Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AD1-033

Fentress 230kV
42 MW Capacity / 70 MW Energy

February 2018

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 City of Chesapeake County, Virginia. The installed facilities will have a total capability of 70 MW with 42 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is December 31, 2020. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AD1-033 will interconnect with the ITO transmission system via one of the following Points of Interconnection:

Option 1: AD1-033 will interconnect into the existing Fentress 230kV Substation

Option 2: AD1-033 will interconnect via a new three breaker ring bus switching station that connects the Fentress – Landstown 230kV line.

Cost Summary

The AD1-033 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 1,800,000
Direct Connection Network Upgrades	$ 0
Non Direct Connection Network Upgrades	$ 1,200,000
Total Costs	**$ 3,000,000**

In addition, the AD1-033 project may be responsible for a contribution to the following costs:

Description	Total Cost
New System Upgrades	$ 0
Previously Identified Upgrades	$ 17,500,000
Total Costs	**$ 17,500,000**

PJM Open Access Transmission Tariff (OATT) section 217.3A outline cost allocation rules. The rules are further clarified in PJM Manual 14A Attachment B. For New System Upgrades, the cost allocation rule differ depending on whether the minimum amount of upgrades to resolve a single reliability criteria violation will cost less than $5,000,000. For upgrades estimated to cost less than $5,000,000 the allocation of costs will not occur outside of the Queue in which the need for the Network Upgrade was identified. Cost allocation within the Queue will be contingent each Queue projects Distribution Factor on the overloaded facility. For upgrades estimated to cost $5,000,000 or greater the allocation of costs 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.

The Feasibility Study is used to make a preliminary determination of the type and scope of Attachment Facilities, Local Upgrades, and Network Upgrades that will be necessary to accommodate the Interconnection Request and to provide the Interconnection Customer a preliminary estimate of the time that will be required to construct any necessary facilities and upgrades and the Interconnection Customer's cost responsibility. The System Impact Study provides refined and comprehensive estimates of cost responsibility and construction lead times for new facilities and system upgrades. Facilities Studies will include, commensurate with the degree of engineering specificity as provided in the Facilities Study Agreement, good faith estimates of the cost, determined in accordance with Section 217 of the Tariff,

(a) to be charged to each affected New Service Customer for the Facilities and System Upgrades that are necessary to accommodate this queue project;

(b) the time required to complete detailed design and construction of the facilities and upgrades; and

(c) a description of any site-specific environmental issues or requirements that could reasonably be anticipated to affect the cost or time required to complete construction of such facilities and upgrades.

System Reinforcements

Violation #	Upgrade Description	Upgrade Cost
	NEW SYSTEM REINFORCEMENTS	
	NONE	
	CONTRIBUTIONS TO PREVIOUS SYSTEM REINFORCEMENTS	
1	Replace the 500-230 kV transformer #1 increase its line rating to 1134 MVA (normal), 1203 MVA (emergency), and 1365 MVA (load dump). It is estimated to cost $17,500,000 and 24-30 months to engineer and construct.	$17,500,000
	Total Network Upgrades	**$17,500,000**

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 Fentress 230 kV 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 Facility Study phase.

Direct Connection Cost Estimate

None.

Non-Direct Connection Cost Estimate

Substation: Add one 230 kV circuit breaker to the existing Fentress 230kV Substation. The estimated cost of this work scope is $1,200,000.

The total estimated cost to complete the Non-Direct Connection Network Facilities is $1,200,000. It is estimated to take 24-36 months to complete this work upon execution of an Interconnection Construction Service Agreement.

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

OPTION 1:

Network Impacts

PJM assessed the impact of the proposed Queue Project as an injection into the ITO's transmission system, for compliance with NERC Reliability Criteria. The system was assessed using the summer 2021 RTEP case. When performing analysis, ITO Criteria considers a transmission facility overloaded if it exceeds 94% of its emergency rating under single contingency (normal and stressed system conditions). A full listing of the 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 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. The results of these studies are discussed in more detail below.

