Generation Interconnection

Feasibility Study Report

for

Queue Project AE1-073

BREMO-KIDDS STORE 115 KV

48 MW Capacity / 75 MW Energy

January, 2019

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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 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.

General

The IC has proposed a solar generating facility located in Fluvanna County, Virginia. The installed facilities will have a capability of 75 MW with 48 MW of this output being recognized by PJM as Capacity. The proposed in-service date for the AE1-073 project is 12/01/2021. This study does not imply an ITO commitment to either in-service date.

Queue Number	**AE1-073**
Project Name	BREMO-KIDDS STORE 115 KV
Interconnection Customer	
State	Virginia
County	Fluvanna
Transmission Owner	Dominion
MFO	75
MWE	75
MWC	48
Fuel	Solar
Basecase Study Year	2022

Point of Interconnection

Primary Point of Interconnection

AE1-073 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Bremo – Kidds Store 115kV line # 91. See one line in **Attachment 1**.

Secondary Point of Interconnection

AE1-073 will interconnect with the ITO transmission system via the ITO Kidds Store DP 115kV delivery point which feeds Central Virginia Electrical Co-operative which the IC will interconnection. PJM will not run an additional Feasibility Analysis for this option as the results would not differ from the primary option.

Cost Summary

The AE1-073 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$1,550,000
Direct Connection Network Upgrade	$5,500,000
Non Direct Connection Network Upgrades	$1,000,000
Total Costs	$8,050,000

In addition, the AE1-073 project may be responsible for a contribution to the following costs

(Reference System Reinforcements in the Network Impacts section for details):

Description	Total Cost
System Upgrades	$54,300,000

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. The allocation of costs for a network upgrade 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

Generation Substation: Install metering and associated protection equipment. Estimated Cost is $550,000.

Transmission: Construct approximately one span of 115 kV Attachment line between the generation substation and a new AE1-073 Switching Station. The estimated cost for this work is $1,000,000.

The estimated total cost of the Attachment Facilities is $1,550,000. It is estimated to take 18-24 months to complete this work. 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. 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	$550,000
Transmission	$1,000,000
Total Attachment Facility Costs	$1,550,000

Direct Connection Cost Estimate

Substation: Establish the new 115 kV AE1-073 Switching Substation (interconnection substation). The estimated cost of this work scope is $5,500,000. It is estimated to take 24-36 months to complete this work.

Non-Direct Connection Cost Estimate

Transmission: Install transmission structure in-line with transmission line to allow the proposed interconnection switching station to be interconnected with the transmission system. Estimated cost is $1,000,000 and is estimated to take 24-30 months to complete.

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.

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

Voltage Ride Through Requirements - The Customer Facility shall be designed to remain in service (not trip) for voltages and times as specified for the Eastern Interconnection in Attachment 1 of NERC Reliability Standard PRC-024-1, and successor Reliability Standards, for both high and low voltage conditions, irrespective of generator size, subject to the permissive trip exceptions established in PRC-024-1 (and successor Reliability Standards).

Frequency Ride Through Requirements - The Customer Facility shall be designed to remain in service (not trip) for frequencies and times as specified in Attachment 2 of NERC Reliability Standard PRC-024-1, and successor Reliability Standards, for both high and low frequency condition, irrespective of generator size, subject to the permissive trip exceptions established in PRC-024-1 (and successor Reliability Standards).

Reactive Power - The Generation Interconnection Customer shall design its non-synchronous Customer Facility with the ability to maintain a power factor of at least 0.95 leading to 0.95 lagging measured at the generator's terminals.

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 AE1-073 was evaluated as a 75 MW (Capacity 48 MW) tapping the Kidds Store to Bremo 115kV line in the ITO area. Project AE1-073 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-073 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Load Flow

Generation 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

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	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
126488	313867	6BREMODIST	DVP	314765	6MTEAGLE	DVP	1	DVP_P1-2: LN 2027-B	single	661.76	113.61	116.25	DC	17.5
126489	313867	6BREMODIST	DVP	314765	6MTEAGLE	DVP	1	DVP_P1-2: LN 2027-A	single	661.76	110.85	113.49	DC	17.5
126468	314747	6BREMO	DVP	313867	6BREMODIST	DVP	1	DVP_P1-2: LN 2027-B	single	661.76	115.94	118.58	DC	17.5
126469	314747	6BREMO	DVP	313867	6BREMODIST	DVP	1	DVP_P1-2: LN 2027-A	single	661.76	113.17	115.82	DC	17.5
126522	314765	6MTEAGLE	DVP	314749	6CHARLVL	DVP	1	DVP_P1-2: LN 2027-B	single	661.76	109.87	112.51	DC	17.49
126523	314765	6MTEAGLE	DVP	314749	6CHARLVL	DVP	1	DVP_P1-2: LN 2027-A	single	661.76	105.84	108.48	DC	17.49

