Generation Interconnection
System Impact Study Report

For

PJM Generation Interconnection Request
Queue Position AC1-054

Eatons Ferry – Kerr Dam 115kV
44.5MW Capacity / 65MW Energy

Revised April / 2019

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 Hawtree Creek Farm Solar, 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 solar generating facility located in Macon, NC (Warren County). The installed facilities will have a total capability of 65 MW with 44.5 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 7/31/2018. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AC1-054 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects onto the Kerr Dam – Eatons Ferry – Carolina 115kV line #22.

Cost Summary

The AC1-054 interconnection request will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 1,150,000
Direct Connection Network Upgrades	$ 5,500,000
Non Direct Connection Network Upgrades	$ 1,200,000
Allocation for New System Upgrades	$ 13,485
Contribution for Previously Identified Upgrades	$ 0
Total Costs	**$ 7,863,485**

Attachment Facilities

Generation Substation: Install metering and associated protection equipment. Estimated Cost $450,000.

Transmission: Build approximately 0.5 miles of 115 kV Line. Estimated Cost $700,000.

The estimated total cost of the Attachment Facilities is $1,150,000. It is estimated to take 12-14 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.

Direct Connection Cost Estimate

Substation: Build a new three breaker 115 kV AC1-054 Switching Station and associated facilities on Line #22 between Kerr Dam and Eatons Ferry Substation(s). The estimated cost of this work scope is $5,500,000. It is estimated to take 24-36 months to complete this work.

Non-Direct Connection Cost Estimate

Transmission: Re-arrange Line #22 to interconnect with the new 115 kV AC1-054 Switching Station. The estimated cost of this work is $1,200,000 dollars.

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: Line #259 Chesterfield – Basin 230 kV: Reconductor 0.14 miles of 1109 ACAR with a conductor which will increase the line rating to approximately 706 MVA (normal), 706 MVA (emergency), and 812 MVA (load dump). It was estimated to cost $350,000 and **was placed in service on 4/27/2018**.

Reinforcement: Line #238 Clubhouse to Sapony 230 kV: Replace wave trap at Clubhouse Substation. This will increase emergency rating to 722 MVA. Estimated cost $150,000 and it is estimated to 12-16 months to engineer and construct.

Queue	MW contribution	Percentage of Cost	Cost ($150,000)	Contingency Name	Contingency Type
AC1-034	13.17	**8.51%**	**$12,758.33**	'LN 54-2012_B'	tower
AC1-054	13.92	**8.99%**	**$13,484.89**	'LN 54-2012_B'	tower
AC1-086	74.33	**48.00%**	**$72,006.59**	'LN 54-2012_B'	tower
AC1-099	15.28	**9.87%**	**$14,802.38**	'LN 54-2012_B'	tower
AC1-189	16.14	**10.42%**	**$15,635.49**	246T2034_A'	breaker
AC1-208	22	**14.21%**	**$21,312.32**	246T2034_A	breaker

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

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.

Meteorological Data Reporting Requirement - The solar generation facility shall, at a minimum, be required to provide the Transmission Provider with site-specific meteorological data including:

- Temperature (degrees Fahrenheit)
- Atmospheric pressure (hectopascals)
- Irradiance
- Forced outage data

