Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AC1-076

Locust Grove-Paytes 115 kV
23.8 MW Capacity / 62.5 MW Energy

July / 2019

Introduction

This Facilities Study has been prepared in accordance with the PJM Open Access Transmission Tariff §207, as well as the Facilities Study Agreement between Sol Madison Solar, LLC, (Interconnection Customer (IC)) and PJM Interconnection, LLC (Transmission Provider (TP)). The Interconnected Transmission Owner (ITO) is Virginia Electric and Power Company (VEPCO).

General

The IC has proposed a solar generating facility located in Locust Grove, VA (Orange County). The installed facilities will have a total capability of 62.5 MW with 23.8 MW of this output being recognized by PJM as Capacity. The proposed in-service date as stated in the AC1-076 Attachment N is 4/30/2018. Subsequently, the IC revised the requested in service date to 12/31/2021. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AC1-076 will interconnect with the ITO transmission system via a new three breaker ring bus switching station tapping the Locust Grove – Paytes 115kV line #153.

Cost Summary

The AC1-076 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 492,735
Direct Connection Network Upgrades	$5,124,230
Non Direct Connection Network Upgrades	$2,178,235
Allocation for New System Upgrades	$ 0
Contribution for Previously Identified Upgrades	$ 0
Total Costs	**$7,795,200**

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue AC1-076 is a request to interconnect a new 62.5 MW solar generating facility to be located in Orange County, Virginia. The proposed generating facility will interconnect with the ITO's new AC1-076 115kV Switching Station via a new breaker three breaker ring bus substation tapping the Locust Grove – Paytes 115 kV line #153. The requested in-service date is **December 31, 202**1. Attachment Facility and Network Upgrade construction is estimated to be **14 – 24 months**.

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

The estimates provided in the System Impact Study have been refined as part of the Facilities Study.

3. Interconnection Customer's Submitted Milestone Schedule

- Permits – state level Permit By Rule and county level Final Site Plan approval complete by: December 2, 2020
- Plan to break ground January 15, 2021
- Substantial site work completed April 1, 2021
- Delivery of major electrical equipment April 1, 2021
- Back Feed Power May 1, 2021
- Commercial Operation December 31, 2021

4. Scope of Customer's Work

IC will build a solar generating facility in Orange County, Virginia. The generating facility (Pine Glade Solar) will be comprised of solar arrays. AC1-076 consists of 30 x 2.11 MW Power Electronics Solar inverters. The (30) 0.6-34.5 generator step up (GSU) transformers, each with a rating of 2.225 MVA will connect the solar inverters to the 115kV collector system. The generating facility will connect to the Point of Interconnection (POI) via a 115/34.5 kV Delta Grounded Wye main power transformer with a rating of 42/56/70 MVA. The AC1-076 POI will be at a new Interconnection switching station. .

5. Description of Facilities Included in the Facilities Study

The scope of work for AC1-076 includes the construction of a new interconnection substation and necessary network upgrades to tie a 62.5 MW capacity solar generating facility into the ITO transmission network. The ITO will construct a 115 kV switching station with a three breaker ring bus configuration and the required 115 kV transmission line modifications.

The solar generating facility will be located east of the existing Locust Grove DP Substation. The position of the switching station will be adjacent to the right of way of the existing 115 kV Transmission Line #153, on a property provided and rough graded by the IC. The station will be

positioned in such a way that the two 115 kV Light Duty Backbones provided by the ITO will be installed perpendicular with the existing transmission line.

The line will be cut at Structure #153/15 and routed into the proposed New Three Breaker Ring Substation. The cut 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, located adjacent to the New Three Breaker Ring Substation. The demarcation point between the New Three Breaker Ring Substation and the collector station will be the 4-hole pads on the collector station disconnect switch. ITO will bring its bus to the demarcation point. Metering equipment will be required between the Dominion bus and the collector station. The grounding systems for both the stations will be tied together. All substation permitting, site preparation and grading activity will be performed by the IC.

