Generation Interconnection
System Impact Study Report

For

PJM Generation Interconnection Request
Queue Position AB2-068

Chickahominy 500kV
1060 MW Capacity / 1060 MW Energy

June / 2017

Introduction

This System Impact Study (SIS) has been prepared in accordance with the PJM Open Access Transmission Tariff, Section 205, as well as the System Impact Study Agreement between C4GT LLC, 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 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 IC. As a requirement for interconnection, the IC 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 IC 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 IC 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.

General

The IC has proposed a natural gas combined cycle generating facility located in Charles City, VA. The installed facilities will have a total capability of 1060 MW with 1060 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is June 30, 2020. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AB2-068 will interconnect with the ITO transmission system via an expansion of the Chickahominy 500kV substation.

Cost Summary

The AB2-068 interconnection request will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$4,200,000
Direct Connection Network Upgrades	$6,500,000
Non Direct Connection Network Upgrades	$0
Allocation for New System Upgrades	$ 420,227.99
Contribution for Previously Identified Upgrades	$0
Total Costs	**$11,120,227.99**

Attachment Facilities

Generation Substation: Install metering and associated Protection Equipment. Estimated Cost $700,000.

Transmission: Construct approximately one span of 500 kV Attachment line between the generation substation and the existing Chickahominy 500 kV Switching Substation. The estimated cost for this work is $3,500,000.

The estimated total cost of the Attachment Facilities is $4,200,000. It is estimated to take 24-30 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. These costs do not include CIAC Tax Gross-up. The single line is shown below in Attachment 1.

Non-Direct Connection Cost Estimate

Substation: To reliably interconnect the proposed generation with the Dominion Transmission System, it will be necessary to add three new breakers to the existing 500kV bus at Chickahominy Switching Substation. The estimated cost of this work is $6,500,000. This substation may also need to be expanded to accommodate the additional equipment and additional land and permitting may be required. It is estimated to take 30-36 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.

New System Reinforcements

PJM OATT 217.3 outlines cost responsibility for Network Upgrades and as the minimum amount of Network Upgrades required to resolve a single reliability criteria violation will not meet or exceed $5,000,000 such costs shall be allocated to those Interconnection Requests in the New Services Queue that contribute to the need for such upgrades. Such allocations shall be made in proportion to each Interconnection Request's megawatt contribution to the need for these upgrades subject to the rules for minimum cost allocation thresholds in the PJM Manuals. For the purpose of applying the $5,000,000 threshold, each reliability criteria violation shall be considered separately.

Reinforcement: In order to mitigate the Elmont-Ladysmith 500 kV line overload. Replace the wave trap to accommodate the proposed generation interconnection project. This work is

estimated to take 20-24 months to complete based on typical permitting parameters and is estimated to cost $700,000.

Queue	MW contribution	Percentage of Cost	Cost($0.70M)	Contingency Name	Contingency Type
AB2-051	241.35	34.78%	$243,475.19	LN 576'	single
AB2-068	416.56	60.03%	$420,227.99	LN 576'	single
AB2-190	35.98	5.19%	$36,296.82	LN 576'	single

Interconnection Customer Requirements

ITO's Facility Interconnection 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.

Revenue Metering and SCADA Requirements

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 Sections 24.1 and 24.2.

Interconnected Transmission Owner Requirements

Metering and SCADA/Communication equipment must meet the requirements outlined in section 3.1.6 Metering and Telecommunications of ITO's Facility Connection Requirement NERC Standard FAC-001 which is publically available at www.dom.com.

Network Impacts

The Queue Project AB2-068 was evaluated as a 1060.0 MW (Capacity 1060.0 MW) injection at the Chickahominy 500kV in the ITO area. Project AB2-068 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB2-068 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
LN 576	CONTINGENCY 'LN 576' OPEN BRANCH FROM BUS 314322 TO BUS 314914 CKT 1 /* 6MDLTHAN 230.00 - 8MDLTHAN 500.00 OPEN BRANCH FROM BUS 314914 TO BUS 314918 CKT 1 /* 8MDLTHAN 500.00 - 8NO ANNA 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	Cir.	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
1	N-1	LN 576	DVP - DVP	8ELMONT-8LDYSMTH 500 kV line	314908	314911	1	AC	86.46	103.34	ER	2442	416.56	1

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)

None

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

No mitigations

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this interconnection request)

<table>
<tr><th>Violation #</th><th>Overloaded Facility</th><th>Upgrade Description</th><th>Network Upgrade Number</th><th>Upgrade Cost</th><th>AB2-068 Allocation</th></tr>
<tr><td># 1</td><td>8ELMONT-8LDYSMTH 500 kV line</td><td>Replace the wave trap to accommodate the proposed generation interconnection project. This work is estimated to take 20-24 months to complete based on typical permitting
<table>
<tr><th>Queue</th><th>Impact (MW)</th><th>Cost</th></tr>
<tr><td>AB2-051</td><td>241.35</td><td>$243,475.19</td></tr>
<tr><td>AB2-068</td><td>416.56</td><td>$420,227.99</td></tr>
<tr><td>AB2-190</td><td>35.98</td><td>$36,296.82</td></tr>
</table></td><td>Pending</td><td>$700,000</td><td>$420,227.99</td></tr>
<tr><td colspan="4"></td><td>Total New Network Upgrades</td><td>$420,227.99</td></tr>
</table>

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 is calculated and reported for in 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 interconnection request by addressing 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.

