Generation Interconnection

Impact Study Report

for

Queue Project AE2-346

AHOSKIE 34.5 KV

8.4 MW Capacity / 12 MW Energy

Revision 2, December 2021

Revision 1, March 2020

Revision 0, February 2020

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1 Introduction

This System Impact Study (SIS) has been prepared in accordance with the PJM Open Access Transmission Tariff, 205, as well as the Impact Study Agreement between the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Virginia Electric and Power Company (VEPCO).

2 Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer 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 PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation will be deferred until the System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

The Interconnection Customer seeking to interconnect a wind or solar generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per Schedule H to the Interconnection Service Agreement and Section 8 of Manual 14D.

3 Revision 2, December 2021

This revision is a result of receiving updates from the ITO outlined in section 6 and 7 of this report.

4 General

The Interconnection Customer (IC) has proposed an uprate to the AB2-099 solar generating facility to be located in Hertford, North Carolina. This project requests to increase the install capability of the AB2-099 project by 12 MW with 8.4 MW of this output being recognized by PJM as additional Capacity. The installed

facilities will have a total capability of 17 MW with 11.9 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is December 30, 2019. This study does not imply a TO commitment to this in-service date.

Queue Number	AE2-346
Project Name	AHOSKIE 34.5 KV
Interconnection Customer	Colice Hall Solar, LLC
State	None
County	Hertford
Transmission Owner	Dominion
MFO	17
MWE	12
MWC	8.4
Fuel	Solar
Basecase Study Year	2022

4.1 Point of Interconnection

AE2-346 will interconnect with the Dominion distribution system on a feeder out of the Ahoskie 34.5 kV substation.

4.2 Cost Summary

The AE2-346 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 0
Direct Connection Network Upgrade	$ 0
Non Direct Connection Network Upgrades	$ 0
Total Costs	$ 0

In addition, the AE2-346 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	$ 0

5 Transmission Owner Scope of Work

Dominion assessed the impact of the proposed Queue Project AE2-346 was evaluated as a 8.4 MW Capacity (12.0 MW energy) injection at the Ahoskie 34.5 kV substation in the Dominion Transmission System, for compliance with NERC Reliability Criteria on Dominion Transmission System. The system was assessed using the summer 2022 AE2 case provided to Dominion by PJM. When performing a generation analysis, Dominion's main analysis will be load flow study results under single contingency (both normal and stressed system conditions). Dominion Criteria considers a transmission facility overloaded if it exceeds 94% of its emergency rating under normal and stressed system conditions. A full listing of Dominion's Planning Criteria and interconnection requirements can be found in the Company's Facility Connection Requirements which are publicly available at: http://www.dominionenergy.com.

The results of these studies evaluate the system under a limited set of operating conditions and do not guarantee the full delivery of the capacity and associated energy of this proposed generation facility under all operating conditions. NERC Planning and Operating Reliability Criteria allow for the re-dispatch of generating units to resolve projected and actual deficiencies in real time and planning studies. Specifically in Planning Studies NERC Category C Contingency Conditions (Bus Fault, Tower Line, N-1-1, and Stuck Breaker scenarios) allow for re-dispatch of generating units to resolve potential reliability deficiencies. For Dominion Planning Criteria the re-dispatch of generating units for these contingency conditions is allowed as long as the projected loading does not exceed 100% of a facility Load Dump Rating.

6 Transmission Owner Technical Requirements

This is a UL1741/IEEE 1547 certified inverter based interconnection consisting of 6 SMA SC 4200-UP-US inverters rated 4,200 kW each and operating at 660 V_{AC}. The inverter system is in 6 blocks of inverters each connected to a 3-phase 4,600 kVA pad mounted transformer rated 19.9/34.5kV–660V with a wye-ground/wye winding configuration (ground facing utility). The Colice Hall Solar project will see a total output of 17.0 MW_{AC} at the POI due to the 12.0 MW_{AC} (AE2-346) uprate to 5.0 MW_{AC} (AB2-099).

The resulting protection requirements are based on the following information:

- No more than 17.0 MW_{AC} of total generation will be in parallel with the ITO system at any one time.
- The IC's generation facility will be paralleled with the ITO system by the following connections:
  - The IC's generation facility will be connected to the Ahoskie Circuit 348 via the new Automatic Line Recloser (ALR) 348RYYY, which is sourced by CB 34852, Bus #2, Ahoskie Transformer #2 and Transmission Line 136.
- Transmission Line 136 currently has existing or queued projects totaling 35.0 MW_{AC}. The cumulative total is now 47.0 MW_{AC}. Ahoskie Circuit 348 distribution facilities currently has existing or queued projects totaling 22.0 MW_{AC}.

