Facilities Study Report

For

Physical Interconnection of

PJM Generation Interconnection Request Project ID AH1-033

Sligo 34.5 kV

AH1-033 Sun Energy (hereinafter called "Project Developer") has submitted an Interconnection Request for a 13 MW generation facility to operate in parallel with the distribution system of Virginia Electric and Power Company, doing business as Dominion Energy Virginia in Virginia (hereinafter called "Company"). The results of the Facility Study are as follows:

Preface

The intent of the Facility Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation to the Dominion Energy Virginia Electric System at a location specified by the Project Developer. As a requirement for interconnection, the Project Developer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the Dominion Energy Virginia system. All facilities required for interconnection of a generator must be designed to meet the technical specifications for the appropriate ITO.

> **The Facility Study Cost is an estimated cost only. No engineering has been performed to arrive at the cost and Dominion Energy Virginia does not guarantee the accuracy or completeness of this cost. The estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. All estimates have been calculated in good faith, however, are non-binding.**

General

Address of facility: **Windchaser Way, Moyock NC 27958**
The installed facilities will have a total capability of: **13 MW**
Substation: **Sligo**
Circuit number: **71 467**
Circuit voltage: **34.5 kV**

Transmission Owner (Utility) Provided Transmission Owner Interconnection Facilities

- Extend 3 phase, 477 Al. primary / 246.9 neutral overhead conductor to a new pole and install 600 amp Disconnect Switch at the Point-of-Interconnection
- Extend 3 phase, 477 Al. primary / 246.9 neutral overhead conductor to a new pole and install a single phase OH transformer to supply power for Recloser, Power Quality Monitor, & Transfer Trip controls and extend #2 Triplex to Recloser & Metering Poles
- Extend 3 phase, 477 Al. primary / 246.9 neutral overhead conductor to a new pole and install G&W Viper ST w/SEL 651R-2 Control Recloser.
- Extend 3 phase, 477 Al. primary / 246.9 neutral overhead conductor to a new pole and install Bi-Directional Primary Metering equipment.
- Utility will install Power Quality Monitor at the Primary Meter location
- Extend 3 phase, 477 Al. primary / 246.9 neutral overhead conductor to a new pole and install 600 amp Disconnect Switch.
- Utility will install new metering equipment, CT's and PT's, the meter cabinet, meter, and connect the customer conductor to utilities 34.5kV facilities

Project Developer Requirements (to include but not limited to)

- Installation of road providing accessibility along the Utility interconnection poles suitable for construction and operation vehicle traffic.
- Installation of a gang operated air-break switch or equivalent located 1 span from the point of interconnection providing a visible opening that can be locked and tagged that will be utilized to isolate the Project Developer from the Utility.
- Installation of all conductors, pad mount transformers, and generator breakers between the generating facility and POI.
- Communication lines for all metering.
- Communication circuit(s) for Transfer Trip Scheme, if required, between the DG site and Substation, and between the DG site and inline recloser(s).
- Obtain any required right-of-way for the construction of Utility's facilities necessary for the interconnection of this generator.
- Provide and maintain a telephone line (POTS) to the Utility metering equipment.
- Metering to report real-time to PJM is required when the generation capacity is 10 MW or more total on the circuit.
- All Project Developers must provide generator status and instantaneous MW output to PJM per Manual 14D of the PJM OATT via communication links when the aggregate generation capacity reaches 10MW or more on a circuit. This communication medium is installed, owned, and maintained by the Project Developer. Contact PJM for additional details concerning the requirement [PJM System Planning Division @ (610) 666-8980].

