



**Generation Interconnection  
Feasibility Study Report  
for  
Queue Project AE2-026  
LOUISA-SOUTH ANNA 230KV  
19 MW Capacity / 44.8 MW Energy**

July, 2019

# Table of Contents

1	Introduction.....	4
2	Preface.....	4
3	General.....	5
3.1	Point of Interconnection .....	6
3.2	Cost Summary.....	6
4	Transmission Owner Scope of Work.....	6
4.1	Attachment Facilities.....	7
4.2	Direct Connection Cost Estimate.....	7
4.3	Non-Direct Connection Cost Estimate.....	7
5	Incremental Capacity Transfer Rights (ICTRs) .....	8
6	Schedule.....	8
7	Transmission Owner Analysis.....	8
7.1	Power Flow Analysis .....	8
7.2	Short Circuit Analysis.....	8
7.3	Stability Analysis.....	8
8	Interconnection Customer Requirements.....	8
8.1	System Protection.....	8
8.2	Compliance Issues and Interconnection Customer Requirements .....	9
8.3	Power Factor Requirements.....	9
9	Revenue Metering and SCADA Requirements.....	9
9.1	PJM Requirements .....	9
1.1.1	Meteorological Data Reporting Requirement.....	9
9.2	Dominion Requirements.....	10
10	Network Impacts.....	10
11	Generation Deliverability .....	12
12	Multiple Facility Contingency .....	12
13	Contribution to Previously Identified Overloads .....	12
14	Potential Congestion due to Local Energy Deliverability.....	12
15	System Reinforcements.....	13
16	Flow Gate Details .....	14
16.1	Contingency Descriptions.....	14

16.2	Index 1 .....	15
16.3	Index 2 .....	16
17	Affected Systems .....	18
17.1	LG&E.....	18
17.2	MISO .....	18
17.3	TVA.....	18
17.4	Duke Energy Progress.....	18
17.5	NYISO .....	18
18	Short Circuit.....	20
	Attachment 1 .....	20

## 1 Introduction

This Feasibility Study has been prepared in accordance with the PJM Open Access Transmission Tariff, 36.2, as well as the Feasibility 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 feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. Cost allocation rules for network upgrades can be found in PJM Manual 14A, Attachment B. 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 impact study is performed.

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.

PJM utilizes manufacturer models to ensure the performance of turbines is properly captured during the simulations performed for stability verification and, where applicable, for compliance with low voltage ride through requirements. Turbine manufacturers provide such models to their customers. The list of manufacturer models PJM has already validated is contained in Attachment B of Manual 14G. Manufacturer models may be updated from time to time, for various reasons such as to reflect changes to the control systems or to more accurately represent the capabilities turbines and controls which are currently available in the field. Additionally, as new turbine models are developed, turbine manufacturers provide such new models which must be used in the conduct of these studies. PJM needs adequate time to evaluate the new models in

order to reduce delays to the System Impact Study process timeline for the Interconnection Customer as well as other Interconnection Customers in the study group. Therefore, PJM will require that any Interconnection Customer with a new manufacturer model must supply that model to PJM, along with a \$10,000 fully refundable deposit, no later than three (3) months prior to the starting date of the System Impact Study (See Section 4.3 for starting dates) for the Interconnection Request which shall specify the use of the new model. The Interconnection Customer will be required to submit a completed dynamic model study request form (Attachment B-1 of Manual 14G) in order to document the request for the study.

The Feasibility 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.

### 3 General

The Interconnection Customer (IC), has proposed a Solar generating facility located in Louisa County, Virginia. The installed facilities will have a capability of 150 MW with 90 MW being recognized by PJM as Capacity. This queue request is for an additional 44.8 MW with 19 MW’s being recognized by PJM as capacity. The proposed in-service date for this project is 10/30/2020. This study does not imply a TO commitment to this in-service date.

Note that this project is an increase to the Interconnection Customer's AB2-158 and AE1-154 projects, which will share the same property and connection point. The conduct of light load analysis as required under the PJM planning process is not performed during the Generation Interconnection Feasibility Study phase of the PJM study process. Additional reinforcement requirements for this Interconnection Request may be defined during the conduct of the light load analysis which shall be performed following execution of the System Impact Study agreement.

