Facilities Study Report

For

Physical Interconnection of

PJM Generation Interconnection Request

Project ID AG1-551

Parmele 34.5 kV

AG1-551 Martin County Solar, LLC, (hereinafter called "Project Developer") has submitted an Interconnection Request for a 20MW generation facility to operate in parallel with the distribution system of Virginia Electric and Power Company, doing business as Dominion Energy North Carolina in North Carolina (hereinafter called "Company"). The results of the Facility Study are as follows:

Preface

The intent of the Facilities Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation to the Dominion Energy North Carolina 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 North Carolina system. All facilities required for interconnection of a generator must be designed to meet the technical specifications for the appropriate ITO.

> **The Facilities Study Cost is an estimated cost only. No engineering has been performed to arrive at the cost and Dominion Energy North Carolina 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: **US Hwy 64, Robersonville NC 27871**
The installed facilities will have a total capability of: **20 MW**
Substation: **Parmele**
Circuit number: **62 xxx**
Circuit voltage: **34.5kV**

Transmission Owner (Utility) Provided Transmission Owner Interconnection Facilities

- Installation of approximately 300 feet of three (3) phase overhead 477 Al. Primary / 246.9 Al. Neutral conductor
- Installation of G & W Viper Recloser with a SEL651R-2 Recloser Control
- Power Quality Monitor (SEL-735 or equivalent device) at the Point of Change of Ownership with all required metering/relay functionality
- Transformer and secondary voltage conductors to provide source voltage for the Utility owned Recloser, PQ Monitor, Metering Equipment, and Transfer Trip Equipment.
- All metering needed for interconnection of generation and auxiliary load
- One Disconnect Switch at the Point-of-Interconnection
- Install a single phase OH transformer to supply power for Recloser, SEL-735R, & Transfer Trip controls and extend #2 Triplex to Recloser & Metering Poles.
- Extend 3 phase, 477 Al. primary/neutral overhead to a new pole and install G&W Viper ST w/SEL 651R-2 Control Recloser.
- Extend 3 phase, 477 Al. primary/neutral overhead to a new pole and install Bi-Directional Primary Metering equipment.
- Extend 3 phase, 477 Al. primary/neutral overhead to a new pole and install 600 amp Disconnects.
- Utility will install new metering equipment, CT's and PT's, the meter cabinet, meter, and connect the Project Developer conductor to utilities 34.5kV facilities

The estimated cost of the installation of the new attachment facilities to provide the interconnection is **$181,200.00 (with tax $193,884.00)**

In addition to the onetime cost equal to the estimated cost of the new attachment facilities there will also be an ongoing monthly charge for the operation and maintenance cost of the attachment facilities equal to 0.28% of the estimated cost of the new attachment facilities (i.e., $181,200 x 0.0028 = $507.36 per month).

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 Developer's 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

AG1-551 proposes to build a 20 MW DER facility located near Charlie Manning Dr 1200 US Hwy 64, Robersonville, NC. Based on the location the DER site would interconnect to Dominion Energy North Carolina's Parmele Substation via a New 115/34.5kV, 20.2/26.8/33.6 MVA transformer on a NEW Cir NEW (34.5 kV). The site is located approximately 3 miles in circuit length away from Parmele Substation on the existing 12.5 kV circuit; but a NEW 34.5 kV Circuit approximately 2.3 Miles will need to be constructed. This project is a status "A" Project; there is already 20 MW energized on existing TX #1 at the substation. Fence expansion and a new control enclosure may be needed. Existing transformer and circuit is 12.5 kV; 20MW would be 924 Amps @12.5 kV. Distribution circuits are limited to 600 amps. For a 34.5 kV circuit, 20 MW is 335 Amps. Due to the aggregate size of the generation on the circuit, transfer trip will need to be installed on the interconnect recloser. POI is being re-located to Charlie Manning Dr to eliminate double-build costs.

- Install new underground circuit get-a-way from the station.
- Install approximately 6,800 feet of 1000 MCM cable along transmission ROW and along new ROW along Charlie Manning Rd from station to near P0314YN2100
- Install 1000 MCM, 34.5 kV, riser pole with fault indicators.
- Convert to 34.5 kV and three-phase with 477 AAC (approximately 4,100 feet) from P0314YN2100 to P0315UD0500. Remove fuse 735F505.

