Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AD1-049

Culpeper 35kV
13.3 MW Capacity / 20.0 MW Energy

February 2018

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).

Preface

The intent of the Combined Feasibility/System Impact Study is to determine a plan, with high level estimated cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the IC. The IC may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the IC 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. 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 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 IC is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by ITO, the costs may be included in the study.

General

The IC has proposed a solar generating facility located in Culpeper County, Virginia. The installed facilities will have a total capability of 20 MW with 13.3 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is December 1, 2019. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AD1-049 will interconnect with the ITO distribution system on a Culpeper 34.5kV circuit.

Cost Summary

The AD1-049 project may be responsible for a contribution to the following costs:

Description	Total Estimated Cost
New System Upgrades	$ 2,200.000
Previously Identified Upgrades	$ 0
Total Costs	**$ 2,200,000**

PJM Open Access Transmission Tariff (OATT) section 217.3A outline cost allocation rules. The rules are further clarified in PJM Manual 14A Attachment B. For New System Upgrades, the cost allocation rule differ depending on whether the minimum amount of upgrades to resolve a single reliability criteria violation will cost less than $5,000,000. For upgrades estimated to cost less than $5,000,000 the allocation of costs will not occur outside of the Queue in which the need for the Network Upgrade was identified. Cost allocation within the Queue will be contingent each Queue projects Distribution Factor on the overloaded facility. For upgrades estimated to cost $5,000,000 or greater the allocation of costs will start with the first Queue project to cause the need for the upgrade. Later queue projects will receive cost allocation contingent on their contribution to the violation and are allocated to the queues that have not closed less than 5 years following the execution of the first Interconnection Service Agreement which identifies the need for this upgrade.

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, determined in accordance with Section 217 of the Tariff,

(a) the costs 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.

System Reinforcement

Violation #	Upgrade Description	Upgrade Cost
	***NEW SYSTEM REINFORCEMENTS**	
1	Line #6 Remington – Remington CT 115 kV: wreck and rebuild the line of 1 miles to increase its line rating to 353 MVA (normal), 353 MVA (emergency), and 406 MVA (load dump). It is estimated to cost $2,200,000 and 30-36 months to engineer, permit, and construct. A VA CPCN is required.	$2,200,000
	Sub Total	**$2,200,000**
	CONTRIBUTIONS TO PREVIOUS SYSTEM REINFORCEMENTS	
	None	
	Sub Total	**$0**
	Total Network Upgrades	**$2,200,000**

*Note:
For New System Reinforcements, only violations in which the AD1-049 overloads the facility are included in the table above. Costs for New System Reinforcement for which AD1-049 is not the first project to overload the facility are included for reference in the later part of this report. Cost allocation will be provided in the Impact Study.

Transmission Owner Scope of Work

Attachment facilities and local upgrades (if required) along with terms and conditions to interconnect AD1-049 will be specified in a separate two party Interconnection Agreement (IA) between ITO and the IC as this project is considered FERC non-jurisdictional per the PJM Open Access Transmission Tariff (OATT).

From the transmission system perspective, network impacts were identified as detailed later in the report.

Revenue Metering and SCADA Requirements

PJM Requirements

The IC 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 Sections 24.1 and 24.2.

Meteorological Data Reporting Requirement

The solar generation facility shall provide the Transmission Provider with site-specific meteorological data including:

- Temperature (degrees Fahrenheit)
- Atmospheric pressure (hectopascals)
- Irradiance
- Forced outage data

Network Impacts

PJM assessed the impact of the proposed Queue Project as an injection into the ITO, for compliance with NERC Reliability Criteria. The system was assessed using the summer 2021 RTEP case. When performing analysis, ITO Criteria considers a transmission facility overloaded if it exceeds 94% of its emergency rating under single contingency (normal and stressed system conditions). A full listing of the ITO's Planning Criteria and interconnection requirements can be found in the ITO'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 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 ITO 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 results of these studies are discussed in more detail below.

The Queue Project AD1-049 was evaluated as a 20.0 MW (Capacity 13.3 MW) injection at the Culpeper 115kV substation in the VAP area. Project AD1-049 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD1-049 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
DVP_P1-2: LN 70-A	CONTINGENCY 'DVP_P1-2: LN 70-A' OPEN BRANCH FROM BUS 314078 TO BUS 926610 CKT 1 /* 3REMNGTN 115.00 - AC1-143 TAP 115.00 END