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 AC1-054 was evaluated as a 65.0 MW (Capacity 44.5 MW) injection at the Kerr-Eaton 115kV line substation in the ITO area. Project AC1-054 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC1-054 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
246T2034_A	CONTINGENCY '246T2034_A' /* EARLEYS OPEN BRANCH FROM BUS 314569 TO BUS 314575 CKT 1 /* 246 OPEN BRANCH FROM BUS 314575 TO BUS 921571 CKT 1 /* 246 AA1-138 TAP OPEN BRANCH FROM BUS 314575 TO BUS 314590 CKT 1 /* 246 - NUCOR OPEN BRANCH FROM BUS 314569 TO BUS 314620 CKT 1 /* 2034 OPEN BRANCH FROM BUS 314620 TO BUS 314616 CKT 1 /* 2034 OPEN BRANCH FROM BUS 314616 TO BUS 314613 CKT 1 /* TROWBRIDGE TX #1&2 END
3CAROLNA-6CAROLNA	CONTINGENCY '3CAROLNA-6CAROLNA' OPEN BRANCH FROM BUS 314559 TO BUS 314561 CKT 1 END
562T563	CONTINGENCY '562T563' /*CARSON OPEN BRANCH FROM BUS 314902 TO BUS 314923 CKT 1 /*CARSON TO MIDLOTHIAN OPEN BRANCH FROM BUS 314914 TO BUS 314902 CKT 1 /*CARSON 500.00 - 8SEPTA 500.00 END
LN 2012	CONTINGENCY 'LN 2012' OPEN BRANCH FROM BUS 314266 TO BUS 314569 CKT 1 /* 6NORTHAMPTON230.00 - 6EARLEYS 230.00 OPEN BRANCH FROM BUS 314266 TO BUS 314599 CKT 1 /* 6NORTHAMPTON230.00 - 6ROA VAL 230.00 OPEN BUS 314266 /* ISLAND END
LN 2131A	CONTINGENCY 'LN 2131A' OPEN BRANCH FROM BUS 314662 TO BUS 916040 CKT 1 /* 6S HERTFORD 230.00 - Z1-036 TAP 230.00 OPEN BRANCH FROM BUS 314651 TO BUS 314662 CKT 1 /* 6WINFALL 230.00 - 6S HERTFORD 230.00 OPEN BUS 314662 /* ISLAND END

LN 238	CONTINGENCY 'LN 238' OPEN BRANCH FROM BUS 314282 TO BUS 314435 CKT 1 /* 6CARSON 230.00 - 6SAPONY 230.00 OPEN BRANCH FROM BUS 314435 TO BUS 314563 CKT 1 /* 6SAPONY 230.00 - 6CLUBHSE 230.00 OPEN BRANCH FROM BUS 314562 TO BUS 314563 CKT 1 /* 3CLUBHSE 115.00 - 6CLUBHSE 230.00 OPEN BUS 314435 /* ISLAND END
LN 254_A	CONTINGENCY 'LN 254_A' OPEN BRANCH FROM BUS 314563 TO BUS 924510 CKT 1 /* 6CLUBHSE 230.00 - AB2-100 TAP 230.00 END
LN 54-2012_B	CONTINGENCY 'LN 54-2012_B' OPEN BRANCH FROM BUS 921751 TO BUS 314581 CKT 1 /* AA2-053 TAP 115.00 - 3JACKSON 115.00 OPEN BRANCH FROM BUS 314568 TO BUS 314625 CKT 1 /* 3EARLEYS 115.00 - 3AULANDR 115.00 OPEN BRANCH FROM BUS 314581 TO BUS 314626 CKT 1 /* 3JACKSON 115.00 - 3WOODLND 115.00 OPEN BRANCH FROM BUS 314625 TO BUS 314626 CKT 1 /* 3AULANDR 115.00 - 3WOODLND 115.00 OPEN BUS 314581 /* ISLAND OPEN BUS 314625 /* ISLAND OPEN BUS 314626 /* ISLAND OPEN BRANCH FROM BUS 314266 TO BUS 314569 CKT 1 /* 6NORTHAMPTON230.00 - 6EARLEYS 230.00 OPEN BRANCH FROM BUS 314266 TO BUS 314599 CKT 1 /* 6NORTHAMPTON230.00 - 6ROA VAL 230.00 OPEN BUS 314266 /* ISLAND END
LN 563	CONTINGENCY 'LN 563' OPEN BRANCH FROM BUS 314902 TO BUS 314914 CKT 1 /* 8CARSON 500.00 - 8MDLTHAN 500.00 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).

