Generation Interconnection

Feasibility Study Report

for

Queue Project AF1-292

FIELDS CROSSROADS 34.5 KV

8.9 MW Capacity / 14.9 MW Energy

January, 2020

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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.

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 Greensville County, Virginia. The installed facilities will have a total capability of 14.9 MW with 8.9 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is 11/30/2022. This study does not imply a TO commitment to this in-service date.

Queue Number	**AF1-292**
Project Name	FIELDS CROSSROADS 34.5 KV
State	Virginia
County	Greensville
Transmission Owner	Dominion
MFO	14.9
MWE	14.9
MWC	8.9
Fuel	Solar
Basecase Study Year	2023

3.1 Point of Interconnection

AF1-292 will interconnect with the Dominion distribution system on the Fields 34 kV #446 circuit. This is the primary Point of Interconnection (POI) chosen by the IC.

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 substation. 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.

There was no secondary point of interconnection specified for AF1-292.

3.2 Cost Summary

The costs associated with interconnecting the AF1-292 project to the Dominion distribution system will be documented in the two-party Interconnection Agreement between the IC and ITO.

The AF1-031 project may be responsible for a contribution to the following costs.

Description	Total Cost
System Upgrades	**$ 100,000**

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

The Feasibility Study is used to make a preliminary determination of the type and scope of Attachment Facilities, Local Upgrades, and Network Upgrades that will be necessary to accommodate the Interconnection Request and to provide the Interconnection Customer a preliminary estimate of the time that will be required to construct any necessary facilities and upgrades and the Interconnection Customer's cost responsibility. The System Impact Study provides refined and comprehensive estimates of cost responsibility and construction lead times for new facilities and system upgrades. Facilities Studies will include, commensurate with the degree of engineering specificity as provided in the Facilities Study Agreement, good faith estimates of the cost, determined in accordance with Section 217 of the Tariff,

(a) to be charged to each affected New Service Customer for the Facilities and System Upgrades that are necessary to accommodate this queue project;

(b) the time required to complete detailed design and construction of the facilities and upgrades; and

(c) a description of any site-specific environmental issues or requirements that could reasonably be anticipated to affect the cost or time required to complete construction of such facilities and upgrades.

4 Transmission Owner Scope of Work

Dominion assessed the impact of the proposed Queue Project AF1-292. The project was evaluated as an 8.9 MW Capacity (14.9 MW Energy) injection at the existing Greensville 34.5 kV substation in the Dominion Distribution System, for compliance with NERC Reliability Criteria on Dominion Transmission System. The system was assessed using the summer 2023 AF1 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 Planning Event 3 and 6 Contingency Conditions (Loss of generator, transmission circuit,

transformer, shunt device, or Single Pole of a DC line followed by the loss of a generator, transmission circuit, transformer, shunt device or single pole of a DC line) 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 AF1-292 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.

5 Non-Direct Connection Cost Estimate

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.

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 2023 summer peak load flow model and the results were verified by Dominion. Additionally, Dominion performed an analysis of its transmission system and no further deficiencies were identified.

7.2 Short Circuit Analysis

PJM performed a short circuit analysis and the results were verified by Dominion. The connection of AF1-069 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.

9.1.1 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 AF1-292 was evaluated as a 14.9 MW (Capacity 8.9 MW) injection at the Purdy Sw 115 kV substation in the Dominion area. Project AF1-292 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-292 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Load Flow

10.1 Generation Deliverability

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

None

10.2 Multiple Facility Contingency

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

None

10.3 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	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
4295835 6	31455 4	3BTLEBR O	115. 0	DVP	30422 3	3ROCKYMT115 T	115. 0	CPLE	1	DVP_P7 -1: LN 2058-2181	towe r	93.0	490.09	490.62	DC	1.09

10.4 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	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
4325065 1	31460 0	3PLHIT P	115. 0	DVP	31455 9	3CAROLN A	115. 0	DVP	1	DVP_P1 -2: LN 238-B	operatio n	315.8 4	100.69	103.71	DC	9.54

10.5 System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
42958356	1	3BTLEBRO 115.0 kV - 3ROCKYMT115T 115.0 kV Ckt 1	n6118 : Upgrading the breaker leads at DVPs terminal will bring the rating to 239/239/239 MVA (Limited by terminal equipment at Rocky Mount). Project Type : FAC Cost : $100,000 Time Estimate : 18 Months Duke Energy / Progress The external (i.e. Non-PJM) Transmission Owner, Duke Energy / Progress, will not evaluate this violation until the Impact Study phase.	$100,000
			TOTAL COST	**$100,000**

10.6 Flow Gate Details

The following indices contain additional information about each flowgate presented in the body of the report. For each index, 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.

10.6.1 Contingency Descriptions

Contingency Name	Contingency Definition
DVP_P1-2: LN 238-B	CONTINGENCY 'DVP_P1-2: LN 238-B' OPEN BRANCH FROM BUS 940480 TO BUS 314563 CKT 1 /* AE2-033 TAP 230.00 - 6CLUBHSE 230.00 OPEN BRANCH FROM BUS 314562 TO BUS 314563 CKT 1 /* 3CLUBHSE 115.00 - 6CLUBHSE 230.00 END
DVP_P7-1: LN 2058-2181	CONTINGENCY 'DVP_P7-1: LN 2058-2181' /* . OPEN BRANCH FROM BUS 304222 TO BUS 313845 CKT 1 /* 6ROCKYMT230T230.00 - 6HATHAWAY 230.00 OPEN BRANCH FROM BUS 313844 TO BUS 313845 CKT 2 /* 3HATHAWAY 115.00 - 6HATHAWAY 230.00 OPEN BUS 304226 /* ISLAND: 6PA-RMOUNT#4115.00 OPEN BRANCH FROM BUS 304226 TO BUS 314591 CKT 1 /* 6PA-RMOUNT#4230.00 - 6NASH 230.00 OPEN BRANCH FROM BUS 313845 TO BUS 314591 CKT 1 /* 6HATHAWAY 230.00 - 6NASH 230.00 OPEN BUS 314591 /* ISLAND: 6NASH 230.00 END

