Generation Interconnection

System Impact Study Report

for

Queue Project AE1-103

HOLLAND-UNION CAMP 115 KV

16.8 MW Capacity / 40 MW Energy

Revision 2/ April 2022
Revision 1 / January 2022
August, 2019

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1 Introduction

This System Impact Study (SIS) has been prepared in accordance with the PJM Open Access Transmission Tariff, 205, as well as the Feasibility Study Agreement between Aquasan Network Inc, the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Virginia Electric and Power Company (VEPCO).

2 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 Interconnection Customer. As a requirement for interconnection, the Interconnection Customer 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 Interconnection Customer 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 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.

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.

3 Revision 1 (January 2021) Summary

This revision is being issued to incorporate results of a re-tool performed in January of 2022 and results of the Stability Analysis. The Stability Analysis determined that no mitigations will be required.

4 Revision 2 (April 2021) Summary

This revision is being issued due to the project reducing size to 40 MW MFO and 16.8 MW CIR. Re-tool results were also incorporated due to project reduction.

5 General

The IC has proposed a solar generating facility located in Isle of Wight County, Virginia. The installed facilities will have a capability of 40 MW with 16.8 MW of this output being recognized by PJM as Capacity. The proposed in-service date for the AE1-103 project is 4/01/2021. This study does not imply an ITO commitment to either in-service date.

Queue Number	AE1-103
Project Name	HOLLAND-UNION CAMP 115 KV
Interconnection Customer	Aquasan Network Inc
State	Virginia
County	Isle of Wight
Transmission Owner	Dominion
MFO	40
MWE	40
MWC	16.8
Fuel	Solar
Basecase Study Year	2022

5.1 Point of Interconnection

AE1-103 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Union Camp – Holland 115kV line # 68. See one line in Attachment 1.

5.2 Cost Summary

The AE1-103 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 1,700,000
Direct Connection Network Upgrade	$ 5,500,000
Non Direct Connection Network Upgrades	$ 800,000
Total Costs	**$ 8,000,000**

In addition, the AE1-103 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	$ 0

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.

6 Transmission Owner Scope of Work

6.1 Attachment Facilities

Generation Substation: Install metering and associated protection equipment. Estimated Cost $700,000.

Transmission: Construct approximately one span of 115 kV Attachment line between the generation substation and a new AE1-103 Switching Station. The estimated cost for this work is $1,000,000.

The estimated total cost of the Attachment Facilities is $1,700,000. 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.

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
Generator Substation	$ 700,000
Transmission	$ 1,000,000
Total Attachment Facility Costs	**$ 1,700,000**

6.2 Direct Connection Cost Estimate

Substation: Establish the new 115 kV AE1-103 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.

The total preliminary cost estimate for the Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Substation	$ 5,500,000
Total Direct Connection Facility Costs	**$ 5,500,000**

6.3 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 $800,000 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.

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Transmission	$ 800,000
Remote Terminal Work	TBD in the Facilities Study
Total Non-Direct Connection Facility Costs	**$ 800,000**

7 Interconnection Customer Requirements

7.1 System Protection

The IC must design its Customer Facilities in accordance with all applicable standards, including the standards in Dominion's "Dominion Energy Electric Transmission Generator Interconnection Requirements" documented in Dominion's Facility Interconnection Requirements "Exhibit C" located at: https://www.dominionenergy.com/company/moving-energy/electric-transmission-access. Preliminary Protection requirements will be provided as part of the Facilities Study. Detailed Protection Requirements will be provided once the project enters the construction phase.

7.2 Compliance Issues and Interconnection Customer Requirements

The proposed Customer Facilities must be designed in accordance with Dominion's "Dominion's Facility Interconnection Requirements" document located at: https://www.dominionenergy.com/company/moving-energy/electric-transmission-access. In particular, the IC is responsible for the following:

1. The purchase and installation of a fully rated protection device (circuit breaker, circuit switcher, fuse) to protect the IC's GSU transformer(s).

2. The purchase and installation of the minimum required Dominion generation interconnection relaying and control facilities as described in the System Protection noted above. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

3. The purchase and installation of supervisory control and data acquisition ("SCADA") equipment to provide information in a compatible format to the Dominion Transmission System Control Center.

4. Compliance with the Dominion and PJM generator power factor and voltage control requirements.

The GSU(s) associated with the IC queue request shall meet the grounding requirements as noted in Dominion's "Dominion's Facility Interconnection Requirements" document located at: https://www.dominionenergy.com/company/moving-energy/electric-transmission-access.

The IC will also be required to meet all PJM, SERC, and NERC reliability criteria and operating procedures for standards compliance. For example, the IC will need to properly locate and report the over and under voltage and over and under frequency system protection elements for its units as well as the submission of the generator model and protection data required to satisfy the PJM and SERC audits. Failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the Dominion system.