<b>Queue Number</b>	<b>AE2-026</b>
<b>Project Name</b>	LOUISA-SOUTH ANNA 230KV
<b>Interconnection Customer</b>	
<b>State</b>	Virginia
<b>County</b>	Louisa
<b>Transmission Owner</b>	Dominion
<b>MFO</b>	150
<b>MWE</b>	44.8
<b>MWC</b>	19
<b>Fuel</b>	Solar
<b>Basecase Study Year</b>	2022

### 3.1 Point of Interconnection

AE2-026 will interconnect with the Dominion transmission system at the existing AB2-158/AE1-154 230 kV switching station which taps the Louisa to South Anna 230 kV, Line 255.

### 3.2 Cost Summary

The AE2-026 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	\$N/A
Direct Connection Network Upgrade	\$N/A
Non Direct Connection Network Upgrades	\$
Total Costs	\$

In addition, the AE2-026 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	\$300,000

Cost allocations for these upgrades will be provided in the System Impact Study Report.

## 4 Transmission Owner Scope of Work

Dominion assessed the impact of the proposed Queue Project AE2-026 was evaluated as a 19.0 MW Capacity (44.8 MW energy) injection at the AB2-158/AE1-154 230 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.dom.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 AE2-026 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.

#### 4.1 Attachment Facilities

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
	\$N/A
<b>Total Attachment Facility Costs</b>	<b>\$N/A</b>

#### 4.2 Direct Connection Cost Estimate

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
	\$N/A
<b>Total Direct Connection Facility Costs</b>	<b>\$N/A</b>

#### 4.3 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.

Description	Total Cost
Replace Wavetraps at the Louisa and North Anna 230 kV substations.	\$300,000
<b>Total Non-Direct Connection Facility Costs</b>	<b>\$300,000</b>

## 5 Incremental Capacity Transfer Rights (ICTRs)

Will be determined at a later study phase

## 6 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.

## 7 Transmission Owner Analysis

### 7.1 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. At the Primary POI, the AE2-026 project contributes to overloads on the Dominion transmission system as shown in the “Network Impact – Option 1” section of the report. The estimated cost of system reinforcements necessary to mitigate these overloads is also provided. 6

### 7.2 Short Circuit Analysis

PJM performed a short circuit analysis and the results were verified by Dominion. The connection of AE2-026 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

### 7.3 Stability Analysis

PJM will complete a dynamic stability analysis, if necessary, as part of the System Impact 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.

## 8 Interconnection Customer Requirements

### 8.1 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.

## 8.2 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.

## 8.3 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.

# 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.

### 1.1.1 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

## 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 AE2-026 was evaluated as a 44.8 MW (Capacity 19.0 MW) uprate to AB2-158 and AE1-154 which tap the Louisa to South Anna 230 kV Line 255 in the Dominion area. Project AE2-026 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-026 was studied with a commercial probability of 53%. 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)

ID	FROM BUS#	FROM BUS	FROM BUS AREA	TO BUS#	TO BUS	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC DC	MW IMPACT
1667160	314766	6LOUISA	DVP	314232	6NO ANNA	DVP	1	DVP_P1-2: LN 2088	single	749.18	100.04	102.57	DC	18.92
1667152	925020	AB2-158 TAP	DVP	314766	6LOUISA	DVP	1	DVP_P1-2: LN 2088	single	749.18	100.64	103.17	DC	18.92

## 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.

ID	FROM BUS#	FROM BUS	FROM BUS AREA	TO BUS#	TO BUS	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC DC	MW IMPACT
1667159	314766	6LOUISA	DVP	314232	6NO ANNA	DVP	1	DVP_P1-2: LN 2088	operation	749.18	104.59	110.55	DC	44.62
1667151	925020	AB2-158 TAP	DVP	314766	6LOUISA	DVP	1	DVP_P1-2: LN 2088	operation	749.18	105.2	111.15	DC	44.62

## 15 System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
1667152	2	AB2-158 TAP 230.0 kV - 6LOUISA 230.0 kV Ckt 1	No Reinforcement Needed. Not a valid violation	\$0
1667160	1	6LOUISA 230.0 kV - 6NO ANNA 230.0 kV Ckt 1	dom-083 : Replace Wavetraps at the Louisa and North Anna 230 kV substations. Project Type : FAC Cost : \$300,000 Time Estimate : 16-18 Months	\$300,000
			<b>TOTAL COST</b>	<b>\$300,000</b>

## 16 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.

### 16.1 Contingency Descriptions

Contingency Name	Contingency Definition
DVP_P1-2: LN 2088	CONTINGENCY 'DVP_P1-2: LN 2088' OPEN BRANCH FROM BUS 314745 TO BUS 314758 CKT 1 /* 6LOISACT 230.00 - 6GORDNVL 230.00 END

