Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AB2-176

Chase City 34.5kV 9.8MW Capacity / 14MW Energy

September / 2016

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 facility located south of Mecklenburg County, VA. The installed facilities will have a total capability of 14 MW with 9.8 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 6/01/2017. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AB2-176 will interconnect with the ITO distribution system on a new Chase City 34.5kV circuit.

Cost Summary

The AB2-176 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$300,000
Direct Connection Network Upgrades	$0
Non Direct Connection Network Upgrades	$2,300,000
Total Costs	**$2,600,000**

In addition, the AB2-176 project may be responsible for a contribution to the following costs:

Description	Total Cost
New System Upgrades	$5,500,000
Previously Identified Upgrades	$0
Total Costs	**$5,500,000**

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

Transmission Owner Scope of Work

There is an existing three phase 12.5 kV distribution line adjacent to the IC's site and the requested POI. The existing 12.5 kV distribution line is served from a 22.4 MVA, 115/13.2 kV transformer in Chase City Substation. The IC, has requested interconnection of 14 MW of Solar PV generation onto ITO, 34.5 kV Distribution System at a Point of Interconnection (POI).

Attachment Facilities

To provide the interconnection the ITO will install approximately 300 feet of overhead three phase primary voltage conductors will be installed to provide an interconnection to the existing primary voltage conductors. A pole mounted electronic recloser, pole mounted primary bi-directional metering equipment, a power quality monitoring relay and a set of disconnects to provide an isolation point will also be provided. The estimated cost of these attachment facilities is $300,000. These costs do not include CIAC Tax Gross-up. The single line is shown below in Attachment 1.

Non-Direct Connection Local Upgrades Cost Estimate

- Due to the existing limitations on the existing transformer and circuit, the existing 115/13.2 KV, 22.4 MVA transformer in Chase City Substation will need to be changed out with an 84 MVA 115/34.5 KV transformer on the previous project AB2-090. Substation upgrades including but not limited to project AB2-090 are a new circuit breaker, a new bay, protection work, scada monitoring adjustments and adjusting regulators for reverse power flow will have an anticipated cost of **($500,000)**.

- Install 3 miles of overbuild from Chase City Substation to POI. **($1,500,000)**

- A Transfer Trip protection scheme will be required on the Automatic Line recloser to be located at the Chase City POI and at the Chase City Substation Circuit Breaker. **($300,000)**

The estimated cost of these required System Upgrades to accommodate the 36 MW request is **$2,300,000**. The estimated time to interconnect the IC with the required System Upgrades is 12-18 months.

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.

Reinforcement: Upgrade the Clubhouse 230/115kV transformer. It is estimated to take 24-28 months to complete and it is estimated to cost $5,500,000 to resolve this deficiency.

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

The ITO's preferred transformer configuration is wye grounded (primary)/delta (secondary) with provisions for external resistance grounding of the primary with the level of resistance to be determined by the IC and approved by the ITO. If a wye (primary)/wye (secondary) transformer configuration is utilized the IC will apply a ground bank configured transformer [zig-zag or wye (interconnection side) – delta (floated)] at (near) the point where the generation is connected. Additionally, the ITO will require the IC to provide specific inverter information including the model and parameter data required for a short-circuit analysis including Positive, Negative and Zero Sequence Resistance and Reactance for the initial 4 to 6 cycles.

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.

Network Impacts

The Queue Project AB2-176 was evaluated as a 14.0 MW (Capacity 9.8 MW) injection at the Chase City 115kV substation in the ITO area. Project AB2-176 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB2-176 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
T122C	CONTINGENCY 'T122C' /* CAROLINA OPEN BUS 314559 /* CAROLINA 115KV BUS OPEN BUS 315126 /* ROANOKE RAPIDS GEN 1 AND 2 OPEN BUS 315128 /* ROANOKE RAPIDS GEN 3 AND 4 OPEN BRANCH FROM BUS 314559 TO BUS 314561 CKT 1 /* TX. #4 END
2202_A	CONTINGENCY '2202_A' /* CAROLINA OPEN BRANCH FROM BUS 314559 TO BUS 314571 CKT 1 /* LINE 22 OPEN BRANCH FROM BUS 314571 TO BUS 314702 CKT 1 /* LINE 22 OPEN BRANCH FROM BUS 314559 TO BUS 314259 CKT Z1 /* LINE 56 OPEN BRANCH FROM BUS 314559 TO BUS 921751 CKT 1 /* LINE 54 AA2-053 TAP OPEN BRANCH FROM BUS 314559 TO BUS 314600 CKT 1 /* LINE 130 OPEN BRANCH FROM BUS 314559 TO BUS 314561 CKT 1 /* TX. #4 DECREASE BUS 314559 LOAD BY 100 PERCENT /* REMOVE ALL LOAD AT CAROLINA END

