



**Generation Interconnection
System Impact Study Report
for
Queue Project AE1-173
CARSON-SUFFOLK 500 KV
480 MW Capacity / 800 MW Energy**

Revision 2 June 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 1.21 GW 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).

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 History

January 2022 - This revision is being issued due to a re-tool performed.

June 2022 – This revision is being issued to include overloaded breakers found in the Short Circuit analysis.

4 General

The IC has proposed a solar and storage generating facility located in Sussex County, Virginia. The installed facilities will have a capability of 800 MW with 480 MW of this output being recognized by PJM as Capacity. The proposed in-service date for the AE1-173 project is 12/31/2021. This study does not imply an ITO commitment to either in-service date.

Queue Number	AE1-173
Project Name	CARSON-SUFFOLK 500 KV
Interconnection Customer	1.21 GW LLC
State	Virginia
County	Sussex
Transmission Owner	Dominion
MFO	800
MWE	800
MWC	480
Fuel	Solar
Basecase Study Year	2022

4.1 Point of Interconnection

AE1-173 will interconnect with the Dominion transmission system via a new three breaker ring bus switching station that connects on the Carson – Suffolk 500kV line # 544. See one line in **Attachment 1**.

4.2 Cost Summary

The AE1-173 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	\$ 2,800,000
Direct Connection Network Upgrade	\$ 14,000,000
Non Direct Connection Network Upgrades	\$ 2,500,000
Total Costs	\$ 19,300,000

In addition, the AE1-173 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	\$ 39,353,501

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.

5 Transmission Owner Scope of Work

5.1 Attachment Facilities

Generation Substation: Install metering and associated protection equipment. Estimated Cost \$800,000.

Transmission: Construct approximately one span of 500 kV Attachment line between the generation substation and a new AE1-173 Switching Station. The estimated cost for this work is \$2,000,000.

The estimated total cost of the Attachment Facilities is \$2,800,000. 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. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Generator Substation	\$ 800,000
Transmission	\$ 2,000,000
Total Attachment Facility Costs	\$ 2,800,000

5.2 Direct Connection Cost Estimate

Substation: Establish the new 500 kV AE1-173 switching substation (interconnection substation). The estimated cost of this work scope is \$14,000,000. 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	\$ 14,000,000
Total Direct Connection Facility Costs	\$ 14,000,000

5.3 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 \$2,500,000 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	\$ 2,500,000
Remote Terminal Work	TBD in the Facilities Study
Total Non-Direct Connection Facility Costs	\$ 2,500,000

6 Interconnection Customer Requirements

6.1 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.

6.2 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.

6.3 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.

7 Revenue Metering and SCADA Requirements

7.1 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

7.2 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>.

8 Network Impacts

The Queue Project AE1-173 was evaluated as an 800 MW (Capacity 480 MW) injection tapping the Carson to Suffolk 500 kV line in the Dominion area. Project AE1-173 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-173 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

9 Generation Deliverability

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

None

10 Multiple Facility Contingency

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

None

11 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)

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	314282	6CARSON	DVP	314285	6CHRL249	DVP	1	DVP_P4-2: 562T563	breaker	684.0	119.53	127.25	AC	62.32
2	314285	6CHRL249	DVP	314316	6LOCKS	DVP	1	DVP_P4-2: 562T563	breaker	684.0	116.77	124.45	AC	62.32
3	314287	6CHESTF B	DVP	314276	6BASIN	DVP	1	DVP_P4-2: 562T563	breaker	812	100.46	106.13	AC	53.3
4	314902	8CARSON	DVP	314282	6CARSON	DVP	1	DVP_P4-2: 562T563	breaker	1040	109.05	121.82	AC	132.98

12 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
-	314282	6CARSON	DVP	314285	6CHRL249	DVP	1	DVP_P1-2: LN 563	operation	559	105.94	111	AC	52.84

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
-	314285	6CHRL249	DVP	314316	6LOCKS	DVP	1	DVP_P1-2: LN 563	operation	559	103.03	111.2	AC	52.84
-	314287	6CHESTF B	DVP	314276	6BASIN	DVP	1	DVP_P1-2: LN 563	operation	664	119.14	125.58	AC	49.48
-	314905	8CHANCE	DVP	314900	8BRISTER	DVP	1	DVP_P1-2: LN 594	operation	2442	111.73	117.28	AC	156.96
-	314908	8ELMONT	DVP	314911	8LADYSMITH	DVP	1	DVP_P1-2: LN 576	operation	2442	124.98	133.74	AC	249.02
-	314911	8LADYSMITH	DVP	314905	8CHANCE	DVP	1	DVP_P1-2: LN 573	operation	2738	100.29	105.32	AC	159.39
-	314911	8LADYSMITH	DVP	314922	8POSSUM	DVP	1	DVP_P1-2: LN 594	operation	2442	96.78	101.38	AC	130.3
-	314914	8MDLTHAN	DVP	314918	8NO ANNA	DVP	1	DVP_P1-2: LN 574	operation	2442	124.37	134.88	AC	254.34
-	314918	8NO ANNA	DVP	314911	8LADYSMITH	DVP	1	DVP_P1-2: LN 594	operation	3219	97.26	101.12	AC	140.28
-	314918	8NO ANNA	DVP	314934	8SPOTSYL	DVP	1	DVP_P1-2: LN 575	operation	3219	103.96	109.28	AC	165.47
-	314934	8SPOTSYL	DVP	314916	8MORRSVL	DVP	1	DVP_P1-2: LN 575	operation	3219	105.49	109.91	AC	162.71

