

***Generation Interconnection
Feasibility Study Report***

For

***PJM Generation Interconnection Request
Queue Position AD1-105***

***Kings Dominion DP 115kV
45.4 MW Capacity / 77 MW Energy***

Revised March / 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 Feasibility 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 Enfield, VA (King William County). The installed facilities will have a total capability of 77 MW with 45.4 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 12/31/2019.

This study does not imply an ITO commitment to this in-service date.

Point of Interconnection

AD1-105 will interconnect with the ITO transmission system via ITO King Dominion DP 115kV tap which feeds Rappahannock Electrical Co-operative's system.

Cost Summary

The AD1-105 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	\$0
Direct Connection Network Upgrades	\$0
Non Direct Connection Network Upgrades	\$0
Total Costs	\$0

In addition, the AD1-105 project may be responsible for a contribution to the following costs:

Description	Total Cost
New System Upgrades	\$17,500,000
Previously Identified Upgrades	\$0
Total Costs	\$17,500,000

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

Note: 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 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.

Transmission Owner Scope of Work

Attachment facilities and local upgrades (if required) along with terms and conditions to interconnect AD1-105 will be specified in a separate two party Interconnection Agreement (IA) between Rappahannock Electrical Co-operative and the IC as this project is considered FERC non-jurisdictional per the PJM Open Access Transmission Tariff (OATT). The single line is shown below in Attachment 1.

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. **Note: The ITO identified at the Feasibility kickoff that during the Facilities Study there will likely be required metering and protection requirements which might include a new 3 breaker ringbus at Kings Dominion DP.**

System Reinforcement

Replace the Ladysmith 500/230 kV transformer #1 increase its line rating to 1134 MVA (normal), 1203 MVA (emergency), and 1365 MVA (load dump). It is estimated to take 24-30 months to engineer and construct. Estimated cost \$17,500,000.

Interconnection Customer Requirements

ITO's Facility Connection Requirements as posted on PJM's website
<http://www.pjm.com/~media/planning/plan-standards/private-dominion/facility-connection-requirements1.ashx>

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

The Queue Project AD1-105 was evaluated as a 77.0 MW (Capacity 45.4 MW) injection at the King's Dominion 115kV substation in the ITO area. Project AD1-105 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD1-105 was studied with a commercial probability of 53%. Potential network impacts were as follows:

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.

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
DVP_P4-2: H2T557	CONTINGENCY 'DVP_P4-2: H2T557' /* ELMONT OPEN BRANCH FROM BUS 314908 TO BUS 314903 CKT 1 /*ELMONT TO CHICKAHOMINY (LINE 557) OPEN BRANCH FROM BUS 314903 TO BUS 314214 CKT 1 /*CHICKAHOMINY 500-230 (TX#1) OPEN BRANCH FROM BUS 314908 TO BUS 314218 CKT 2 /*ELMONT 500-230 (TX#2) 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, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

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)

Contingency			Affected Area	Facility Description	Bus			Power Flow	Loading %		Rating		MW Contribution	Ref
#	Type	Name			From	To	Cir.		Initial	Final	Type	MVA		
1	LFFB	DVP_P4-2: H2T557	DVP - DVP	8ELMONT 500/230 kV transformer	314218	314908	1	DC	127.41	128.14		1051	19.52	1

Steady-State Voltage Requirements

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

To be determined during 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)

To be determined during Impact Study

New System Reinforcements

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

None

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)

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
# 1	8LADYSMITH 500/230 kV transformer	Replace the Ladysmith 500/230 kV transformer #1 increase its line rating to 1134 MVA (normal), 1203 MVA (emergency), and 1365 MVA (load dump). It is estimated to take 24-30 months to engineer and construct.	Pending	\$17,500,000
Total New Network Upgrades				\$17,500,000

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.

None

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).

Attachment 1.

Flowgate Appendices – Option 1

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 gauge other generators impact. When a flowgate is identified in multiple analysis the appendix is presented for only the analysis with the greatest overload.

