Generation Interconnection

Feasibility Study Report

for

Queue Project AF1-069

CARSON-ROGERS RD 500 KV

67.7 MW Capacity / 94 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.

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 an uprate to an existing solar/storage generating facility located in Sussex County, Virginia. This projects requests an increase to the AE2-094 request of 94 MW with 67.7 MW of this output being recognized by PJM as Capacity. The installed facilities will have a total capability of 394 MW with 274.9 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is 06/01/2022. 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 AE2-094 project, which will share the same property. The additional capacity will be added behind the step-up transformer. 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.

Queue Number	AF1-069
Project Name	CARSON-ROGERS RD 500 KV
State	Virginia
County	Sussex
Transmission Owner	Dominion
MFO	394
MWE	94
MWC	67.7
Fuel	Solar; Storage
Basecase Study Year	2023

3.1 Point of Interconnection

AF1-069 will interconnect with the Dominion transmission system. The project is an upgrade to AE2-094 project. The additional capacity will be added behind the step-up transformer for that project. The POI is an existing Carson-Rogers Rd 500 kV substation.

3.2 Cost Summary

The AF1-069 project will utilize the interconnection facilities being developed under the AE2-094 project.

In addition, the AF1-069 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	**$50,995,000**

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 AF1-069. The project was evaluated as a 67.7 MW Capacity (94 MW Energy) injection at the existing Trowbridge 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 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 AF1-069 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 AF1-069 was evaluated as a 94.0 MW (Capacity 67.7 MW) injection as an uprate to AE2-094 tapping the Carson to Rodgers Road 500 kV line in the Dominion area. Project AF1-069 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-069 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
42858936	941030	AE2-094 TAP	500.0	DVP	314902	8CARSON	500.0	DVP	1	DVP_P1-2: LN 511-A	single	4070.2	102.57	103.69	DC	45.67

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
42858829	314902	8CARSON	500.0	DVP	314914	8MDLTHAN	500.0	DVP	1	DVP_P1-2: LN 557	operation	3218.56	126.96	127.59	DC	33.99
42858781	314914	8MDLTHAN	500.0	DVP	314918	8NO ANNA	500.0	DVP	1	DVP_P1-2: LN 557	operation	2442.12	145.08	145.69	DC	29.26
42858791	314914	8MDLTHAN	500.0	DVP	314918	8NO ANNA	500.0	DVP	1	Base Case	operation	2442.12	115.49	115.52	DC	24.68
42858955	314936	8RAWLINGS	500.0	DVP	940470	AE2-031 TAP	500.0	DVP	1	DVP_P1-2: LN 585-A	operation	4070.2	107.49	108.85	DC	55.55
42858916	940470	AE2-031 TAP	500.0	DVP	314902	8CARSON	500.0	DVP	1	DVP_P1-2: LN 585-A	operation	4070.2	117.24	118.6	DC	55.55
42858934	941030	AE2-094 TAP	500.0	DVP	314902	8CARSON	500.0	DVP	1	DVP_P1-2: LN 511-A	operation	4070.2	114.67	116.22	DC	63.41

10.5 System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
42858936	1	AE2-094 TAP 500.0 kV - 8CARSON 500.0 kV Ckt 1	dom-125 (654) : Rebuild 16.45 miles of 500 kV Line 585 from AE2-094 Tap to Carson with 3-1351.5 125C ACSR. Project Type : FAC Cost : $50,995,000 Time Estimate : 48-60 Months	$50,995,000
			TOTAL COST	**$50,995,000**

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
Base Case	
DVP_P1-2: LN 585-A	CONTINGENCY 'DVP_P1-2: LN 585-A' OPEN BRANCH FROM BUS 314902 TO BUS 941030 CKT 1 /* 8CARSON 500.00 - AE2-094 TAP 500.00 END
DVP_P1-2: LN 557	CONTINGENCY 'DVP_P1-2: LN 557' OPEN BRANCH FROM BUS 314214 TO BUS 314903 CKT 1 /* 6CHCKAHM 230.00 - 8CHCKAHM 500.00 OPEN BRANCH FROM BUS 314903 TO BUS 314908 CKT 1 /* 8CHCKAHM 500.00 - 8ELMONT 500.00 END
DVP_P1-2: LN 511-A	CONTINGENCY 'DVP_P1-2: LN 511-A' OPEN BRANCH FROM BUS 314902 TO BUS 940470 CKT 1 /* 8CARSON 500.00 - AE2-031 TAP 500.00 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
42858936	941030	AE2-094 TAP	DVP	314902	8CARSON	DVP	1	DVP_P1-2: LN 511-A	single	4070.2	102.57	103.69	DC	45.67