Contingency Name	Description
T132_A	CONTINGENCY 'T132_A' /* CAROLINA OPEN BRANCH FROM BUS 314559 TO BUS 314259 CKT Z1 /* LINE 56 OPEN BRANCH FROM BUS 314559 TO BUS 921751 CKT 1 /* LINE 54 AA2-053 TAP OPEN BRANCH FROM BUS 314559 TO BUS 314571 CKT 1 /* LINE 22 OPEN BRANCH FROM BUS 314559 TO BUS 314600 CKT 1 /* LINE 130 OPEN BRANCH FROM BUS 314559 TO BUS 314561 CKT 1 /* TX. #4 DECREASE BUS 314559 LOAD BY 100 PERCENT /* REMOVE ALL LOAD AT CAROLINA END
5602_A	CONTINGENCY '5602_A' /* CAROLINA OPEN BRANCH FROM BUS 314559 TO BUS 314259 CKT Z1 /* LINE 56 OPEN BRANCH FROM BUS 314259 TO BUS 921161 CKT 1 /* LINE 56 AA1-063A TAP OPEN BRANCH FROM BUS 314559 TO BUS 921751 CKT 1 /* LINE 54 AA2-053 TAP OPEN BRANCH FROM BUS 314559 TO BUS 314571 CKT 1 /* LINE 22 OPEN BRANCH FROM BUS 314559 TO BUS 314600 CKT 1 /* LINE 130 OPEN BRANCH FROM BUS 314559 TO BUS 314561 CKT 1 /* TX. #4 DECREASE BUS 314559 LOAD BY 100 PERCENT /* REMOVE ALL LOAD AT CAROLINA END

Contingency Name	Description
5402_A	CONTINGENCY '5402_A' /* CAROLINA OPEN BRANCH FROM BUS 314559 TO BUS 921751 CKT 1 /* LINE 54 AA2-053 TAP OPEN BRANCH FROM BUS 314559 TO BUS 314571 CKT 1 /* LINE 22 OPEN BRANCH FROM BUS 314559 TO BUS 314259 CKT Z1 /* LINE 56 OPEN BRANCH FROM BUS 314559 TO BUS 314600 CKT 1 /* LINE 130 OPEN BRANCH FROM BUS 314559 TO BUS 314561 CKT 1 /* TX. #4 DECREASE BUS 314559 LOAD BY 100 PERCENT /* REMOVE ALL LOAD AT CAROLINA END
3CAROLNA-6CAROLNA	CONTINGENCY '3CAROLNA-6CAROLNA' OPEN BRANCH FROM BUS 314559 TO BUS 314561 CKT 1 END

Summer Peak Analysis - 2020

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.)

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		Bus			Power	Loading %		Rating		MW	
#	Type	Name	Area	Facility Description	From	To	Cir.	Flow	Initial	Final	Type	MVA	Contribution	Ref
1	LFFB	T122C	DVP - DVP	6CLUBHSE 230/115 kV transformer	314562	314563	1	DC	135.01	136.21	ER	194	2.33	1

#	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	Ref
2	LFFB	2202_A	DVP - DVP	6CLUBHSE 230/115 kV transformer	314562	314563	1	DC	132	133.13	ER	194	2.2	
3	LFFB	T132_A	DVP - DVP	6CLUBHSE 230/115 kV transformer	314562	314563	1	DC	130.97	132.1	ER	194	2.2	
4	LFFB	5602_A	DVP - DVP	6CLUBHSE 230/115 kV transformer	314562	314563	1	DC	130.92	132.05	ER	194	2.2	
5	LFFB	5402_A	DVP - DVP	6CLUBHSE 230/115 kV transformer	314562	314563	1	DC	130.76	131.89	ER	194	2.2	

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 - 5	6CLUBHSE 230/115 kV transformer	Upgrade the Clubhouse 230/115kV transformer	Pending	**$5,500,000**
			Total New Network Upgrades	**$5,500,000**

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.