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	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
126486	313867	6BREMODIST	DVP	314765	6MTEAGLE	DVP	1	DVP_P1-2: LN 2027-B	operation	661.76	124.64	128.77	DC	27.34
126466	314747	6BREMO	DVP	313867	6BREMODIST	DVP	1	DVP_P1-2: LN 2027-B	operation	661.76	126.97	131.1	DC	27.34
126520	314765	6MTEAGLE	DVP	314749	6CHARLVL	DVP	1	DVP_P1-2: LN 2027-B	operation	661.76	121.62	125.75	DC	27.33

System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
126522,126523	3	**6MTEAGLE 230.0 kV - 6CHARLVL 230.0 kV Ckt 1**	Description : Rebuild / Uprate 6.5 miles of 230kV Line # 2028 between Charlottesville and Mount Eagle substations. A VA CPCN will be required. Time Estimate : 36-44 Months Cost : $16,500,000	$16,500,000
126468,126469	2	**6BREMO 230.0 kV - 6BREMODIST 230.0 kV Ckt 1**	Description : Rebuild / Uprate 0.13 miles of 230kV Line # 202 between Bremo substation and Bremo Distribution. Time Estimate : 13-18 Months Cost : $300,000	$300,000
126488,126489	1	**6BREMODIST 230.0 kV - 6MTEAGLE 230.0 kV Ckt 1**	Description : Rebuild / Uprate 15 miles of 230kV Line # 2028 between Bremo Distribution and Mount Eagle substation. A VA CPCN will be required. Time Estimate : 36-44 Months Cost : $37,500,000	$37,500,000
			TOTAL COST	**$54,300,000**

Flow Gate Details

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.

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
126488	313867	6BREMODIST	DVP	314765	6MTEAGLE	DVP	1	DVP_P1-2: LN 2027-B	single	661.76	113.61	116.25	DC	17.5

Bus #	Bus	MW Impact
314429	3JTRSVLE	0.61
315150	1BUGGS 1	7.34
315151	1BUGGS 2	7.34
315153	1CLOVER1	7.46
315154	1CLOVER2	7.36
315159	1KERR 2	0.86
315164	1KERR 7	0.85
315170	1BREMO 3	30.26
315171	1BREMO 4	66.49
315191	1BEARGRDN G1	15.31
315192	1BEARGRDN G2	15.31
315193	1BEARGRDN S1	31.5
920291	AA2-127	3.18
924021	AB2-043 C O1	0.44
924031	AB2-045 C	1.08
924161	AB2-060 C O1	1.29
924301	AB2-077 C O1	0.27
924311	AB2-078 C O1	0.27
924321	AB2-079 C O1	0.27
925611	AC1-036 C	0.19
925831	AC1-062	0.08
926271	AC1-105 C O1	3.21
926761	AC1-162 C	48.07
932511	AC2-071 C	1.07
933501	AC2-165 C	32.69
934621	AD1-088 C	14.6
935221	AD1-157 C	0.42
935231	AD1-160 C	1.78
936261	AD2-033 C	14.43
936361	AD2-046 C O1	5.51
936481	AD2-063 C O1	14.25
936651	AD2-082 C	2.73
938071	AE1-009 C O1	5.58
938371	AE1-056 C	10.48
938541	AE1-073 C	17.5
AA2-074	AA2-074	1.48
CARR	CARR	0.28
CBM-S1	CBM-S1	2.87
CBM-S2	CBM-S2	4.1
CBM-W1	CBM-W1	1.77

Bus #	Bus	MW Impact
CBM-W2	CBM-W2	17.71
CIN	CIN	0.88
CPLE	CPLE	2.18
IPL	IPL	0.53
LGEE	LGEE	0.26
MEC	MEC	2.3
MECS	MECS	0.29
RENSSELAER	RENSSELAER	0.22
WEC	WEC	0.23

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
126468	314747	6BREMO	DVP	313867	6BREMODIST	DVP	1	DVP_P1-2: LN 2027-B	single	661.76	115.94	118.58	DC	17.5

