



**Generation Interconnection
Study Impact Study Report
for
Queue Project AE1-153
REMINGTON-GORDONSVILLE 230 KV
89.4 MW Capacity / 149 MW Energy**

Revision 1 / November 2021

August, 2019

Table of Contents

1	Introduction.....	3
2	Preface.....	3
3	Revision 1 (November 2021) Summary.....	4
4	General.....	4
4.1	Point of Interconnection	4
4.2	Cost Summary.....	4
5	Transmission Owner Scope of Work.....	5
5.1	Attachment Facilities.....	5
5.2	Direct Connection Cost Estimate.....	5
5.3	Non-Direct Connection Cost Estimate.....	6
6	Interconnection Customer Requirements.....	6
6.1	System Protection.....	6
6.2	Compliance Issues and Interconnection Customer Requirements	6
6.3	Power Factor Requirements.....	7
7	Revenue Metering and SCADA Requirements.....	7
7.1	PJM Requirements.....	7
7.1.1	Meteorological Data Reporting Requirement.....	7
7.2	Dominion Requirements.....	8
8	Network Impacts	9
9	Generation Deliverability.....	11
10	Multiple Facility Contingency	11
11	Contribution to Previously Identified Overloads	11
12	Potential Congestion due to Local Energy Deliverability.....	11
13	System Reinforcements.....	12
14	Flow Gate Details	13
15	Affected Systems	15
15.1	Duke Energy Progress.....	15
16	Short Circuit.....	17
17	Stability	19
17.1	Executive Summary	19
	Attachment 1.....	21

1 Introduction

This System Impact Study (SIS) has been prepared in accordance with the PJM Open Access Transmission Tariff, 205, as well as the Feasibility Study Agreement between Sumerduck Solar, LLC, 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.

An Interconnection Customer with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

3 Revision 1 (November 2021) Summary

This revision is being issued to incorporate results of a re-tool performed in November of 2021 as well as the Stability Analysis and Reactive Power Assessment results.

The reactive power assessment for this project reveals that the project meets the reactive power requirements at the high side of the main transformer.

4 General

The IC has proposed a new solar generating facility located in Stevensburg (Culpepper County), Virginia. The installed facilities will have a capability of 149 MW with 89.4 MW of this output being recognized by PJM as Capacity. The proposed in-service date for the AE1-153 project is 10/23/2020. This study does not imply an ITO commitment to either in-service date.

Queue Number	AE1-153
Project Name	REMINGTON-GORDONSVILLE 230 KV
Interconnection Customer	Sumerduck Solar, LLC
State	Virginia
County	Culpeper
Transmission Owner	Dominion
MFO	149
MWE	149
MWC	89.4
Fuel	Solar
Basecase Study Year	2022

4.1 Point of Interconnection

The AE1-153 project will interconnect with the ITO transmission system via a tap off of the Remington-Gordonville 230 kV line. See one line in Attachment 1.

4.2 Cost Summary

The AE1-153 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	\$ 1,550,000
Direct Connection Network Upgrade	\$ 5,500,000
Non Direct Connection Network Upgrades	\$ 800,000
Total Costs	\$ 7,850,000

In addition, the AE1-153 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	\$ 0

Note: PJM Open Access Transmission Tariff (OATT) section 217.3A outline cost allocation rules. The rules are further clarified in PJM Manual 14A Attachment B. The allocation of costs for a network upgrade will start with the first Queue project to cause the need for the upgrade. Later queue projects will receive cost allocation contingent on their contribution to the violation and are allocated to the queues that have not closed less than 5 years following the execution of the first Interconnection Service Agreement which identifies the need for this upgrade.

5 Transmission Owner Scope of Work

5.1 Attachment Facilities

Generation Substation: Install metering and associated protection equipment. Estimated Cost \$600,000.

Transmission: Construct approximately one span of 230 kV Attachment line between the generation substation and a new AE1-153 Switching Station. The estimated cost for this work is \$1,200,000.

The estimated total cost of the Attachment Facilities is \$1,800,000. It is estimated to take 18-24 months to complete this work. These preliminary cost estimates are based on typical engineering costs. A more detailed engineering cost estimates are normally done when the IC provides an exact site plan location for the generation substation during the Facility Study phase. See **Attachment 1**.

The total preliminary cost estimate for the Attachment work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Generation Substation	\$ 600,000
Transmission	\$ 1,200,000
Total Attachment Facility Costs	\$ 1,800,000

5.2 Direct Connection Cost Estimate

Substation: Establish the new 230 kV AE1-153 Switching Substation (interconnection substation). The arrangement of the substation will be as shown below in **Attachment 1**. The estimated cost of this work scope is \$6,300,000. It is estimated to take 24-36 months to complete this work.

The total preliminary cost estimate for the Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Substation	\$ 6,300,000
Total Direct Connection Facility Costs	\$ 6,300,000

5.3 Non-Direct Connection Cost Estimate

Transmission: Install transmission structure in-line with transmission line to allow the proposed interconnection switching station to be interconnected with the transmission system. Estimated cost is \$1,000,000 and it is estimated to take 24-30 months to complete. See Attachment 1.

Remote Terminal Work: During the Facilities Study, ITO's System Protection Engineering Department will review transmission line protection as well as anti-islanding required to accommodate the new generation and interconnection substation. System Protection Engineering will determine the minimal acceptable protection requirements to reliably interconnect the proposed generating facility with the transmission system. The review is based on maintaining system reliability by reviewing ITO's protection requirements with the known transmission system configuration which includes generating facilities in the area. This review may determine that transmission line protection and communication upgrades are required at remote substations.