	Contingency		Affected		Bus			Power	Loading %		Rating		MW
#	Type	Name	Area	Facility Description	From	To	Circuit	Flow	Initial	Final	Type	MVA	Contribution
6	N-1	3CAROLNA-6CAROLNA	DVP - DVP	6CLUBHSE 230/115 kV transformer	314562	314563	1	DC	102.08	103.18	ER	194	2.14

Light Load Analysis

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

ITO Analysis

ITO assessed the impact of the proposed Queue Project #AB2-176 interconnection of a 14.0 MW Energy (9.8 MW Capacity) injection into the ITO's Transmission System, for compliance with NERC Reliability Criteria on ITO's Transmission System. The system was assessed using the summer 2020 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 (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 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's 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, the 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 (greater than 20 MW). The results of these studies are discussed in more detail below.

Category B Analysis (Single Contingency):

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

Category C Analysis: (Multiple Facility Analysis)

1. Bus Fault - No deficiencies identified
2. Line Stuck Breaker - No deficiencies identified
3. Tower Line – No deficiencies identified

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 gage 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 6CLUBHSE 230/115 kV transformer (from bus 314562 to bus 314563 ckt 1) loads from 135.01% to 136.21% (**DC power flow**) of its emergency rating (194 MVA) for the line fault with failed breaker contingency outage of 'T122C'. This project contributes approximately 2.33 MW to the thermal violation.

```
CONTINGENCY 'T122C'                                    /* CAROLINA
  OPEN BUS 314559                                  /* CAROLINA 115KV BUS
  OPEN BUS 315126                                  /* ROANOKE RAPIDS GEN 1 AND 2
  OPEN BUS 315128                                  /* ROANOKE RAPIDS GEN 3 AND 4
  OPEN BRANCH FROM BUS 314559 TO BUS 314561 CKT 1          /* TX. #4
  END
```

Bus Number	*Bus Name*	*Full Contribution*
315159	*1KERR 2*	*1.27*
315163	*1KERR 6*	*1.25*
315164	*1KERR 7*	*1.25*
314704	*3LAWRENC*	*1.43*
922472	*AA2-169 C*	*1.68*
922473	*AA2-169 E*	*0.77*
923572	*AB1-173 C OP*	*10.72*
923573	*AB1-173 E OP*	*5.*
923582	*AB1-173AC OP*	*10.72*
923583	*AB1-173AE OP*	*5.*
923911	*AB2-031 C OP*	*10.64*
923912	*AB2-031 E OP*	*5.24*
923991	*AB2-040 C OP*	*36.2*
923992	*AB2-040 E OP*	*27.31*
924021	*AB2-043 C OP*	*3.15*
924022	*AB2-043 E OP*	*5.16*
924161	*AB2-060 C OP*	*7.15*
924162	*AB2-060 E OP*	*3.37*
924251	*AB2-069 C OP*	*2.46*
924252	*AB2-069 E OP*	*3.88*
924301	*AB2-077 C OP*	*1.93*
924302	*AB2-077 E OP*	*1.29*
924311	*AB2-078 C OP*	*1.93*
924312	*AB2-078 E OP*	*1.29*
924321	*AB2-079 C OP*	*1.93*
924322	*AB2-079 E OP*	*1.29*
924401	*AB2-089 C*	*1.61*
924402	*AB2-089 E*	*0.83*
924411	*AB2-090 C*	*3.96*

924412	*AB2-090 E*	*2.03*
924931	*AB2-147 C*	*11.39*
924932	*AB2-147 E*	*18.59*
924951	*AB2-150 C OP*	*11.39*
924952	*AB2-150 E OP*	*18.59*
925171	*AB2-174 C OP*	*33.34*
925172	*AB2-174 E OP*	*30.17*
925221	*AB2-176 C*	*1.63*
925222	*AB2-176 E*	*0.7*