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 8ELMONT 500/230 kV transformer (from bus 314218 to bus 314908 ckt 1) loads from 127.41% to 128.14% (**DC power flow**) of its load dump rating (1051 MVA) for the line fault with failed breaker contingency outage of 'DVP_P4-2: H2T557'. This project contributes approximately 19.52 MW to the thermal violation.

```
CONTINGENCY 'DVP_P4-2: H2T557'                                /* ELMONT
  OPEN BRANCH FROM BUS 314908 TO BUS 314903 CKT 1            /*ELMONT TO
CHICKAHOMINY (LINE 557)
  OPEN BRANCH FROM BUS 314903 TO BUS 314214 CKT 1
/*CHICKAHOMINY 500-230 (TX#1)
  OPEN BRANCH FROM BUS 314908 TO BUS 314218 CKT 2            /*ELMONT 500-
230 (TX#2)
END
```

Bus Number	Bus Name	Full Contribution
315067	1DARBY 1	4.99
315068	1DARBY 2	4.99
315069	1DARBY 3	5.01
315070	1DARBY 4	5.01
315043	1FOUR RIVERA	6.63
315044	1FOUR RIVERB	5.13
315045	1FOUR RIVERC	6.63
315046	1FOUR RIVERD	5.13
315047	1FOUR RIVERE	5.13
315048	1FOUR RIVERF	6.63
315074	1HOPCGN1	11.28
315075	1HOPCGN2	11.14
315083	1SPRUNCA	14.95
315084	1SPRUNCB	14.95
315085	1SPRUNCC	11.08
315086	1SPRUNCD	11.08
315073	1STONECA	9.36
314566	3CRESWEL	2.11
314572	3EMPORIA	0.36
314315	3LOCKS E	1.65
314617	3TUNIS	0.71
314539	3UNCAMP	2.19
314541	3WATKINS	0.61
314620	6CASHIE	0.72
314229	6MT RD221	1.41
314236	6NRTHEST	0.37
314189	6PAPERMILL	8.82

314594	6PLYMOTH	0.73
314250	6ROCKVILLE	0.4
314256	6ROCKVILLE E	1.15
314648	6SUNBURY	0.81
314651	6WINFALL	1.59
932041	AC2-012 C	9.62
932042	AC2-012 E	15.7
932501	AC2-070 C	2.9
932502	AC2-070 E	1.2
932531	AC2-073 C	3.1
932532	AC2-073 E	1.56
932581	AC2-078 C	4.75
932582	AC2-078 E	7.75
932591	AC2-079 C	6.82
932592	AC2-079 E	11.13
932831	AC2-110 C	1.74
932832	AC2-110 E	2.84
933061	AC2-130	3.48
933071	AC2-131 1	2.36
933081	AC2-131 2	1.07
933111	AC2-132 1	1.24
933121	AC2-132 2	0.63
933261	AC2-137 C	3.16
933262	AC2-137 E	2.05
933271	AC2-138 C	0.87
933272	AC2-138 E	1.09
933291	AC2-141 C	27.16
933292	AC2-141 E	11.59
933451	AC2-158 C	4.63
933452	AC2-158 E	4.63
933471	AC2-161 C	2.47
933472	AC2-161 E	1.27
933481	AC2-162 C	4.17
933482	AC2-162 E	2.15
933711	AC2-194 C	0.98
933712	AC2-194 E	1.59
933731	AC2-196 C	1.66
933732	AC2-196 E	1.1
933991	AD1-023 C	11.29
933992	AD1-023 E	6.14
934011	AD1-025 C O1	20.82
934012	AD1-025 E O1	12.33
934061	AD1-033 C O1	6.96
934062	AD1-033 E O1	4.64
934071	AD1-034 C O1	10.6