Bus #	Bus	MW Impact
314429	3JTRSVLE	0.61
315150	1BUGGS 1	7.34
315151	1BUGGS 2	7.34
315153	1CLOVER1	7.46
315154	1CLOVER2	7.36
315159	1KERR 2	0.86
315164	1KERR 7	0.85
315170	1BREMO 3	30.26
315171	1BREMO 4	66.49
315191	1BEARGRDN G1	15.31
315192	1BEARGRDN G2	15.31
315193	1BEARGRDN S1	31.5
920291	AA2-127	3.18
924021	AB2-043 C O1	0.44
924031	AB2-045 C	1.08
924161	AB2-060 C O1	1.29
924301	AB2-077 C O1	0.27
924311	AB2-078 C O1	0.27
924321	AB2-079 C O1	0.27
925611	AC1-036 C	0.19
925831	AC1-062	0.08
926271	AC1-105 C O1	3.21
926761	AC1-162 C	48.07
932511	AC2-071 C	1.07
933501	AC2-165 C	32.69
934621	AD1-088 C	14.6
935221	AD1-157 C	0.42
935231	AD1-160 C	1.78
936261	AD2-033 C	14.43
936361	AD2-046 C O1	5.51
936481	AD2-063 C O1	14.25
936651	AD2-082 C	2.73
938071	AE1-009 C O1	5.58
938371	AE1-056 C	10.48
938541	AE1-073 C	17.5
AA2-074	AA2-074	1.48
CARR	CARR	0.28
CBM-S1	CBM-S1	2.87
CBM-S2	CBM-S2	4.1
CBM-W1	CBM-W1	1.77

Bus #	Bus	MW Impact
CBM-W2	CBM-W2	17.71
CIN	CIN	0.88
CPLE	CPLE	2.18
IPL	IPL	0.53
LGEE	LGEE	0.26
MEC	MEC	2.3
MECS	MECS	0.29
RENSSELAER	RENSSELAER	0.22
WEC	WEC	0.23

Index 3

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
126522	314765	6MTEAGLE	DVP	314749	6CHARLVL	DVP	1	DVP_P1-2: LN 2027-B	single	661.76	109.87	112.51	DC	17.49

Bus #	Bus	MW Impact
314429	3JTRSVLE	0.61
315150	1BUGGS 1	7.34
315151	1BUGGS 2	7.34
315153	1CLOVER1	7.46
315154	1CLOVER2	7.36
315159	1KERR 2	0.86
315164	1KERR 7	0.85
315170	1BREMO 3	30.26
315171	1BREMO 4	66.49
315191	1BEARGRDN G1	15.31
315192	1BEARGRDN G2	15.31
315193	1BEARGRDN S1	31.5
920291	AA2-127	3.18
924021	AB2-043 C O1	0.44
924031	AB2-045 C	1.08
924161	AB2-060 C O1	1.29
924301	AB2-077 C O1	0.27
924311	AB2-078 C O1	0.27
924321	AB2-079 C O1	0.27
925611	AC1-036 C	0.19
925831	AC1-062	0.08
926451	AC1-116 C	0.63
926761	AC1-162 C	48.06
932511	AC2-071 C	1.07
933501	AC2-165 C	32.69
934621	AD1-088 C	14.6
935221	AD1-157 C	0.42
935231	AD1-160 C	1.78
936261	AD2-033 C	14.43
936361	AD2-046 C O1	5.51
936481	AD2-063 C O1	14.25
936651	AD2-082 C	2.73
938071	AE1-009 C O1	5.58
938371	AE1-056 C	10.47
938541	AE1-073 C	17.49
AA2-074	AA2-074	1.48
CARR	CARR	0.28
CBM-S1	CBM-S1	2.86
CBM-S2	CBM-S2	4.1
CBM-W1	CBM-W1	1.75

Bus #	Bus	MW Impact
CBM-W2	CBM-W2	17.64
CIN	CIN	0.87
CPLE	CPLE	2.17
IPL	IPL	0.53
LGEE	LGEE	0.26
MEC	MEC	2.28
MECS	MECS	0.28
RENSSELAER	RENSSELAER	0.22
WEC	WEC	0.23

Contingency Name	Contingency Defintion
DVP_P1-2: LN 2027-A	CONTINGENCY 'DVP_P1-2: LN 2027-A' OPEN BRANCH FROM BUS 313868 TO BUS 933500 CKT 1 /* 6CARTERV 230.00 - AC2-165 TAP 230.00 OPEN BRANCH FROM BUS 313868 TO BUS 314747 CKT 1 /* 6CARTERV 230.00 - 6BREMO 230.00 OPEN BRANCH FROM BUS 314310 TO BUS 314333 CKT 1 /* 6JUDES F 230.00 - 6POWHATN 230.00 OPEN BUS 313868 /* ISLAND: 6CARTERV 230.00 END
DVP_P1-2: LN 2027-B	CONTINGENCY 'DVP_P1-2: LN 2027-B' OPEN BRANCH FROM BUS 933500 TO BUS 314333 CKT 1 /* AC2-165 TAP 230.00 - 6POWHATN 230.00 OPEN BRANCH FROM BUS 314310 TO BUS 314322 CKT 1 /* 6JUDES F 230.00 - 6MDLTHAN 230.00 OPEN BRANCH FROM BUS 314310 TO BUS 314333 CKT 1 /* 6JUDES F 230.00 - 6POWHATN 230.00 OPEN BUS 314310 /* ISLAND: 6JUDES F 230.00 OPEN BUS 314333 /* ISLAND: 6POWHATN 230.00 END

Short Circuit

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

Attachment 1

Single Line Diagram