13 System Reinforcements

ID	Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AE1-173 Allocation																				
1	6CARSON-6CHRL249 230 kV line	DVP Project Id: n6112 Project Description: Line #249 Carson-Chaparral wreck and rebuild the line of 7.5 miles from Carson to Chaparral to increase its line rating. Project Type: FAC Cost: \$22,500,000 Time Estimate: 30-36 Months New Ratings : Rate A: 1047 MVA Rate B: 1047 MVA Rate C: 1204 MVA Cost Allocation Table is : <table><tr><th>Queue Project</th><th>MW Impact</th><th>Cost (%)</th><th>Cost (\$)</th></tr><tr><td>AE1-068</td><td>51.71</td><td>31.85%</td><td>\$7,166,461</td></tr><tr><td>AE1-069</td><td>41.37</td><td>25.48%</td><td>\$5,733,446</td></tr><tr><td>AE1-148</td><td>6.95</td><td>4.28%</td><td>\$963,197</td></tr><tr><td>AE1-173</td><td>62.32</td><td>38.39%</td><td>\$8,636,896</td></tr></table>	Queue Project	MW Impact	Cost (%)	Cost (\$)	AE1-068	51.71	31.85%	\$7,166,461	AE1-069	41.37	25.48%	\$5,733,446	AE1-148	6.95	4.28%	\$963,197	AE1-173	62.32	38.39%	\$8,636,896	n6112	\$22,500,000	\$8,636,896
Queue Project	MW Impact	Cost (%)	Cost (\$)																						
AE1-068	51.71	31.85%	\$7,166,461																						
AE1-069	41.37	25.48%	\$5,733,446																						
AE1-148	6.95	4.28%	\$963,197																						
AE1-173	62.32	38.39%	\$8,636,896																						

ID	Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AE1-173 Allocation																				
2	6CHRL249-6LOCKS 230 kV line	DVP Project Id: n6116 Project Description: Line #249 Chaparra - Locks: wreck and rebuild the line of 3 miles from Carson to Chaparral to increase its line rating to A VA CPCN is required. Project Type: FAC Cost: \$9,000,000 Time Estimate: 30-36 Months New Ratings: Rate A: 1047 MVA Rate B: 1047 MVA Rate C: 1204 MVA Cost Allocation Table is : <table><tr><th>Queue Project</th><th>MW Impact</th><th>Cost (%)</th><th>Cost (\$)</th></tr><tr><td>AE1-068</td><td>51.71</td><td>31.85%</td><td>\$2,866,761</td></tr><tr><td>AE1-069</td><td>41.37</td><td>25.48%</td><td>\$2,293,520</td></tr><tr><td>AE1-148</td><td>6.95</td><td>4.28%</td><td>\$385,302</td></tr><tr><td>AE1-173</td><td>62.31</td><td>38.38%</td><td>\$3,454,417</td></tr></table>	Queue Project	MW Impact	Cost (%)	Cost (\$)	AE1-068	51.71	31.85%	\$2,866,761	AE1-069	41.37	25.48%	\$2,293,520	AE1-148	6.95	4.28%	\$385,302	AE1-173	62.31	38.38%	\$3,454,417	n6116	\$9,000,000	\$3,454,417
Queue Project	MW Impact	Cost (%)	Cost (\$)																						
AE1-068	51.71	31.85%	\$2,866,761																						
AE1-069	41.37	25.48%	\$2,293,520																						
AE1-148	6.95	4.28%	\$385,302																						
AE1-173	62.31	38.38%	\$3,454,417																						

ID	Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AE1-173 Allocation												
3	6CHESTF B-6BASIN 230 kV line	DVP: Project Id: n6130 Project Description: Rebuild 12.4 miles of 230 kV Line 259 from Chesterfield to Basin with 2-636 ACSR. Type: FAC Total Cost: \$31,000,000 Time Estimate: 30-36 Month New Rating: Rate A: 1047.0 MVA Rate B: 1047.0 MVA Rate C: 1204.0 MVA Cost Allocation Table is: <table><tr><th>Queue Project</th><th>MW Impact</th><th>Cost (%)</th><th>Cost (\$)</th></tr><tr><td>AE1-149</td><td>8.65</td><td>13.94%</td><td>\$4,322,211</td></tr><tr><td>AE1-173</td><td>53.39</td><td>86.06%</td><td>\$26,677,789</td></tr></table>	Queue Project	MW Impact	Cost (%)	Cost (\$)	AE1-149	8.65	13.94%	\$4,322,211	AE1-173	53.39	86.06%	\$26,677,789	n6130	\$31,000,000	\$26,677,789
Queue Project	MW Impact	Cost (%)	Cost (\$)														
AE1-149	8.65	13.94%	\$4,322,211														
AE1-173	53.39	86.06%	\$26,677,789														

