Generation Interconnection

Feasibility Study Report

for

Queue Project AF1-246

CLOVER-RAWLINGS 500 KV

42 MW Capacity / 100 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 a solar generating facility located in Charlotte County, Virginia. The installed facilities will have a total capability of 100 MW with 42 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is 07/01/2022. This study does not imply a TO commitment to this in-service date.

Queue Number	AF1-246
Project Name	CLOVER-RAWLINGS 500 KV
State	Virginia
County	Charlotte
Transmission Owner	Dominion
MFO	100
MWE	100
MWC	42
Fuel	Solar
Basecase Study Year	2023

3.1 Primary Point of Interconnection

AF1-246 will interconnect with the Dominion transmission system via a new 500kV three breaker ring bus tapping the Clover to Rawlings 500 kV line. 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.

3.2 Secondary Point of Interconnection

The IC chose a direct connection into the Clover 230kV substation as the secondary POI. This report does not provide costs for the physical interconnection of the secondary point of interconnection. It was only analyzed for network impacts. Results are shown in the Network Impacts – Secondary Point of Interconnection section of this report.

3.3 Cost Summary

The AF1-246 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 2,750,000
Direct Connection Network Upgrade	$ 17,000,000
Non Direct Connection Network Upgrades	$ 2,200,000
Total Costs	**$ 21,950,000**

In addition, the AF1-246 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	**$ 3,000,000**

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 AF1-246. The project was evaluated as a 42 MW Capacity (100 MW Energy) injection at a single line tap between Clover 500 kV substation and Rawlings 500 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 AF1-246 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 Attachment Facilities

To accommodate the proposed AF1-246 Project, Dominion Energy will install one span of overhead 500 kV line to the point of interconnection ("POI") including 500 kV interconnection metering.

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)	$ 750,000
Transmission (One span)	$ 2,000,000
Total Attachment Facility Costs	**$ 2,750,000**

It is estimated to take 18-24 months to complete this work upon execution of an Interconnection Construction Service Agreement (ICSA). These preliminary cost estimates are based on typical engineering costs. A more detailed engineering cost estimates are normally done when the IC provides an exact site plan location for the generation substation during the Facility Study phase. See Attachment 1.

6 Direct Connection Cost Estimate

To accommodate the proposed AF1-246 Project, Dominion Energy will build a new three breaker 500 kV Switching Station and re-arrange the existing section of the line between Clover and Rawlings Substations to allow for the proposed interconnection.

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	$ 17,000,000
Total Direct Connection Facility Costs	**$ 17,000,000**

It is estimated to take 24-30 months to complete this work upon execution of an Interconnection Construction Service Agreement (ICSA). These preliminary cost estimates are based on typical engineering costs. A more detailed engineering cost estimates are normally done when the IC provides an exact site plan location for the generation substation during the Facility Study phase. See Attachment 1.

7 Non-Direct Connection Cost Estimate

To accommodate the proposed AF1-246 Project, Dominion Energy will re-arrange the existing section of the line between Clover and Rawlings substations.

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
Transmission (one span)	$ 2,200,000
Total Direct Connection Facility Costs	**$ 2,200,000**

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.

8 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.

9 Transmission Owner Analysis

9.1 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.

9.2 Short Circuit Analysis

PJM performed a short circuit analysis and the results were verified by Dominion. The connection of AF1-246 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

9.3 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.

10 Interconnection Customer Requirements

10.1 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.

10.2 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.

10.3 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.

11 Revenue Metering and SCADA Requirements

11.1 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.

11.1.1 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

11.2 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.

