

***Generation Interconnection
System Impact Study Report***

For

***PJM Generation Interconnection Request
Queue Position AB1-081***

***Anaconda – Battleboro 115kV
56MW Capacity / 80MW Energy***

September / 2016

Introduction

This System Impact Study (SIS) has been prepared in accordance with the PJM Open Access Transmission Tariff, Section 205, as well as the System Impact Study Agreement between Harts Mill Solar, LLC, 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 System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the IC. As a requirement for interconnection, the IC may be responsible for the cost of constructing Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an IC may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, 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 System Impact Study is performed.

The System Impact 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 Transmission Owners, the costs may be included in the study.

General

The IC has proposed a solar generating facility located near Tarboro, NC in Edgecombe County. The installed facilities will have a total capability of 80 MW with 56 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 11/01/2016.

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

Point of Interconnection

AB1-081 will interconnect with the ITO transmission system at via a new three breaker ring bus switching station that connects on the Anaconda – Heartease portion of the Anaconda – Battleboro 115kV line #80.

Cost Summary

The AB1-081 interconnection request will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	\$1,500,000
Direct Connection Network Upgrades	\$4,500,000
Non Direct Connection Network Upgrades	\$ 700,000
Allocation for New System Upgrades	\$0
Contribution for Previously Identified Upgrades	\$0
Total Costs	\$6,700,000

Attachment Facilities

Generation Substation: Install metering and associated Protection Equipment. Estimated Cost \$500,000.

Transmission: Construct approximately one span of 115 kV Attachment line between the generation substation and a new AB1-081 115 kV Switching Substation. The estimated cost for this work is \$1,000,000.

The estimated total cost of the Attachment Facilities is \$1,500,000. 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. These costs do not include CIAC Tax Gross-up. The single line is shown below in Attachment 1.

Direct Connection Cost Estimate

Substation: Establish the new 115 kV AB1-081 Switching Substation (interconnection substation). The estimated cost of this facility is \$4,500,000. 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 (In the vicinity of Heartsease DP) to allow the proposed interconnection switching station to be interconnected with the transmission system. Estimated cost \$700,000 dollars 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 Interconnection 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 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 Sections 24.1 and 24.2.

Interconnected Transmission Owner Requirements

Metering and SCADA/Communication equipment must meet the requirements outlined in section 3.1.6 Metering and Telecommunications of ITO's Facility Connection Requirement NERC Standard FAC-001 which is publically available at www.dom.com.

Network Impacts

The Queue Project AB1-081 was evaluated as an 80.0 MW (Capacity 56.0 MW) injection at the Hearts 115kV substation in the ITO area. Project AB1-081 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB1-081 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
LN 2058-2181	CONTINGENCY 'LN 2058-2181' OPEN BRANCH FROM BUS 313845 TO BUS 314591 CKT 1 /* 2181 OPEN BRANCH FROM BUS 304226 TO BUS 314591 CKT 1 /* 2181 OPEN BRANCH FROM BUS 304222 TO BUS 313845 CKT 1 /* 2058 END

Summer Peak Analysis – 2019

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 are performed for the Impact Study.)

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	DCTL	LN 2058-2181	DVP - CPLE	3BTLEBRO-3ROCKYMT115T 115 kV line	314554	304223	1	AC	118.05	146.56	ER	94	28.5	1

Steady-State Voltage Requirements

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

None

Stability and Reactive Power Requirement for Low Voltage Ride Through

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

No mitigations were found to be required

New System Reinforcements

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

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 is calculated and reported for in the Impact Study)

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AB1-054 Allocation
# 1	3BTLEBRO-3ROCKYMT115T 115 kV line	Build a new Hathaway 230/115kV substation	b1794		\$0
Total New Network Upgrades					\$

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 interconnection request by addressing 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		Affected Area	Facility Description	Bus		Circuit	Power Flow	Loading %		Rating		MW Contribution
	Type	Name			From	To			Initial	Final	Type	MVA	
2	N-1	LN 563	DVP - DVP	6CHSTF B-6BASIN 230 kV line	314287	314276	1	AC	102.0	102.9	ER	470	4.99

Light Load Analysis in 2019

Not required

ITO Analysis

ITO assessed the impact of the proposed Queue Project #AB1-081 interconnection of 80 MW of energy (Capacity 56 MW) for compliance with reliability criteria on ITO's Transmission System. The system was assessed using the summer 2019 RTEP case provided to ITO by PJM. When performing a generation analysis, ITO's main analysis will be load flow study results under single contingency and multiple facility contingency (both normal and stressed system conditions). ITO Criteria considers a transmission facility overloaded if it exceeds 94% of its emergency rating under normal and stressed system conditions. A full listing of 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 interconnection request 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.