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Transmission	\$ 1,000,000
Remote Terminal Work	\$ TBD during the Facilities Study
	\$
Total Non-Direct Connection Facility Costs	\$ 1,000,000

6 Interconnection Customer Requirements

6.1 System Protection

The IC must design its Customer Facilities in accordance with all applicable standards, including the standards in Dominion's "Dominion Energy Electric Transmission Generator Interconnection Requirements" documented in Dominion's Facility Interconnection Requirements "Exhibit C" located at: <https://www.dominionenergy.com/company/moving-energy/electric-transmission-access>. Preliminary Protection requirements will be provided as part of the Facilities Study. Detailed Protection Requirements will be provided once the project enters the construction phase.

6.2 Compliance Issues and Interconnection Customer Requirements

The proposed Customer Facilities must be designed in accordance with Dominion's "Dominion's Facility Interconnection Requirements" document located at: <https://www.dominionenergy.com/company/moving-energy/electric-transmission-access>. In particular, the IC is responsible for the following:

1. The purchase and installation of a fully rated protection device (circuit breaker, circuit switcher, fuse) to protect the IC's GSU transformer(s).
2. The purchase and installation of the minimum required Dominion generation interconnection relaying and control facilities as described in the System Protection noted above. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.
3. The purchase and installation of supervisory control and data acquisition ("SCADA") equipment to provide information in a compatible format to the Dominion Transmission System Control Center.
4. Compliance with the Dominion and PJM generator power factor and voltage control requirements.

The GSU(s) associated with the IC queue request shall meet the grounding requirements as noted in Dominion's "Dominion's Facility Interconnection Requirements" document located at: <https://www.dominionenergy.com/company/moving-energy/electric-transmission-access>.

The IC will also be required to meet all PJM, SERC, and NERC reliability criteria and operating procedures for standards compliance. For example, the IC will need to properly locate and report the over and under voltage and over and under frequency system protection elements for its units as well as the submission of the generator model and protection data required to satisfy the PJM and SERC audits. Failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the Dominion system.

6.3 Power Factor Requirements

The IC shall design its non-synchronous Customer Facility with the ability to maintain a power factor of at least 0.95 leading (absorbing VARs) to 0.95 lagging (supplying VARs) measured at the high-side of the facility substation transformer(s) connected to the Dominion transmission system.

7 Revenue Metering and SCADA Requirements

7.1 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.

7.1.1 Meteorological Data Reporting Requirement

The solar generation facility shall provide the Transmission Provider with site-specific meteorological data including:

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

7.2 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>.

8 Network Impacts

The Queue Project AE1-153 was evaluated as a 149.0 MW (Capacity 89.4 MW) injection at Remington-Gordonsville 230kV line in the Dominion area. Project AE1-153 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-153 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

9 Generation Deliverability

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

None

10 Multiple Facility Contingency

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

None

11 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

12 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

13 System Reinforcements

None

14 Flow Gate Details

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact. It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

None

Affected Systems

15 Affected Systems

15.1 Duke Energy Progress

None

Short Circuit

16 Short Circuit

The following Breakers are overdutied:

None

Stability

17 Stability

17.1 Executive Summary

Generator Interconnection Request AE1-153 is for 149 MW Maximum Facility Output (MFO) solar generation plant. AE1-153 consists of 192 x 0.7854 MW TMEIC PVU-L0840GR solar inverters with a Point of Interconnection (POI) on the existing Remington – Gordonsville 230kV transmission line in the Dominion Virginia Power (DVP) transmission system, Culpeper County, Virginia.

The power flow scenario for the analysis was based on the RTEP 2022 summer peak case, modified to include applicable queue projects. AE1-153 has been dispatched online at maximum facility output, with approximately unity power factor at the high side of the station transformer.

AE1-153 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. For this study, 82 contingencies were simulated, each with a 20 second simulation time period. Studied faults included:

- Steady-state operation (30 second simulation)
- Three-phase faults with normal clearing time
- Single-phase faults with a stuck breaker with delayed clearing time
- Single-phase faults placed at 80% of the line with delayed (Zone 2) clearing at remote line end because of primary communications/relaying failure
- Single-phase faults with loss of multiple circuits caused by a common tower contingency

The 82 fault contingencies tested on the 2022 summer peak case met the recovery criteria:

- The AE1-153 generator was able to ride through the faults except for faults where protective actions trip one or more generator(s).
- All generators maintained synchronism and any post-contingency oscillations are positively damped with a damping margin of at least 3%.
- All bus voltages recover to 0.7 p.u. within 2.5 seconds and the final voltages are within the steady-state voltage ranges below per DVP's transmission planning criteria.
 - P1 Category Contingencies:
 - 0.93 to 1.05 p.u. for 230, 138, 115, 69 kV facilities
 - 1.01 to 1.08 p.u. for 500 kV facilities

- P2, P4, P5, and P7 Category Contingencies:
 - 0.90 to 1.05 p.u. for 230, 138, 115, 69 kV facilities
 - 1.01 to 1.08 p.u. for 500 kV facilities
- No transmission element trips, other than those either directly connected or designated to trip as a consequence of the fault.

The AE1-153 queue project met both the 0.95 lagging and 0.95 leading power factor requirement.

Attachment 1

System Configuration