12 Network Impacts – Primary Point of Interconnection

The Queue Project AF1-246 was evaluated as a 100.0 MW (Capacity 42.0 MW) injection tapping the Clover to Rawlings 500 kV line in the Dominion area. Project AF1-246 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-246 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Load Flow

12.1 Generation Deliverability

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

None

12.2 Multiple Facility Contingency

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

None

12.3 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
4293749 5	92725 0	AC1-221 TAP	230. 0	DVP	30407 0	6PERSON23 0 T	230. 0	CPLE	1	DVP_P1 -2: LN 570	singl e	718.0	129.36	130.48	DC	8.14
4293749 7	92725 0	AC1-221 TAP	230. 0	DVP	30407 0	6PERSON23 0 T	230. 0	CPLE	1	DVP_P1 -2: LN 556-B	singl e	718.0	114.86	117.89	DC	21.74

12.4 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
4320691 8	31469 4	3GRIT	115. 0	DVP	31471 2	3OTTER R	115. 0	DVP	1	DVP_P1 -2: LN 556-B	operatio n	285.7 6	110.34	111.63	DC	8.2
4320690 2	31471 2	3OTTER R	115. 0	DVP	31466 6	3ALTVSTA	115. 0	DVP	1	DVP_P1 -2: LN 556-B	operatio n	269.7 8	111.24	112.61	DC	8.2
4293767 5	31493 6	8RAWLING S	500. 0	DVP	94047 0	AE2-031 TAP	500. 0	DVP	1	DVP_P1 -2: LN 585-A	operatio n	4070. 2	109.09	110.35	DC	51.45
4293770 1	31494 0	8ROGERS RD	500. 0	DVP	93849 0	AE1-068 TAP	500. 0	DVP	1	DVP_P1 -2: LN 511-A	operatio n	4070. 2	102.45	103.57	DC	45.78

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
42937493	927250	AC1-221 TAP	230.0	DVP	304070	6PERSON230 T	230.0	CPLE	1	DVP_P1-2: LN 556-B	operation	718.0	142.43	149.62	DC	51.77
42937671	938490	AE1-068 TAP	500.0	DVP	941030	AE2-094 TAP	500.0	DVP	1	DVP_P1-2: LN 511-A	operation	4070.2	110.07	111.19	DC	45.78
42937636	940470	AE2-031 TAP	500.0	DVP	314902	8CARSON	500.0	DVP	1	DVP_P1-2: LN 585-A	operation	4070.2	118.84	120.1	DC	51.45
42937654	941030	AE2-094 TAP	500.0	DVP	314902	8CARSON	500.0	DVP	1	DVP_P1-2: LN 511-A	operation	4070.2	116.45	117.57	DC	45.78
43206908	942750	AE2-291 TAP	115.0	DVP	314694	3GRIT	115.0	DVP	1	DVP_P1-2: LN 556-B	operation	285.76	111.04	112.33	DC	8.2

12.5 System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
42937495,42937497	1	**AC1-221 TAP 230.0 kV - 6PERSON230 T 230.0 kV Ckt 1**	**dom-006 (558) : For DEV portion, rebuild 2 miles of 230 kV Line 296 from AC1-221 Tap to Persons (Duke Energy/Progress) with 2-636 ACSR.** **Cost : $3,000,000** **Time Estimate : 30-36 Months**	$3,000,000
			TOTAL COST	**$3,000,000**

12.6 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.

12.6.1 Contingency Descriptions

Contingency Name	Contingency Definition
DVP_P1-2: LN 570	CONTINGENCY 'DVP_P1-2: LN 570' OPEN BRANCH FROM BUS 304183 TO BUS 314935 CKT 1 /* 8WAKE 500 TT500.00 - 8HERITAGE 500.00 END

Contingency Name	Contingency Definition
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
DVP_P1-2: LN 556-B	CONTINGENCY 'DVP_P1-2: LN 556-B' OPEN BRANCH FROM BUS 945810 TO BUS 314936 CKT 1 /* AF1-246 TAP 500.00 - 8RAWLINGS 500.00 END
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

12.6.2 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
42937495	927250	AC1-221 TAP	DVP	304070	6PERSON230 T	CPLE	1	DVP_P1-2: LN 570	single	718.0	129.36	130.48	DC	8.14