- Ahoskie Circuit 348 feeder breaker has reclosing times at 10 seconds and 45 seconds after the first trip.
- Transmission Line 136 has both time delayed and instantaneous reclosing applied on its terminal breakers.
- IC parallel operation will not be limited to any particular time or utility circuit-loading condition (daylight is required for generation to be available); however, IC parallel operation will not be permitted during periods when the source circuit is switched into an abnormal configuration.
- The load data for the pertinent sectionalizing devices are as follows:
  - Ahoskie Circuit 348 (34852) has a typical "light" loading of 0.00 MVA.
  - Ahoskie Transformer #2 has a typical "light" loading of 3.72 MVA.
  - Transmission Line 136 has a typical "light" loading of 5.44 MVA.

Based on projected minimum loads given for the applicable ITO 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 34852	0.000
Transformer #2	0.169
Transmission Line 136	0.116

Table 1 - *Light Load to Cumulative Generation Ratio*

Based on the size and type of this generation, the applicable ITO 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 ITO owned Automatic Line Recloser (ALR) at the Point of Interconnection with all required relaying (described in Table 3 below) at the IC expense.
2. Installation of an additional ITO owned protective relaying (SEL-735 Power Quality Package) at the PCC (ITO Metering Instrument Transformer Cabinet) with all required metering/relay functionality at the IC's 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 as well as providing a trip initiation to the ALR when either harmonic standard limits are exceeded or other undesirable conditions are detected.
3. Power Quality baseline readings will be required at the PCC before and after the interconnection is completed in order to monitor the harmonic effects of the generation unit and will be obtained at the IC's expense. The plant shall meet the IEEE Standard 519 – 2014 "*IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems*". If there is evidence that the Voltage Total Harmonic

Distortion (THD) is ≥ 5%, Current Total Demand Distortion (TDD) is ≥ 5%, or any single harmonic exceeds the distortion limits specified in IEEE Standard 519- 2014, the IC would be required to add a filtering system to its installation to meet the requirements of IEEE 519 – 2014.

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

    b. A light load to generation ratio greater than 3:1 for the nearest upline device from the POI.

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

    a. Add Potential Transformers (PT) to 34.5 kV Bus to provide directionality.

    b. Add the relay panel; SEL-451 and SEL-735.

    c. Add transmission line transfer trip to Line 136 to serve as an input to the SEL-451 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.

    d. Install Direct Pilot Wire Tripping (or Transfer Trip) from each of the upline ITO devices: CB 34852, Bus #2, and the Ahoskie Transformer #2 to the site recloser. Transfer trip is required due to light load to generation ratio being less than 3.0:1.

    e. Wire Transformer #2 LORs 86T2 and 86T2BU and Bus#2 LOR 86B2 to trip and prevent reclosing of CB 34852.

    f. Add the reverse interlock scheme between the POI recloser and the CB 34852 relay due to the proximity to the station. This will allow instantaneous protection on the circuit to overreach the POI recloser and block instantaneous trip for a fault in the solar farm. When this reverse interlock scheme is required, a communications path is needed. Therefore, it would be logical to also install transfer trip from the station to the POI recloser.

The required relay functions and the corresponding set points, with each sectionalizing all of the IC's generation and always enabled on the ALR regardless of the operating condition, are listed in the following table:

Function	Set Point	Duration to Disconnection (sec)

27	Under-voltage	25 % of nominal operating voltage	2.0
59	Over-voltage	110% of nominal operating voltage	2.0
		120% of nominal operating voltage	0.083
81U	Under-frequency	59.5 Hz	2.0
81O	Over-frequency	60.5 Hz	2.0
51	Phase Time-delay Overcurrent	Set for minimum, with adequate load allowance	Maintain proper coordination with IC high side fuse

Table 3: *ALR Set Points*

7 Interconnection Customer Requirements

- Installation of all conductors between the generating facility and POI
- Installation of pad mounted transformers
- Installation of a three phase interruption device
- Installation of all generator breakers and associated equipment
- Communication lines for all metering
- Communication between IC breaker and ITO's Ahoskie Substation

In addition to the ITO facilities indicated above the IC will also be responsible for providing and maintaining telephone lines to the ITO's metering equipment at the Point of Interconnection and between the ITO's Reclosers, Ahoskie Substation and IC's facility. The IC provided 34.5 kV 3- phase circuit will interconnect overhead at the Point of Interconnection which will be the load side terminals of the ITO provided pole mounted disconnect switch. It will be the IC's responsibility to obtain any required right-of-way between the ITO's existing facilities and the Point of Interconnection.

