

***Generation Interconnection  
Feasibility Study Report***

***For***

***PJM Generation Interconnection Request  
Queue Position AC2-107***

***Perth 115kV***

***68.1 MW Capacity / 100 MW Energy***

October / 2017

## 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 and battery generating facility located in Halifax County, Virginia. The installed facilities will have a total capability of 100 MW with 68.1 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is October 2019.

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

## Point of Interconnection

AC2-107 will interconnect with the ITO transmission system at one of the following points of interconnection:

Option 1: AC2-107 will interconnect into the existing Perth 115kV Substation

Option 2: AC2-107 will connect via a new three breaker ring bus switching station that connects on the Perth – Crystal Hill 115kV line.

## Cost Summary

The AC2-107 project will be responsible for the following costs:

<b>Description</b>	<b>Total Cost</b>
Attachment Facilities	\$ 1,550,000
Direct Connection Network Upgrades	\$ 0
Non Direct Connection Network Upgrades	\$ 1,800,000
<b>Total Costs</b>	<b>\$ 3,350,000</b>

In addition, the AC2-107 project may be responsible for a contribution to the following costs:

<b>Description</b>	<b>Total Cost</b>
New System Upgrades	\$ 100,000
Previously Identified Upgrades	\$ 0
<b>Total Costs</b>	<b>\$ 100,000</b>

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

## **Attachment Facilities**

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

Transmission: Construct approximately one span of 115kV Attachment line between the generation substation and the Perth 115kV substation. 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 upon execution of an Interconnection Construction Service Agreement (ICSA). 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. See Attachment One.

## **Non-Direct Connection Cost Estimate**

Substation: PJM baseline reliability project b2719.1 expands the Perth substation adding a four breaker 115kV ring bus with a targeted completion date of 12/01/2017. The AC2-107 IC will be responsible for the costs to add two 115 kV breakers to convert the station to a breaker and half scheme and create the new breaker bay to interconnect the proposed AC1-075 Attachment Line and install associated facilities. A site expansion will be required for this work. The estimated cost of this work scope is \$1,800,000. It is estimated to take 24-30 months to complete this work.

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.

## System Reinforcement

Violation #	Upgrade Description	Upgrade Cost
# 1	Replace risers at the Otter substation; The estimated cost is \$100,000. The estimated construction time is 12 months after signing an interconnection agreement	\$100,000
Total Network Upgrades		<b>\$100,000</b>

## **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>

An Interconnection Customer entering the New Services Queue on or after October 1, 2012 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.

**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 AC2-107 was evaluated as a 100.0 MW (Capacity 68.1 MW) injection at the Perth 115 kV substation in the ITO area. Project AC2-107 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-107 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
3312	CONTINGENCY '3312' OPEN BUS 314267 /* CHASE CITY OPEN BUS 314669 /*CHASE CITY 115KV BUS 3 OPEN BUS 314684 /*LINE 33 BARNS J OPEN BUS 314696 /*LINE 33 MT LAUREL OPEN BUS 314518 /*LINE 33 HALIFAX END /*SC312
5366_B2_TOR42_A	CONTINGENCY '5366_B2_TOR42_A' OPEN BRANCH FROM BUS 242549 TO BUS 242550 CKT 1 / 242549 05BANSTR 138 242550 05BEARSK 138 1 OPEN BRANCH FROM BUS 242549 TO BUS 242632 CKT 1 / 242549 05BANSTR 138 242632 05EDAN 2 138 1 OPEN BRANCH FROM BUS 242549 TO BUS 314668 CKT Z1 / 242549 05BANSTR 138 314668 4BANISTR 138 Z1 OPEN BRANCH FROM BUS 242550 TO BUS 926050 CKT 1 / 242550 05BEARSK 138 926050 AC1-083 TAP 138 1 OPEN BRANCH FROM BUS 242550 TO BUS 314671 CKT Z1 / 242550 05BEARSK 138 314671 4BEARSKN 138 Z1 OPEN BRANCH FROM BUS 314671 TO BUS 314789 CKT 1 / 314671 4BEARSKN 138 314789 2BEARSKN 69.0 1 END
LN 556	CONTINGENCY 'LN 556' OPEN BRANCH FROM BUS 314686 TO BUS 314906 CKT 1 /* 6CLOVER 230.00 - 8CLOVER 500.00 OPEN BRANCH FROM BUS 314686 TO BUS 314906 CKT 2 /* 6CLOVER 230.00 - 8CLOVER 500.00 OPEN BRANCH FROM BUS 314686 TO BUS 314906 CKT 3 /* 6CLOVER 230.00 - 8CLOVER 500.00 OPEN BRANCH FROM BUS 314906 TO BUS 314936 CKT 1 /* 8CLOVER 500.00 - 8RAWLINGS 500.00 OPEN BUS 314906 /* ISLAND 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, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)*

#	Contingency		Affected Area	Facility Description	Bus			Power Flow	Loading %		Rating		MW Contribution	Ref
	Type	Name			From	To	Cir.		Initial	Final	Type	MVA		
1	LFFB	3312	DVP - AEP	4ALTVSTA-05OTTER 138 kV line	314667	242741	1	DC	87.31	102.51	ER	235	35.71	1
2	LFFB	3312	DVP - AEP	4ALTVSTA-05OTTER 138 kV line	314667	242741	1	DC	87.31	102.51	ER	235	35.71	

### **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

### **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

### **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)*

<b>Violation #</b>	<b>Overloaded Facility</b>	<b>Upgrade Description</b>	<b>Network Upgrade Number</b>	<b>Upgrade Cost</b>
1	4ALTVSTA-05OTTER 138 kV line	AEP: Replace the Otter substation risers. The estimated cost: \$100,000. The estimated construction time is 12 months after signing an interconnection agreement  DVP: Dominion adopts 100% load dumping rating (Rate C) for failed breaker contingency type, this is not a violation.	Pending	\$100,000
<b>Total New Network Upgrades</b>				<b>\$100,000</b>

