Generation Interconnection

System Impact Study Report

for

Queue Project AF1-042

GARNER DP-LANCASTER 115 KV

17.1 MW Capacity / 45 MW Energy

Revision 1: November 2021

Revision 0: August 2020

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1 Introduction

This System Impact Study has been prepared in accordance with the PJM Open Access Transmission Tariff, 205, as well as the System Impact Study Agreement between the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Dominion.

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.

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.

3 Revision 1 Summary – November 2021

This revision is being issued to incorporate the results of a stability study which was recently performed.

4 General

The Interconnection Customer (IC) has proposed an uprate to a planned/existing Solar generating facility located in Lancaster, Virginia. This project is an increase to the Interconnection Customer's AD2-074 project, which will share the same point of interconnection. The AF1-042 queue position is a 45 MW uprate (17.1 MW Capacity uprate) to the previous project. The total installed facilities will have a capability of 131 MW with 49.8 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this uprate project is November 30, 2021. This study does not imply a TO commitment to this in-service date.

Queue Number	AF1-042
Project Name	GARNER DP-LANCASTER 115 KV
State	Virginia
County	Lancaster
Transmission Owner	Dominion
MFO	131
MWE	45
MWC	17.1
Fuel	Solar
Basecase Study Year	2023

Any new service customers who can feasibly be commercially operable prior to June 1st of the basecase study year are required to request interim deliverability analysis.

5 Point of Interconnection

AF1-042 will interconnect with the Dominion transmission system. The POI will be the AD2-074 115 kV substation tapping the Garner - Lancaster 115kV line. The POI will be 5.58 miles away from Dominion Garner substation and 8.40 miles away from Lancaster substation.

6 Cost Summary

The AF1-042 project will utilize the interconnection facilities being developed under the AD2-074 project.

The AF1-042 project will be responsible for the following costs:

Description	Total Cost
Total Physical Interconnection Costs	$ 0
Allocation towards System Network Upgrade Costs*	$ 0
Total Costs	**$ 0**

*As your project progresses through the study process and other projects modify their request or withdraw, then your cost allocation could change.

This cost excludes a Federal Income Tax Gross Up charges. This tax may or may not be charged based on whether this project meets the eligibility requirements of IRS Notice 88-129. If at a future date it is determined that the Federal Income Tax Gross charge is required, the Transmission Owner shall be reimbursed by the Interconnection Customer for such taxes.

Note 1: 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.

Note 2: For customers with System Reinforcements listed: If your present cost allocation to a System Reinforcement indicates $0, then please be aware that as changes to the interconnection process occur, such as prior queued projects withdrawing from the queue, reducing in size, etc, the cost responsibilities can change and a cost allocation may be assigned to your project. In addition, although your present cost allocation to a System Reinforcement is presently $0, your project may need this system reinforcement completed to be deliverable to the PJM system. If your project comes into service prior to completion of the system reinforcement, an interim deliverability study for your project will be required.

7 Transmission Owner Scope of Work

Dominion assessed the impact of the proposed Queue Project AF1-042. The project was evaluated as a 17.1 MW Capacity (45.0 MW energy) injection at the existing AD2-074 substation in the Dominion Transmission System, for compliance with NERC Reliability Criteria on Dominion Transmission System. The system was assessed using the summer 2023 AF1 case provided to Dominion by PJM. When performing a generation analysis, Dominion's main analysis will be load flow study results under single contingency (both normal and stressed system conditions). Dominion Criteria considers a transmission facility overloaded if it exceeds 94% of its emergency rating under normal and stressed system conditions. A full listing of Dominion's Planning Criteria and interconnection requirements can be found in the Company's Facility Connection Requirements which are publicly available at: http://www.dominionenergy.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, in Planning

Studies, NERC Planning Event 3 and 6 Contingency Conditions (Loss of generator, transmission circuit, transformer, shunt device, or Single Pole of a DC line followed by the loss of a generator, transmission circuit, transformer, shunt device or single pole of a DC line) allow for re-dispatch of generating units to resolve potential reliability deficiencies. For Dominion 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.

Note that the ITO findings were made from a conceptual review of this project and cost estimate data contained in this document should be considered high level estimates since it was produced without a detailed engineering review. The applicant will be responsible for the actual cost of construction. ITO herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the transmission systems.

8 Schedule

The schedule for the required Network Impact Reinforcements will be more clearly identified in future study phases. The estimate elapsed time to complete each of the required reinforcements is identified in the "System Reinforcements" section of the report.

9 Transmission Owner Analysis

9.1 Power Flow Analysis

PJM performed a power flow analysis of the transmission system using a 2023 summer peak load flow model and the results were verified by Dominion. Additionally, Dominion performed an analysis of its transmission system and no further deficiencies were identified.

9.2 Stability Analysis

PJM has completed a dynamic stability analysis and the results of this analysis has been reviewed by Dominion. Based on the Impact Study data provided, the AF1-042 queue project meets the 0.95 lagging and 0.95 leading reactive power factor requirement. See the result summary in **Section 14 Stability and Reactive Power**.

10 Interconnection Customer Requirements

10.1 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.

10.2 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.

10.3 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.

11 Revenue Metering and SCADA Requirements

11.1 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.