Overload Number	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	Flowgate Appendix
1	LFFB	562T563	DVP - DVP	6CHSTF B-6BASIN 230 kV line	314287	314276	1	AC	99.42	100.06	LD	549	4.11	1
2	LFFB	246T2034_A	DVP - DVP	6CLUBHSE-6SAPONY 230 kV line	314563	314435	1	AC	81.12	83.35	LD	637	14.24	2
3	DCTL	LN 54-2012_B	DVP - DVP	6CLUBHSE-6SAPONY 230 kV line	314563	314435	1	AC	81.45	83.65	LD	637	13.92	

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 were found to be required.

New System Reinforcements

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

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AC1-054 Allocation
# 1	Line #259 Chesterfield – Basin 230 kV	Reconductor 0.14 miles of 1109 ACAR with a conductor which will increase the line rating to approximately 706 MVA (normal), 706 MVA (emergency), and 812 MVA (load dump). It was estimated to cost $350,000 and **was placed in service on 4/27/2018**.	b2990	$350,000	**0**

<table>
<tr><th>Violation #</th><th>Overloaded Facility</th><th>Upgrade Description</th><th>Network Upgrade Number</th><th>Upgrade Cost</th><th>AC1-054 Allocation</th></tr>
<tr><td># 2, 3</td><td>6CLUBHSE-6SAPONY 230 kV line</td><td>Replace wave trap at Clubhouse Substation. This will increase emergency rating to 722 MVA. Estimated time 12-16 months to engineer and construct.
<table><tr><th>Queue</th><th>Impact (MW)</th><th>Cost</th></tr><tr><td>AC1-034</td><td>13.17</td><td>$12,758</td></tr><tr><td>AC1-054</td><td>13.92</td><td>$13,485</td></tr><tr><td>AC1-086</td><td>74.33</td><td>$72,007</td></tr><tr><td>AC1-099</td><td>15.28</td><td>$14,802</td></tr><tr><td>AC1-189</td><td>16.14</td><td>$15,635</td></tr><tr><td>AC1-208</td><td>22.0</td><td>$21,312</td></tr></table></td><td>n6051</td><td>$150,000</td><td>$13,485</td></tr>
<tr><td colspan="5">Total New Network Upgrades</td><td>$13,485</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.

Overload Number	Type	Contingency Name	Affected Area	Facility Description	Bus		Ckt	Power Flow	Loading %		Rating		MW Contribution
					From	To			Initial	Final	Type	MVA	
4	N-1	LN 254_A	DVP - DVP	6CLUBHSE 230/115 kV transformer	314562	314563	1	AC	102.2	106.28	ER	183	8.36
5	N-1	LN 2012	DVP - DVP	6CLUBHSE-6SAPONY 230 kV line	314563	314435	1	AC	81.38	83.58	ER	599	13.12
6	N-1	LN 2131A	DVP - DVP	6EARLEYS-6NUCO TP 230 kV line	314569	314575	1	AC	84.78	85.94	ER	572	7.77
7	N-1	3CAROLNA-6CAROLNA	DVP - DVP	3COX DP-3WITAKRS 115 kV line	314577	314623	1	AC	64.03	67.59	ER	134	5.69
8	N-1	LN 2012	DVP - DVP	6HORNRTN-6HATHAWAY 230 kV line	314579	313845	1	AC	89.28	90.46	ER	442	6.26
9	N-1	LN 2012	DVP - DVP	6LAKEVEW-AB2-100 TAP 230 kV line	314583	924510	1	AC	93.74	95.13	ER	375	6.3
10	N-1	LN 238	DVP - DVP	6ROA VAL-6NORTHAMPTON 230 kV line	314599	314266	1	AC	88.22	89.65	ER	548	7.78
11	N-1	3CAROLNA-6CAROLNA	DVP - DVP	3WITAKRS-3BTLEBRO 115 kV line	314623	314554	1	AC	62.52	66.1	ER	134	5.68
12	N-1	LN 563	DVP - DVP	8ELMONT-8LDYSMTH 500 kV line	314908	314911	1	AC	99.89	100.33	ER	2442	12.56
13	N-1	LN 2012	DVP - DVP	AB2-100 TAP-6CLUBHSE 230 kV line	924510	314563	1	AC	110.3	111.7	ER	375	6.3