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 bus, structures, disconnect switch, metering accuracy CCVT's, metering accuracy CT's, metering and associated protection equipment.

ITO will renumber structures between the New Three Breaker Ring Substation and Spotsylvania Substation.

The Fence and Security Type will be Design 4.

Refer to the single line is shown in Attachment 1and site plan in Attachment 2 for additional details.

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

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Attachment Facilities (N6085)	$280,573	$149,090	$45,698	$17,374	$492,735
Total Attachment Facilities Cost	$280,573	$149,090	$45,698	$17,374	$492,735
Direct Network Upgrade Interconnection Substation Construction (N6083)	$2,258,027	$2,254,494	$369,730	$241,979	$5,124,230
Total Direct Network Upgrade Costs	$2,258,027	$2,254,494	$369,730	$241,979	$5,124,230
Non-Direct Network Upgrade Line #153 Transmission work (N6084)	$737,910	$623,368	$331,759	$325,941	$2,018,978
Non-Direct Network Upgrade Remote relay (N6086)	$79,090	$54,638	$16,989	$8,540	$159,257
Total Non-Direct Network Upgrade Costs	$817,000	$678,006	$348,748	$334,481	$2,178,235
Total Network Upgrades	$3,075,027	$2,932,500	$718,478	$576,460	$7,302,465
Total Project Costs	$3,355,600	$3,081,590	$764,176	$593,834	$7,795,200

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 1, 2020.

B. Transmission Owner Facilities Study Results

1. Attachment Facilities

PJM Network Upgrade # N608: Metering and associated protection equipment at the AC1-076 generator substation

Purchase and install substation material – Attachment facilities:
1. One (1), 115kV, 2000A Center Break Switch
2. Three (3), 115kV, Metering Accuracy CCVT's
3. Three (3), 115kV, 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 – Attachment facilities:
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 # N6084 – Modifications to the Locust Grove DP – Paytes 115kV, line #153

Re-built in 2006, the 153 line consists of mostly single shaft Dom poles. Project AC1-076 was initiated by a solar Generation Interconnection Request that came to Dominion via PJM. Project AC1-076 will install a new substation that taps off of a location near existing Structure 153/14. After some discussion with the developer, a new, more complex design was determined to be required. Instead of the substation adjoining the edge of our existing ROW, the new substation will be located almost 1/3 mile away from the POI near structure 153/14. New 150' ROW will need to be cleared and accessed to build the new tap line.

The following estimate is for the construction of that new substation and transmission line tapping off existing Transmission Line 153 between Oak Green and Spotsylvania Substations. The line connection will require the installation of two (2) backbone structures, one(1) static pole structure, and three (3) engineered double circuit double dead end structures. The new substation will create a new line (Line XXXX) from the new sub to Spotsylvania Substation.
The conceptual design and estimate includes costs for the following:

ESTIMATE – FACILITIES TO BE INSTALLED:

1. Install two (2) 115kV SC Heavy Duty Steel Backbone structure with a foundation at Structure 153/17 and Structure XXXX/11.
2. Install one (1) Galvanized Steel Static Pole with foundations (Strs. 153/17A).

3. Install three (3) DDE DC Engineered Structures.
4. Cut and transfer 3-Phase 795 ACSR conductor, and 3/8" Steel shield wire to both arms of the new Structure 153/14.
5. Install approximately 1600 feet of double circuit 3 –Phase 795 ACSR conductor and 2-3#6 AW shield wire from new Structure 153/14, XXXX/14 to new backbones 153/17, XXXX/11.
6. Install approximately 400 feet of 1-7#7 static wire from the new Backbone Structures to the new Static pole.
7. Renumber approximately 67 Structures from the New Substation to Spotsylvania Substation

ESTIMATE – FACILITIES TO BE REMOVED:

1. Remove one (1) existing weathering steel RA structure, Structure 153/14

3. New Substation/Switchyard Facilities

PJM Network Upgrade Number, N5972 and N6083 – Build a three breaker AC1-076 115kV switching station

Purchase and install substation material – Direct Network Upgrade:
1. Approximately 300' X 230' site preparation and grading as required for installation of the switching station, not including any added land as required for Storm Water Management, etc.