- Install 1/0 cable, 34.5 kV Terminal pole to 2500 kVA, 34.5/12.5 kV Step-down Pad
- Install three-phase 2500 kVA 34.5/12.5 kV step-down pad mount transformers near Grid Address P0315UD0500
- Install 1/0 cable, 12.5 kV Riser pole from Step-down and G&W recloser for proper step-down protection.
- Make provisions for 2-inch conduit for fiber run in underground section and appropriate pole spacing on over-head section.
- Remove Capacitor P0415EI7800
- Install New N.O. Load-break Tie Switch at P0415EI7800 and Stencil "A"NEW T735.
- Re-stencil existing Tie Switch at P0314HL9800 as "A"NEW T755.
- Re-Stencil Devices / Fuses in NEW "A" Stepdown Area.
- Third Party easements will be required
- Transmission encroachment will be required
- Constructability of upgrades is contingent upon the acquisition of required easements and/or encroachments to this section.

Protection Requirements for Project Developer 20MW of Generation

The utility has reviewed the 20.0 MW_{AC} Project Developer (AG1-551) request for installation of parallel generation units located at Charlie Manning Road, Robersonville, NC 27871. The Distributed Energy Resources (DER) owner desires to both export power into the Dominion Energy North Carolina's (UTILITY) utility source and provide site power via site solar generation.

This is a UL1741/IEEE 1547 certified inverter-based interconnection consisting of eight (8) Sungrow SG3150U-MV inverters rated 3150 kW, and operating at 630 V_{AC}. The inverter system is in eight (8) blocks of single 3150 kW inverters connected to a 3-phase 3150 kVA pad mounted transformer. All transformers are rated 19.9/34.5kV–630V with a wye-ground/wye (ground facing utility) winding configuration.

Power export is limited to 20.0 MW_{AC} 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 20.0 MW_{AC} 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 Parmele Circuit NEW via the new Automatic Line Recloser (ALR) NEWRYYY, which is sourced by CB NEWZ2, Bus #2, Parmele New Transformer #2 and Transmission Line 96.
- Transmission Line 96 has existing or queued project DER totaling 40.0 MW_{AC}. Parmele Transformer #2 currently has existing or queued project DER totaling 20.0 MW_{AC}. Parmele Circuit NEW distribution facilities has existing or queued project DER totaling 20.0 MW_{AC}.
- Parmele Circuit NEW feeder breaker has reclosing times at 10 seconds and 45 seconds after the first trip.
- Transmission Line 96 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:

- Parmele Circuit NEW (NEWZ2) has a typical "light" loading of 0.00 MVA.
- Parmele New Transformer #2 has a typical "light" loading of 0.00 MVA.
- Transmission Line 96 has a typical "light" loading of 11.30 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*
CB NEWZ2	0.00
Transformer #2	0.00
Transmission Line 96	0.028

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 V_{AC}) to this Power Monitor shall be supplied from a 2 kVA or larger Station Service (Primary kV – 120 V_{AC}) 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 Project Developer 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 (I_0) 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), 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. Add DER relay panel; SEL-451 and SEL-735.
b. Add Potential Transformers (PT) to New 34.5 kV Bus.
c. Add New Transformer #2, Bus # 2 and New Circuit relays to digital relays.
d. Add transmission line transfer trip to Line 96 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: CB NEWZ2, Bus #2, and the Parmele Transformer #2 to the DER site recloser. Transfer trip is required due to light load to generation ratio <3:1.
f. Wire Transformer #2 LORs 86T2, 86T2BU and Bus#2 LOR 86B2 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.

Currently, this site is intended to operate with utility interactive inverter functionality enabled and with grid support utility interactive inverter functionality disabled. Therefore, the following inverter functions listed in Table 2 are to be disabled: LVRT, HVRT, ZVRT, VAR Support, and Voltage Regulation.

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	
LVRT	Low Voltage Ride Through	DISABLE	
HVRT	High Voltage Ride Through	DISABLE	
ZVRT	Zero Voltage Ride Through	DISABLE	

	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 this Interconnection Agreement, 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 AG1-551 provides for the installation of 2nd 33.6 MVA 115-34.5kV transformer and a high side circuit switcher off-line 115kV line # 96 after site expansion. A new distribution breaker and distribution bay will be added along with necessary circuit protection equipment on the new feeder. The new distribution bay will consist of a starter bay, a left add-on bay and left add on sectionalizing bay (3 bays total). Also install accompanying load-break disconnects and a 4800kVAR capacitor bank on the new bus. Additionally, bus PTs, station service and DG panel will be installed to support the interconnection. The proposed SS # 2 will be tied with SS # 1 through the exiting throw-overs.
Existing circuits 735 and 740 to be turned U/G at the bay for locating the new TX/bus.
Transfer Trip to be installed to support this distributed generation due to light load to generation ratio.
Developer/Operator supplied fiber-based TT communication to DG site is considered for scoping purposes.

Additional work will be needed at Everetts, Robersonville subs and Wilson-Robersonville & Martin County DP line tap for supporting transfer trip over line 96.

