Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AC2-094

Louisa – North Anna 230kV
66.3 MW Capacity / 99.9 MW Energy

September 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 generating facility located in Louisa County, Virginia. The installed facilities will have a total capability of 99.9 MW with 66.3 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

AC2-094 will interconnect with the ITO transmission system via a new three breaker ring bus that connects the Louisa – North Anna 230kV line.

Cost Summary

The AC2-094 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 1,800,000
Direct Connection Network Upgrades	$ 6,300,000
Non Direct Connection Network Upgrades	$ 1,000,000
Total Costs	**$ 9,100,000**

In addition, the AC2-094 project may be responsible for a contribution to the following costs:

Description	Total Cost
New System Upgrades	$ 68,120,000
Previously Identified Upgrades	$ 0
Total Costs	**$ 68,120,000**

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

System Reinforcement

Violation #	Upgrade Description	Upgrade Cost
# 1, 2	Wreck and rebuild the North Anna – Ladysmith 500kV line of 14.5 miles for a higher capacity since the overload exceeds the conductor rating. It is estimated to take 44-48 months to permit (VA CPCN required), engineer and construct.	$43,620,000
# 3	Wreck and rebuild the AC2-094 Tap - North Anna 230kV line of 10 miles for a higher capacity, since the overload exceeds the conductor rating. It is estimated to take 30-36 months to permit (VA CPCN Required), engineer and construct.	$24,500,000
	Total Network Upgrades	**$68,120,000**

Attachment Facilities

Generation Substation: Install metering and associated protection equipment. Estimated Cost $600,000.

Transmission: Construct approximately one span of 230 kV Attachment line between the generation substation and the AC2-094 interconnection substation. The estimated cost for this work is $1,200,000.

The estimated total cost of the Attachment Facilities is $1,800,000. 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 Facilities 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 230 kV AC2-094 Switching Substation (interconnection substation). The estimated cost of this work scope is $6,300,000. It is estimated to take 24-36 months to complete.

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 $1,000,000 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 Connection 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 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 AC2-094 was evaluated as a 99.9 MW (Capacity 66.2 MW) injection tapping the Louisa – North Anna 230kV line in the Dominion area. Project AC2-094 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-094 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 2088	CONTINGENCY 'LN 2088' OPEN BRANCH FROM BUS 314745 TO BUS 314758 CKT 1 /* 6LOISACT 230.00 - 6GORDNVL 230.00 OPEN BRANCH FROM BUS 314757 TO BUS 314758 CKT 2 /* 3GORDNVL 115.00 - 6GORDNVL 230.00 END
LN 568	CONTINGENCY 'LN 568' OPEN BRANCH FROM BUS 314911 TO BUS 314922 CKT 1 /* 8LDYSMTH 500.00 - 8POSSUM 500.00 END
LN 573	CONTINGENCY 'LN 573' OPEN BRANCH FROM BUS 314918 TO BUS 314934 CKT 1 /* 8NO ANNA 500.00 - 8SPOTSYL 500.00 END
LN 575	CONTINGENCY 'LN 575' OPEN BRANCH FROM BUS 314911 TO BUS 314918 CKT 1 /* 8LDYSMTH 500.00 - 8NO ANNA 500.00 END
LN 594	CONTINGENCY 'LN 594' OPEN BRANCH FROM BUS 314916 TO BUS 314934 CKT 1 /* 8MORRSVL 500.00 - 8SPOTSYL 500.00 END

Summer Peak Analysis - 2020

Generator Deliverability

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

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Ckt	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
1	N-1	LN 594	DVP - DVP	8NO ANNA-8LDYSMTH 500 kV line	314918	314911	1	DC	99.82	100.78	ER	3219	30.83	1
2	N-1	LN 573	DVP – DVP	8NO ANNA-8LDYSMTH 500 kV line	314918	314911	1	DC	99.24	100.21	ER	3219	31.02	
3	N-1	LN 2088	DVP – DVP	AC2-094 TAP-6NO ANNA 230 kV line	931710	314232	1	DC	96.12	104.54	ER	749	63.07	2

Multiple Facility Contingency

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

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)

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)