Transmission Owner (Utility) Provided Distribution Upgrades

AH1-033 proposes to build a 13 MW DER facility located on Off Windchaser Way, Moyock NC, 279588. Based on the location the DER site would interconnect to the Utility's Sligo Substation on 71_Cir 467 (34.5 kV). The site is located approximately 5.9 miles in circuit length away from Sligo Substation. This project is in status "A" and has 10 MW Energized ahead of it. The existing conductor between the substation and the interconnection site is approximately 5.12 mi OH 477 AAC, 0.04 mi OH 477 ACSR 24/7, 0.43 mi OH 1/0 AAAC. The site is approximately 0.33 miles from existing three-phase service; new Right-of-Way and three-phase line extension will be needed. The proposed line extension will cross a transmission ROW; a transmission encroachment will be needed. Due to the aggregate size of the generation on the circuit, transfer trip will need to be installed on the interconnect recloser, the upline new recloser and the station breaker. Additional Transformer, Substation, and Transmission Upgrades will be provided in the Facility Study. Developer has asked for an Underground POI.

- In Reconductor 0.43 miles Q0846WO7200 from to Q0846WO7200 with 477 AAC primary and neutral.
- Remove 71467 F514 and replace with G&W Viper recloser with 3-Ø Trip and Transfer Trip capability.
- Install new 1000 MCM terminal pole from Q0846WO7200.
- Install 0.67 miles from Q0846WO7200 to Q0846SI6500 with 1000 MCM Al cable.
- Constructability of upgrades is contingent upon the acquisition of required easements and/or encroachments.

Protection Requirements for Customer 13 MW of Generation

The utility has done a preliminary review on the 13 MWAC Interconnect Customer (AH1-033) request for installation of parallel generation units located at Windchaser Way, Moyock NC, 27958. The Distributed Energy Resources (DER) owner desires to both export power into the Dominion Energy Virginia (UTILITY) utility source and provide site power via site solar generation.

This is a UL1741/IEEE 1547 certified inverter-based interconnection consisting of six (6) SC4200-UP-US inverters rated 4200 kW, and operating at 630 VAC. The inverter system is in six (6) blocks, with each block having one (1) 4200 kW inverters connected to one (1) 3-phase 4200 kVA pad mounted transformer. Note: All transformers are rated 19.9/34.5kV–630V and must be wye-ground/wye (ground facing utility) or wye-ground/wye-ground winding configuration.

Power export is limited to 13 MWAC at the POI using a site controller, or by digitally limiting the output of each individual inverter.

The resulting protection requirements are based on the following information:

- No more than 13 MWAC of total generation will be in parallel with the utility system at any one time.
- The DER owner's generation facility will be paralleled with the utility system by the following connections:
  - The DER owner’s generation facility will be connected to the Sligo Circuit 467 via the new Automatic Line Recloser (ALR) 467RYYY, which is sourced by in-line recloser 467RNEW, CB 46732, Bus #1, Sligo Transformer #1 and Transmission Line 269.
- Transmission Line 269 has existing or queued project DER totaling 14.22 MWAC when excluding sites that have Direct Transfer Trip enabled. Sligo Transformer #1 currently has existing or queued project DER totaling 14.22 MWAC when excluding sites that have Direct Transfer Trip enabled. Sligo Circuit 467 distribution facilities has existing or queued project DER totaling 14.06 MWAC.
- Sligo Circuit 467 feeder breaker has reclosing times set at 10 seconds and 45 seconds.
- Transmission Line 269 has both time delayed and instantaneous reclosing applied on its terminal breakers.
- DER owner parallel operation will not be limited to any particular time or utility circuit-loading condition; however, DER owner parallel operation will not be permitted during periods when the source circuit is switched into an abnormal configuration.
- The DER owner will be contracting with the utility to export power into the utility distribution system.
- The load data for the pertinent sectionalizing devices are as follows:
  - In-line Recloser 467RNEW has a typical light load of less than 5.52 MVA
  - Sligo Circuit 467 (46732) has a typical "light" loading of 5.52 MVA
  - Sligo Transformer #1 has a typical "light" loading of 8.00 MVA
  - Transmission Line 269 has a typical "light" loading of 8.00 MVA

Based on projected minimum loads given for the applicable utility sectionalizing devices, the following minimum "Light Load to Cumulative Generation Capacity" ratios will apply for this installation. Transfer trip is required from each zone with a ratio less than 3:1.