Bus #	Bus	MW Impact
313853	3PONTONDP	0.0570
314295	6BIRDNECK	0.0129
314333	6POWHATN	0.1249
314429	3JTRSVLE	0.2280
314491	3PENDLTN	0.0963
314507	3THOMPSN	0.0977
314677	6BUCKING	0.1929
314704	3LAWRENC	0.1015
314947	8GREENSVILLE	23.0274
315098	1CHESPKA	0.1295
315099	**1CHESPKB (Deativation : 05/31/19)**	**0.9868**
315102	1BRUNSWICKG1	3.9336
315103	1BRUNSWICKG2	3.9336
315104	1BRUNSWICKG3	3.9336
315105	1BRUNSWICKS1	8.1721
315108	1ELIZAR1	0.9552
315109	1ELIZAR2	0.9386
315110	1ELIZAR3	0.9674
315153	1CLOVER1	14.3989
315154	1CLOVER2	14.2554
315191	1BEARGRDN G1	1.5614
315192	1BEARGRDN G2	1.5614
315193	1BEARGRDN S1	3.2135
315233	1SURRY 2	7.6012
315260	1GOSPORTA	0.1032
315261	1GOSPORTB	0.1319
315262	1GOSPORTC	0.1119
315266	1PLYWOOD A	1.7461
920291	AA2-127	0.3244
924021	AB2-043 C O1	2.4166
924161	AB2-060 C OP	6.9588

Bus #	Bus	MW Impact
924301	AB2-077 C O1	1.5570
924311	AB2-078 C O1	1.5570
924321	AB2-079 C O1	1.5570
925611	AC1-036 C	0.7279
925831	AC1-062	0.0338
925991	AC1-075 C	7.3467
926021	AC1-080 C	2.4553
926271	AC1-105 C O1	9.4015
926661	AC1-147 C	0.7846
926751	AC1-161 C O1	11.5301
927251	AC1-221 C	9.8772
927261	AC1-222 C	6.5915
932041	AC2-012 C	3.5494
932511	AC2-071 C	1.3618
932761	AC2-100 C	22.7311
933291	AC2-141 C	11.5301
933501	AC2-165 C	3.7688
934061	AD1-033 C	2.5679
934311	AD1-055 C	4.5767
934341	AD1-058 C	24.7606
934611	AD1-087 C O1	15.4053
934621	AD1-088 C	11.6382
934991	AD1-131 C	8.1182
935171	AD1-152 C O1	15.3096
935221	AD1-157 C	1.1478
935231	AD1-160 C	0.8417
936261	AD2-033 C	9.9676
936331	**AD2-043 C (Withdrawn : 12/20/2019)**	**8.5281**
936361	AD2-046 C O1	3.9204
936481	AD2-063 C O1	11.5020
937481	AD2-202 C O1	4.0826
938371	AE1-056 C	4.9482
938491	AE1-068 C O1	31.9201
938501	AE1-069 C O1	25.7579
938561	AE1-075 C	0.7846
939181	AE1-148 C O1	4.0187
939371	AE1-168 C	11.4894
939411	AE1-173 C	37.2816
940241	AE2-006	0.3704
940251	AE2-007 O1	60.4847

Bus #	Bus	MW Impact
940471	AE2-031 C	18.0734
940641	AE2-051 C O1	7.4826
940661	AE2-053 O1	1.4884
941031	AE2-094 C	19.7130
941281	AE2-122 C O1	9.7739
941291	AE2-123 C O1	10.0446
941301	AE2-124 C O1	9.1209
941591	AE2-156 O1	6.2430
941791	AE2-182 C	2.2168
942451	AE2-258	1.8028
942461	AE2-259 C O1	7.6440
942751	AE2-291 C O1	9.2075
942761	AE2-292 C O1	11.4643
942931	AE2-313 C	19.5691
943901	AF1-058 C	3.7769
943911	AF1-059	8.8730
944011	AF1-069 C	6.4410
944581	AF1-123 C O1	15.5158
944591	AF1-124 C O1	15.5158
944601	AF1-125 C O1	15.5158
945811	AF1-246 C O1	8.1358
946301	AF1-294 C	3.8283
946461	**AF1-310 C O1 (Withdrawn : 11/05/2019)**	**26.6361**
DUCKCREEK	DUCKCREEK	4.2467
NEWTON	NEWTON	4.2056
FARMERCITY	FARMERCITY	0.2430
G-007A	G-007A	2.7284
VFT	VFT	7.2498
AF1-020	AF1-020	18.1800
PRAIRIE	PRAIRIE	11.4504
AC1-131	AC1-131	10.9538
COFFEEN	COFFEEN	2.0828
EDWARDS	EDWARDS	1.2617
CHEOAH	CHEOAH	3.5636
TILTON	TILTON	2.2283
GIBSON	GIBSON	2.0235
CALDERWOOD	CALDERWOOD	3.4696
BLUEG	BLUEG	6.2288
TRIMBLE	TRIMBLE	1.9750
CATAWBA	CATAWBA	3.8616