Bus #	Bus	MW Impact
246844	05SMG2	2.7406
246845	05SMG3	1.5555
246846	05SMG4	2.7406
247284	05LEESVG	0.7818
313853	3PONTONDP	0.0678
314429	3JTRSVLE	0.2713
314947	8GREENSVILLE	139.8048
315102	1BRUNSWICKG1	22.2003
315103	1BRUNSWICKG2	22.2003
315104	1BRUNSWICKG3	22.2003
315105	1BRUNSWICKS1	46.1209
315153	1CLOVER1	25.1791
315154	1CLOVER2	24.9282
315156	1HALLBR1	0.9305
315158	1KERR 1	0.2909
315159	1KERR 2	0.8145
315160	1KERR 3	0.8145
315161	1KERR 4	0.8145
315162	1KERR 5	0.8145
315163	1KERR 6	0.8145
315164	1KERR 7	0.8145
315266	1PLYWOOD A	1.5532
919841	AA2-070	0.5037
922922	AB1-081 C OP	5.9506
923831	AB2-022 C	-1.6220
924021	AB2-043 C O1	2.8771
924151	AB2-059 C OP	7.0132
924161	AB2-060 C OP	8.2846
924301	AB2-077 C O1	1.8559
924311	AB2-078 C O1	1.8559
924321	AB2-079 C O1	1.8559

Bus #	Bus	MW Impact
925591	AC1-034 C	4.5426
925611	AC1-036 C	0.8665
925661	AC1-042 C	1.8889
925781	AC1-054 C O1	4.7935
925831	AC1-062	0.0403
925861	AC1-065 C	-2.3007
925991	AC1-075 C	7.6910
926021	AC1-080 C	2.5704
926051	AC1-083 C O1	4.9761
926271	AC1-105 C O1	8.2568
926461	AC1-117 C	0.9296
926641	AC1-145 C	2.2486
926661	AC1-147 C	-1.8266
927251	AC1-221 C	3.7675
927261	AC1-222 C	5.7646
932761	AC2-100 C	8.6705
932831	AC2-110 C	-0.9203
933941	AD1-017 C	0.9952
934311	AD1-055 C	4.0025
934341	AD1-058 C	9.4446
934611	AD1-087 C O1	17.5001
934621	AD1-088 C	16.9782
934991	AD1-131 C	3.0966
935111	AD1-144 C	-1.2923
935171	AD1-152 C O1	17.3914
935211	AD1-156 C	-1.5858
935221	AD1-157 C	1.3660
935231	AD1-160 C	1.0017
936161	AD2-022 C O1	12.7572
936171	AD2-023 C O1	7.4417
936261	AD2-033 C	11.8646
936301	AD2-039 C	-0.9203
936331	**AD2-043 C (Withdrawn : 12/20/2019)**	**7.4952**
936361	AD2-046 C O1	7.7279
936481	AD2-063 C O1	13.6935
937251	AD2-164	-3.6330
937481	AD2-202 C O1	4.6377
937541	AD2-215 C	-1.3056
938371	AE1-056 C	5.8891
938491	AE1-068 C O1	204.6527

Bus #	Bus	MW Impact
938501	AE1-069 C O1	156.3826
938741	AE1-100 C O1	5.3179
938931	AE1-121 O1	61.3024
939181	AE1-148 C O1	7.6464
939371	AE1-168 C	13.6746
939941	AE1-230 C	0.8521
940081	AE1-250 C	13.4460
940241	AE2-006	0.4409
940471	AE2-031 C	97.3808
940571	AE2-044 C	2.9753
940601	AE2-047 C O1	4.3857
940661	AE2-053 O1	2.8320
941031	AE2-094 C	139.7730
941431	AE2-140 C O1	16.0671
941671	AE2-166 C	6.6053
941791	AE2-182 C	3.2339
941801	AE2-185 C	4.2606
941821	AE2-187 C	4.2606
942321	AE2-245	0.8452
942451	AE2-258	2.1464
942461	AE2-259 C O1	9.0960
942671	AE2-283 C	4.6867
942751	AE2-291 C O1	10.9468
942761	AE2-292 C O1	13.6299
942931	AE2-313 C	105.4399
943811	AF1-049 C O1	11.2957
943901	AF1-058 C	3.1920
944011	AF1-069 C	45.6691
944141	AF1-082	1.9127
945081	AF1-173	1.6510
945811	AF1-246 C O1	19.2263
946301	AF1-294 C	4.5561
946461	**AF1-310 C O1 (Withdrawn : 11/05/2019)**	**46.5781**
LGEE	LGEE	2.8074
CPLE	CPLE	14.1581
WEC	WEC	1.4874
CBM-W2	CBM-W2	59.0745
NY	NY	1.8614
CBM-W1	CBM-W1	55.4818
TVA	TVA	12.4390

Bus #	Bus	MW Impact
CBM-S2	CBM-S2	101.1327
CBM-S1	CBM-S1	69.4295
MADISON	MADISON	3.4070
MEC	MEC	8.9763
AA2-074	AA2-074	9.6520

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