2. Approximately 1060 linear FT of 5/8" Chain Link, 12 FT tall, perimeter fence around the substation along with the security cameras and integrators (Design 4 Standard).
3. Full substation ground grid as per engineering standards
4. Two (2), Single Circuit Backbones
5. One (1), Shield wire pole and two span of shield wires
6. Three (3), 115kV, 3000A, 40 kA, SF6 Circuit Breakers
7. Six (6), 115kV, 2000A Center Break Switches
8. Six (6), 115kV, CCVT's, relay accuracy
9. Two (2), 2000A, Vertically Mounted, Wave Traps along with two (2), Line Tuners
10. Nine (9), 90kV MO, 74kV MCOV Station Class Arresters
11. Four (4), 115kV, 100 KVA Power PT's for Station Service
12. Two (2), 115kV, 2000A, 2-Pole Center Break Switches (for PVT's)
13. One (1), 24' x 40' Control Enclosure
14. One (1), 135VDC, 577Ah Batteries and 50A Charger
15. Oil Containment system for the 115kV PVT's.
16. Cable Trough, concrete w/cover, 2' 6'' wide, approximately 250 FT, with a 20 FT road crossing section.
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 and grounding materials as per engineering standards

Purchase and install relay material – Direct Connect:
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 # N6086 - 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 Spotsylvania, Oak Green, Unionville and Locust Grove 115kV substations. These costs include the following:

Spotsylvania 115 kV Substation

Project Summary:
Project AC1-076 provides for the drawing work, relay resets, and field support necessary to change Line 153 number and destination from Oak Green to AC1-076 Substation. Also install Line 153 Islanding Transfer Trip scheme to work with the new AC1-076 Substation and activate the existing Line 153 Breaker Failure Transfer Trip Receiver.

Purchase and install relay material:

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

Oak Green 115 kV Substation

Project Summary:
Project AC1-076 provides for the drawing work, relay resets, and field support necessary to change Line 153 destination from Spotsylvania to AC1-076 Substation. Also install Line 153 Islanding Transfer Trip scheme and activate existing Breaker Failure Transfer Trip Transmitter (currently out of service) to work with the new AC1076 Substation.

Purchase and install relay material:
1. One (1), 1604 – 24" Transmission Transfer Trip Panel

Unionville Substation 115 kV

Project Summary:
Project GIT-AC1076 provides for the drawing work, relay resets, and field support necessary to change the Line 153 destination from Locust Grove Substation to the new AC1-076 Generator Interconnect Substation.

Purchase and install relay material:
1. No Relay Material

Locust Grove 115 kV

Project Summary
Project AC1-076 provides for the drawing work, relay resets, and field support necessary to change the Line 153 destination from Spotsylvania Substation to the new AC1076 Generator Interconnect Substation.

Purchase and install relay material:
1. No Relay Material

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Spotsylvania Substation Upgrades	$34,502	$27,319	$7,099	$4,270	$73,190
Oak Green Substation Upgrades	$29,586	$27,319	$6,326	$4,270	$67,501
Unionville Substation Upgrades	$7,501	$0	$1,782	$0	$9,283
Locust Grove Substation Upgrades	$7,501	$0	$1,782	$0	$9,283
Total Remote Relay Cost	$79,090	$54,638	$16,989	$8,540	$159,257