Short Circuit

12.7 Short Circuit

The following Breakers are overdutied:

None

13 Network Impacts – Secondary Point of Interconnection

The Queue Project AF1-246 was evaluated as a 100.0 MW (Capacity 42.0 MW) injection at the Clover 230 kV substation in the Dominion area. Project AF1-246 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-246 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Load Flow

13.1 Generation Deliverability

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

None

13.2 Multiple Facility Contingency

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

None

13.3 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
43945475	242631	05EDAN 1	138.0	AEP	242620	05DANVL2	138.0	AEP	1	AEP_P4_#11112_05J. FERR 765_A1	breaker	402.0	119.8	120.45	DC	5.79
43945476	242631	05EDAN 1	138.0	AEP	242620	05DANVL2	138.0	AEP	1	AEP_P4_#11111_05J. FERR 765_B1	breaker	402.0	118.27	118.95	DC	6.04
42937495	927250	AC1-221 TAP	230.0	DVP	304070	6PERSON2 30 T	230.0	CPLE	1	DVP_P1-2: LN 570	single	718.0	133.33	134.69	DC	9.81
53032091	927250	AC1-221 TAP	230.0	DVP	304070	6PERSON2 30 T	230.0	CPLE	1	DVP_P1-2: LN 556	single	718.0	114.92	117.95	DC	21.74
53032092	927250	AC1-221 TAP	230.0	DVP	304070	6PERSON2 30 T	230.0	CPLE	1	314906 8CLOVER 500 314936 8RAWLINGS 500 1	single	718.0	114.92	117.95	DC	21.74

13.4 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
43945951	242631	05EDAN 1	138.0	AEP	242620	05DANVL2	138.0	AEP	1	AEP_P1-2_#1377	operation	402.0	118.25	118.92	DC	6.04
53486668	314694	3GRIT	115.0	DVP	314712	3OTTER R	115.0	DVP	1	DVP_P1-2: LN 556	operation	285.76	110.34	111.63	DC	8.2