The Queue Project AD1-033 was evaluated as a 70.0 MW (Capacity 42 MW) injection at Fentress 230kV substation in the ITO area. Project AD1-033 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD1-033 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
DVP_P1-2: LN 557	CONTINGENCY 'DVP_P1-2: LN 557' OPEN BRANCH FROM BUS 314214 TO BUS 314903 CKT 1 /* 6CHCKAHM 230.00 – 8CHCKAHM 500.00 OPEN BRANCH FROM BUS 314903 TO BUS 314908 CKT 1 /* 8CHCKAHM 500.00 – 8ELMONT 500.00 END

Contingency Name	Description
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_P4-2: H2T557	CONTINGENCY 'DVP_P4-2: H2T557' /* ELMONT OPEN BRANCH FROM BUS 314908 TO BUS 314903 CKT 1 /*ELMONT TO CHICKAHOMINY (LINE 557) OPEN BRANCH FROM BUS 314903 TO BUS 314214 CKT 1 /*CHICKAHOMINY 500-230 (TX#1) OPEN BRANCH FROM BUS 314908 TO BUS 314218 CKT 2 /*ELMONT 500-230 (TX#2) END

Summer Peak Analysis – 2021

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)

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)

#	Contingency		Affected		Bus			Power	Loading %		Rating		MW	
	Type	Name	Area	Facility Description	From	To	Ckt	Flow	Initial	Final	Type	MVA	Contribution	Ref
1	LFFB	DVP_P4-2: H2T557	DVP - DVP	8ELMONT 500/230 kV transformer	314218	314908	1	DC	121.4	121.83	LD	1051	11.6	1

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)

None.

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 %

#	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
1	8ELMONT 500/230 kV transformer	Replace the 500-230 kV transformer #1 increase its line rating to 1134 MVA (normal), 1203 MVA (emergency), and 1365 MVA (load dump). It is estimated to cost $17,500,000 and 24-30 months to engineer and construct.	Pending	$17,500,000
			Total New Network Upgrades	**$17,500,000**

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	Ckt	Flow	Initial	Final	Type	MVA	Contribution
2	N-1	DVP_P1-2: LN 557	DVP - DVP	6SKIFF CREEK-6KINGS M 230 kV line	314209	314386	1	DC	135.1	135.62	ER	442	5.17
3	N-1	DVP_P1-2: LN 557	DVP - DVP	6PENNIMAN-6WALR209 230 kV line	314296	314415	1	DC	124.1	124.67	ER	442	5.17
4	N-1	DVP_P1-2: LN 557	DVP - DVP	6KINGS M-6PENNIMAN 230 kV line	314386	314296	1	DC	127.6	128.11	ER	442	5.17
5	N-1	DVP_P1-2: LN 557	DVP - DVP	6WALR209-6LIGH209 230 kV line	314415	314391	1	DC	110	110.54	ER	442	5.17
6	N-1	DVP_P1-2: LN 563	DVP - DVP	8SURRY-8CHCKAHM 500 kV line	314924	314903	1	DC	102.2	103.26	ER	1809	20.57

Light Load Analysis

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

Affected System Analysis & Mitigation

Duke, Progress & TVA Impacts:

Duke Carolina, Progress, & TVA Impacts to be determined during later study phases (as applicable).

OPTION 2

Network Impacts

PJM assessed the impact of the proposed Queue Project as an injection into the ITO's transmission system, for compliance with NERC Reliability Criteria. The system was assessed using the summer 2021 RTEP case. When performing analysis, ITO Criteria considers a transmission facility overloaded if it exceeds 94% of its emergency rating under single contingency (normal and stressed system conditions). A full listing of the 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 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. The results of these studies are discussed in more detail below.