ID	Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AE1-173 Allocation																
4	8CARSON 500/230 kV transformer	DVP: Project Id: n6209 Project Description: Add Additional 500/230 kV Transformer at Carson Substation. According to TO a spare transformer is already at Carson Substation. Cost is only for energizing the existing transformer. Type: CON Total Cost: \$1,000,000 Time Estimate: 16-18 Month New Rating: Rate A: 1133.0 MVA Rate B: 1203.0 MVA Rate C: 1365.0 MVA Cost Allocation Table is: <table><tr><th>Queue Project</th><th>MW Impact</th><th>Cost (%)</th><th>Cost (\$)</th></tr><tr><td>AE1-068</td><td>6.76</td><td>2.97%</td><td>\$ 29,708</td></tr><tr><td>AE1-069</td><td>87.81</td><td>38.59%</td><td>\$ 385,893</td></tr><tr><td>AE1-173</td><td>132.98</td><td>58.44%</td><td>\$ 584,399</td></tr></table>	Queue Project	MW Impact	Cost (%)	Cost (\$)	AE1-068	6.76	2.97%	\$ 29,708	AE1-069	87.81	38.59%	\$ 385,893	AE1-173	132.98	58.44%	\$ 584,399	n6209	\$1,000,000	\$584,399
Queue Project	MW Impact	Cost (%)	Cost (\$)																		
AE1-068	6.76	2.97%	\$ 29,708																		
AE1-069	87.81	38.59%	\$ 385,893																		
AE1-173	132.98	58.44%	\$ 584,399																		
		TOTAL COST		\$63,500,000	\$39,353,501																

14 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.

14.1 Contingency Descriptions

Contingency Name	Contingency Definition
DVP_P4-2: 562T563	CONTINGENCY 'DVP_P4-2: 562T563' /* CARSON 500 KV OPEN BRANCH FROM BUS 314902 TO BUS 314923 CKT 1 /* 8CARSON 500.00 - 8SEPTA 500.00 OPEN BRANCH FROM BUS 314902 TO BUS 314914 CKT 1 /* 8CARSON 500.00 - 8MDLTHAN 500.00 END
DVP_P1-2: LN 563	CONTINGENCY 'DVP_P1-2: LN 563' OPEN BRANCH FROM BUS 314902 TO BUS 314914 CKT 1 /* 8CARSON 500.00 - 8MDLTHAN 500.00 END
DVP_P1-2: LN 594	CONTINGENCY 'DVP_P1-2: LN 594' OPEN BRANCH FROM BUS 314916 TO BUS 314934 CKT 1 /* 8MORRSVL 500.00 - 8SPOTSYL 500.00 END
DVP_P1-2: LN 576	CONTINGENCY 'DVP_P1-2: LN 576' OPEN BRANCH FROM BUS 314914 TO BUS 314918 CKT 1 /* 8MDLTHAN 500.00 - 8NO ANNA 500.00 END
DVP_P1-2: LN 573	CONTINGENCY 'DVP_P1-2: LN 573' OPEN BRANCH FROM BUS 314918 TO BUS 314934 CKT 1 /* 8NO ANNA 500.00 - 8SPOTSYL 500.00 END
DVP_P1-2: LN 574	CONTINGENCY 'DVP_P1-2: LN 574' OPEN BRANCH FROM BUS 314908 TO BUS 314911 CKT 1 /* 8ELMONT 500.00 - 8LADYSMITH 500.00 END
DVP_P1-2: LN 575	CONTINGENCY 'DVP_P1-2: LN 575' OPEN BRANCH FROM BUS 314911 TO BUS 314918 CKT 1 /* 8LADYSMITH 500.00 - 8NO ANNA 500.00 END

14.2 Index 1

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	314282	6CARSON	DVP	314285	6CHRL249	DVP	1	DVP_P4-2: 562T563	breaker	684.0	119.53	127.25	AC	62.32

Bus #	Bus	MW Impact
315102	1BRUNSWICKG1	4.82
315103	1BRUNSWICKG2	4.82
315104	1BRUNSWICKG3	4.82
315105	1BRUNSWICKS1	10.02
315131	1EDGECSMA	4.08
315132	1EDGECSMB	4.08
315139	1GASTONA	2.2
315141	1GASTONB	2.2
315136	1ROSEMG1	1.52
315138	1ROSEMG2	0.71
315137	1ROSEMS1	0.95
315073	1STONECA	-2.76
314557	3BETHEL C	0.39
314554	3BTLEBRO	0.4
314572	3EMPORIA	0.33
314578	3HORNRTN	1.92
314704	3LAWRENC	0.25
314603	3SCOT NK	1.61
314617	3TUNIS	0.36
314541	3WATKINS	0.23
314623	3WITAKRS	0.69
314620	6CASHIE	0.31
314574	6EVERETS	1.77
314594	6PLYMOTH	0.28
932631	AC2-084 C	3.33
932632	AC2-084 E	1.64
932761	AC2-100 C	2.14
932762	AC2-100 E	1.04
933991	AD1-023 C	4.64
933992	AD1-023 E	2.53
934311	AD1-055 C	1.02
934312	AD1-055 E	0.26
934331	AD1-057 C O1	5.86
934332	AD1-057 E O1	3.12
934341	AD1-058 C	2.33
934342	AD1-058 E	0.59
934521	AD1-076 C	18.15
934522	AD1-076 E	9.24
934611	AD1-087 C O1	3.32
934612	AD1-087 E O1	1.56
934621	AD1-088 C	4.84