Light Load Analysis in 2020

Not required

ITO Analysis

ITO assessed the impact of the proposed Queue Project #AC1-054 interconnection of 65 MW of energy (Capacity 44.5 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 – No deficiencies identified
- Critical System Condition (No Surry 230 kV Unit) OR (Possum Point Unit #6 (230kV Unit) – No deficiencies identified.

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 AC1-054	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 AC1-054	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 AC1-054 (Transfer) will not impact ITO's import or export capability

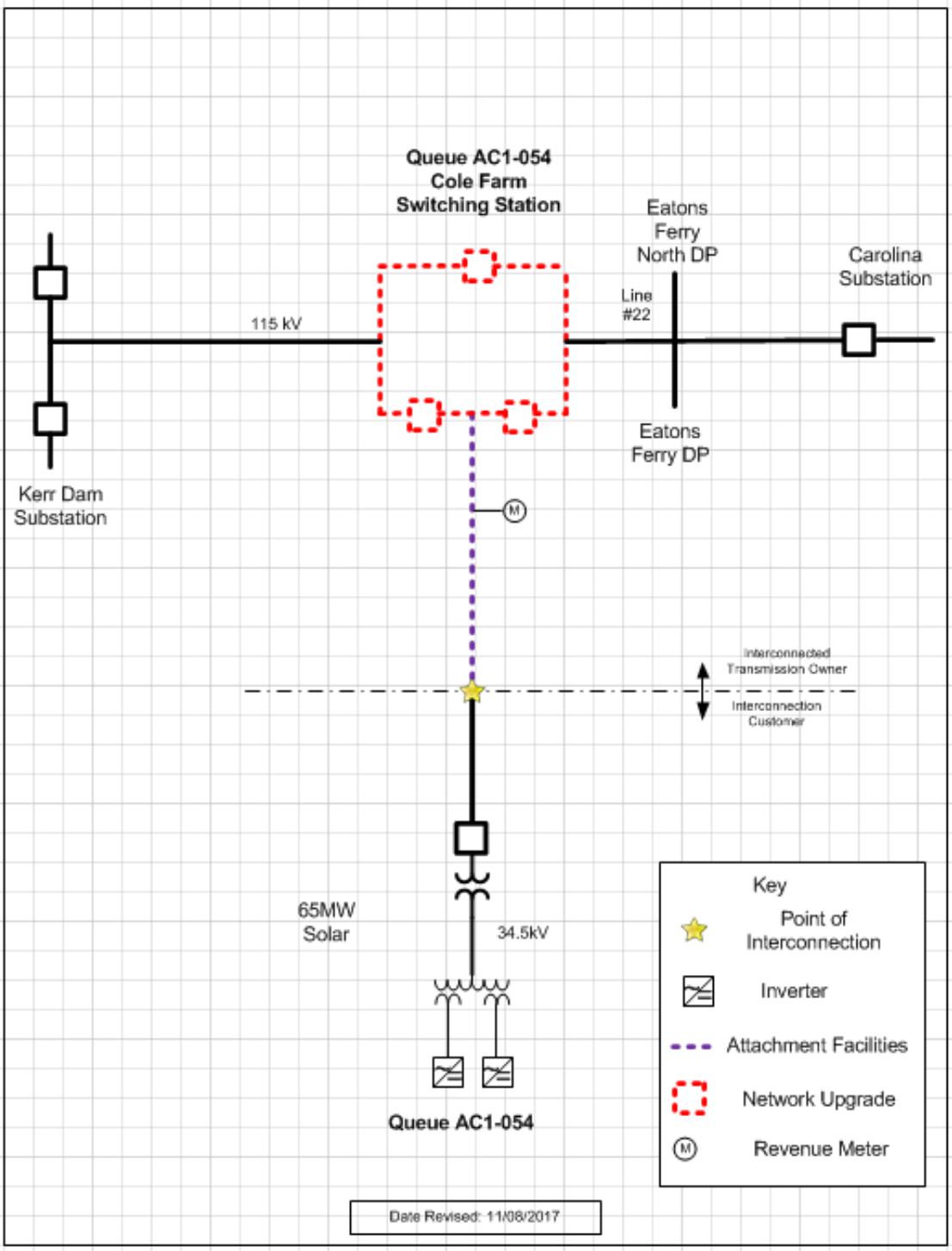
Affected System Analysis & Mitigation

Duke Energy:

None

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 6CHSTF B-6BASIN 230 kV line (from bus 314287 to bus 314276 ckt 1) loads from 99.42% to 100.06% (AC power flow) of its load dump rating (549 MVA) for the line fault with failed breaker contingency outage of '562T563'. This project contributes approximately 4.11 MW to the thermal violation.

CONTINGENCY '562T563' /*CARSON
OPEN BRANCH FROM BUS 314902 TO BUS 314923 CKT 1 /*CARSON TO MIDLOTHIAN
OPEN BRANCH FROM BUS 314914 TO BUS 314902 CKT 1 /*CARSON 500.00 - 8SEPTA 500.00