10.6.2 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
42958356	314554	3BTLEBRO	DVP	304223	3ROCKYMT115T	CPLE	1	DVP_P7-1: LN 2058-2181	tower	93.0	490.09	490.62	DC	1.09

Bus #	Bus	MW Impact
314582	3KELFORD	0.3143
314623	3WITAKRS	0.4481
315131	**1EDGECMA (Deativation : 04/22/19)**	**12.1498**
315132	**1EDGECMB (Deativation : 04/22/19)**	**12.1498**
315136	1ROSEMG1	1.2901
315137	1ROSEMS1	0.8000
315138	1ROSEMG2	0.6046
315139	1GASTONA	1.6581
315141	1GASTONB	1.6581
315601	1CONETOE2SOL	1.0750
315612	3AA2-057SOLA	2.0693
900672	V4-068 E	0.1239
917332	Z2-043 E	0.9790
917342	Z2-044 E	1.3758
917512	Z2-088 E OP1	3.3007
918492	AA1-063AE OP	1.9453
918512	AA1-065 E OP	1.4321
918532	AA1-067 E	0.2468
919692	AA2-053 E OP	1.9802
919702	AA2-057 E OP	6.9980
920042	AA2-088 E OP	4.0205
920591	AA2-165 C	0.2454
920592	AA2-165 E	0.9618
920672	AA2-174 E OP	0.2288
922922	AB1-081 C OP	22.9734
922923	AB1-081 E OP	9.8458
923262	AB1-132 C OP	9.0712
923263	AB1-132 E OP	3.8876
923572	AB1-173 C OP	1.0087
923573	AB1-173 E OP	0.4707
923582	AB1-173AC OP	1.0087

Bus #	Bus	MW Impact
923583	AB1-173AE OP	0.4707
923911	AB2-031 C O1	1.0012
923912	AB2-031 E O1	0.4931
923991	AB2-040 C O1	3.2875
923992	AB2-040 E O1	2.6897
924151	AB2-059 C OP	27.0758
924152	AB2-059 E OP	13.9482
924501	AB2-099 C	0.2639
924502	AB2-099 E	0.1131
924511	AB2-100 C	4.2530
924512	AB2-100 E	2.0948
925171	AB2-174 C O1	2.9963
925172	AB2-174 E O1	2.7109
925591	AC1-034 C	17.5378
925592	AC1-034 E	13.2302
926071	AC1-086 C	13.3584
926072	AC1-086 E	6.0798
926201	AC1-098 C	8.4863
926202	AC1-098 E	5.0557
926211	AC1-099 C	2.8438
926212	AC1-099 E	1.6702
927021	AC1-189 C	6.0737
927022	AC1-189 E	3.0255
927141	AC1-208 C	13.5259
927142	AC1-208 E	6.0061
932631	AC2-084 C	12.0975
932632	AC2-084 E	5.9585
934201	AD1-047 C	3.5863
934202	AD1-047 E	2.3909
934331	AD1-057 C O1	10.1868
934332	AD1-057 E O1	5.4341
936401	AD2-051 C O1	3.1730
936402	AD2-051 E O1	1.3625
936701	**AD2-089 C (Withdrawn : 12/09/2019)**	**7.0241**
936702	**AD2-089 E (Withdrawn : 12/09/2019)**	**4.6827**
936711	AD2-090 C O1	2.4240
936712	AD2-090 E O1	1.6160
937571	AD2-169 C	4.7032
937572	AD2-169 E	3.1355
938221	AE1-035 C	0.7996

Bus #	Bus	MW Impact
938222	AE1-035 E	0.3938
940521	AE2-037 C	2.8495
940522	AE2-037 E	1.3774
940571	AE2-044 C	11.4867
940572	AE2-044 E	4.9229
941541	AE2-151 C	0.5015
941542	AE2-151 E	0.2700
942471	AE2-260 C O1	4.9572
942472	AE2-260 E O1	7.0312
943171	AE2-346 C	0.3356
943172	AE2-346 E	0.1438
944141	AF1-082	7.3843
946281	AF1-292 C	0.2945
946282	AF1-292 E	0.1986
DUCKCREEK	DUCKCREEK	0.8625
NEWTON	NEWTON	0.8510
FARMERCITY	FARMERCITY	0.0489
G-007A	G-007A	0.4531
VFT	VFT	1.1997
PRAIRIE	PRAIRIE	2.3015
COFFEEN	COFFEEN	0.4212
EDWARDS	EDWARDS	0.2565
CHEOAH	CHEOAH	0.6977
TILTON	TILTON	0.4536
GIBSON	GIBSON	0.4106
CALDERWOOD	CALDERWOOD	0.6799
BLUEG	BLUEG	1.2673
TRIMBLE	TRIMBLE	0.4018
CATAWBA	CATAWBA	0.7364

Short Circuit

10.7 Short Circuit

The following Breakers are overdutied:

None

Affected Systems

11 Affected Systems

11.1 Duke Energy Progress

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

Attachment 1

System Configuration