Bus #	Bus	MW Impact
934622	AD1-088 E	2.27
934991	AD1-131 C	0.76
934992	AD1-131 E	0.51
935171	AD1-152 C O1	3.65
935172	AD1-152 E O1	2.43
936261	AD2-033 C	5.16
936262	AD2-033 E	3.44
936361	AD2-046 C O1	4.24
936362	AD2-046 E O1	1.95
936401	AD2-051 C O1	3.66
936402	AD2-051 E O1	1.57
936481	AD2-063 C O1	6.37
936482	AD2-063 E O1	4.24
937481	AD2-202 C O1	0.91
937482	AD2-202 E O1	0.52
938221	AE1-035 C	0.92
938222	AE1-035 E	0.45
938491	AE1-068 C O1	33.32
938492	AE1-068 E O1	18.4
938501	AE1-069 C O1	26.33
938502	AE1-069 E O1	15.05
939181	AE1-148 C O1	4.17
939182	AE1-148 E O1	2.78
939411	AE1-173 C	37.39
939412	AE1-173 E	24.93
LTF	CARR	0.31
LTF	CBM-S1	6.67
LTF	CBM-S2	7.56
LTF	CBM-W1	6.68
LTF	CBM-W2	43.48
LTF	CIN	3.02
LTF	CPLE	3.87
LTF	G-007	1.06
LTF	IPL	1.89
LTF	LGEE	0.88
LTF	MEC	6.72
LTF	MECS	2.81
LTF	O-066	6.73
LTF	RENSSELAER	0.25
900672	V4-068 E	0.13
LTF	WEC	0.81
916301	Z1-086 C	29.39
916302	Z1-086 E	5.22
917332	Z2-043 E	0.46
917342	Z2-044 E	0.3
917512	Z2-088 E OP1	1.76
918492	AA1-063AE OP	2.09
918512	AA1-065 E OP	1.81
918532	AA1-067 E	0.31
918562	AA1-072 E	0.08
919692	AA2-053 E	2.08
919702	AA2-057 E	1.83

Bus #	Bus	MW Impact
LTF	AA2-074	2.63
920042	AA2-088 E OP	4.27
920592	AA2-165 E	0.24
920672	AA2-174 E	0.24
930402	AB1-081 E O1	1.94
930861	AB1-132 C O1	9.54
930862	AB1-132 E O1	4.09
931231	AB1-173 C	0.28
931232	AB1-173 E	0.75
931241	AB1-173AC	0.28
931242	AB1-173AE	0.75
923851	AB2-025 C	0.51
923852	AB2-025 E	1.3
923911	AB2-031 C O1	1.6
923912	AB2-031 E O1	0.79
923991	AB2-040 C O1	5.24
923992	AB2-040 E O1	4.29
924022	AB2-043 E O1	2.32
924152	AB2-059 E O1	2.75
924162	AB2-060 E O1	1.9
924302	AB2-077 E O1	0.6
924312	AB2-078 E O1	0.6
924322	AB2-079 E O1	0.6
924501	AB2-099 C	0.25
924502	AB2-099 E	0.11
924511	AB2-100 C	10.63
924512	AB2-100 E	5.23
925051	AB2-160 C O1	-8.03
925122	AB2-169 E	2.2
925171	AB2-174 C O1	5.2
925172	AB2-174 E O1	4.7
925591	AC1-034 C	3.46
925592	AC1-034 E	2.61
925612	AC1-036 E	0.6
925781	AC1-054 C O1	3.69
925782	AC1-054 E O1	1.7
926071	AC1-086 C	14.05
926072	AC1-086 E	6.4
926201	AC1-098 C	3.12
926202	AC1-098 E	1.86
926211	AC1-099 C	1.04
926212	AC1-099 E	0.61
926271	AC1-105 C O1	2.36
926272	AC1-105 E O1	1.18
927021	AC1-189 C	3.85
927022	AC1-189 E	1.92
927141	AC1-208 C	4.79
927142	AC1-208 E	2.13
927251	AC1-221 C	0.93
927252	AC1-221 E	0.93
927261	AC1-222 C	1.47
927262	AC1-222 E	1.4

14.3 Index 2

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
2	314285	6CHRL249	DVP	314316	6LOCKS	DVP	1	DVP_P4-2: 562T563	breaker	684.0	116.77	124.45	AC	62.32