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

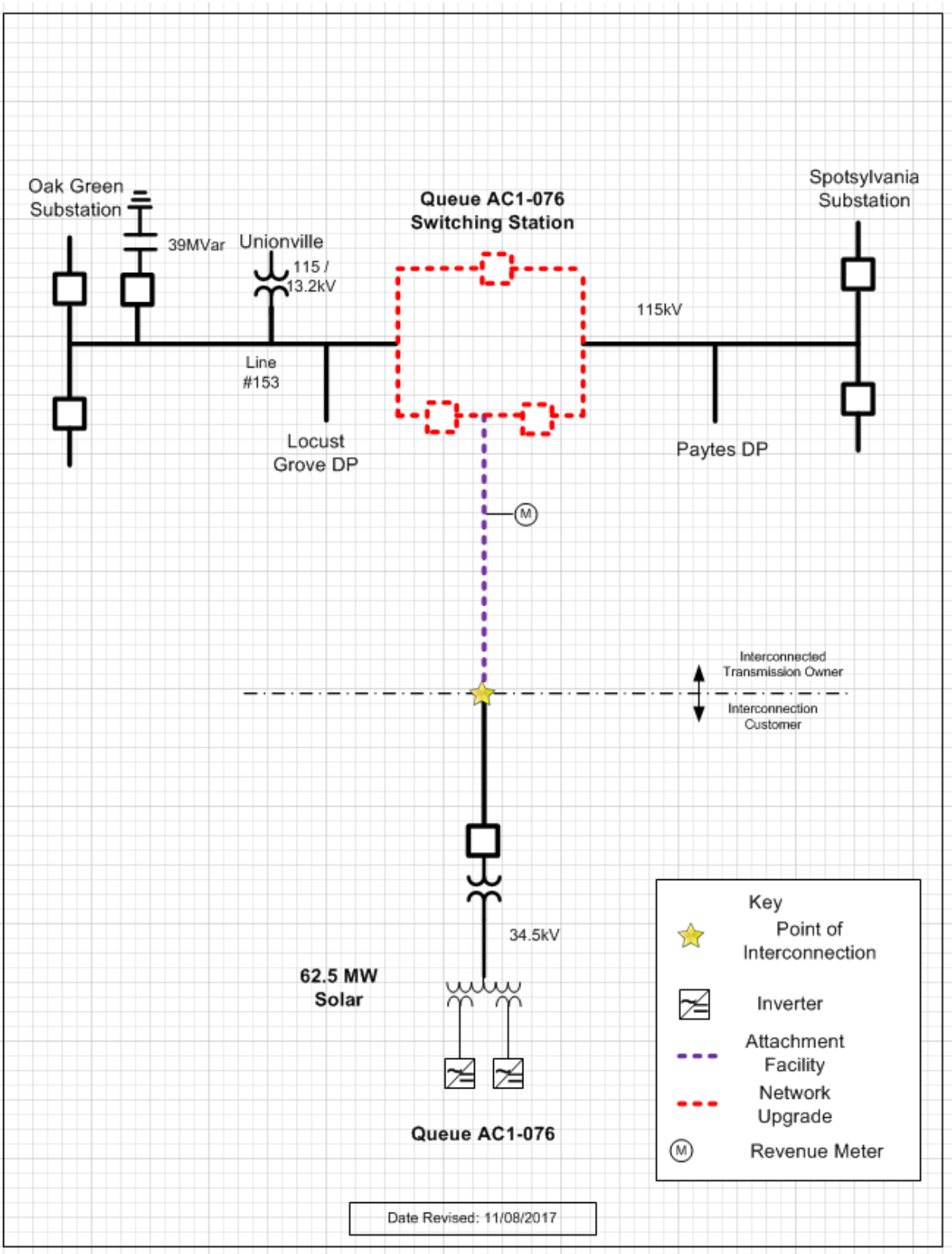
The IC would be responsible for the following expectations in the area of Environmental, Real Estate and Permitting:

- 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 300' x 230' 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 1, 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.

AC1-076 Switching Station General Arrangement