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
1,2	8NO ANNA-8LDYSMTH 500 kV line	Wreck and rebuild the line of 14.5 miles for a higher capacity since the overload exceeds the conductor rating. The estimated cost is $43,620,000 and it is estimated to 44-48 months to permit (VA CPCN Required), engineer and construct.	Pending	**$43,620,000**
3	AC2-094 TAP-6NO ANNA 230 kV line	Wreck and rebuild the line of 10 miles for a higher capacity since the overload exceeds the conductor rating. The estimated cost is $24,500,000 dollars and it is estimated to take 30-36 months to permit (VA CPCN Required), engineer and construct.	Pending	**$24,500,000**
			Total New Network Upgrades	**$68,120,000**

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 System 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		Bus			Power	Loading %		Rating		MW
	Type	Name	Area	Facility Description	From	To	Circuit	Flow	Initial	Final	Type	MVA	Contribution
4	N-1	LN 568	DVP - DVP	8MORRSVL-8LOUDOUN 500 kV line	314916	314913	1	DC	99.77	100.36	ER	2738	16.17
5	N-1	LN 594	DVP - DVP	8NO ANNA-8LDYSMTH 500 kV line	314918	314911	1	DC	106.3	107.84	ER	3219	48.66
6	N-1	LN 575	DVP - DVP	8NO ANNA-8SPOTSYL 500 kV line	314918	314934	1	DC	108.4	109.72	ER	3219	41.86
7	N-1	LN 575	DVP - DVP	8SPOTSYL-8MORRSVL 500 kV line	314934	314916	1	DC	114	115.24	ER	3219	41.6
8	N-1	LN 2088	DVP - DVP	AC2-094 TAP-6NO ANNA 230 kV line	931710	314232	1	DC	99.74	113.03	ER	749	99.54

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 #AC2-094 interconnection of a 99.9 MW Energy (63.3 MW Capacity) injection into the ITO's Transmission System at a new interconnection switching station located between the Louisa – North Anna section of Line #255, 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 – Same as PJM
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).

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 - DVP) The 8NO ANNA-8LDYSMTH 500 kV line (from bus 314918 to bus 314911 ckt 1) loads from 99.82% to 100.78% (**DC power flow**) of its emergency rating (3219 MVA) for the single line contingency outage of 'LN 594'. This project contributes approximately 30.83 MW to the thermal violation.

CONTINGENCY 'LN 594'
OPEN BRANCH FROM BUS 314916 TO BUS 314934 CKT 1 /* 8MORRSVL 500.00 - 8SPOTSYL 500.00
END

Bus Number	*Bus Name*	*Full Contribution*
315102	*1BRUNSWICKG1*	*8.73*
315103	*1BRUNSWICKG2*	*8.73*
315104	*1BRUNSWICKG3*	*8.73*
315105	*1BRUNSWICKS1*	*18.14*
315153	*1CLOVER1*	*12.48*
315154	*1CLOVER2*	*12.26*
315108	*1ELIZAR1*	*2.59*
315109	*1ELIZAR2*	*2.54*
315110	*1ELIZAR3*	*2.62*
315172	*1LOISA A*	*3.39*
315173	*1LOISA B*	*3.4*
315174	*1LOISA C*	*3.4*
315175	*1LOISA D*	*3.4*
315176	*1LOISA E*	*6.94*
315225	*1N ANNA1*	*118.45*
315226	*1N ANNA2*	*116.62*
315134	*1ROAVALA*	*21.66*
315135	*1ROAVALB*	*5.78*
315177	*1SANNAG1*	*2.07*
315179	*1SANNAG2*	*2.07*
315178	*1SANNAS1*	*1.07*
315180	*1SANNAS2*	*1.07*
314643	*3O INLET*	*0.36*
931041	*AC2-012 C OP*	*7.65*
931511	*AC2-071 C*	*1.8*
931591	*AC2-079 C OP*	*4.99*
931631	*AC2-084 C*	*6.8*
931701	*AC2-093 C*	*72.73*
931711	*AC2-094 C*	*30.83*