11.1.1 Meteorological Data Reporting Requirements

The solar generation facility shall provide the Transmission Provider with site-specific meteorological data including:

- Back Panel temperature (Fahrenheit)
- Irradiance (Watts/meter2)
- Ambient air temperature (Fahrenheit) – (Accepted, not required)
- Wind speed (meters/second) – (Accepted, not required)
- Wind direction (decimal degrees from true north) – (Accepted, not required)

11.2 Interconnected Transmission Owner 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.

12 Summer Peak Analysis

The Queue Project AF1-042 was evaluated as a 45.0 MW (Capacity 17.1 MW) uprate to AD2-074 which is an injection that taps the Garner to Lancaster 115 kV line in the Dominion area. Project AF1-042 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-042 was studied with a commercial probability of 100%. Potential network impacts were as follows:

12.1 Generation Deliverability

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

None

12.2 Multiple Facility Contingency

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

None

12.3 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

12.4 Steady-State Voltage Requirements

None

12.5 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	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
89852700	314134	6CRANES	230.0	DVP	314142	6STAFORD	230.0	DVP	1	DVP_P1-2: LN 2089	operation	678.68	117.87	118.83	AC	7.68
89852831	314142	6STAFORD	230.0	DVP	314145	6AQUI_HARB_B	230.0	DVP	1	DVP_P1-2: LN 2089	operation	678.68	103.84	104.8	AC	7.68
43014816	314173	3GARNER	115.0	DVP	314181	3NORNECK	115.0	DVP	1	DVP_P1-2: LN 65-B	operation	203.98	103.36	125.01	AC	45.0
45983808	314173	3GARNER	115.0	DVP	314181	3NORNECK	115.0	DVP	1	3141783LANCAST 115 936590 AD2-074 TAP 1151	operation	203.98	103.36	125.02	AC	45.0

12.6 System Reinforcements

None

12.7 Contingency Descriptions

Contingency Name	Contingency Definition
DVP_P1-2: LN 65-B	CONTINGENCY 'DVP_P1-2: LN 65-B' OPEN BRANCH FROM BUS 313813 TO BUS 314178 CKT 1 /* 3OCRAN 115.00 - 3LANCAST 115.00 OPEN BRANCH FROM BUS 313813 TO BUS 314191 CKT 1 /* 3OCRAN 115.00 - 3WHIT STONE 115.00 OPEN BRANCH FROM BUS 313870 TO BUS 314191 CKT 1 /* 3RAPPAHNCK 115.00 - 3WHIT STONE 115.00 OPEN BRANCH FROM BUS 936590 TO BUS 314178 CKT 1 /* AD2-074 TAP 115.00 - 3LANCAST 115.00 OPEN BRANCH FROM BUS 314178 TO BUS 314400 CKT 1 /* 3LANCAST 115.00 - 3LANCA_1 115.00 OPEN BUS 313813 /* ISLAND: 3OCRAN 115.00 OPEN BUS 314178 /* ISLAND: 3LANCAST 115.00 OPEN BUS 314191 /* ISLAND: 3WHIT STONE 115.00 OPEN BUS 314400 /* ISLAND: 3LANCA_1 115.00 END
314178 3LANCAST 115 936590 AD2-074 TAP 115 1	CONTINGENCY '314178 3LANCAST 115 936590 AD2-074 TAP 115 1' OPEN BRANCH FROM BUS 314178 TO BUS 936590 CKT 1 END
DVP_P1-2: LN 2089	CONTINGENCY 'DVP_P1-2: LN 2089' OPEN BRANCH FROM BUS 314196 TO BUS 314197 CKT 1 /* 6LADYSMITH 230.00 - 6LDYSMITH CT230.00 END

13 Short Circuit Analysis

No circuit breakers were identified as overdutied as part of this analysis.

14 Stability and Reactive Power

Generator Interconnection Request AF1-042 is for an increase in energy injection capability of the AD2-074 queue project. The AF1-042 uprate increases the Maximum Facility Output (MFO) of the plant from 86 MW to 131 MW. AF1-042 consists of 22 x 2.136 MW SMA SC 2200 inverters. AF1-042 has a Point of Interconnection (POI) connecting to the transmission line between Dominion Garner and Lancaster 115 kV Substations in Lancaster, Virginia, in the Dominion Virginia Power (DVP) transmission system.

The power flow scenario for the analysis was based on the RTEP 2023 summer peak case, modified to include applicable queue projects. AF1-042 has been dispatched online at maximum facility output, with approximately unity power factor at the high side of the station transformer.

AF1-042 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. For this study, 150 contingencies were simulated, each with a 20 second simulation time period. Studied faults included:

- Steady-state operation (30 second simulation)
- Three-phase faults with normal clearing time
- Single-phase bus faults
- Single-phase faults with a stuck breaker with delayed clearing time
- Single-phase faults placed at 80% of the line with delayed (Zone 2) clearing at remote line end because of primary communications/relaying failure
- Single-phase faults with loss of multiple circuit tower lines

The 150 fault contingencies tested on the 2023 summer peak case met the recovery criteria:

- The AF1-042 generator was able to ride through the faults except for faults where protective actions trip one or more generator(s).
- All generators maintained synchronism and any post-contingency oscillations are positively damped with a damping margin of at least 3%.
- All bus voltages recover to 0.7 p.u. within 2.5 seconds and the final voltages are within the steady-state voltage ranges below per DVP's transmission planning criteria.
    - P1 Category Contingencies:
        - 0.93 to 1.05 p.u. for 230, 138, 115, 69 kV facilities
        - 1.01 to 1.08 p.u. for 500 kV facilities
    - P2, P4, P5, and P7 Category Contingencies:
        - 0.90 to 1.05 p.u. for 230, 138, 115, 69 kV facilities
        - 1.00 to 1.08 p.u. for 500 kV facilities

No transmission element trips, other than those either directly connected or designated to trip as a consequence of the fault.

Based on the Impact Study Data provided, the AF1-042 queue project meets the 0.95 lagging and leading power factor requirement.

15 Affected Systems

No Affected Systems issues were identified as part of this analysis.

Attachment 1: One Line Diagram