## 16.2 Index 1

ID	FROM BUS#	FROM BUS	FROM BUS AREA	TO BUS#	TO BUS	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC DC	MW IMPACT
1667160	314766	6LOUISA	DVP	314232	6NO ANNA	DVP	1	DVP_P1-2: LN 2088	single	749.18	100.04	102.57	DC	18.92

Bus #	Bus	MW Impact
315172	1LOISA A	9.36
315173	1LOISA B	9.4
315174	1LOISA C	9.4
315175	1LOISA D	9.4
315176	1LOISA E	19.17
315177	1S ANNAG1	5.38
315178	1S ANNAS1	2.77
315179	1S ANNAG2	5.38
315180	1S ANNAS2	2.77
925021	AB2-158 C	7.4
939231	AE1-154 C	9.96
940421	AE2-026 C	18.92
BLUEG	BLUEG	2.08
CALDERWOOD	CALDERWOOD	0.23
CANNELTON	CANNELTON	0.13
CARR	CARR	0.15
CATAWBA	CATAWBA	0.15
CHEOAH	CHEOAH	0.21
CHILHOWEE	CHILHOWEE	0.07
COFFEEN	COFFEEN	0.22
COTTONWOOD	COTTONWOOD	0.87
DUCKCREEK	DUCKCREEK	0.48
EDWARDS	EDWARDS	0.22
ELMERSMITH	ELMERSMITH	0.22
FARMERCITY	FARMERCITY	0.15
GIBSON	GIBSON	0.09
HAMLET	HAMLET	0.24
NEWTON	NEWTON	0.58
PRAIRIE	PRAIRIE	1.07
RENSELAER	RENSELAER	0.12
SANTEETLA	SANTEETLA	0.06
SMITHLAND	SMITHLAND	0.09
TATANKA	TATANKA	0.26
TILTON	TILTON	0.26
TRIMBLE	TRIMBLE	0.23
TVA	TVA	0.73
UNIONPOWER	UNIONPOWER	0.32

## 16.3 Index 2

ID	FROM BUS#	FROM BUS	FROM BUS AREA	TO BUS#	TO BUS	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC DC	MW IMPACT
1667152	925020	AB2-158 TAP	DVP	314766	6LOUISA	DVP	1	DVP_P1-2: LN 2088	single	749.18	100.64	103.17	DC	18.92

Bus #	Bus	MW Impact
315172	1LOISA A	9.36
315173	1LOISA B	9.4
315174	1LOISA C	9.4
315175	1LOISA D	9.4
315176	1LOISA E	19.17
315177	1S ANNAG1	5.38
315178	1S ANNAS1	2.77
315179	1S ANNAG2	5.38
315180	1S ANNAS2	2.77
925021	AB2-158 C	7.4
939231	AE1-154 C	9.96
940421	AE2-026 C	18.92
BLUEG	BLUEG	2.08
CALDERWOOD	CALDERWOOD	0.23
CANNELTON	CANNELTON	0.13
CARR	CARR	0.15
CATAWBA	CATAWBA	0.15
CHEOAH	CHEOAH	0.21
CHILHOWEE	CHILHOWEE	0.07
COFFEEN	COFFEEN	0.22
COTTONWOOD	COTTONWOOD	0.87
DUCKCREEK	DUCKCREEK	0.48
EDWARDS	EDWARDS	0.22
ELMERSMITH	ELMERSMITH	0.22
FARMERCITY	FARMERCITY	0.15
GIBSON	GIBSON	0.09
HAMLET	HAMLET	0.24
NEWTON	NEWTON	0.58
PRAIRIE	PRAIRIE	1.07
RENSELAER	RENSELAER	0.12
SANTEETLA	SANTEETLA	0.06
SMITHLAND	SMITHLAND	0.09
TATANKA	TATANKA	0.26
TILTON	TILTON	0.26
TRIMBLE	TRIMBLE	0.23
TVA	TVA	0.73
UNIONPOWER	UNIONPOWER	0.32

## Affected Systems

## **17 Affected Systems**

### **17.1 LG&E**

LG&E Impacts to be determined during later study phases (as applicable).

### **17.2 MISO**

MISO Impacts to be determined during later study phases (as applicable).

### **17.3 TVA**

TVA Impacts to be determined during later study phases (as applicable).

### **17.4 Duke Energy Progress**

Duke Energy Progress Impacts to be determined during later study phases (as applicable).

### **17.5 NYISO**

NYISO Impacts to be determined during later study phases (as applicable).

# Short Circuit

## 18 Short Circuit

The following Breakers are overduty: None

# Attachment 1

## System Configuration