As part of its generation impact analysis ITO routinely evaluates the impact that a proposed new generation resource will have under maximum generation conditions, stress system conditions and import/export system conditions. The results of these studies are discussed in more detail below.

Category B Analysis (Single Contingency):

- System Normal – No deficiencies identified
- Critical System Condition (No Surry 230 kV Unit) – No deficiencies identified.

Category C Analysis: (Multiple Facility Contingency)

- Bus Fault - No deficiencies identified
- Line Stuck Breaker - No deficiencies identified
- Tower Line – No deficiencies identified

As part of its generation impact analysis ITO routinely evaluates the impact that a proposed new generation resource (greater than 20 MW) will have under import/export system conditions.

Table A: Import Study Results

Import Study Results			
Area	Summer 2019	Summer 2019 with AB1-081	Limiting Element
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

Table B: Export Study Results

Export Study Results			
Area	Summer 2019	Summer 2019 with AB1-081	Limiting Element
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

ITO’s Planning Criteria indicates a need to have approximately 2000 MW of import and export capability. The results of these import and export studies indicate that the proposed AB1-081 will not impact ITO’s import or export capability.

Affected System Analysis & Mitigation

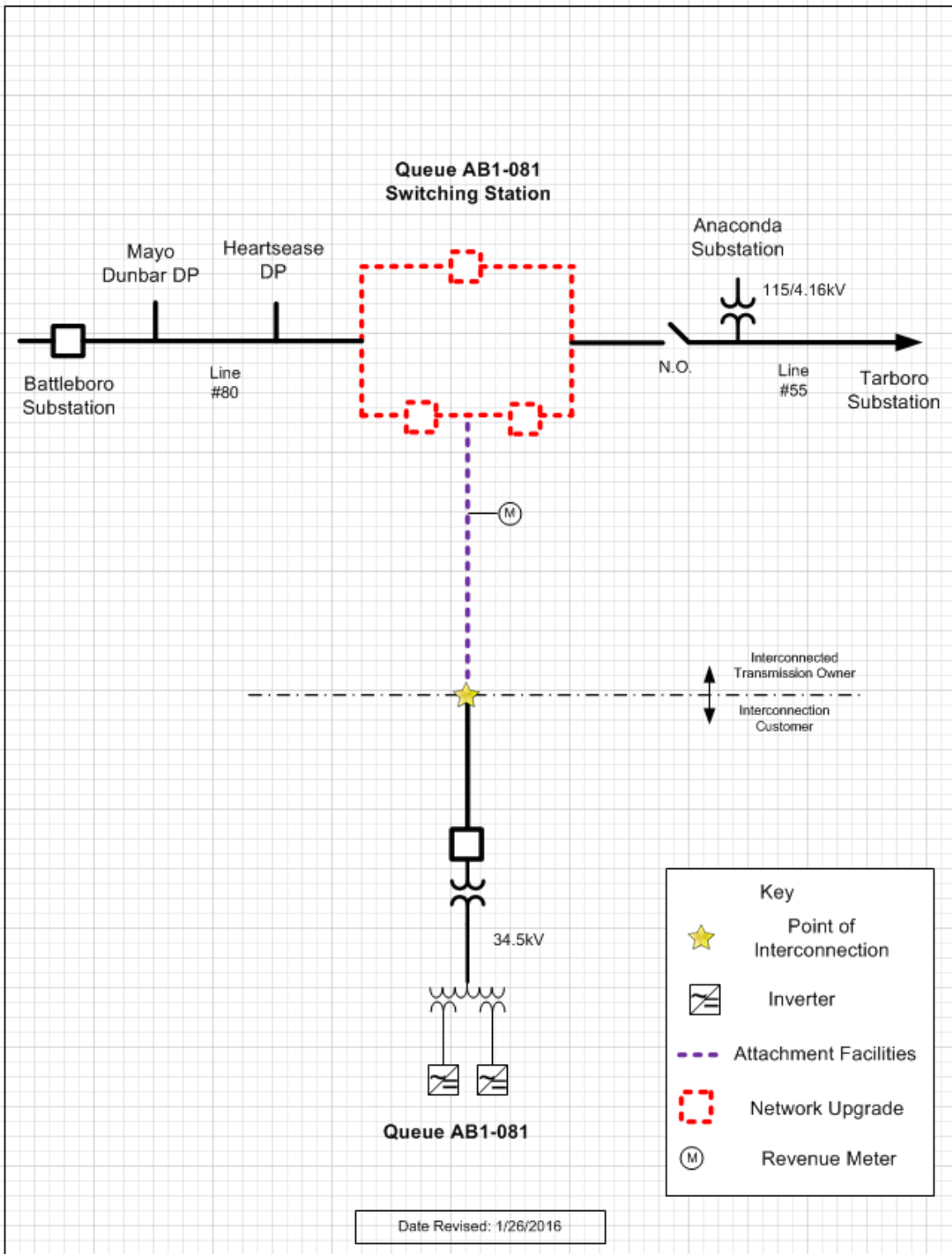
Duke, Progress & TVA Impacts:

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

Overload #1: 3BTLEBRO-3ROCKYMT115T 115 kV line overload was identified on PJM Queue projects in the AA2 queue with current rating of 94MVA. Duke Progress requires a project to enter into an Affected System Study with Duke Progress so that Duke Progress can determine if a network upgrade is required. In the AA2 queue, Duke Progress preliminary analysis has identified a network upgrade to increase the rating of the line rating from 94MVA to 164MVA. The network upgrade cost responsibility will be governed by the Duke Progress FERC tariff.

Attachment 1.

System Configuration



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 - CPLE) The 3BTLEBRO-3ROCKYMT115T 115 kV line (from bus 314554 to bus 304223 ckt 1) loads from 118.05% to 146.56% (AC power flow) of its emergency rating (94 MVA) for the tower line contingency outage of 'LN 2058-2181'. This project contributes approximately 28.5 MW to the thermal violation.

CONTINGENCY 'LN 2058-2181'

OPEN BRANCH FROM BUS 313845 TO BUS 314591 CKT 1 /* 2181
 OPEN BRANCH FROM BUS 304226 TO BUS 314591 CKT 1 /* 2181
 OPEN BRANCH FROM BUS 304222 TO BUS 313845 CKT 1 /* 2058
 END

<i>Bus Number</i>	<i>Bus Name</i>	<i>Full Contribution</i>
315131	1EDGECEMA	1.54
315132	1EDGECEMB	1.54
315139	1GASTONA	1.49
315141	1GASTONB	1.47
315126	1ROARAP2	0.62
315128	1ROARAP4	0.6
315134	1ROAVALA	2.09
315135	1ROAVALB	0.56
315136	1ROSEMG1	1.19
315138	1ROSEMG2	0.56
315137	1ROSEMS1	0.74
314539	3UNCAMP	0.83
314541	3WATKINS	0.27
314784	P-043 E	0.77
900672	V4-068 E	0.15
902241	W2-022 C OPI	0.61
902242	W2-022 E OPI	4.1
907092	X1-038 E	2.08
917331	Z2-043 C	0.23
917332	Z2-043 E	0.85
917341	Z2-044 C	0.34
917342	Z2-044 E	1.26
917511	Z2-088 C OPI	0.42
917512	Z2-088 E OPI	2.9
917592	Z2-099 E	0.21

918411	AA1-050	0.35
LTF	AA1-053	6.08
LTF	AA1-054	5.26
LTF	AA1-055	9.46
918491	AA1-063AC OP	5.23
918492	AA1-063AE OP	2.47
918512	AA1-065 E OP	1.97
918532	AA1-067 E	0.31
918561	AA1-072 C	0.3
918562	AA1-072 E	0.14
919131	AA1-135 C OP	4.03
919132	AA1-135 E OP	1.73
919691	AA2-053 C OP	5.53
919692	AA2-053 E OP	2.38
919701	AA2-057 C OP	12.21
919702	AA2-057 E OP	5.74
919821	AA2-068 C	3.39
919822	AA2-068 E	1.56
920022	AA2-086 E	0.11
920041	AA2-088 C OP	3.
920042	AA2-088 E OP	4.9
920091	AA2-105 C	1.75
920092	AA2-105 E	0.82
920181	AA2-113 C	1.4
920182	AA2-113 E	0.66
920591	AA2-165 C	1.39
920592	AA2-165 E	0.79
920631	AA2-169 C	0.9
920632	AA2-169 E	0.41
920671	AA2-174 C OP	0.25
920672	AA2-174 E OP	0.27
930171	ABI-053 C	0.84
930172	ABI-053 E	0.47
930181	ABI-054 C	3.22
930182	ABI-054 E	1.59
930401	ABI-081 C OP	19.95
930402	ABI-081 E OP	8.55
930861	ABI-132 C OP	9.83
930862	ABI-132 E OP	4.21

<i>931231</i>	<i>ABI-173 C</i>	<i>1.24</i>
<i>931232</i>	<i>ABI-173 E</i>	<i>0.58</i>
<i>931241</i>	<i>ABI-173AC</i>	<i>1.24</i>
<i>931242</i>	<i>ABI-173AE</i>	<i>0.58</i>