Contingency Name	Description
DVP_P4-2: 280T2077	CONTINGENCY 'DVP_P4-2: 280T2077' /* STUCK 280T2077 - AT REMINGTON OPEN BRANCH FROM BUS 314080 TO BUS 314099 CKT 1 /* REMINGTON TO MARSH RUN CTS OPEN BRANCH FROM BUS 314085 TO BUS 314080 CKT 1 /* REMINGTON CTS TO REMINGTON END
DVP_P4-2: 642	CONTINGENCY 'DVP_P4-2: 642' /* STUCK 642 - AT REMINGTON OPEN BRANCH FROM BUS 314078 TO BUS 314090 CKT 1 /* LINE 6 - REMINGTON TO REMINGTON CT OPEN BRANCH FROM BUS 314078 TO BUS 314080 CKT 1 /* REMINGTON 230-115 TX#3 OPEN BRANCH FROM BUS 314078 TO BUS 926610 CKT 1 /* LINE 70 - REMINGTON TO AC1-143 TAP END

Summer Peak Analysis - 2021

Generator Deliverability

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

None

Multiple Facility Contingency

(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)

	Contingency		Affected		Bus			Power	Loading %		Rating		MW	
#	Type	Name	Area	Facility Description	From	To	Cir.	Flow	Initial	Final	Type	MVA	Contribution	Ref
1	LFFB	DVP_P4-2: 280T2077	DVP - DVP	3REMNGTN-3REMNGCT 115 kV line	314078	314090	1	DC	99.92	102.43	LD	275	6.91	1
2	LFFB	DVP_P4-2: 280T2077	DVP - DVP	6REMNGCT 230/115 kV transformer	314090	314085	1	DC	93.97	96.34	LD	292	6.91	2
3	LFFB	DVP_P4-2: 642	DVP - DVP	AC1-076 TAP-3PAY TAP 115 kV line	926000	314778	1	DC	87.13	91.53	LD	260	11.44	3

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None.

Contributions to previously identified circuit breakers found to be over-duty:

None.

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

None

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

To be determined during the System Impact Study.

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

Not required.

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

#	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
1	3REMNGTN-3REMNGCT 115 kV line	Line #6 Remington – Remington CT 115 kV: wreck and rebuild the line of 1 miles to increase its line rating to 353 MVA (normal), 353 MVA (emergency), and 406 MVA (load dump). It is estimated to cost $2,200,000 and 30-36 months to engineer, permit, and construct. A VA CPCN is required.	Pending	$2,200,000
2	6REMNGCT 230/115 kV transformer	Remington 230 – 115 kV Tx#1: replace the 230-115 kV transformer #1 increase its line rating to 276.8 MVA (normal), 292.4 MVA (emergency), and 328.7 MVA (load dump). It is estimated to cost $5,500,000 and 24-30 months to engineer and construct.	Pending	$5,500,000

#	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
3	AC1-076 TAP-3PAY TAP 115 kV line	Wreck and rebuild the line of 3 miles to increase its line rating to 262 MVA (normal), 287 MVA (emergency), and 349 MVA (load dump). It is estimated to cost $6,500,000 and 24-36 months to engineer, permit and construct. A VA CPCN is required.	Pending	$6,500,000
			Total New Network Upgrades	**$14,200,000**

Note: AD1-049 is not the first to cause the mitigation for violations #2 and #3. However, since the mitigation estimated cost is greater than $5 million, the violations were left in the report for reference. The violations will be further evaluated during the System Impact Study phase.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

None.

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 IC 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.

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution
4	N-1	DVP_P1-2: LN 70-A	DVP - DVP	3UNIONVILLE-3LOCST G 115 kV line	313703	314764	1	DC	88.54	94.51	ER	192	11.44

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution
5	N-1	DVP_P1-2: LN 70-A	DVP - DVP	3LOCST G-AC1-076 TAP 115 kV line	314764	926000	1	DC	85.69	91.07	ER	212	11.44
6	N-1	DVP_P1-2: LN 70-A	DVP - DVP	3MITCHEL-3OAK GRE 115 kV line	314768	314815	1	DC	94.41	103.62	ER	217	20
7	N-1	DVP_P1-2: LN 70-A	DVP - DVP	3PAY TAP-3SPOTSYL 115 kV line	314778	314755	1	DC	89.88	95.27	ER	212	11.44
8	N-1	DVP_P1-2: LN 70-A	DVP - DVP	AC1-076 TAP-3PAY TAP 115 kV line	926000	314778	1	DC	106.5	111.88	ER	212	11.44

Light Load Analysis

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B)

Affected System Analysis & Mitigation

Duke, Progress & TVA Impacts:

Duke Carolina, Progress, & TVA Impacts to be determined during later study phases (as applicable).

Appendices

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.

Appendix 1

(DVP - DVP) The 3REMNGTN-3REMNGCT 115 kV line (from bus 314078 to bus 314090 ckt 1) loads from 99.92% to 102.43% (**DC power flow**) of its load dump rating (275 MVA) for the line fault with failed breaker contingency outage of 'DVP_P4-2: 280T2077'. This project contributes approximately 6.91 MW to the thermal violation.