The Queue Project AD1-033 was evaluated as a 70.0 MW (Capacity 42 MW) injection tapping the Fentress - Landstown 230kV substation in the ITO area. Project AD1-033 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD1-033 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Contingency Descriptions

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Contingency Name	Description
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_P4-2: H2T557	CONTINGENCY 'DVP_P4-2: H2T557' /* ELMONT OPEN BRANCH FROM BUS 314908 TO BUS 314903 CKT 1 /*ELMONT TO CHICKAHOMINY (LINE 557) OPEN BRANCH FROM BUS 314903 TO BUS 314214 CKT 1 /*CHICKAHOMINY 500-230 (TX#1) OPEN BRANCH FROM BUS 314908 TO BUS 314218 CKT 2 /*ELMONT 500-230 (TX#2) END

Summer Peak Analysis – 2021

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)

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)

#	Contingency		Affected		Bus			Power	Loading %		Rating		MW	
	Type	Name	Area	Facility Description	From	To	Ckt	Flow	Initial	Final	Type	MVA	Contribution	Ref
1	LFFB	DVP_P4-2: H2T557	DVP - DVP	8ELMONT 500/230 kV transformer	314218	314908	1	DC	121.39	121.83	LD	1051	11.62	1

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

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	Cir.	Flow	Initial	Final	Type	MVA	Contribution
2	N-1	DVP_P1-2: LN 557	DVP - DVP	6SKIFF CREEK-6KINGS M 230 kV line	314209	314386	1	DC	135.11	135.64	ER	442	5.17
3	N-1	DVP_P1-2: LN 557	DVP - DVP	6PENNIMAN-6WALR209 230 kV line	314296	314415	1	DC	124.13	124.66	ER	442	5.17
4	N-1	DVP_P1-2: LN 557	DVP - DVP	6KINGS M-6PENNIMAN 230 kV line	314386	314296	1	DC	127.59	128.13	ER	442	5.17
5	N-1	DVP_P1-2: LN 557	DVP - DVP	6WALR209-6LIGH209 230 kV line	314415	314391	1	DC	110.03	110.56	ER	442	5.17

#	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
6	N-1	DVP_P1-2: LN 563	DVP - DVP	8SURRY-AD1-151 TAP 500 kV line	314924	935160	1	DC	102.11	103.02	ER	1809	20.55
7	N-1	DVP_P1-2: LN 563	DVP - DVP	AD1-151 TAP- 8CHCKAHM 500 kV line	935160	314903	1	DC	102.17	103.12	ER	1809	20.55

Light Load Analysis

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

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. All New Service Queue Requests, through the end of the Queue under study, that are contributors to a flowgate will be listed in the Appendices. Please note that there may be contributors that are subsequently queued after the queue under study that are not listed in the Appendices. Although this information is not used "as is" for cost allocation purposes, it can be used to gage the impact of other projects/generators.

It should be noted the project/generator MW contributions presented in the body of the report and appendices sections are full contributions, whereas the loading percentages reported in the body of the report, those contributions take into consideration the commercial probability of each project as well as the ramping impact of "Adder" contributions.

OPTION 1

Appendix 1

(DVP - DVP) The 8ELMONT 500/230 kV transformer (from bus 314218 to bus 314908 ckt 1) loads from 121.4% to 121.83% (**DC power flow**) of its load dump rating (1051 MVA) for the line fault with failed breaker contingency outage of 'DVP_P4-2: H2T557'. This project contributes approximately 11.6 MW to the thermal violation.

CONTINGENCY 'DVP_P4-2: H2T557' /* ELMONT
OPEN BRANCH FROM BUS 314908 TO BUS 314903 CKT 1 /*ELMONT TO CHICKAHOMINY (LINE 557)
OPEN BRANCH FROM BUS 314903 TO BUS 314214 CKT 1 /*CHICKAHOMINY 500-230 (TX#1)
OPEN BRANCH FROM BUS 314908 TO BUS 314218 CKT 2 /*ELMONT 500-230 (TX#2)
END