The voltage and frequency set points, listed in Table 2, are derived from IEEE-1547a-2014 (Amendment to IEEE Standard 1547-2003). The "Total Clearing Time (sec)" listed in Table 2 is a summation of the detection time, field adjustable clearing time, and trip time. The IC will be required to apply all the enabled protection settings and not exceed the "Total Clearing Time (sec)".

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, LFRT, HFRT, ZVRT, VAR Support, and Voltage Regulation.

Function		Set Point	Total Clearing Time (sec)
27	Under-voltage	V < 45% nominal voltage	0.160
		45% ≤ V < 60%	0.160
		60% ≤ V <88%	0.160
59	Over-voltage	110% < V < 120%	0.160
		V ≥ 120% nominal voltage	0.160
81U	Under-frequency	F < 57.0 Hz	0.160
		F < 59.5 Hz	0.160
81O	Over-frequency	F > 60.5 Hz	0.160
		F > 62.0 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	
LFRT	Low Frequency Ride Through	DISABLE	
HFRT	High Frequency Ride Through	DISABLE	
ZVRT	Zero Voltage Ride Through	DISABLE	
	Volt/Var Control	DISABLE	
	Volt/Watt Control	DISABLE	
	Frequency/Watt	DISABLE	

Table 2: *Inverter Settings*

Voltage Ride Through Requirements - The Customer Facility shall be designed to remain in service (not trip) for voltages and times as specified for the Eastern Interconnection in Attachment 1 of NERC Reliability Standard

PRC-024-1, and successor Reliability Standards, for both high and low voltage conditions, irrespective of generator size, subject to the permissive trip exceptions established in PRC-024-1 (and successor Reliability Standards).

Frequency Ride Through Requirements - The Customer Facility shall be designed to remain in service (not trip) for frequencies and times as specified in Attachment 2 of NERC Reliability Standard PRC-024-1, and successor Reliability Standards, for both high and low frequency condition, irrespective of generator size, subject to the permissive trip exceptions established in PRC-024-1 (and successor Reliability Standards).

Reactive Power - The Generation Interconnection Customer shall design its non-synchronous Customer Facility with the ability to maintain a power factor of at least 0.95 leading to 0.95 lagging measured at the generator's terminals.

Meteorological Data Reporting Requirement - The solar generation facility shall, at a minimum, be required to provide the Transmission Provider with site-specific meteorological data including:

- Temperature (degrees Fahrenheit)
- Atmospheric pressure (hectopascals)
- Irradiance
- Forced outage data

8 Transmission Owner Analysis

8.1 Power Flow Analysis

PJM performed a power flow analysis of the transmission system using a 2022 summer peak load flow model and the results were verified by Dominion. Additionally, Dominion performed an analysis of its transmission system and determined there were no additional reinforcements required.

8.2 Short Circuit Analysis

PJM performed a short circuit analysis and the results were verified by Dominion. The connection of AE2-346 project to the system does not result in any newly overdutied circuit breakers on the Dominion transmission system and does not have a significant fault current contribution to existing overdutied circuit breakers

8.3 Stability Analysis

Not required for this project.

9 Revenue Metering and SCADA Requirements

9.1 PJM Requirements

The Interconnection Customer 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.

9.2 Dominion Requirements

See Section 3.4.6 “Metering and Telecommunications” of Dominion’s “Dominion’s Facility Interconnection Requirements” document located at: https://www.dominionenergy.com/company/moving-energy/electric-transmission-access

10 Network Impacts

The Queue Project AE2-346 was evaluated as a 12.0 MW (Capacity 8.4 MW) injection at the Ahoskie 115 kV in the Dominion area. Project AE2-346 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-346 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

11 Generation Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

None

12 Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

13 Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

None

14 Potential Congestion due to Local Energy Deliverability

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified.

None

15 System Reinforcements

None

Affected Systems

16 Affected Systems

16.1 Duke Energy Progress

No Duke Energy Progress impacts were identified as part of this study.

Short Circuit

17 Short Circuit

The following Breakers are overdutied:

None

Attachment 1

System Configuration