



**Generation Interconnection  
Impact Study Report  
for  
Queue Project AE2-029  
GROTTOES-MERCK 115KV  
30 MW Capacity / 50 MW Energy**

Revision 1 / October 2021

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## Table of Contents

1	Introduction.....	4
2	Preface.....	4
3	Revision 1 Summary.....	4
4	General.....	5
4.1	Point of Interconnection .....	5
4.2	Cost Summary.....	5
5	Transmission Owner Scope of Work .....	6
6	Attachment Facilities .....	7
7	Direct Connection Cost Estimate.....	7
8	Non-Direct Connection Cost Estimate.....	7
9	Schedule.....	8
10	Transmission Owner Analysis.....	8
10.1	Power Flow Analysis .....	8
10.2	Short Circuit Analysis .....	8
10.3	Stability Analysis .....	8
11	Interconnection Customer Requirements .....	9
11.1	System Protection.....	9
11.2	Compliance Issues and Interconnection Customer Requirements .....	9
11.3	Power Factor Requirements.....	9
12	Revenue Metering and SCADA Requirements .....	10
12.1	PJM Requirements .....	10
12.2	Meteorological Data Reporting Requirement .....	10
12.3	Dominion Requirements.....	10
13	Network Impacts.....	11
14	Generation Deliverability .....	13
15	Multiple Facility Contingency .....	13
16	Contribution to Previously Identified Overloads .....	13
17	Potential Congestion due to Local Energy Deliverability.....	13
18	System Reinforcements.....	13
19	Affected Systems .....	15
20	Short Circuit.....	17

21	Light Load Flow .....	19
22	Stability Analysis and Reactive Power Assessment.....	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 Blue Ridge 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.

## 3 Revision 1 Summary

This revision is being issued to incorporate the results of the Stability Study performed. Additionally, Affected Systems was updated with no impact.

## 4 General

The Interconnection Customer (IC), has proposed a Solar/Storage generating facility located in Rockingham County, Virginia. The installed facilities will have a total capability of 50 MW with 30 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is 12/30/2022. This study does not imply a TO commitment to this in-service date.

<b>Queue Number</b>	<b>AE2-029</b>
<b>Project Name</b>	GROTTOES-MERCK 115KV
<b>Interconnection Customer</b>	Blue Ridge Solar, LLC
<b>State</b>	None
<b>County</b>	Rockingham
<b>Transmission Owner</b>	Dominion
<b>MFO</b>	50
<b>MWE</b>	50
<b>MWC</b>	30
<b>Fuel</b>	Solar
<b>Basecase Study Year</b>	2022

### 4.1 Point of Interconnection

AE2-029 “Grottoes-Merck 115 kV” will interconnect with the Dominion’s transmission system through a new three breaker 115 kV switching station which will be adjacent to the transmission right-of-way. This is the primary Point of Interconnection (POI) chose by the IC with the ITO’s transmission system. The IC is responsible for securing right-of-way, permits and constructing the proposed attachment line from the solar facility site to the proposed new switching station. Attachment 1 shows a one-line diagram of the proposed interconnection facilities. The IC may not install any facilities on Dominion’s right-of-way without first obtaining the necessary approval from Dominion Energy.

### 4.2 Cost Summary

The AE2-029 project will be responsible for the following costs:

<b>Description</b>	<b>Total Cost</b>
<b>Attachment Facilities</b>	\$1,700,000
<b>Direct Connection Network Upgrade</b>	\$7,100,000
<b>Non Direct Connection Network Upgrades</b>	\$0
<b>Total Costs</b>	<b>\$8,800,000</b>

In addition, the AE2-029 project may be responsible for a contribution to the following costs

<b>Description</b>	<b>Total Cost</b>
<b>System Upgrades</b>	\$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

Dominion assessed the impact of the proposed Queue Project AE2-029 was evaluated as a 30 MW Capacity (50.0 MW Energy) injection at the AE2-029 115 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.

The required Attachment Facilities, Direct Connection and Non-Direct Connection work for the interconnection of the AE2-029 generation project to the Dominion Transmission System is detailed in the following sections. The associated one-line with the generation project attachment facilities and primary direct and non-direct connection are shown in Attachment 1.

Note that the ITO findings were made from a conceptual review of this project. A more detailed review of the connection facilities and their cost will be identified in a future study phases. Further note that the cost estimate data contained in this document should be considered high level estimates since it was produced without a detailed engineering review. The applicant will be responsible for the actual cost of construction. ITO herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the transmission systems.