Bus Number	*Bus Name*	*Full Contribution*
315067	*1DARBY 1*	*4.99*
315068	*1DARBY 2*	*4.99*
315069	*1DARBY 3*	*5.01*
315070	*1DARBY 4*	*5.01*
315043	*1FOUR RIVERA*	*6.63*
315044	*1FOUR RIVERB*	*5.13*
315045	*1FOUR RIVERC*	*6.63*
315046	*1FOUR RIVERD*	*5.13*
315047	*1FOUR RIVERE*	*5.13*
315048	*1FOUR RIVERF*	*6.63*
315074	*1HOPCGN1*	*11.28*
315075	*1HOPCGN2*	*11.14*
315083	*1SPRUNCA*	*14.95*
315084	*1SPRUNCB*	*14.95*
315085	*1SPRUNCC*	*11.08*

315086	*1SPRUNCD*	*11.08*
315073	*1STONECA*	*9.36*
314566	*3CRESWEL*	*2.11*
314572	*3EMPORIA*	*0.36*
314315	*3LOCKS E*	*1.65*
314617	*3TUNIS*	*0.71*
314539	*3UNCAMP*	*2.19*
314541	*3WATKINS*	*0.61*
314620	*6CASHIE*	*0.72*
314229	*6MT RD221*	*1.41*
314236	*6NRTHEST*	*0.37*
314189	*6PAPERMILL*	*8.82*
314594	*6PLYMOTH*	*0.73*
314250	*6ROCKVILLE*	*0.4*
314256	*6ROCKVILLE E*	*1.15*
314648	*6SUNBURY*	*0.81*
314651	*6WINFALL*	*1.59*
932041	*AC2-012 C*	*9.62*
932042	*AC2-012 E*	*15.7*
932501	*AC2-070 C*	*2.9*
932502	*AC2-070 E*	*1.2*
932531	*AC2-073 C*	*3.1*
932532	*AC2-073 E*	*1.56*
932581	*AC2-078 C*	*4.75*
932582	*AC2-078 E*	*7.75*
932591	*AC2-079 C*	*6.82*

932592	*AC2-079 E*	*11.13*
932831	*AC2-110 C*	*1.74*
932832	*AC2-110 E*	*2.84*
933061	*AC2-130*	*3.48*
933071	*AC2-131 1*	*2.36*
933081	*AC2-131 2*	*1.07*
933111	*AC2-132 1*	*1.24*
933121	*AC2-132 2*	*0.63*
933261	*AC2-137 C*	*3.16*
933262	*AC2-137 E*	*2.05*
933271	*AC2-138 C*	*0.87*
933272	*AC2-138 E*	*1.09*
933291	*AC2-141 C*	*27.16*
933292	*AC2-141 E*	*11.59*
933451	*AC2-158 C*	*4.63*
933452	*AC2-158 E*	*4.63*
933471	*AC2-161 C*	*2.47*
933472	*AC2-161 E*	*1.27*
933481	*AC2-162 C*	*4.17*
933482	*AC2-162 E*	*2.15*
933711	*AC2-194 C*	*0.98*
933712	*AC2-194 E*	*1.59*
933731	*AC2-196 C*	*1.66*
933732	*AC2-196 E*	*1.1*
933991	*AD1-023 C*	*11.29*
933992	*AD1-023 E*	*6.14*

934011	*AD1-025 C O1*	*20.82*
934012	*AD1-025 E O1*	*12.33*
934061	*AD1-033 C O1*	*6.96*
934062	*AD1-033 E O1*	*4.64*
934071	*AD1-034 C O1*	*10.6*
934072	*AD1-034 E O1*	*6.87*
934141	*AD1-041 C O1*	*6.74*
934142	*AD1-041 E O1*	*4.49*
934191	*AD1-046 C*	*4.71*
934192	*AD1-046 E*	*3.14*
934201	*AD1-047 C*	*6.75*
934202	*AD1-047 E*	*4.5*
934211	*AD1-048 C*	*3.82*
934212	*AD1-048 E*	*1.93*
934391	*AD1-063 C*	*2.1*
934392	*AD1-063 E*	*1.4*
934521	*AD1-076 C O1*	*46.88*
934522	*AD1-076 E O1*	*23.87*
934571	*AD1-082 C O1*	*8.27*
934572	*AD1-082 E O1*	*4.72*
934781	*AD1-105 C*	*8.08*
934782	*AD1-105 E*	*5.62*
LTF	*AD1-120*	*5.93*
LTF	*AD1-121*	*5.89*
935111	*AD1-144 C*	*1.68*
935112	*AD1-144 E*	*0.92*