931781	*AC2-102 C OP*	*6.32*
931861	*AC2-113 C*	*1.83*
916191	*Z1-068 C*	*0.04*
916301	*Z1-086 C*	*53.15*
921092	*AA1-049 C*	*1.83*
LTF	*AA1-058*	*0.67*
921162	*AA1-063AC*	*6.66*
921532	*AA1-132 C*	*5.66*
921562	*AA1-135 C*	*7.09*
921572	*AA1-138 C*	*7.42*
921582	*AA1-139 C*	*11.34*
921752	*AA2-053 C*	*6.83*
921772	*AA2-059 C*	*0.9*
921862	*AA2-068 C*	*1.73*
LTF	*AA2-074*	*4.59*
921982	*AA2-088 C*	*4.99*
922192	*AA2-127*	*4.21*
922472	*AA2-169 C*	*1.76*
922512	*AA2-174 C*	*0.31*
922532	*AA2-178 C*	*7.34*
922602	*AB1-013 C*	*2.21*
923262	*AB1-132 C OP*	*11.06*
923572	*AB1-173 C OP*	*1.8*
923582	*AB1-173AC OP*	*1.8*
923801	*AB2-015 C OP*	*6.59*
923831	*AB2-022 C*	*1.74*
923851	*AB2-025 C*	*2.*
923861	*AB2-026 C*	*2.38*
923911	*AB2-031 C OP*	*1.79*
923981	*AB2-039 C OP*	*6.07*
923991	*AB2-040 C OP*	*5.87*
924021	*AB2-043 C OP*	*2.46*
924031	*AB2-045 C*	*1.83*
924071	*AB2-051 C OP*	*102.98*
924161	*AB2-060 C OP*	*7.2*
924301	*AB2-077 C OP*	*1.56*
924311	*AB2-078 C OP*	*1.56*
924321	*AB2-079 C OP*	*1.56*
924381	*AB2-087 C*	*0.44*
924401	*AB2-089 C*	*1.68*
924411	*AB2-090 C*	*3.09*
924501	*AB2-099 C*	*0.45*
924511	*AB2-100 C*	*9.07*
924761	*AB2-128 C*	*7.77*
924931	*AB2-147 C*	*2.06*

924941	*AB2-149 C OP*	*2.49*
924951	*AB2-150 C OP*	*2.06*
925021	*AB2-158 C*	*20.83*
925061	*AB2-161 C OP*	*2.45*
925121	*AB2-169 C OP*	*4.97*
925141	*AB2-171 C OP*	*3.75*
925171	*AB2-174 C OP*	*5.64*
925221	*AB2-176 C*	*1.27*
925281	*AB2-186 C*	*0.47*
925291	*AB2-188 C OP*	*1.81*
925521	*AC1-027 C*	*1.51*
925611	*AC1-036 C*	*0.75*
925691	*AC1-045 C*	*1.25*
925701	*AC1-046 C*	*1.31*
925711	*AC1-047 C*	*1.74*
925781	*AC1-054 C OP*	*5.68*
925831	*AC1-062*	*0.26*
926001	*AC1-076 C*	*6.6*
926071	*AC1-086 C*	*16.29*
926201	*AC1-098 C*	*4.77*
926211	*AC1-099 C*	*1.6*
926271	*AC1-105 C OP*	*4.36*
926481	*AC1-120 C OP*	*6.84*
926501	*AC1-121 C OP*	*2.35*
926661	*AC1-147 C*	*1.69*
926731	*AC1-158 C*	*225.5*
926741	*AC1-159 C*	*102.19*
926751	*AC1-161 C OP*	*22.91*
926761	*AC1-162 C*	*24.21*
926771	*AC1-163 C*	*1.63*
927051	*AC1-193 C*	*2.75*
927141	*AC1-208 C*	*6.99*
927211	*AC1-215 C*	*9.01*

Appendix 2

(DVP - DVP) The AC2-094 TAP-6NO ANNA 230 kV line (from bus 931710 to bus 314232 ckt 1) loads from 96.12% to 104.54% (**DC power flow**) of its emergency rating (749 MVA) for the single line contingency outage of 'LN 2088'. This project contributes approximately 63.07 MW to the thermal violation.

CONTINGENCY 'LN 2088'
OPEN BRANCH FROM BUS 314745 TO BUS 314758 CKT 1 /* 6LOISACT 230.00 - 6GORDNVL 230.00
OPEN BRANCH FROM BUS 314757 TO BUS 314758 CKT 2 /* 3GORDNVL 115.00 - 6GORDNVL 230.00
END

Bus Number	*Bus Name*	*Full Contribution*
315172	*1LOISA A*	*13.51*
315173	*1LOISA B*	*13.58*
315174	*1LOISA C*	*13.58*
315175	*1LOISA D*	*13.58*
315176	*1LOISA E*	*27.69*
315177	*1SANNAG1*	*7.86*
315179	*1SANNAG2*	*7.86*
315178	*1SANNAS1*	*4.04*
315180	*1SANNAS2*	*4.04*
931711	*AC2-094 C*	*63.07*
925021	*AB2-158 C*	*60.78*