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
53486669	314694	3GRIT	115.0	DVP	314712	3OTTER R	115.0	DVP	1	3149068CLOVER 500 3149368RAWLINGS 500 1	operation	285.76	110.34	111.63	DC	8.2
53486651	314712	3OTTER R	115.0	DVP	314666	3ALTVSTA	115.0	DVP	1	DVP_P1-2: LN 556	operation	269.78	111.24	112.61	DC	8.2
53486652	314712	3OTTER R	115.0	DVP	314666	3ALTVSTA	115.0	DVP	1	3149068CLOVER 500 3149368RAWLINGS 500 1	operation	269.78	111.24	112.61	DC	8.2
42937675	314936	8RAWLINGS	500.0	DVP	940470	AE2-031 TAP	500.0	DVP	1	DVP_P1-2: LN 585-A	operation	4070.2	109.09	110.21	DC	45.79
42937701	314940	8ROGERS RD	500.0	DVP	938490	AE1-068 TAP	500.0	DVP	1	DVP_P1-2: LN 511-A	operation	4070.2	102.44	103.45	DC	40.86
42937499	927250	AC1-221 TAP	230.0	DVP	304070	6PERSON230 T	230.0	CPLE	1	Base Case	operation	542.0	96.89	100.8	DC	21.19
53032087	927250	AC1-221 TAP	230.0	DVP	304070	6PERSON230 T	230.0	CPLE	1	DVP_P1-2: LN 556	operation	718.0	142.49	149.67	DC	51.77
53032088	927250	AC1-221 TAP	230.0	DVP	304070	6PERSON230 T	230.0	CPLE	1	3149068CLOVER 500 3149368RAWLINGS 500 1	operation	718.0	142.49	149.67	DC	51.77
42937671	938490	AE1-068 TAP	500.0	DVP	941030	AE2-094 TAP	500.0	DVP	1	DVP_P1-2: LN 511-A	operation	4070.2	110.06	111.07	DC	40.86
42937636	940470	AE2-031 TAP	500.0	DVP	314902	8CARSON	500.0	DVP	1	DVP_P1-2: LN 585-A	operation	4070.2	118.83	119.96	DC	45.79
42937654	941030	AE2-094 TAP	500.0	DVP	314902	8CARSON	500.0	DVP	1	DVP_P1-2: LN 511-A	operation	4070.2	116.45	117.45	DC	40.86
53486662	942750	AE2-291 TAP	115.0	DVP	314694	3GRIT	115.0	DVP	1	3149068CLOVER 500 3149368RAWLINGS 500 1	operation	285.76	111.08	112.37	DC	8.2
53486663	942750	AE2-291 TAP	115.0	DVP	314694	3GRIT	115.0	DVP	1	DVP_P1-2: LN 556	operation	285.76	111.08	112.37	DC	8.2

13.5 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.

13.5.1 Contingency Descriptions

Contingency Name	Contingency Definition
DVP_P1-2: LN 556	CONTINGENCY 'DVP_P1-2: LN 556' OPEN BRANCH FROM BUS 314686 TO BUS 314906 CKT 1 /* 6CLOVER 230.00 - 8CLOVER 500.00 OPEN BRANCH FROM BUS 314686 TO BUS 314906 CKT 2 /* 6CLOVER 230.00 - 8CLOVER 500.00 OPEN BRANCH FROM BUS 314686 TO BUS 314906 CKT 3 /* 6CLOVER 230.00 - 8CLOVER 500.00 OPEN BRANCH FROM BUS 314906 TO BUS 314936 CKT 1 /* 8CLOVER 500.00 - 8RAWLINGS 500.00 OPEN BUS 314906 /* ISLAND: 8CLOVER 500.00 OPEN BUS 314915 /* ISLAND: 8CLOVER_STC 500.00 END
AEP_P4_#11111_05J.FERR 765_B1	CONTINGENCY 'AEP_P4_#11111_05J.FERR 765_B1' OPEN BRANCH FROM BUS 242514 TO BUS 242520 CKT 1 / 242514 05J.FERR 765 242520 05J.FERR 500 1 OPEN BRANCH FROM BUS 242514 TO BUS 242684 CKT 2 / 242514 05J.FERR 765 242684 05J.FERR 138 2 OPEN BRANCH FROM BUS 242520 TO BUS 306719 CKT 1 / 242520 05J.FERR 500 306719 8ANTIOCH 500 1 END
DVP_P1-2: LN 570	CONTINGENCY 'DVP_P1-2: LN 570' OPEN BRANCH FROM BUS 304183 TO BUS 314935 CKT 1 /* 8WAKE 500 TT500.00 - 8HERITAGE 500.00 END
AEP_P1-2_#1377	CONTINGENCY 'AEP_P1-2_#1377' OPEN BRANCH FROM BUS 242514 TO BUS 242520 CKT 1 / 242514 05J.FERR 765 242520 05J.FERR 500 1 OPEN BRANCH FROM BUS 242520 TO BUS 306719 CKT 1 / 242520 05J.FERR 500 306719 8ANTIOCH 500 1 END
Base Case	
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
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