END

Bus Number	*Bus Name*	*Full Contribution*
315065	*1CHESTF6*	*34.34*
315077	*1HOPHCF1*	*1.82*
315078	*1HOPHCF2*	*1.82*
315079	*1HOPHCF3*	*1.82*
315080	*1HOPHCF4*	*2.76*
315076	*1HOPPOLC*	*1.56*
315073	*1STONECA*	*5.23*
314784	*1WEYRHSB*	*0.81*
314539	*3UNCAMP*	*0.97*
314541	*3WATKINS*	*0.28*
315074	*CIR_AB2-152*	*7.35*
315075	*CIR_AB2-152*	*0.63*
292791	*U1-032 E*	*2.72*
900672	*V4-068 E*	*0.13*
901082	*W1-029E*	*15.86*
907092	*X1-038 E*	*2.43*
913392	*Y1-086 E*	*0.74*
914231	*Y2-077*	*0.73*

916042	*Z1-036 E*	*16.15*
916192	*Z1-068 E*	*0.61*
916302	*Z1-086 E*	*3.97*
917122	*Z2-027 E*	*0.36*
917332	*Z2-043 E*	*0.42*
917342	*Z2-044 E*	*0.24*
917512	*Z2-088 E OP1*	*3.19*
921162	*AA1-063AC*	*3.94*
921163	*AA1-063AE*	*1.86*
918512	*AA1-065 E OP*	*1.82*
921183	*AA1-067 E*	*0.29*
918562	*AA1-072 E*	*0.07*
921583	*AA1-139 E*	*2.08*
921752	*AA2-053 C*	*4.01*
921753	*AA2-053 E*	*1.72*
921762	*AA2-057 C*	*3.02*
921763	*AA2-057 E*	*1.51*
921982	*AA2-088 C*	*2.88*
921983	*AA2-088 E*	*4.7*
922442	*AA2-165 C*	*0.41*
922443	*AA2-165 E*	*0.2*
922512	*AA2-174 C*	*0.18*
922513	*AA2-174 E*	*0.2*
922532	*AA2-178 C*	*3.57*
922533	*AA2-178 E*	*1.53*
922922	*AB1-081 C OP*	*3.65*