Bus #	Bus	MW Impact
315102	1BRUNSWICKG1	4.82
315103	1BRUNSWICKG2	4.82
315104	1BRUNSWICKG3	4.82
315105	1BRUNSWICKS1	10.02
315131	1EDGECSMA	4.08
315132	1EDGECSMB	4.08
315139	1GASTONA	2.2
315141	1GASTONB	2.2
315136	1ROSEMG1	1.52
315138	1ROSEMG2	0.71
315137	1ROSEMS1	0.95
315073	1STONECA	-2.76
314557	3BETHEL	0.39
314554	3BTLEBRO	0.4
314572	3EMPORIA	0.33
314578	3HORNRTN	1.92
314704	3LAWRENC	0.25
314603	3SCOT NK	1.61
314617	3TUNIS	0.36
314541	3WATKINS	0.23
314623	3WITAKRS	0.69
314620	6CASHIE	0.31
314574	6EVERETS	1.77
314594	6PLYMOTH	0.28
932631	AC2-084 C	3.33
932632	AC2-084 E	1.64
932761	AC2-100 C	2.14
932762	AC2-100 E	1.04
933991	AD1-023 C	4.64
933992	AD1-023 E	2.53
934311	AD1-055 C	1.02
934312	AD1-055 E	0.26
934331	AD1-057 C O1	5.86
934332	AD1-057 E O1	3.12
934341	AD1-058 C	2.33
934342	AD1-058 E	0.59
934521	AD1-076 C	18.15
934522	AD1-076 E	9.24
934611	AD1-087 C O1	3.32

Bus #	Bus	MW Impact
934612	AD1-087 E O1	1.56
934621	AD1-088 C	4.84
934622	AD1-088 E	2.27
934991	AD1-131 C	0.76
934992	AD1-131 E	0.51
935171	AD1-152 C O1	3.65
935172	AD1-152 E O1	2.43
936261	AD2-033 C	5.16
936262	AD2-033 E	3.44
936361	AD2-046 C O1	4.24
936362	AD2-046 E O1	1.95
936401	AD2-051 C O1	3.66
936402	AD2-051 E O1	1.57
936481	AD2-063 C O1	6.37
936482	AD2-063 E O1	4.24
937481	AD2-202 C O1	0.91
937482	AD2-202 E O1	0.52
938221	AE1-035 C	0.92
938222	AE1-035 E	0.45
938491	AE1-068 C O1	33.32
938492	AE1-068 E O1	18.4
938501	AE1-069 C O1	26.33
938502	AE1-069 E O1	15.05
939181	AE1-148 C O1	4.17
939182	AE1-148 E O1	2.78
939411	AE1-173 C	37.39
939412	AE1-173 E	24.93
LTF	CARR	0.31
LTF	CBM-S1	6.67
LTF	CBM-S2	7.56
LTF	CBM-W1	6.68
LTF	CBM-W2	43.48
LTF	CIN	3.02
LTF	CPLE	3.87
LTF	G-007	1.06
LTF	IPL	1.89
LTF	LGEE	0.88
LTF	MEC	6.72
LTF	MECS	2.81
LTF	O-066	6.73
LTF	RENSSELAER	0.25
900672	V4-068 E	0.13
LTF	WEC	0.81
916301	Z1-086 C	29.39
916302	Z1-086 E	5.22
917332	Z2-043 E	0.46
917342	Z2-044 E	0.3
917512	Z2-088 E OP1	1.76
918492	AA1-063AE OP	2.09
918512	AA1-065 E OP	1.81
918532	AA1-067 E	0.31
918562	AA1-072 E	0.08

Bus #	Bus	MW Impact
919692	AA2-053 E	2.08
919702	AA2-057 E	1.83
LTF	AA2-074	2.63
920042	AA2-088 E OP	4.27
920592	AA2-165 E	0.24
920672	AA2-174 E	0.24
930402	AB1-081 E O1	1.94
930861	AB1-132 C O1	9.54
930862	AB1-132 E O1	4.09
931231	AB1-173 C	0.28
931232	AB1-173 E	0.75
931241	AB1-173AC	0.28
931242	AB1-173AE	0.75
923851	AB2-025 C	0.51
923852	AB2-025 E	1.3
923911	AB2-031 C O1	1.6
923912	AB2-031 E O1	0.79
923991	AB2-040 C O1	5.24
923992	AB2-040 E O1	4.29
924022	AB2-043 E O1	2.32
924152	AB2-059 E O1	2.75
924162	AB2-060 E O1	1.9
924302	AB2-077 E O1	0.6
924312	AB2-078 E O1	0.6
924322	AB2-079 E O1	0.6
924501	AB2-099 C	0.25
924502	AB2-099 E	0.11
924511	AB2-100 C	10.63
924512	AB2-100 E	5.23
925051	AB2-160 C O1	-8.03
925122	AB2-169 E	2.2
925171	AB2-174 C O1	5.2
925172	AB2-174 E O1	4.7
925591	AC1-034 C	3.46
925592	AC1-034 E	2.61
925612	AC1-036 E	0.6
925781	AC1-054 C O1	3.69
925782	AC1-054 E O1	1.7
926071	AC1-086 C	14.05
926072	AC1-086 E	6.4
926201	AC1-098 C	3.12
926202	AC1-098 E	1.86
926211	AC1-099 C	1.04
926212	AC1-099 E	0.61
926271	AC1-105 C O1	2.36
926272	AC1-105 E O1	1.18
927021	AC1-189 C	3.85
927022	AC1-189 E	1.92
927141	AC1-208 C	4.79
927142	AC1-208 E	2.13
927251	AC1-221 C	0.93
927252	AC1-221 E	0.93