Contingency Name	Contingency Definition
AEP_P4_#11112_05J.FERR 765_A1	CONTINGENCY 'AEP_P4_#11112_05J.FERR 765_A1' OPEN BRANCH FROM BUS 242511 TO BUS 242514 CKT 1 / 242511 05BROADF 765 242514 05J.FERR 765 1 OPEN BRANCH FROM BUS 242514 TO BUS 242520 CKT 1 / 242514 05J.FERR 765 242520 05J.FERR 500 1 OPEN BRANCH FROM BUS 242520 TO BUS 306719 CKT 1 / 242520 05J.FERR 500 306719 8ANTIOCH 500 1 OPEN BRANCH FROM BUS 242566 TO BUS 242567 CKT ZB / 242566 05BROADF 138 242567 05BROADX 138 ZB END
314906 8CLOVER 500 314936 8RAWLINGS 500 1	CONTINGENCY '314906 8CLOVER 500 314936 8RAWLINGS 500 1' OPEN BRANCH FROM BUS 314906 TO BUS 314936 CKT 1 END

13.5.2 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
4394547 5	24263 1	05EDA N 1	AEP	24262 0	05DANVL 2	AEP	1	AEP_P4_#11112_05J.FER R 765_A1	breake r	402.0	119.8	120.45	DC	5.79

Bus #	Bus	MW Impact
244012	05PINNACLE	-1.8111
315131	**1EDGECMA (Deativation : 04/22/19)**	**3.5417**
315132	**1EDGECMB (Deativation : 04/22/19)**	**3.5417**
917332	Z2-043 E	0.3400
917342	Z2-044 E	0.2123
917512	Z2-088 E OP1	1.3776
918532	AA1-067 E	0.2416
919692	AA2-053 E OP	1.0943
919702	AA2-057 E OP	1.2033
920592	AA2-165 E	0.1654
920672	AA2-174 E OP	0.1265
922922	AB1-081 C OP	3.4143
922923	AB1-081 E OP	1.4633
923262	AB1-132 C OP	4.0434
923263	AB1-132 E OP	1.7329
924021	AB2-043 C O1	0.9885
924022	AB2-043 E O1	0.8839
924151	AB2-059 C OP	4.0241
924152	AB2-059 E OP	2.0730
924161	AB2-060 C OP	2.8276
924162	AB2-060 E OP	1.3306
924301	AB2-077 C O1	0.6329
924302	AB2-077 E O1	0.4219
924311	AB2-078 C O1	0.6329
924312	AB2-078 E O1	0.4219
924321	AB2-079 C O1	0.6329
924322	AB2-079 E O1	0.4219
925121	AB2-169 C	1.8680
925122	AB2-169 E	1.6764
925591	AC1-034 C	2.6065
925592	AC1-034 E	1.9663
925781	AC1-054 C O1	2.4878

Bus #	Bus	MW Impact
925782	AC1-054 E O1	1.1460
926051	AC1-083 C O1	3.9543
926052	AC1-083 E O1	6.4517
926071	AC1-086 C	5.9544
926072	AC1-086 E	2.7100
926201	AC1-098 C	1.9796
926202	AC1-098 E	1.1793
926211	AC1-099 C	0.6634
926212	AC1-099 E	0.3896
926271	AC1-105 C O1	1.9507
926272	AC1-105 E O1	0.9711
927021	AC1-189 C	3.0007
927022	AC1-189 E	1.4947
927141	AC1-208 C	2.9780
927142	AC1-208 E	1.3223
927251	AC1-221 C	1.5613
927252	AC1-221 E	1.5613
927261	AC1-222 C	1.2469
927262	AC1-222 E	1.1870
932631	AC2-084 C	2.8220
932632	AC2-084 E	1.3899
932761	AC2-100 C	3.5932
932762	AC2-100 E	1.7538
933941	AD1-017 C	0.7909
933942	AD1-017 E	1.2903
934311	AD1-055 C	0.8658
934312	AD1-055 E	0.2232
934331	AD1-057 C O1	3.3993
934332	AD1-057 E O1	1.8133
934341	AD1-058 C	3.9140
934342	AD1-058 E	0.9945
934611	AD1-087 C O1	2.7778
934612	AD1-087 E O1	1.3055
934991	AD1-131 C	1.2833
934992	AD1-131 E	0.8555
935171	AD1-152 C O1	2.7605
935172	AD1-152 E O1	1.8404
936161	AD2-022 C O1	10.5666
936162	AD2-022 E O1	6.3400
936171	AD2-023 C O1	6.1638