## 6 Attachment Facilities

Generation Substation: Install metering and associated protection equipment. Estimated Cost is \$500,000.

Transmission: Construct approximately one span of 115 kV Attachment line between the generation substation and a new AE2-029 Switching Station. The estimated cost for this work is \$1,200,000.

The estimated total cost of the Attachment Facilities is \$1,700,000.

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. 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
Substation (Metering)	\$ 500,000
Transmission (One span)	\$ 1,200,000
<b>Total Attachment Facility Costs</b>	<b>\$1,700,000</b>

## 7 Direct Connection Cost Estimate

Substation: Build a new three breaker 115 kV Switching Station and re-arrange the existing section of the line between Grottoes and Merck Substations to allow for the proposed interconnection. 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 (Metering)	\$ 5,500,000
Transmission (one span)	\$ 1,600,000
<b>Total Direct Connection Facility Costs</b>	<b>\$ 7,100,000</b>

## 8 Non-Direct Connection Cost Estimate

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.

None.

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.

## **9 Schedule**

The schedule for the required Network Impact Reinforcements will be more clearly identified in future study phases. The estimate elapsed time to complete each of the required reinforcements is identified in the "System Reinforcements" section of the report.

## **10 Transmission Owner Analysis**

### **10.1 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 no deficiencies were identified.

### **10.2 Short Circuit Analysis**

PJM performed a short circuit analysis and the results were verified by Dominion. The connection of AE2-052 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

### **10.3 Stability Analysis**

PJM will complete a dynamic stability analysis as part of Facilities Study. The results of this analysis will be reviewed by Dominion. Should stability concerns be identified in PJM's study, Dominion will develop appropriate system reinforcement(s) and included the estimated cost of any reinforcement(s) in Dominion's System Impact Study report.



## 11 Interconnection Customer Requirements

### 11.1 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.

### 11.2 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.

### 11.3 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.

## 12 Revenue Metering and SCADA Requirements

### 12.1 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.

### 12.2 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

### 12.3 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>.

### 13 Network Impacts

The Queue Project AE2-029 was evaluated as a 50.0 MW (Capacity 30.0 MW) injection at Grottes to Elkton 115 kV line in the Dominion area. Project AE2-029 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-029 was studied with a commercial probability of 100%. Potential network impacts were as follows:

## Summer Peak Load Flow

## **14 Generation Deliverability**

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

None

## **15 Multiple Facility Contingency**

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

None

## **16 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

## **17 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

## **18 System Reinforcements**

None

## Affected Systems

## 19 Affected Systems

None Affected Systems were identified

## Short Circuit



## 20 Short Circuit

The following Breakers are overdutied:

None.

## Light Load Flow

## 21 Light Load Flow

No issues identified.

## Stability

## 22 Stability Analysis and Reactive Power Assessment

Generator Interconnection Request AE2-029 is for a 50 MW photovoltaic (PV) solar generation plant coupled with a 15 MW Battery Energy Storage System (BESS) consisting of 18 x 2.8054 MW FS3150M PV inverters. The BESS will connect to the DC side of the PV inverters, using the same inverters at the PV modules. The Maximum Facility Output (MFO) for this project is 50 MW. AE2-029 has a Point of Interconnection (POI) connecting to the transmission line between Grottoes and Merck 115 kV in Rockingham County, Virginia, in the Dominion Virginia Power (DVP) transmission system.

The power flow scenario for the analysis was based on the RTEP 2022 summer peak case, modified to include applicable queue projects. AE2-029 has been dispatched online at maximum facility output, with approximately unity power factor at the high side of the station transformer.

AE2-029 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. For this study, 56 contingencies were simulated, each with a 20 second simulation time period. Studied faults included:

- Steady-state operation (20 second simulation)
- Three-phase faults with normal clearing time
- Single-phase bus faults with normal clearing time
- Single-phase faults with a stuck breaker
- Single-phase faults placed at 80% of the line with delayed (Zone 2) clearing at remote line end because of primary communications/relaying failure

The 56 fault contingencies tested on the 2022 summer peak case met the recovery criteria:

- The AE2-029 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 voltage is within the range of 0.92 p.u. to 1.05 p.u. for buses other than 500 kV. The final voltages for 500 kV buses should be within 1.02 p.u. to 1.08 p.u.
- No transmission element trips, other than those either directly connected or designated to trip as a consequence of the fault.

The queue project AE2-029, meets both the 0.95 leading and 0.95 lagging power factor requirement at the high side of station transformer.

## Attachment 1