CONTINGENCY 'DVP_P4-2: 280T2077' /* STUCK 280T2077 - AT REMINGTON
OPEN BRANCH FROM BUS 314080 TO BUS 314099 CKT 1 /* REMINGTON TO MARSH RUN CTS
OPEN BRANCH FROM BUS 314085 TO BUS 314080 CKT 1 /* REMINGTON CTS TO REMINGTON
END

Bus Number	*Bus Name*	*Full Contribution*
315172	*1LOISA A*	*2.05*
315173	*1LOISA B*	*2.06*
315174	*1LOISA C*	*2.06*
315175	*1LOISA D*	*2.06*
315176	*1LOISA E*	*4.19*
315177	*1S ANNAG1*	*1.2*
315179	*1S ANNAG2*	*1.2*
315178	*1S ANNAS1*	*0.62*
315180	*1S ANNAS2*	*0.62*
932151	*AC2-022 C*	*16.82*
932152	*AC2-022 E*	*7.*
932711	*AC2-094 C*	*3.94*
932712	*AC2-094 E*	*2.28*
932781	*AC2-102 C*	*7.05*
932782	*AC2-102 E*	*11.51*
932861	*AC2-113 C*	*4.6*

932862	*AC2-113 E*	*2.32*
932971	*AC2-121 C*	*13.58*
932972	*AC2-121 E*	*22.15*
934221	*AD1-049 C*	*4.6*
934222	*AD1-049 E*	*2.32*
934531	*AD1-077 C*	*1.77*
934532	*AD1-077 E*	*1.11*
934541	*AD1-078 C*	*1.26*
934542	*AD1-078 E*	*0.74*
934861	*AD1-115 C*	*6.57*
934862	*AD1-115 E*	*10.72*
LTF	*CARR*	*0.09*
LTF	*CBM-S1*	*1.23*
LTF	*CBM-S2*	*1.64*
LTF	*CBM-W1*	*3.16*
LTF	*CBM-W2*	*6.74*
LTF	*CIN*	*0.74*
LTF	*CPLE*	*0.45*
LTF	*G-007*	*0.49*
LTF	*IPL*	*0.48*
LTF	*LGEE*	*0.16*
LTF	*MEC*	*1.52*
LTF	*MECS*	*0.76*
LTF	*O-066*	*1.63*
LTF	*RENSSELAER*	*0.07*
LTF	*ROSETON*	*0.51*

LTF	*WEC*	*0.2*
923891	*AB2-029 C*	*0.51*
923892	*AB2-029 E*	*4.13*
924182	*AB2-062 E*	*2.77*
925021	*AB2-158 C*	*5.18*
925022	*AB2-158 E*	*2.31*
925671	*AC1-043 C*	*13.14*
925672	*AC1-043 E*	*21.43*
926001	*AC1-076 C*	*3.13*
926002	*AC1-076 E*	*5.1*
926481	*AC1-120 C*	*10.88*
926482	*AC1-120 E*	*5.61*
926501	*AC1-121 C*	*3.74*
926502	*AC1-121 E*	*1.76*
926611	*AC1-143 C*	*19.81*
926612	*AC1-143 E*	*9.04*

Appendix 2

(DVP - DVP) The 6REMNGCT 230/115 kV transformer (from bus 314090 to bus 314085 ckt 1) loads from 93.97% to 96.34% (**DC power flow**) of its load dump rating (292 MVA) for the line fault with failed breaker contingency outage of 'DVP_P4-2: 280T2077'. This project contributes approximately 6.91 MW to the thermal violation.

CONTINGENCY 'DVP_P4-2: 280T2077' /* STUCK 280T2077 - AT REMINGTON
OPEN BRANCH FROM BUS 314080 TO BUS 314099 CKT 1 /* REMINGTON TO MARSH RUN CTS
OPEN BRANCH FROM BUS 314085 TO BUS 314080 CKT 1 /* REMINGTON CTS TO REMINGTON
END

Bus Number	*Bus Name*	*Full Contribution*
315172	*1LOISA A*	*2.05*
315173	*1LOISA B*	*2.06*
315174	*1LOISA C*	*2.06*
315175	*1LOISA D*	*2.06*
315176	*1LOISA E*	*4.19*
315177	*1S ANNAG1*	*1.2*
315179	*1S ANNAG2*	*1.2*
315178	*1S ANNAS1*	*0.62*
315180	*1S ANNAS2*	*0.62*
932151	*AC2-022 C*	*16.82*
932152	*AC2-022 E*	*7.*
932711	*AC2-094 C*	*3.94*
932712	*AC2-094 E*	*2.28*
932781	*AC2-102 C*	*7.05*
932782	*AC2-102 E*	*11.51*
932861	*AC2-113 C*	*4.6*