Bus #	Bus	MW Impact
936172	AD2-023 E O1	3.3461
936261	AD2-033 C	3.7334
936262	AD2-033 E	2.4889
936331	**AD2-043 C (Withdrawn : 12/20/2019)**	**1.6170**
936332	**AD2-043 E (Withdrawn : 12/20/2019)**	**1.9134**
936361	AD2-046 C O1	3.1372
936362	AD2-046 E O1	1.4426
936481	AD2-063 C O1	4.5196
936482	AD2-063 E O1	2.9880
936701	**AD2-089 C (Withdrawn : 12/09/2019)**	**2.6255**
936702	**AD2-089 E (Withdrawn : 12/09/2019)**	**1.7503**
937481	AD2-202 C O1	0.7361
937482	AD2-202 E O1	0.4141
938661	AE1-088	0.9580
939181	AE1-148 C O1	3.0781
939182	AE1-148 E O1	2.0520
940081	AE1-250 C	14.0319
940082	AE1-250 E	9.3546
940571	AE2-044 C	0.9048
940572	AE2-044 E	0.3878
940661	AE2-053 O1	1.1400
942451	AE2-258	0.7374
943901	AF1-058 C	0.3726
943902	AF1-058 E	0.2484
943911	AF1-059	2.5989
944141	AF1-082	0.5817
945811	AF1-246 C O2	1.0955
945812	AF1-246 E O2	1.5129
946461	**AF1-310 C O1 (Withdrawn : 11/05/2019)**	**2.9736**
946462	**AF1-310 E O1 (Withdrawn : 11/05/2019)**	**4.8516**
DUCKCREEK	DUCKCREEK	0.5159
NEWTON	NEWTON	0.3686
CPLE	CPLE	5.5024
G-007A	G-007A	0.4196
VFT	VFT	1.0900
CBM-W2	CBM-W2	5.0532
TVA	TVA	1.9222
COFFEEN	COFFEEN	0.1559
CBM-S2	CBM-S2	36.9631
EDWARDS	EDWARDS	0.1778
CBM-S1	CBM-S1	8.4774

Bus #	Bus	MW Impact
TILTON	TILTON	0.3925
MADISON	MADISON	1.8688
GIBSON	GIBSON	0.2970
BLUEG	BLUEG	1.2378
TRIMBLE	TRIMBLE	0.4157
AA2-074	AA2-074	3.7368

13.5.3 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
42937495	927250	AC1-221 TAP	DVP	304070	6PERSON230 T	CPLE	1	DVP_P1-2: LN 570	single	718.0	133.33	134.69	DC	9.81

Bus #	Bus	MW Impact
313853	3PONTONDP	0.0570
314295	6BIRDNECK	0.0129
314333	6POWHATN	0.1249
314429	3JTRSVLE	0.2280
314491	3PENDLTN	0.0963
314507	3THOMPSN	0.0977
314677	6BUCKING	0.1929
314704	3LAWRENC	0.1015
314947	8GREENSVILLE	23.0274
315098	1CHESPKA	0.1295
315099	**1CHESPKB (Deativation : 05/31/19)**	**0.9868**
315102	1BRUNSWICKG1	3.9336
315103	1BRUNSWICKG2	3.9336
315104	1BRUNSWICKG3	3.9336
315105	1BRUNSWICKS1	8.1721
315108	1ELIZAR1	0.9552
315109	1ELIZAR2	0.9386
315110	1ELIZAR3	0.9674
315153	1CLOVER1	14.3989
315154	1CLOVER2	14.2554
315191	1BEARGRDN G1	1.5614
315192	1BEARGRDN G2	1.5614
315193	1BEARGRDN S1	3.2135
315233	1SURRY 2	7.6012
315260	1GOSPORTA	0.1032
315261	1GOSPORTB	0.1319
315262	1GOSPORTC	0.1119
315266	1PLYWOOD A	1.7461
920291	AA2-127	0.3244
924021	AB2-043 C O1	2.4166
924161	AB2-060 C OP	6.9588