Bus #	Bus	MW Impact
927261	AC1-222 C	1.47
927262	AC1-222 E	1.4

14.4 Index 3

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
3	314287	6CHESTF B	DVP	314276	6BASIN	DVP	1	DVP_P4-2: 562T563	breaker	812	100.46	106.13	AC	53.3

Bus #	Bus	MW Impact
315065	1CHESTF6	30.32
315131	1EDGECEMA	3.03
315132	1EDGECEMB	3.03
315074	1HOPCGN1	5.97
315075	1HOPCGN2	5.9
315077	1HOPHCF1	1.89
315078	1HOPHCF2	1.89
315079	1HOPHCF3	1.89
315080	1HOPHCF4	2.86
315076	1HOPPOLC	1.21
315073	1STONECA	4.95
314557	3BETHEL	0.3
314554	3BTLEBRO	0.3
314566	3CRESWEL	0.83
314572	3EMPORIA	0.21
314578	3HORNRTN	1.41
314314	3LOCKS	0.2
314603	3SCOT NK	1.29
314617	3TUNIS	0.33
314541	3WATKINS	0.27
314623	3WITAKRS	0.52
314620	6CASHIE	0.31
314574	6EVERETS	1.53
314594	6PLYMOTH	0.3
314648	6SUNBURY	0.28
314651	6WINFALL	0.57
932591	AC2-079 C O1	2.72
932592	AC2-079 E O1	4.44
932631	AC2-084 C	2.6
932632	AC2-084 E	1.28
933991	AD1-023 C	4.73
933992	AD1-023 E	2.58
934011	AD1-025 C	9.24
934012	AD1-025 E	5.48
934331	AD1-057 C O1	4.21
934332	AD1-057 E O1	2.24
934521	AD1-076 C	19.3
934522	AD1-076 E	9.83
934571	AD1-082 C	4.44
934572	AD1-082 E	2.53
935112	AD1-144 E	0.31

Bus #	Bus	MW Impact
935161	AD1-151 C O1	9.2
935162	AD1-151 E O1	6.13
936041	AD2-007	0.98
936051	AD2-008 C	1.61
936052	AD2-008 E	3.5
936401	AD2-051 C O1	3.32
936402	AD2-051 E O1	1.43
936661	AD2-085 C	1.66
936662	AD2-085 E	2.7
938221	AE1-035 C	0.84
938222	AE1-035 E	0.42
938491	AE1-068 C O1	23.37
938492	AE1-068 E O1	12.91
938501	AE1-069 C O1	18.46
938502	AE1-069 E O1	10.56
938631	AE1-085 C O1	6.41
938632	AE1-085 E O1	3.21
938771	AE1-103 C O1	1.39
938772	AE1-103 E O1	1.92
939191	AE1-149 C O1	8.27
939192	AE1-149 E O1	5.51
939311	AE1-162 C	0.81
939312	AE1-162 E	0.54
939411	AE1-173 C	32.04
939412	AE1-173 E	21.36
LTF	CARR	0.34
LTF	CBM-S1	4.07
LTF	CBM-S2	5.22
LTF	CBM-W1	3.32
LTF	CBM-W2	25.77
LTF	CIN	1.55
LTF	CPLE	2.74
LTF	G-007	1.1
LTF	IPL	0.96
LTF	LGEE	0.45
LTF	MEC	3.7
LTF	MECS	1.08
LTF	O-066	6.98
LTF	RENSSELAER	0.27
900672	V4-068 E	0.12
901082	W1-029 E	14.81
LTF	WEC	0.41
907092	X1-038 E	2.33
913392	Y1-086 E	0.69
916041	Z1-036 C	2.24
916042	Z1-036 E	15.02
916302	Z1-086 E	3.66
917122	Z2-027 E	0.34
917332	Z2-043 E	0.39
917342	Z2-044 E	0.22
917512	Z2-088 E OP1	1.44
918492	AA1-063AE OP	1.68