934072	AD1-034 E O1	6.87
934141	AD1-041 C O1	6.74
934142	AD1-041 E O1	4.49
934191	AD1-046 C	4.71
934192	AD1-046 E	3.14
934201	AD1-047 C	6.75
934202	AD1-047 E	4.5
934211	AD1-048 C	3.82
934212	AD1-048 E	1.93
934391	AD1-063 C	2.1
934392	AD1-063 E	1.4
934521	AD1-076 C O1	46.88
934522	AD1-076 E O1	23.87
934571	AD1-082 C O1	8.27
934572	AD1-082 E O1	4.72
934781	AD1-105 C	11.52
934782	AD1-105 E	8.
LTF	AD1-120	5.93
LTF	AD1-121	5.89
935111	AD1-144 C	1.68
935112	AD1-144 E	0.92
935161	AD1-151 C O1	19.89
935162	AD1-151 E O1	13.26
935211	AD1-156 C	2.56
935212	AD1-156 E	1.71
LTF	CARR	0.67
LTF	CBM-S1	3.86
LTF	CBM-S2	13.84
LTF	CBM-W1	0.21
LTF	CBM-W2	17.91
LTF	CIN	0.13
LTF	CLIFTY	1.62
LTF	CPLE	4.75
LTF	DEARBORN	0.47
LTF	G-007	2.31
LTF	IPL	0.06
LTF	LGEE	0.05
LTF	MEC	1.99
LTF	O-066	7.73
LTF	RENSSELAER	0.53
LTF	ROSETON	3.84
292791	U1-032 E	4.87
297087	V2-040	0.28
900672	V4-068 E	0.26
901082	W1-029E	41.82

LTF	WEC	0.06
907092	X1-038 E	5.47
913392	Y1-086 E	1.99
916042	Z1-036 E	40.84
916192	Z1-068 E	1.76
917122	Z2-027 E	0.96
917592	Z2-099 E	0.38
918492	AA1-063AE OP	3.35
918512	AA1-065 E OP	3.74
918691	AA1-083	1.16
919152	AA1-139 E	5.92
919211	AA1-145	19.79
919732	AA2-059 E	0.5
LTF	AA2-074	3.23
920022	AA2-086 E	0.21
920042	AA2-088 E	9.15
920691	AA2-178 C	8.43
920692	AA2-178 E	3.61
930051	AB1-013 C	2.54
930052	AB1-013 E	17.02
930121	AB1-027 C	0.87
930122	AB1-027 E	1.89
930861	AB1-132 C	11.78
930862	AB1-132 E	5.05
931231	AB1-173 C	1.9
931232	AB1-173 E	0.89
931241	AB1-173AC	1.9
931242	AB1-173AE	0.89
923801	AB2-015 C O1	7.73
923802	AB2-015 E O1	6.34
923831	AB2-022 C	2.1
923832	AB2-022 E	1.13
923842	AB2-024 E	1.49
923852	AB2-025 E	1.09
923862	AB2-026 E	0.88
923911	AB2-031 C O1	1.88
923912	AB2-031 E O1	0.93
923991	AB2-040 C O1	6.19
923992	AB2-040 E O1	5.06
924061	AB2-050	1.16
924071	AB2-051	128.86
924241	AB2-068 O1	177.95
924381	AB2-087 C	0.48
924382	AB2-087 E	0.22
924501	AB2-099 C	0.49

924502	AB2-099 E	0.21
924511	AB2-100 C	10.48
924512	AB2-100 E	5.16
924811	AB2-134 C O1	15.87
924812	AB2-134 E O1	15.6
925051	AB2-160 C O1	7.18
925052	AB2-160 E O1	11.71
925061	AB2-161 C O1	3.63
925062	AB2-161 E O1	5.92
925171	AB2-174 C O1	5.96
925172	AB2-174 E O1	5.39
925281	AB2-186 C	0.55
925282	AB2-186 E	0.24
925291	AB2-188 C O1	2.08
925292	AB2-188 E O1	0.93
925331	AB2-190 C	24.76
925332	AB2-190 E	10.61
925522	AC1-027 E	1.07
925692	AC1-045 E	0.92
925861	AC1-065 C	4.36
925862	AC1-065 E	7.11
926071	AC1-086 C	17.34
926072	AC1-086 E	7.89
926291	AC1-107	268.61
926411	AC1-112 C	0.68
926412	AC1-112 E	1.93
926441	AC1-115 C	1.01
926442	AC1-115 E	1.64
926472	AC1-118 E	1.07
926551	AC1-134	14.83
926662	AC1-147 E	1.25
926741	AC1-159	62.13
926751	AC1-161 C	27.16
926752	AC1-161 E	11.59
926771	AC1-163 C	1.63
926772	AC1-163 E	0.76
926781	AC1-164 C	58.41
926782	AC1-164 E	26.24
927041	AC1-191 C	17.46
927042	AC1-191 E	8.7
927111	AC1-206 C	9.15
927112	AC1-206 E	4.32
927221	AC1-216 C O1	12.11
927222	AC1-216 E O1	9.53