,631	$5,934	$2,756	$55,339
Oak Green	$29,337	$17,631	$5,981	$2,756	$55,705
Total Remote Relay Upgrades	**$87,330**	**$60,638**	**$18,425**	**$9,420**	**$175,813**

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.

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

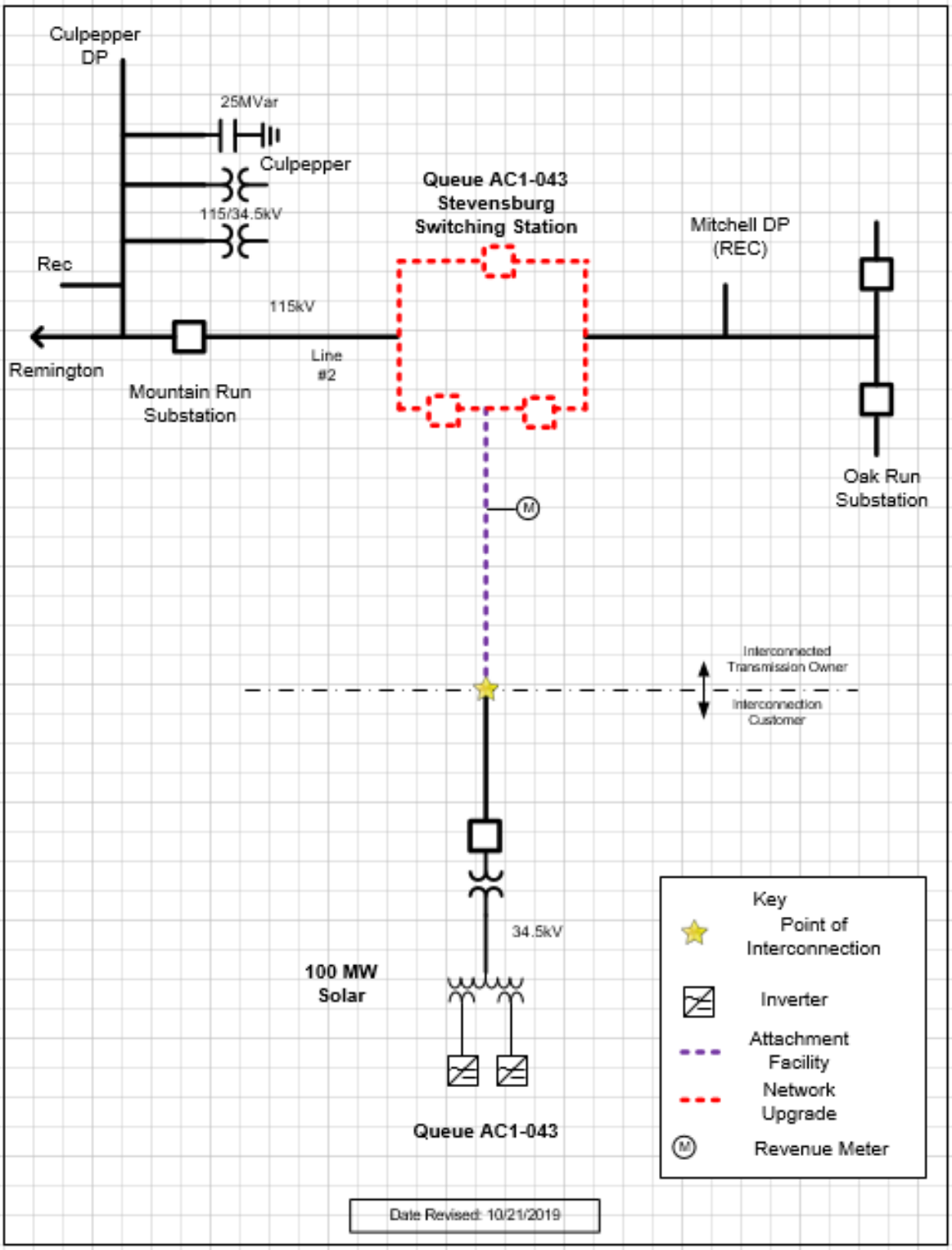
The IC would be responsible for the following expectations in the area of environmental, real estate and permitting:

- Suitable access road from substation to a Virginia 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 275'x 250' 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 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 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.

Attachment 1.
Single Line



Attachment 2.
AC1-042 Switching Station General Arrangement