935161	*AD1-151 C O1*	*19.89*
935162	*AD1-151 E O1*	*13.26*
935211	*AD1-156 C*	*2.56*
935212	*AD1-156 E*	*1.71*
LTF	*CARR*	*0.67*
LTF	*CBM-S1*	*3.86*
LTF	*CBM-S2*	*13.84*
LTF	*CBM-W1*	*0.21*
LTF	*CBM-W2*	*17.91*
LTF	*CIN*	*0.13*
LTF	*CLIFTY*	*1.62*
LTF	*CPLE*	*4.75*
LTF	*DEARBORN*	*0.47*
LTF	*G-007*	*2.31*
LTF	*IPL*	*0.06*
LTF	*LGEE*	*0.05*
LTF	*MEC*	*1.99*
LTF	*O-066*	*7.73*
LTF	*RENSSELAER*	*0.53*
LTF	*ROSETON*	*3.84*
292791	*U1-032 E*	*4.87*
297087	*V2-040*	*0.28*
900672	*V4-068 E*	*0.26*
901082	*W1-029E*	*41.82*
LTF	*WEC*	*0.06*
907092	*X1-038 E*	*5.47*

913392	*Y1-086 E*	*1.99*
916042	*Z1-036 E*	*40.84*
916192	*Z1-068 E*	*1.76*
917122	*Z2-027 E*	*0.96*
917592	*Z2-099 E*	*0.38*
918492	*AA1-063AE OP*	*3.35*
918512	*AA1-065 E OP*	*3.74*
918691	*AA1-083*	*1.16*
919152	*AA1-139 E*	*5.92*
919211	*AA1-145*	*19.79*
919732	*AA2-059 E*	*0.5*
LTF	*AA2-074*	*3.23*
920022	*AA2-086 E*	*0.21*
920042	*AA2-088 E*	*9.15*
920691	*AA2-178 C*	*8.43*
920692	*AA2-178 E*	*3.61*
930051	*AB1-013 C*	*2.54*
930052	*AB1-013 E*	*17.02*
930121	*AB1-027 C*	*0.87*
930122	*AB1-027 E*	*1.89*
930861	*AB1-132 C*	*11.78*
930862	*AB1-132 E*	*5.05*
931231	*AB1-173 C*	*1.9*
931232	*AB1-173 E*	*0.89*
931241	*AB1-173AC*	*1.9*
931242	*AB1-173AE*	*0.89*

923801	*AB2-015 C O1*	*7.73*
923802	*AB2-015 E O1*	*6.34*
923831	*AB2-022 C*	*2.1*
923832	*AB2-022 E*	*1.13*
923842	*AB2-024 E*	*1.49*
923852	*AB2-025 E*	*1.09*
923862	*AB2-026 E*	*0.88*
923911	*AB2-031 C O1*	*1.88*
923912	*AB2-031 E O1*	*0.93*
923991	*AB2-040 C O1*	*6.19*
923992	*AB2-040 E O1*	*5.06*
924061	*AB2-050*	*1.16*
924071	*AB2-051*	*128.86*
924241	*AB2-068 O1*	*177.95*
924381	*AB2-087 C*	*0.48*
924382	*AB2-087 E*	*0.22*
924501	*AB2-099 C*	*0.49*
924502	*AB2-099 E*	*0.21*
924511	*AB2-100 C*	*10.48*
924512	*AB2-100 E*	*5.16*
924811	*AB2-134 C O1*	*15.87*
924812	*AB2-134 E O1*	*15.6*
925051	*AB2-160 C O1*	*7.18*
925052	*AB2-160 E O1*	*11.71*
925061	*AB2-161 C O1*	*3.63*
925062	*AB2-161 E O1*	*5.92*