922923	*AB1-081 E OP*	*1.56*
923262	*AB1-132 C OP*	*7.24*
923263	*AB1-132 E OP*	*3.1*
923572	*AB1-173 C OP*	*1.19*
923573	*AB1-173 E OP*	*0.56*
923582	*AB1-173AC OP*	*1.19*
923583	*AB1-173AE OP*	*0.56*
923801	*AB2-015 C OP*	*3.47*
923802	*AB2-015 E OP*	*2.84*
923831	*AB2-022 C*	*0.77*
923832	*AB2-022 E*	*0.41*
923851	*AB2-025 C*	*1.86*
923852	*AB2-025 E*	*0.84*
923911	*AB2-031 C OP*	*1.18*
923912	*AB2-031 E OP*	*0.58*
923991	*AB2-040 C OP*	*3.88*
923992	*AB2-040 E OP*	*3.17*
924151	*AB2-059 C*	*4.3*
924152	*AB2-059 E*	*2.21*
924401	*AB2-089 C*	*0.81*
924402	*AB2-089 E*	*0.42*
924491	*AB2-098 C*	*0.22*
924492	*AB2-098 E*	*0.1*
924501	*AB2-099 C*	*0.25*
924502	*AB2-099 E*	*0.11*
924511	*AB2-100 C*	*7.29*

924512	*AB2-100 E*	*3.59*
924811	*AB2-134 C OP*	*7.75*
924812	*AB2-134 E OP*	*7.62*
925051	*AB2-160 C OP*	*3.89*
925052	*AB2-160 E OP*	*6.35*
925061	*AB2-161 C OP*	*2.1*
925062	*AB2-161 E OP*	*3.43*
925122	*AB2-169 E*	*2.25*
925171	*AB2-174 C O1*	*3.79*
925172	*AB2-174 E O1*	*3.43*
925281	*AB2-186 C*	*0.22*
925282	*AB2-186 E*	*0.09*
925331	*AB2-190 C*	*11.61*
925332	*AB2-190 E*	*4.97*
926261	*AC1-027 C*	*0.65*
926262	*AC1-027 E*	*0.37*
926331	*AC1-034 C*	*2.78*
926332	*AC1-034 E*	*2.1*
926531	*AC1-054 C OP*	*2.81*
926532	*AC1-054 E OP*	*1.29*
926601	*AC1-061*	*0.03*
926851	*AC1-086 C*	*10.67*
926852	*AC1-086 E*	*4.85*
926981	*AC1-099 C*	*3.54*
926982	*AC1-099 E*	*2.1*
927561	*AC1-147 C*	*0.74*

927562	*AC1-147 E*	*0.43*
927991	*AC1-189 C*	*3.42*
927992	*AC1-189 E*	*1.7*
928191	*AC1-208 C O1*	*3.96*
928192	*AC1-208 E O1*	*1.76*
928271	*AC1-216 C OP*	*5.91*
928272	*AC1-216 E OP*	*4.65*

Appendix 2

(DVP - DVP) The 6CLUBHSE-6SAPONY 230 kV line (from bus 314563 to bus 314435 ckt 1) loads from 81.12% to 83.35% (AC power flow) of its load dump rating (637 MVA) for the line fault with failed breaker contingency outage of '246T2034_A'. This project contributes approximately 14.24 MW to the thermal violation.

```
CONTINGENCY '246T2034_A'                                    /* EARLEYS
  OPEN BRANCH FROM BUS 314569 TO BUS 314575 CKT 1           /* 246
  OPEN BRANCH FROM BUS 314575 TO BUS 921571 CKT 1           /* 246 AA1-138
TAP
  OPEN BRANCH FROM BUS 314575 TO BUS 314590 CKT 1           /* 246 - NUCOR
  OPEN BRANCH FROM BUS 314569 TO BUS 314620 CKT 1           /* 2034
  OPEN BRANCH FROM BUS 314620 TO BUS 314616 CKT 1           /* 2034
  OPEN BRANCH FROM BUS 314616 TO BUS 314613 CKT 1           /* TROWBRIDGE
TX #1&2
  END
```