7.3 Power Factor Requirements

The IC shall design its non-synchronous Customer Facility with the ability to maintain a power factor of at least 0.95 leading (absorbing VARs) to 0.95 lagging (supplying VARs) measured at the high-side of the facility substation transformer(s) connected to the Dominion transmission system.

8 Revenue Metering and SCADA Requirements

8.1 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 Section 8 of Attachment O.

7.1.1 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

8.2 Dominion Requirements

See Section 3.4.6 "Metering and Telecommunications" of Dominion's "Dominion's Facility Interconnection Requirements" document located at: https://www.dominionenergy.com/company/moving-energy/electric-transmission-access.

9 Network Impacts

The Queue Project AE1-103 was evaluated as a 40.0 MW (Capacity 16.8 MW) injection at Holland-Union Camp 115kV in the Dominion area. Project AE1-103 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-103 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

10 Generation Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

None.

11 Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None.

12 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

13 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
1	314559	3CAROLNA	DVP	314561	6CAROLNA	DVP	1	DVP_P1-3: 6CLUBHSE-TX#1	operation	240	102.09	104.24	AC	5.34

14 System Reinforcements

None

15 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.

15.1 Contingency Descriptions

Contingency Name	Contingency Definition
DVP_P1-3: 6CLUBHSE-TX#1	CONTINGENCY 'DVP_P1-3: 6CLUBHSE-TX#1' OPEN BRANCH FROM BUS 314562 TO BUS 314563 CKT 1 /* 3CLUBHSE 115.00 - 6CLUBHSE 230.00 END

Affected Systems

16 Affected Systems

16.1 Duke Energy Progress

None.

Short Circuit

17 Short Circuit

The following Breakers are overduty

None

Stability

18 Stability

18.1 Executive Summary

Generator Interconnection Request AE1-103 is for a 40.0 MW Maximum Facility Output (MFO) solar generation plant. AE1-103 consists of 56 × 0.903572 MW, Power Electronics HEC PLUS FS1004CU solar PV inverters with a total capacity of 40.6 MW. The Point of Interconnection (POI) is at a tap on Union Camp – Holland 115 kV circuit in the Dominion Virginia Electric and Power (DVP) transmission system, Isle of Wight county, Virginia.

This report describes a dynamic simulation analysis of AE1-103 as part of the overall system impact study.

The load flow scenario for the analysis was based on the RTEP 2022 peak load case, modified to include applicable queue projects. AE1-103 has been dispatched online at maximum power output, with 1.0 p.u. voltage at the generator bus.

AE1-103 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. Steady-state condition and 41 contingencies were studied, each with a 20 second simulation time period. Studied faults included:

a) Steady-state operation (30 second);

b) Three-phase faults with normal clearing time;

c) Single-phase faults with stuck breaker;

d) Single-phase fault with loss of multi-circuit tower line.

No relevant bus faults and high speed reclosing (HSR) schemes were identified for this study. There are no delayed (Zone 2) clearing faults due to dual primary relays being employed.

For all simulations, the queue project under study along with the rest of the PJM system were required to maintain synchronism and with all states returning to an acceptable new condition following the disturbance.

For all of the fault contingencies tested on the 2022 peak load case:

a) AE1-103 was able to ride through the faults (except for faults where protective action trips a generator(s)),

b) The system with AE1-103 included is transiently stable and post-contingency oscillations were positively damped with a damping margin of at least 3% for interarea modes and 4% for local modes.

c) Following fault clearing, all bus voltages recovered to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).

d) No transmission element tripped, other than those either directly connected or designed to trip as a consequence of that fault.

e) Surry 500 kV bus voltage is within 510 kV – 530 kV range with less than 4.5% voltage drop for all contingencies, per PJM M03.

f) Surry 230 kV bus voltage is within 222.3 kV – 239.2 kV range with less than 6.0% voltage drop for all contingencies, per PJM M03.

The reactive power capability of AE1-103 meets the 0.95 PF lagging and leading requirements at the high side of the main transformer.

AC2-079 was tripped by its overvoltage protection at around 8.9 seconds for contingency P7.04. The reactive limits CON(J+10) and CON(J+11) in PE_CONT were set to 0.2935 to reflect the model's capabilities in loadflow. The tripping issue was resolved after the change.

The simulation results showed that the QELEC of AE1-103 did not achieve flat response at the end of 20 second simulation window under plant level V control for contingencies P4.10 – P4.13. No instability and voltage issues were observed. The selected contingencies were run for 30 seconds and the QELEC achieved a flat response at the end of 30 second simulation time period.

No mitigations were found to be required.

Attachment 1

System Configuration