None

Light Load Analysis in 2020

None

ITO Analysis

ITO assessed the impact of the proposed Queue Project #AB2-068 interconnection of 1060 MW of energy (Capacity 1060 MW) for compliance with 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 and multiple facility 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 interconnection request 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 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 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):

- System Normal – Same as PJM Analysis
- Critical System Condition (No Front Royal 500 kV Unit) – Same as PJM Analysis.

Category C Analysis: (Multiple Facility Contingency)

- Bus Fault - No deficiencies identified
- Line Stuck Breaker - No deficiencies identified
- Tower Line – No deficiencies identified

As part of its generation impact analysis ITO routinely evaluates the impact that a proposed new generation resource (greater than 20 MW) will have under maximum generation conditions, stress system conditions and import/export system conditions. The results of these studies are discussed in Table A and B below.

Table A: Import Study Results

Import Study Results			
Area	Summer 2020	Summer 2020 with AB2-068	Limiting Element
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

Table B: Export Study Results

Export Study Results

Area	Summer 2020	Summer 2020 with AB2-068	Limiting Element
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

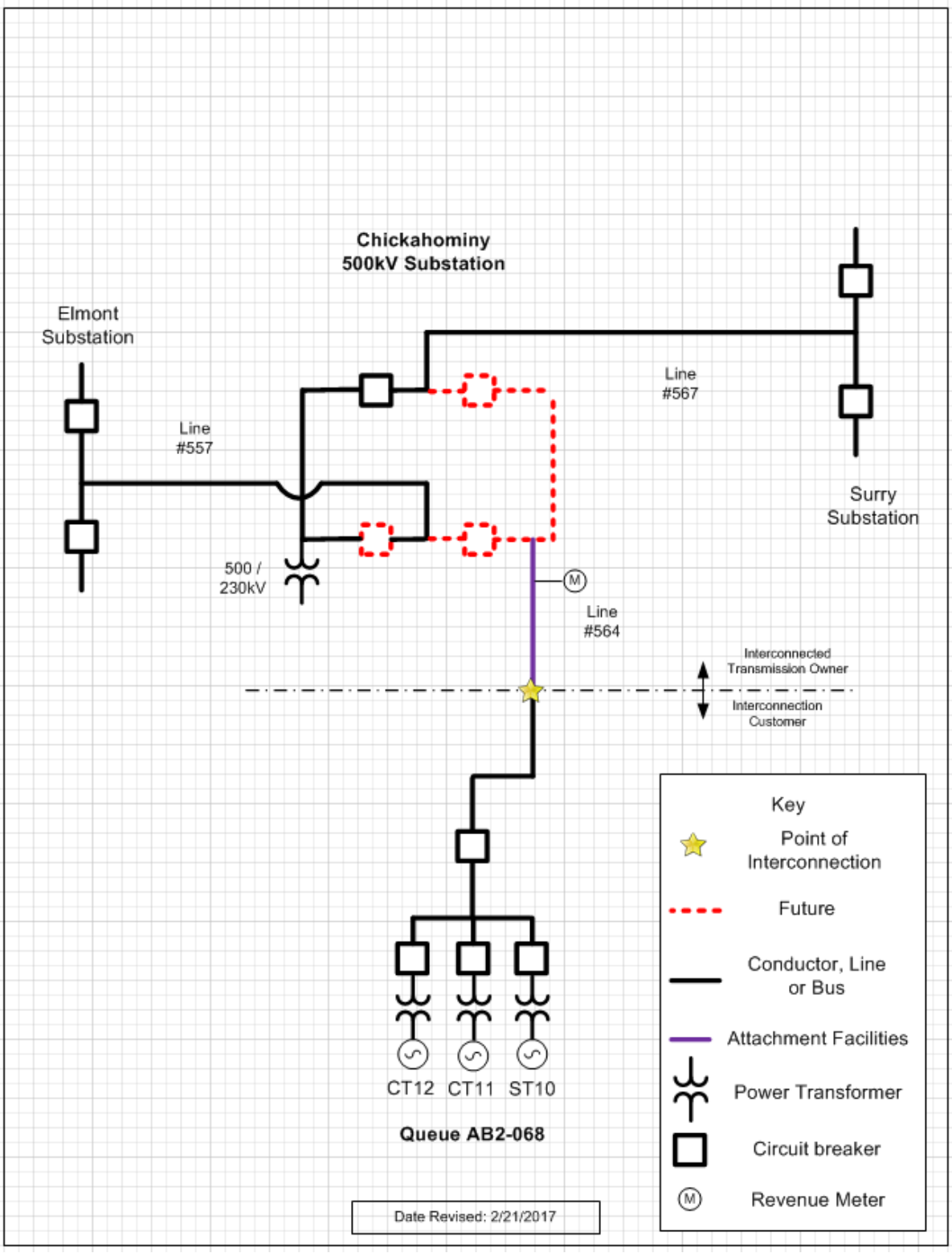
ITO's Planning Criteria indicates a need to have approximately 2000 MW of import and export capability. The results of these import and export studies indicate that the proposed AB2-068 (Transfer) will not impact ITO's import or export capability