Utility Device	*Minimum Ratio*
467RNEW	<0.39
CB 46732	0.39
Transformer #1	0.56
Transmission Line 269	0.56

Table 1 - Light Load to Cumulative Generation Ratio

Based on the size and type of this generation, the applicable utility standards and the minimum load ratios applicable for this installation, the following requirements must be met in their entirety before permission to parallel operations can be granted:

1. Installation of a utility owned Automatic Line Recloser (ALR) at the point of common coupling (PCC) with all required relaying at the DER owner expense.

2. Installation of an additional utility owned protective relaying (SEL-735 Power Quality Package, or similar) at the PCC (Utility Metering Instrument Transformer Cabinet) with all required metering/relay functionality at the DER owner expense. The power source (single phase, 120 VAC) to this Power Monitor shall be supplied from a 2 kVA or larger Station Service (Primary kV – 120 VAC) source (low exposure) independent of any other generation, load or exposure. Such protective relaying should aid in the determination of on-going harmonic levels among other information regarding the interconnection site.

3. Power Quality baseline readings will be required before and after the interconnection is completed in order to monitor the PQ effects of the generation unit and will be obtained at the DER owner's expense. If there is evidence that the new interconnection is the source of power quality anomalies (as defined by industry standards and based on Good Utility Practice), the DER owner will be required to take the necessary actions to mitigate the issue in a reasonable timeframe. Dominion Energy Virginia (DEV) reserves the right to disconnect the generation via the POI recloser if DEV and Interconnection Customer cannot agree, in a timely manner, on a solution which resolves the PQ issues. Please refer to Appendix 1 for examples of industry Standards and/or Good Utility Practice for power quality.

4. Zero Sequence Sources: The utility does not allow zero sequence (I0) sources, like wye-ground/delta transformers, to connect to the distribution grid. The zero sequence sources desensitize protective overcurrent relays on the electric power system. The utility requires a wye-ground/wye with ground facing utility, or wye-ground/wye-ground transformer configuration.

5. Effective Grounding: Due to the step-up transformer configuration being wye-ground/wye (ground facing utility) or wye-ground/wye-ground, the utility Electric Power System (EPS) will not be effectively grounded when an upline device opens to clear a fault and the

DER remains connected to the islanded segment for a period of time. One of the two following requirements will be needed to mitigate this issue.

a) Install Direct Pilot Wire Tripping (Transfer Trip) from each of the upline utility devices to the DER site recloser.
b) A light load to generation ratio greater than 3:1 for the nearest upline device from the POI.

6. Station upgrades listed below are required (if not already existing):

a) Utilize the existing DER relay panel; SEL-451 and SEL-735.
b) Update SEL-735 Transformer meter logic to latest standard to incorporate power quality enhancements.
c) Use existing Potential Transformers (PT) to 34.5 kV Bus.
d) Add transmission line transfer trip to Line 269 to serve as an input to the SEL-451 DER panel relay to send transfer trip to the POI recloser to clear all potential sources to a transmission fault. Ensure that line terminal stations have been upgraded to provide line transfer trip functionality.
e) Install Direct Pilot Wire Tripping (or Transfer Trip) from each of the upline utility devices: 467RNEW, CB 46732, Bus #1, Sligo Transformer #1, and transmission line 269 to the DER site recloser. Transfer trip is required due to light load to generation ratio being less than 3:1.
f) Wire Transformer #1 LORs 86T1, 86T1BU and Bus#1 LOR 86B1 to serve as an input to the SEL-451 DER panel relay to send transfer trip and prevent reclosing of the POI recloser to clear all potential sources to an upstream fault.