925171	*AB2-174 C O1*	*5.96*
925172	*AB2-174 E O1*	*5.39*
925281	*AB2-186 C*	*0.55*
925282	*AB2-186 E*	*0.24*
925291	*AB2-188 C O1*	*2.08*
925292	*AB2-188 E O1*	*0.93*
925331	*AB2-190 C*	*24.76*
925332	*AB2-190 E*	*10.61*
925522	*AC1-027 E*	*1.07*
925692	*AC1-045 E*	*0.92*
925861	*AC1-065 C*	*4.36*
925862	*AC1-065 E*	*7.11*
926071	*AC1-086 C*	*17.34*
926072	*AC1-086 E*	*7.89*
926291	*AC1-107*	*268.61*
926411	*AC1-112 C*	*0.68*
926412	*AC1-112 E*	*1.93*
926441	*AC1-115 C*	*1.01*
926442	*AC1-115 E*	*1.64*
926472	*AC1-118 E*	*1.07*
926551	*AC1-134*	*14.83*
926662	*AC1-147 E*	*1.25*
926741	*AC1-159*	*62.13*
926751	*AC1-161 C*	*27.16*
926752	*AC1-161 E*	*11.59*
926771	*AC1-163 C*	*1.63*

926772	*AC1-163 E*	*0.76*
926781	*AC1-164 C*	*58.41*
926782	*AC1-164 E*	*26.24*
927041	*AC1-191 C*	*17.46*
927042	*AC1-191 E*	*8.7*
927111	*AC1-206 C*	*9.15*
927112	*AC1-206 E*	*4.32*
927221	*AC1-216 C O1*	*12.11*
927222	*AC1-216 E O1*	*9.53*

OPTION 2

Appendix 1

(DVP - DVP) The 8ELMONT 500/230 kV transformer (from bus 314218 to bus 314908 ckt 1) loads from 121.39% to 121.83% (**DC power flow**) of its load dump rating (1051 MVA) for the line fault with failed breaker contingency outage of 'DVP_P4-2: H2T557'. This project contributes approximately 11.62 MW to the thermal violation.

CONTINGENCY 'DVP_P4-2: H2T557' /* ELMONT
OPEN BRANCH FROM BUS 314908 TO BUS 314903 CKT 1 /*ELMONT TO CHICKAHOMINY (LINE 557)
OPEN BRANCH FROM BUS 314903 TO BUS 314214 CKT 1 /*CHICKAHOMINY 500-230 (TX#1)
OPEN BRANCH FROM BUS 314908 TO BUS 314218 CKT 2 /*ELMONT 500-230 (TX#2)
END

Bus Number	*Bus Name*	*Full Contribution*
315067	*1DARBY 1*	*4.99*
315068	*1DARBY 2*	*4.99*
315069	*1DARBY 3*	*5.01*
315070	*1DARBY 4*	*5.01*
315043	*1FOUR RIVERA*	*6.63*
315044	*1FOUR RIVERB*	*5.13*
315045	*1FOUR RIVERC*	*6.63*
315046	*1FOUR RIVERD*	*5.13*
315047	*1FOUR RIVERE*	*5.13*
315048	*1FOUR RIVERF*	*6.63*
315074	*1HOPCGN1*	*11.28*
315075	*1HOPCGN2*	*11.14*
315083	*1SPRUNCA*	*14.95*
315084	*1SPRUNCB*	*14.95*
315085	*1SPRUNCC*	*11.08*
315086	*1SPRUNCD*	*11.08*
315073	*1STONECA*	*9.36*
314566	*3CRESWEL*	*2.11*
314572	*3EMPORIA*	*0.36*
314315	*3LOCKS E*	*1.65*
314617	*3TUNIS*	*0.71*
314539	*3UNCAMP*	*2.19*
314541	*3WATKINS*	*0.61*
314620	*6CASHIE*	*0.72*
314229	*6MT RD221*	*1.41*
314236	*6NRTHEST*	*0.37*
314189	*6PAPERMILL*	*8.82*