Bus #	Bus	MW Impact
918512	AA1-065 E OP	1.66
918532	AA1-067 E	0.27
918562	AA1-072 E	0.06
919692	AA2-053 E	1.57
919702	AA2-057 E	1.38
LTF	AA2-074	1.86
920042	AA2-088 E OP	4.19
920592	AA2-165 E	0.18
920672	AA2-174 E	0.18
920692	AA2-178 E	1.42
930402	AB1-081 E O1	1.44
930861	AB1-132 C O1	6.64
930862	AB1-132 E O1	2.85
931232	AB1-173 E	0.51
931242	AB1-173AE	0.51
923832	AB2-022 E	0.39
923851	AB2-025 C	0.3
923852	AB2-025 E	0.77
923911	AB2-031 C O1	1.08
923912	AB2-031 E O1	0.53
923991	AB2-040 C O1	3.54
923992	AB2-040 E O1	2.9
924152	AB2-059 E O1	2.05
924501	AB2-099 C	0.23
924502	AB2-099 E	0.1
924511	AB2-100 C	6.68
924512	AB2-100 E	3.29
924812	AB2-134 E O1	6.69
925051	AB2-160 C O1	3.54
925052	AB2-160 E O1	5.77
925061	AB2-161 C O1	1.95
925062	AB2-161 E O1	3.18
925122	AB2-169 E	2.1
925171	AB2-174 C O1	3.46
925172	AB2-174 E O1	3.13
925331	AB2-190 C	11.44
925332	AB2-190 E	4.9
925591	AC1-034 C	2.57
925592	AC1-034 E	1.94
925781	AC1-054 C O1	2.56
925782	AC1-054 E O1	1.18
925821	AC1-061	< 0.01
926071	AC1-086 C	9.78
926072	AC1-086 E	4.45
926201	AC1-098 C	2.43
926202	AC1-098 E	1.45
926211	AC1-099 C	0.82
926212	AC1-099 E	0.48
927021	AC1-189 C	3.21
927022	AC1-189 E	1.6
927141	AC1-208 C	3.63
927142	AC1-208 E	1.61

Bus #	Bus	MW Impact
927221	AC1-216 C O1	5.38
927222	AC1-216 E O1	4.23

14.5 Index 4

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
4	314902	8CARSON	DVP	314282	6CARSON	DVP	1	DVP_P4-2: 562T563	breaker	1040	109.05	121.82	AC	132.98

Bus #	Bus	MW Impact
315102	1BRUNSWICKG1	10.09
315103	1BRUNSWICKG2	10.09
315104	1BRUNSWICKG3	10.09
315105	1BRUNSWICKS1	20.96
315153	1CLOVER1	11.76
315154	1CLOVER2	11.6
315073	1STONECA	-4.18
934611	AD1-087 C O1	5.67
934612	AD1-087 E O1	2.66
934621	AD1-088 C	8.69
934622	AD1-088 E	4.08
935171	AD1-152 C O1	6.23
935172	AD1-152 E O1	4.15
937481	AD2-202 C O1	1.56
937482	AD2-202 E O1	0.88
938491	AE1-068 C O1	70.71
938492	AE1-068 E O1	39.06
938501	AE1-069 C O1	55.87
938502	AE1-069 E O1	31.94
939411	AE1-173 C	79.79
939412	AE1-173 E	53.19
LTF	CARR	0.4
LTF	CBM-S1	8.22
LTF	CBM-S2	9.1
LTF	CBM-W1	8.18
LTF	CBM-W2	53.55
LTF	CIN	3.71
LTF	CPLE	4.41
LTF	G-007	1.35
LTF	IPL	2.32
LTF	LGEE	1.07
LTF	MEC	8.27
LTF	MECS	3.42
LTF	O-066	8.57
LTF	RENSSELAER	0.31
LTF	WEC	0.99
916301	Z1-086 C	62.01
916302	Z1-086 E	11.01
LTF	AA2-074	3.
930861	AB1-132 C O1	-8.44
923911	AB2-031 C O1	-1.52

Bus #	Bus	MW Impact
923991	AB2-040 C O1	-5.
924511	AB2-100 C	-14.03
925051	AB2-160 C O1	-6.7
925171	AB2-174 C O1	-5.22

Affected Systems

15 Affected Systems

15.1 Duke Energy Progress

None.

Short Circuit

16 Short Circuit

Short Circuit

(Summary of impacted circuit breakers)

The following load flow reinforcement was tested for short circuit: b3694.7- Energize in-service spare 500/230 kV Carson Tx#1. The reinforcement was tested at the AE1-068 queue position (the driver project for this violation), and the following breakers are overduty as a result of the network upgrade. Any queue project relying on b3694.7 will receive cost allocation towards replacing these circuit breakers if it meets cost allocation rules.