The voltage and frequency set points, listed in Table 2, are derived from IEEE-1547-2018. The “Total Clearing Time (sec)” listed in Table 2 is a summation of the detection time, field adjustable clearing time, and trip time. The DER owner will be required to apply all the enabled protection settings and not exceed the “Total Clearing Time (sec)”. The DER owner shall provide detailed, manufacturer-supplied computer simulation models (Aspen OneLiner, PSS/E, and/or PSCAD) of the inverter, to include full control and hardware details, needed to investigate DER impacts. If the site is using a site controller, setpoints may be achieved at the controller instead of individual inverters. Once inverter/site controller settings have been field verified, the settings may not be changed without approval from the utility.

Currently, this site is intended to operate with utility interactive inverter functionality enabled and with grid support utility interactive inverter functionality disabled.

Function		Set Point	Total Clearing Time (sec)
27	Under-voltage (UV1)	V < 88% nominal voltage	2.0
27	Under-voltage (UV2)	V < 50% nominal voltage	0.160
59	Over-voltage (OV1)	V ≥ 110% nominal voltage	1.0
59	Over-voltage (OV2)	V ≥ 120% nominal voltage	0.160
81U	Under-frequency (UF1)	F < 59.0 Hz	180
81U	Under-frequency (UF2)	F < 57.0 Hz	0.160
81O	Over-frequency (OF1)	F > 61.0 Hz	180
81O	Over-frequency (OF2)	F > 61.8 Hz	0.160
	Overall Anti-Islanding	Disconnect inverter from system (PCC)	0.160
	Steady State Power Factor	UNITY Power Factor	
	Watt/Var Control	DISABLE	
	Volt/Var Control	DISABLE	
	Volt/Watt Control	DISABLE	
	Frequency/Watt	DISABLE	

Table 2: *DER Inverter Settings*

Since the installation of the utility owned ALR at the PCC, associated relaying, Protective Relaying (SEL-735 Power Quality package, or similar) and the related additional substation work are all provided at the DER owner expense, we will need to work out details to coordinate the planned interconnection with the associated engineering, equipment acquisition and installation times. Please note that the DER owner will not be allowed to interconnect until all the permanent facilities and associated relaying are installed, tested and fully functional.

Should any changes occur in the IEEE guidelines for the interconnection of a DER system and/or changes occur in system conditions (i.e. penetration level of DER on that part of the system), the utility reserves the right to re-evaluate the protection application and require upgrade(s) as it deems necessary for the utility and/or the DER owner. Any necessary upgrades will be assigned according to how the changes impact the DER owner's generation and interconnection to the grid. In accordance with Article 3 of the GIA, the utility reserves the right to require the DER owner to remedy any adverse operating conditions at the DER owner's expense, should they occur.

Finally, please promptly provide us details/confirmation concerning the DER owner's final inverter model (nameplate photos), the applied inverter trip points, and interface transformer specifications (i.e. transformer impedance, load losses, high side fuse make, model, rating, etc.), as soon as possible.

Transmission Owner (Utility) Provided Substation Upgrades

Project AH1-033 provides for upgrades to support the 13 MW DER interconnection request on circuit 467. Add SEL-2440 to the existing TX # 1 DG support panel for sending TT to the DG site. Transfer Trip is to be installed to support this distributed generation due to light load to generation ratio. Third party Fiber is to be used for the transfer trip communication from Sligo sub to the POI and in-line recloser. Install a Fiber MU Box outside the substation fence for customer fiber pickup.

Purchase and Install (Sligo Substation):

1. 2 - 2" conduit from control enclosure/cable trough to Dist. Gen. fiber MU box (location TBD by Substation)
2. Install conductor, connectors, conduit, control cable, foundations, steel, and grounding material as per engineering standards

Purchase and Install Relay Material (Sligo Substation):

1. Add SEL-2440 to TX # 1 DG Panel
2. One (1), 4528_A - Distributed Generation Fiber MU Box
3. One (1), 5610 – Wall Mounted Fiber Management Box

Purchase and Install Relay Material (DG Site):

1. N/A - necessary equipment to be provided and installed by distribution

Schedule Estimate

The total expected time for engineering and construction of all work required will be approximately **30 months** from the execution of an Interconnection Agreement and payment of all required costs.