314594	*6PLYMOTH*	*0.73*
314250	*6ROCKVILLE*	*0.4*
314256	*6ROCKVILLE E*	*1.15*
314648	*6SUNBURY*	*0.81*
314651	*6WINFALL*	*1.59*
932041	*AC2-012 C*	*9.62*
932042	*AC2-012 E*	*15.7*
932501	*AC2-070 C*	*2.9*
932502	*AC2-070 E*	*1.2*
932531	*AC2-073 C*	*3.1*
932532	*AC2-073 E*	*1.56*
932581	*AC2-078 C*	*4.75*
932582	*AC2-078 E*	*7.75*
932591	*AC2-079 C*	*6.82*
932592	*AC2-079 E*	*11.13*
932831	*AC2-110 C*	*1.74*
932832	*AC2-110 E*	*2.84*
933061	*AC2-130*	*3.48*
933071	*AC2-131 1*	*2.36*
933081	*AC2-131 2*	*1.07*
933111	*AC2-132 1*	*1.24*
933121	*AC2-132 2*	*0.63*
933261	*AC2-137 C*	*3.16*
933262	*AC2-137 E*	*2.05*
933271	*AC2-138 C*	*0.87*
933272	*AC2-138 E*	*1.09*
933291	*AC2-141 C*	*27.16*
933292	*AC2-141 E*	*11.59*
933451	*AC2-158 C*	*4.63*
933452	*AC2-158 E*	*4.63*
933471	*AC2-161 C*	*2.47*
933472	*AC2-161 E*	*1.27*
933481	*AC2-162 C*	*4.17*
933482	*AC2-162 E*	*2.15*
933711	*AC2-194 C*	*0.98*
933712	*AC2-194 E*	*1.59*
933731	*AC2-196 C*	*1.66*
933732	*AC2-196 E*	*1.1*
933991	*AD1-023 C*	*11.29*
933992	*AD1-023 E*	*6.14*
934011	*AD1-025 C O2*	*20.82*
934012	*AD1-025 E O2*	*12.33*
934061	*AD1-033 C O2*	*6.97*
934062	*AD1-033 E O2*	*4.65*
934071	*AD1-034 C O2*	*7.83*

934072	*AD1-034 E O2*	*5.07*
934141	*AD1-041 C O2*	*7.07*
934142	*AD1-041 E O2*	*4.71*
934191	*AD1-046 C*	*4.71*
934192	*AD1-046 E*	*3.14*
934201	*AD1-047 C*	*6.75*
934202	*AD1-047 E*	*4.5*
934211	*AD1-048 C*	*3.82*
934212	*AD1-048 E*	*1.93*
934391	*AD1-063 C*	*2.1*
934392	*AD1-063 E*	*1.4*
934521	*AD1-076 C O2*	*44.5*
934522	*AD1-076 E O2*	*22.66*
934571	*AD1-082 C O2*	*8.78*
934572	*AD1-082 E O2*	*5.01*
934781	*AD1-105 C*	*8.08*
934782	*AD1-105 E*	*5.62*
LTF	*AD1-120*	*5.93*
LTF	*AD1-121*	*5.89*
935111	*AD1-144 C*	*1.68*
935112	*AD1-144 E*	*0.92*
935161	*AD1-151 C O2*	*15.11*
935162	*AD1-151 E O2*	*10.07*
935211	*AD1-156 C*	*2.56*
935212	*AD1-156 E*	*1.71*
LTF	*CARR*	*0.67*
LTF	*CBM-S1*	*3.86*
LTF	*CBM-S2*	*13.84*
LTF	*CBM-W1*	*0.21*
LTF	*CBM-W2*	*17.92*
LTF	*CIN*	*0.13*
LTF	*CLIFTY*	*1.61*
LTF	*CPLE*	*4.75*
LTF	*DEARBORN*	*0.47*
LTF	*G-007*	*2.31*
LTF	*IPL*	*0.06*
LTF	*LGEE*	*0.05*
LTF	*MEC*	*1.99*
LTF	*O-066*	*7.73*
LTF	*RENSSELAER*	*0.53*
LTF	*ROSETON*	*3.84*
292791	*U1-032 E*	*4.87*
297087	*V2-040*	*0.28*
900672	*V4-068 E*	*0.26*
901082	*W1-029E*	*41.82*