932862	*AC2-113 E*	*2.32*
932971	*AC2-121 C*	*13.58*
932972	*AC2-121 E*	*22.15*
934221	*AD1-049 C*	*4.6*
934222	*AD1-049 E*	*2.32*
934531	*AD1-077 C*	*1.77*
934532	*AD1-077 E*	*1.11*
934541	*AD1-078 C*	*1.26*
934542	*AD1-078 E*	*0.74*
934861	*AD1-115 C*	*6.57*
934862	*AD1-115 E*	*10.72*
LTF	*CARR*	*0.09*
LTF	*CBM-S1*	*1.23*
LTF	*CBM-S2*	*1.64*
LTF	*CBM-W1*	*3.16*
LTF	*CBM-W2*	*6.74*
LTF	*CIN*	*0.74*
LTF	*CPLE*	*0.45*
LTF	*G-007*	*0.49*
LTF	*IPL*	*0.48*
LTF	*LGEE*	*0.16*
LTF	*MEC*	*1.52*
LTF	*MECS*	*0.76*
LTF	*O-066*	*1.63*
LTF	*RENSSELAER*	*0.07*
LTF	*ROSETON*	*0.51*

LTF	*WEC*	*0.2*
923891	*AB2-029 C*	*0.51*
923892	*AB2-029 E*	*4.13*
924182	*AB2-062 E*	*2.77*
925021	*AB2-158 C*	*5.18*
925022	*AB2-158 E*	*2.31*
925671	*AC1-043 C*	*13.14*
925672	*AC1-043 E*	*21.43*
926001	*AC1-076 C*	*3.13*
926002	*AC1-076 E*	*5.1*
926481	*AC1-120 C*	*10.88*
926482	*AC1-120 E*	*5.61*
926501	*AC1-121 C*	*3.74*
926502	*AC1-121 E*	*1.76*
926611	*AC1-143 C*	*19.81*
926612	*AC1-143 E*	*9.04*

Appendix 3

(DVP - DVP) The AC1-076 TAP-3PAY TAP 115 kV line (from bus 926000 to bus 314778 ckt 1) loads from 87.13% to 91.53% (**DC power flow**) of its load dump rating (260 MVA) for the line fault with failed breaker contingency outage of 'DVP_P4-2: 642'. This project contributes approximately 11.44 MW to the thermal violation.

CONTINGENCY 'DVP_P4-2: 642' /* STUCK 642 - AT REMINGTON
OPEN BRANCH FROM BUS 314078 TO BUS 314090 CKT 1 /* LINE 6 - REMINGTON TO REMINGTON CT
OPEN BRANCH FROM BUS 314078 TO BUS 314080 CKT 1 /* REMINGTON 230-115 TX#3
OPEN BRANCH FROM BUS 314078 TO BUS 926610 CKT 1 /* LINE 70 - REMINGTON TO AC1-143 TAP
END

Bus Number	*Bus Name*	*Full Contribution*
932781	*AC2-102 C*	*17.38*
932782	*AC2-102 E*	*28.36*
932861	*AC2-113 C*	*7.61*
932862	*AC2-113 E*	*3.83*
934221	*AD1-049 C*	*7.61*
934222	*AD1-049 E*	*3.83*
934531	*AD1-077 C*	*1.49*
934532	*AD1-077 E*	*0.93*
934861	*AD1-115 C*	*10.87*
934862	*AD1-115 E*	*17.73*
LTF	*CARR*	*0.02*
LTF	*CBM-S1*	*0.25*
LTF	*CBM-S2*	*0.2*
LTF	*CBM-W1*	*0.75*
LTF	*CBM-W2*	*1.39*

LTF	*CIN*	*0.18*
LTF	*CPLE*	*0.04*
LTF	*G-007*	*0.12*
LTF	*IPL*	*0.12*
LTF	*LGEE*	*0.04*
LTF	*MEC*	*0.34*
LTF	*MECS*	*0.2*
LTF	*O-066*	*0.42*
LTF	*RENSSELAER*	*0.02*
LTF	*ROSETON*	*0.12*
LTF	*WEC*	*0.05*
924182	*AB2-062 E*	*13.85*
925671	*AC1-043 C*	*21.73*
925672	*AC1-043 E*	*35.46*
926001	*AC1-076 C*	*16.84*
926002	*AC1-076 E*	*27.38*
926481	*AC1-120 C*	*22.65*
926482	*AC1-120 E*	*11.67*
926501	*AC1-121 C*	*7.78*
926502	*AC1-121 E*	*3.66*
926611	*AC1-143 C*	*23.56*
926612	*AC1-143 E*	*10.75*