Purchase and install (Parmele Substation):

1. Grade, expand ground grid, fence perimeter (approx. 21000 SQ FT) and obtain necessary permits for site expansion to accommodate the new TX and bus
2. Steel for the 115 KV SW “A” frame structure (By Transmission)
3. One (1), 115kV 2000A center break switch
4. One (1), 10k in-lb, 125 VDC, Motor Operator
5. One (1), Line tuning box
6. Two (2), 800A Wave trap (Confirm Phase during detail design)
7. One (1), 115kV, 1200A, 25 kAIC Circuit Switcher (Verify fault values with System protection/Circuit Calculations prior to ordering switcher)
8. One (1), 115-34.5kV, 33.6MVA, Delta-Wye Transformer with LTC
9. Install oil containment for one (1) transformer (Confirm during detail design)
10. Three (3), 90kV, MO, 74kV MCOV Station Class lightning Arresters
11. Three (3), 30kV, MO, 24.4kV MCOV Station Class lightning Arresters
12. One (1), 34.5kV, 3000A, 40kA, SF6 Circuit Breaker
13. One (1), 34.5kV, 1200A Aldi-Rupter load break switch
14. Three (3), 34.5kV, 2000A Vertical Mounted Hook-stick Disconnects
15. Two (2), 34.5kV, 1200A End-break switch
16. Nine (9), 34.5kV, 1200A Hook-stick Disconnects
17. Three (3), 30kV MO (DI), 24.4kV MCOV lightning Arresters
18. Six (6), 12kV MO (DI), 10.2 kV MCOV lightning Arresters
19. Three (3), UG circuit getaway structure (Verify with Dist. Engineering)
20. Three (3), 34.5kV, 175/300:1, Potential Transformers
21. Two (2), 19.9-.24/.12kV, 167kVA Station Service Transformers (Size pending confirmation from Standards team)
22. One (1), 4800KVAR @ 37.4kV capacitor bank
23. One (1), 34.5kV, 600A, SF6 cap- switcher
24. Three (3), 600V, 2000/5 blinding CTs
25. Three (3), 34.5kV, SMU-20, 200A-E, Fuse Unit
26. Three (3), 34.5kV, SMU-20, 1A-E, Fuse Unit
27. Two (2), 34.5kV, SMU-20, 10A-K Fuse Unit
28. Five (5), 23kV, 12A-K, BCL Fuses
29. Eight (8), 34.5kV, SMD-20, 200A, Fuse Mount
30. Six (6), 30kV, MO, 24.4kV MCOV lightning Arresters
31. 2 - 2” conduit from control enclosure/cable trough to Dist. Gen. fiber MU box (location TBD by Substation)
32. Steel structures and 3 ¼” x 3 ¼” x ¼” Aluminum angle as required to create 34.5kV bus
33. Cable Trough as required.
34. Install conductor, connectors, conduit, control cable, foundations, and grounding material as per Dominion Substation Engineering Standards

Purchase and install relay material (Parmele Substation):

1. One (1), 1221 – SEL-387A/351A Distribution Transformer Panel w/o L-Breaker
2. One (1), SPR Relay Auxiliary Package
3. One (1), 4510 - SEL-2411 Equipment Annunciator
4. One (1), 4526_A – TX Fiber Optic Makeup Box
5. One (1), 1112 – SEL-311C Distribution Bus Panel
6. One (1), 4516 - 3Ø Distribution Bus Potential Makeup Box
7. One (1), 4540 – Indoor Distribution Bus Potential Makeup Box
8. Modify Panel # 6 to add SEL-451 for CB 12
9. One (1), 4202 - Cap bank C.T. M.U. Box
10. One (1), 4304 – CAPCON Cap Switch Control Box
11. One (1), 1607 - SEL-451-5 & SEL-735 DG Support Panel (w/ Fiber TT)
12. One (1), 4000 – Station Service Potential Makeup Box

13. One (1), 4018 – 800A Station Service AC Distribution Panel
14. One (1), 4017 – 600A Streamliner Disconnect Switch
15. One (1), 4528 – DG Fiber Optic Makeup Box

Purchase and install relay material (DG Site):

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

Purchase and install (Everetts Substation):

1. One (1), 2000A Wave trap

Purchase and install relay material (Everetts Substation):

1. Add TT transmitter on line 96

Purchase and install (Robersonville Substation):

1. One (1), 800A Wave trap

Purchase and install (Wilson-Robersonville DP Line Tap):

1. One (1), 800A Wave trap

Purchase and install (Martin County DP Line Tap):

1. One (1), 800A Wave trap

Schedule Estimate

The total expected time for engineering and construction of all work required will be approximately **48 months** from the execution of an Interconnection Agreement and payment of all required costs.