Affected System Analysis & Mitigation

Duke Energy:

Attachment 1.

System Configuration



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 8ELMONT-8LDYSMTH 500 kV line (from bus 314908 to bus 314911 ckt 1) loads from 86.46% to 103.34% (AC power flow) of its emergency rating (2442 MVA) for the single line contingency outage of 'LN 576'. This project contributes approximately 416.56 MW to the thermal violation.

CONTINGENCY 'LN 576'
 OPEN BRANCH FROM BUS 314322 TO BUS 314914 CKT 1 /* 6MDLTHAN 230.00 - 8MDLTHAN 500.00
 OPEN BRANCH FROM BUS 314914 TO BUS 314918 CKT 1 /* 8MDLTHAN 500.00 - 8NO ANNA 500.00
 END

Bus Number	Bus Name	Full Contribution
315058	1CHESTF3	6.7
315059	1CHESTF4	10.85
315060	1CHESTF5	23.01
315061	1CHESTG7	9.02
315063	1CHESTG8	8.94
315062	1CHESTS7	4.1
315064	1CHESTS8	4.58
315067	1DARBY 1	5.88
315068	1DARBY 2	5.88
315069	1DARBY 3	5.96
315070	1DARBY 4	5.96
315233	1SURRY 2	58.46
315091	1YORKTN2	53.69
315092	1YORKTN3	52.8
314309	6IRON208	0.88
314236	6NRTHEST	0.42
314251	6S PUMP	1.79
297087	V2-040	0.28
902241	W2-022 C OP1	2.57
LTF	Z2-067	28.75
921092	AA1-049 C	4.22
LTF	AA1-058	1.25
921172	AA1-064 C	13.27
921532	AA1-132 C	13.04
921542	AA1-133 C	17.45
921552	AA1-134 C	17.02
921562	AA1-135 C	14.68
921572	AA1-138 C	16.68

921752	AA2-053 C	13.8
921762	AA2-057 C	10.83
921772	AA2-059 C	4.03
921862	AA2-068 C	3.44
LTF	AA2-074	8.44
921982	AA2-088 C	10.62
922442	AA2-165 C	1.48
922472	AA2-169 C	3.33
922512	AA2-174 C	0.63
922522	AA2-177 C	17.99
922532	AA2-178 C	16.09
922602	AB1-013 C	4.86
922682	AB1-027 C	4.79
922722	AB1-053 C	1.67
922922	AB1-081 C OP	13.26
923262	AB1-132 C OP	22.23
923272	AB1-135 C OP	4.79
923572	AB1-173 C OP	3.57
923582	AB1-173AC OP	3.57
923801	AB2-015 C OP	14.44
923831	AB2-022 C	3.99
923841	AB2-024 C	4.41
923851	AB2-025 C	4.02
923861	AB2-026 C	3.55
923911	AB2-031 C OP	3.55
923941	AB2-035 C	0.51
923981	AB2-039 C OP	14.69
923991	AB2-040 C OP	11.64
924061	AB2-050	4.83
924071	AB2-051 C OP	241.35
924151	AB2-059 C	15.62
924241	AB2-068 OP	416.56
LTF	AB2-075	4.54
LTF	AB2-076	5.35
924381	AB2-087 C	0.92
924391	AB2-088 C	0.65
924401	AB2-089 C	3.11
924491	AB2-098 C	0.88
924501	AB2-099 C	0.95
924511	AB2-100 C	18.54
924761	AB2-128 C	15.89
924811	AB2-134 C OP	23.09
924931	AB2-147 C	4.05
924941	AB2-149 C OP	5.87
924951	AB2-150 C OP	4.05

925051	AB2-160 C OP	9.59
925061	AB2-161 C OP	5.94
925141	AB2-171 C OP	8.13
925171	AB2-174 C OP	11.16
925281	AB2-186 C	1.03
925291	AB2-188 C OP	3.97
925331	AB2-190 C	35.99