### **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		Affected Area	Facility Description	Bus		Circuit	Power Flow	Loading %		Rating		MW Contribution
	Type	Name			From	To			Initial	Final	Type	MVA	
3	Non	Non	AEP - DVP	05LEESVI-4ALTVSTA 138 kV line	242701	314667	1	DC	90.37	100.47	NR	205	20.69
4	Non	Non	AEP - DVP	05LEESVI-4ALTVSTA 138 kV line	242701	314667	1	DC	90.37	100.47	NR	205	20.69
5	N-1	5366_B2_T OR42_A	AEP - AEP	05SMITHMTN2-05ROCKCA 138 kV line	247499	242775	1	DC	98.64	100.18	ER	286	9.77
6	N-1	LN 556	DVP - DVP	6PRINCE EDW-6FARMVIL 230 kV line	313802	314692	1	DC	99.55	100.32	ER	572	9.86
7	N-1	LN 556	DVP - DVP	6BRIERY-6PRINCE EDW 230 kV line	314268	313802	1	DC	100.6	101.34	ER	572	9.86
8	Non	Non	DVP - AEP	4ALTVSTA-05OTTER 138 kV line	314667	242741	1	DC	100.5	110.62	NR	151	15.33

**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 #AC2-107 interconnection of a 100 MW Energy (68.1 MW Capacity) injection into the ITO's Transmission System at the existing Perth 115 substation, 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 or Possum Point 6 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

The import and export conditions into and out of the ITO System are evaluated with any new interconnection greater than 20 MW, any new facility that is interconnected with the ITO System should not significantly decrement FCITC between utilities. These studies will be performed during the System Impact Study.

## **Affected System Analysis & Mitigation**

**Duke, Progress & TVA Impacts:**

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

Note: Reinforcement for Violation # 1 and 2 on the Altavista – Otter 115kV line has been identified to include work to be performed by AEP.

## Option 2

### Network Impacts

The Queue Project AC2-107 was evaluated as a 100.0 MW (Capacity 68.1 MW) injection tapping the Perth – Crystal Hill 115 kV line in the ITO area. Project AC2-107 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-107 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	
LN 556	CONTINGENCY 'LN 556'	
	OPEN BRANCH FROM BUS 314686 TO BUS 314906 CKT 1 230.00 - 8CLOVER 500.00	/* 6CLOVER
	OPEN BRANCH FROM BUS 314686 TO BUS 314906 CKT 2 230.00 - 8CLOVER 500.00	/* 6CLOVER
	OPEN BRANCH FROM BUS 314686 TO BUS 314906 CKT 3 230.00 - 8CLOVER 500.00	/* 6CLOVER
	OPEN BRANCH FROM BUS 314906 TO BUS 314936 CKT 1 500.00 - 8RAWLINGS 500.00	/* 8CLOVER
	OPEN BUS 314906	/* ISLAND
	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, 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)*

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

### **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)*

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### **Potential Congestion due to Local Energy Deliverability**

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#	Contingency		Affected Area	Facility Description	Bus		Cir.	Power Flow	Loading %	
	Type	Name			From	To			Initial	Final
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3	Non	Non	DVP - AEP	4ALTVSTA-05OTTER 138 kV line	314667	242741	1	DC	100.5	100
4	Non	Non	DVP - AEP	4ALTVSTA-05OTTER 138 kV line	314667	242741	1	DC	100.5	100

### **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 #AC2-107 interconnection of a 100 MW Energy (68.1 MW Capacity) injection into the ITO's Transmission System at a new AC2-107 interconnection switching station located between the Perth – Crystal Hill 115kV line, 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>.

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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):

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## **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*

## **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 - AEP) The 4ALTVSTA-05OTTER 138 kV line (from bus 314667 to bus 242741 ckt 1) loads from 87.31% to 102.51% (**DC power flow**) of its emergency rating (235 MVA) for the line fault with failed breaker contingency outage of '3312'. This project contributes approximately 35.71 MW to the thermal violation.

CONTINGENCY '3312'

OPEN BUS 314267  
 OPEN BUS 314669  
 OPEN BUS 314684  
 OPEN BUS 314696  
 OPEN BUS 314518  
 END

/\* CHASE CITY  
 /\*CHASE CITY 115KV BUS 3  
 /\*LINE 33 BARNES J  
 /\*LINE 33 MT LAUREL  
 /\*LINE 33 HALIFAX  
 /\*SC312

<i>Bus Number</i>	<i>Bus Name</i>	<i>Full Contribution</i>
247284	05LEESVG	2.11
246843	05SMG1	1.38
246844	05SMG2	3.63
246845	05SMG3	2.13
246846	05SMG4	3.75
246847	05SMG5	1.42
315156	1HALLBRI	3.77
315165	1HURT 1	2.61
315166	1HURT 2	2.61
931821	AC2-107 C OP	24.32
931822	AC2-107 E OP	11.39
921882	AA2-070	3.92
925661	AC1-042 C	5.93
925662	AC1-042 E	9.67
925991	AC1-075 C	13.68
925992	AC1-075 E	7.75
926021	AC1-080 C	4.57
926022	AC1-080 E	2.57
926051	AC1-083 C OP	3.6
926052	AC1-083 E OP	5.88
926641	AC1-145 C	7.06
926642	AC1-145 E	11.51
927261	AC1-222 C	10.82
927262	AC1-222 E	5.25