AE1-173 Cost Allocation

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AE1-173 Allocation																
1	Carson 230kV 200272	Replace the Carson 230kV 200272 circuit breaker with a 50kA device	N8084.1	\$458,693	\$184,526																
		<table><tr><th>Queue Project</th><th>Cost (%)</th><th>Cost(\$)</th><th>MW Impact</th></tr><tr><td>AE1-068</td><td>33.21%</td><td>\$ 152,320</td><td>109.77</td></tr><tr><td>AE1-069</td><td>26.56%</td><td>\$ 121,847</td><td>87.81</td></tr><tr><td>AE1-173</td><td>40.23%</td><td>\$ 184,526</td><td>132.98</td></tr></table>				Queue Project	Cost (%)	Cost(\$)	MW Impact	AE1-068	33.21%	\$ 152,320	109.77	AE1-069	26.56%	\$ 121,847	87.81	AE1-173	40.23%	\$ 184,526	132.98
		Queue Project				Cost (%)	Cost(\$)	MW Impact													
		AE1-068				33.21%	\$ 152,320	109.77													
		AE1-069				26.56%	\$ 121,847	87.81													
AE1-173	40.23%	\$ 184,526	132.98																		
2	Carson 230kV 238T2002	Replace the Carson 230kV 238T2002 circuit breaker with a 50kA device	N8084.3	\$458,693	\$184,526																
		<table><tr><th>Queue Project</th><th>Cost (%)</th><th>Cost(\$)</th><th>MW Impact</th></tr><tr><td>AE1-068</td><td>33.21%</td><td>\$ 152,320</td><td>109.77</td></tr><tr><td>AE1-069</td><td>26.56%</td><td>\$ 121,847</td><td>87.81</td></tr><tr><td>AE1-173</td><td>40.23%</td><td>\$ 184,526</td><td>132.98</td></tr></table>				Queue Project	Cost (%)	Cost(\$)	MW Impact	AE1-068	33.21%	\$ 152,320	109.77	AE1-069	26.56%	\$ 121,847	87.81	AE1-173	40.23%	\$ 184,526	132.98
		Queue Project				Cost (%)	Cost(\$)	MW Impact													
		AE1-068				33.21%	\$ 152,320	109.77													
		AE1-069				26.56%	\$ 121,847	87.81													
AE1-173	40.23%	\$ 184,526	132.98																		
3	Carson 230kV 23872	Replace the Carson 230kV 23872 circuit breaker with a 50kA device	N8084.4	\$458,693	\$184,526																
		<table><tr><th>Queue Project</th><th>Cost (%)</th><th>Cost(\$)</th><th>MW Impact</th></tr><tr><td>AE1-068</td><td>33.21%</td><td>\$ 152,320</td><td>109.77</td></tr><tr><td>AE1-069</td><td>26.56%</td><td>\$ 121,847</td><td>87.81</td></tr><tr><td>AE1-173</td><td>40.23%</td><td>\$ 184,526</td><td>132.98</td></tr></table>				Queue Project	Cost (%)	Cost(\$)	MW Impact	AE1-068	33.21%	\$ 152,320	109.77	AE1-069	26.56%	\$ 121,847	87.81	AE1-173	40.23%	\$ 184,526	132.98
		Queue Project				Cost (%)	Cost(\$)	MW Impact													
		AE1-068				33.21%	\$ 152,320	109.77													
		AE1-069				26.56%	\$ 121,847	87.81													
AE1-173	40.23%	\$ 184,526	132.98																		

4	Hopewell 230kV 212T2046	Replace the Hopewell 230kV 212T2046 circuit breaker with a 50kA device	N8084.5	\$458,693	\$184,526															
<table><tr><th>Queue Project</th><th>Cost (%)</th><th>Cost(\$)</th><th>MW Impact</th></tr><tr><td>AE1-068</td><td>33.21%</td><td>\$ 152,320</td><td>109.77</td></tr><tr><td>AE1-069</td><td>26.56%</td><td>\$ 121,847</td><td>87.81</td></tr><tr><td>AE1-173</td><td>40.23%</td><td>\$ 184,526</td><td>132.98</td></tr></table>		Queue Project				Cost (%)	Cost(\$)	MW Impact	AE1-068	33.21%	\$ 152,320	109.77	AE1-069	26.56%	\$ 121,847	87.81	AE1-173	40.23%	\$ 184,526	132.98
Queue Project	Cost (%)	Cost(\$)				MW Impact														
AE1-068	33.21%	\$ 152,320				109.77														
AE1-069	26.56%	\$ 121,847				87.81														
AE1-173	40.23%	\$ 184,526	132.98																	
5	Hopewell 230kV 228T268	Replace the Hopewell 230kV 228T268circuit breaker with a 50kA device	N8084.6	\$458,693	\$184,526															
<table><tr><th>Queue Project</th><th>Cost (%)</th><th>Cost(\$)</th><th>MW Impact</th></tr><tr><td>AE1-068</td><td>33.21%</td><td>\$ 152,320</td><td>109.77</td></tr><tr><td>AE1-069</td><td>26.56%</td><td>\$ 121,847</td><td>87.81</td></tr><tr><td>AE1-173</td><td>40.23%</td><td>\$ 184,526</td><td>132.98</td></tr></table>		Queue Project				Cost (%)	Cost(\$)	MW Impact	AE1-068	33.21%	\$ 152,320	109.77	AE1-069	26.56%	\$ 121,847	87.81	AE1-173	40.23%	\$ 184,526	132.98
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Total Cost (\$)				\$2,293,465	\$922,360															

Stability

17 Stability

The project Stability Study will be complete as part of the Facilities Study.

Attachment 1

System Configuration