Bus #	Bus	MW Impact
924301	AB2-077 C O1	1.5570
924311	AB2-078 C O1	1.5570
924321	AB2-079 C O1	1.5570
925611	AC1-036 C	0.7279
925831	AC1-062	0.0338
925991	AC1-075 C	7.3467
926021	AC1-080 C	2.4553
926271	AC1-105 C O1	9.4015
926661	AC1-147 C	0.7846
926751	AC1-161 C O1	11.5301
927251	AC1-221 C	9.8772
927261	AC1-222 C	6.5915
932041	AC2-012 C	3.5494
932511	AC2-071 C	1.3618
932761	AC2-100 C	22.7311
933291	AC2-141 C	11.5301
933501	AC2-165 C	3.7688
934061	AD1-033 C	2.5679
934311	AD1-055 C	4.5767
934341	AD1-058 C	24.7606
934611	AD1-087 C O1	15.4053
934621	AD1-088 C	11.6382
934991	AD1-131 C	8.1182
935171	AD1-152 C O1	15.3096
935221	AD1-157 C	1.1478
935231	AD1-160 C	0.8417
936261	AD2-033 C	9.9676
936331	**AD2-043 C (Withdrawn : 12/20/2019)**	**8.5281**
936361	AD2-046 C O1	3.9204
936481	AD2-063 C O1	11.5020
937481	AD2-202 C O1	4.0826
938371	AE1-056 C	4.9482
938491	AE1-068 C O1	31.9201
938501	AE1-069 C O1	25.7579
938561	AE1-075 C	0.7846
939181	AE1-148 C O1	4.0187
939371	AE1-168 C	11.4894
939411	AE1-173 C	37.2816
940241	AE2-006	0.3704
940251	AE2-007 O1	60.4847

Bus #	Bus	MW Impact
940471	AE2-031 C	18.0734
940641	AE2-051 C O1	7.4826
940661	AE2-053 O1	1.4884
941031	AE2-094 C	19.7130
941281	AE2-122 C O1	9.7739
941291	AE2-123 C O1	10.0446
941301	AE2-124 C O1	9.1209
941591	AE2-156 O1	6.2430
941791	AE2-182 C	2.2168
942451	AE2-258	1.8028
942461	AE2-259 C O1	7.6440
942751	AE2-291 C O1	9.2075
942761	AE2-292 C O1	11.4643
942931	AE2-313 C	19.5691
943901	AF1-058 C	3.7769
943911	AF1-059	8.8730
944011	AF1-069 C	6.4410
944581	AF1-123 C O2	14.9558
944591	AF1-124 C O2	14.9558
944601	AF1-125 C O2	14.9558
945711	AF1-236 C O2	30.1353
945811	AF1-246 C O2	9.8133
946291	AF1-293 C O2	6.6818
946301	AF1-294 C	3.8283
946461	**AF1-310 C O1 (Withdrawn : 11/05/2019)**	**26.6361**
DUCKCREEK	DUCKCREEK	4.2467
NEWTON	NEWTON	4.2056
FARMERCITY	FARMERCITY	0.2430
G-007A	G-007A	2.7284
VFT	VFT	7.2498
AF1-020	AF1-020	18.1800
PRAIRIE	PRAIRIE	11.4504
AC1-131	AC1-131	10.9538
COFFEEN	COFFEEN	2.0828
EDWARDS	EDWARDS	1.2617
CHEOAH	CHEOAH	3.5636
TILTON	TILTON	2.2283
GIBSON	GIBSON	2.0235
CALDERWOOD	CALDERWOOD	3.4696
BLUEG	BLUEG	6.2288

Bus #	Bus	MW Impact
TRIMBLE	TRIMBLE	1.9750
CATAWBA	CATAWBA	3.8616

Short Circuit

13.6 Short Circuit

The following Breakers are overdutied:

None

Affected Systems

14 Affected Systems

14.1 Duke Energy Progress

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

Attachment 1

System Configuration