Bus Number	*Bus Name*	*Full Contribution*
315132	*1EDGECMB*	*2.2*
315139	*1GASTONA*	*7.72*
315141	*1GASTONB*	*7.72*
315126	*1ROARAP2*	*2.99*
315128	*1ROARAP4*	*2.87*
315134	*1ROAVALA*	*11.05*
315135	*1ROAVALB*	*2.95*
315136	*1ROSEMG1*	*5.22*
315138	*1ROSEMG2*	*2.44*
315137	*1ROSEMS1*	*3.24*
314704	*3LAWRENC*	*0.81*
900671	*V4-068 C*	*0.18*
900672	*V4-068 E*	*0.55*
917331	*Z2-043 C*	*0.71*

917332	*Z2-043 E*	*1.7*
917341	*Z2-044 C*	*0.34*
917342	*Z2-044 E*	*0.82*
917512	*Z2-088 E OP1*	*10.1*
921162	*AA1-063AC*	*16.77*
921163	*AA1-063AE*	*7.91*
918511	*AA1-065 C OP*	*2.73*
918512	*AA1-065 E OP*	*7.51*
921183	*AA1-067 E*	*0.9*
918561	*AA1-072 C*	*0.11*
918562	*AA1-072 E*	*0.28*
921752	*AA2-053 C*	*17.03*
921753	*AA2-053 E*	*7.31*
921762	*AA2-057 C*	*10.91*
921763	*AA2-057 E*	*5.45*
921982	*AA2-088 C*	*12.17*
921983	*AA2-088 E*	*19.86*
922442	*AA2-165 C*	*1.49*
922443	*AA2-165 E*	*0.72*
922512	*AA2-174 C*	*0.78*
922513	*AA2-174 E*	*0.85*
922922	*AB1-081 C OP*	*11.81*
922923	*AB1-081 E OP*	*5.06*
923262	*AB1-132 C OP*	*32.88*
923263	*AB1-132 E OP*	*14.09*
923572	*AB1-173 C OP*	*5.51*

923573	*AB1-173 E OP*	*2.57*
923582	*AB1-173AC OP*	*5.51*
923583	*AB1-173AE OP*	*2.57*
923911	*AB2-031 C OP*	*5.47*
923912	*AB2-031 E OP*	*2.7*
923991	*AB2-040 C OP*	*17.97*
923992	*AB2-040 E OP*	*14.7*
924021	*AB2-043 C OP*	*3.02*
924022	*AB2-043 E OP*	*4.95*
924151	*AB2-059 C*	*13.92*
924152	*AB2-059 E*	*7.17*
924161	*AB2-060 C*	*8.56*
924162	*AB2-060 E*	*4.03*
924321	*AB2-079 C OP*	*5.68*
924322	*AB2-079 E OP*	*3.79*
924401	*AB2-089 C*	*2.7*
924402	*AB2-089 E*	*1.39*
924491	*AB2-098 C*	*0.7*
924492	*AB2-098 E*	*0.3*
924501	*AB2-099 C*	*1.04*
924502	*AB2-099 E*	*0.44*
924511	*AB2-100 C*	*37.61*
924512	*AB2-100 E*	*18.53*
925122	*AB2-169 E*	*4.7*
925171	*AB2-174 C O1*	*17.82*
925172	*AB2-174 E O1*	*16.12*

926331	*AC1-034 C*	*9.02*
926332	*AC1-034 E*	*6.8*
926351	*AC1-036 C*	*0.72*
926352	*AC1-036 E*	*1.17*
926531	*AC1-054 C OP*	*9.75*
926532	*AC1-054 E OP*	*4.49*
926851	*AC1-086 C*	*48.43*
926852	*AC1-086 E*	*22.04*
926981	*AC1-099 C*	*13.65*
926982	*AC1-099 E*	*8.1*
927991	*AC1-189 C*	*10.77*
927992	*AC1-189 E*	*5.37*
928191	*AC1-208 C O1*	*15.23*
928192	*AC1-208 E O1*	*6.76*