LTF	*WEC*	*0.06*
907092	*X1-038 E*	*5.47*
913392	*Y1-086 E*	*1.99*
916042	*Z1-036 E*	*40.84*
916192	*Z1-068 E*	*1.76*
917122	*Z2-027 E*	*0.96*
917592	*Z2-099 E*	*0.38*
918492	*AA1-063AE OP*	*3.35*
918512	*AA1-065 E OP*	*3.74*
918691	*AA1-083*	*1.16*
919152	*AA1-139 E*	*5.92*
919211	*AA1-145*	*19.79*
919732	*AA2-059 E*	*0.5*
LTF	*AA2-074*	*3.23*
920022	*AA2-086 E*	*0.21*
920042	*AA2-088 E*	*9.15*
920691	*AA2-178 C*	*8.43*
920692	*AA2-178 E*	*3.61*
930051	*AB1-013 C*	*2.54*
930052	*AB1-013 E*	*17.02*
930121	*AB1-027 C*	*0.87*
930122	*AB1-027 E*	*1.89*
930861	*AB1-132 C*	*11.78*
930862	*AB1-132 E*	*5.05*
931231	*AB1-173 C*	*1.9*
931232	*AB1-173 E*	*0.89*
931241	*AB1-173AC*	*1.9*
931242	*AB1-173AE*	*0.89*
923801	*AB2-015 C O1*	*7.73*
923802	*AB2-015 E O1*	*6.34*
923831	*AB2-022 C*	*2.1*
923832	*AB2-022 E*	*1.13*
923842	*AB2-024 E*	*1.49*
923852	*AB2-025 E*	*1.09*
923862	*AB2-026 E*	*0.88*
923911	*AB2-031 C O1*	*1.88*
923912	*AB2-031 E O1*	*0.93*
923991	*AB2-040 C O1*	*6.19*
923992	*AB2-040 E O1*	*5.06*
924061	*AB2-050*	*1.16*
924071	*AB2-051*	*128.86*
924241	*AB2-068 O1*	*177.95*
924381	*AB2-087 C*	*0.48*
924382	*AB2-087 E*	*0.22*
924501	*AB2-099 C*	*0.49*

924502	*AB2-099 E*	*0.21*
924511	*AB2-100 C*	*10.48*
924512	*AB2-100 E*	*5.16*
924811	*AB2-134 C O1*	*15.87*
924812	*AB2-134 E O1*	*15.6*
925051	*AB2-160 C O1*	*7.18*
925052	*AB2-160 E O1*	*11.71*
925061	*AB2-161 C O1*	*3.63*
925062	*AB2-161 E O1*	*5.92*
925171	*AB2-174 C O1*	*5.96*
925172	*AB2-174 E O1*	*5.39*
925281	*AB2-186 C*	*0.55*
925282	*AB2-186 E*	*0.24*
925291	*AB2-188 C O1*	*2.08*
925292	*AB2-188 E O1*	*0.93*
925331	*AB2-190 C*	*24.76*
925332	*AB2-190 E*	*10.61*
925522	*AC1-027 E*	*1.07*
925692	*AC1-045 E*	*0.92*
925861	*AC1-065 C*	*4.36*
925862	*AC1-065 E*	*7.11*
926071	*AC1-086 C*	*17.34*
926072	*AC1-086 E*	*7.89*
926291	*AC1-107*	*268.61*
926411	*AC1-112 C*	*0.68*
926412	*AC1-112 E*	*1.93*
926441	*AC1-115 C*	*1.01*
926442	*AC1-115 E*	*1.64*
926472	*AC1-118 E*	*1.07*
926551	*AC1-134*	*14.83*
926662	*AC1-147 E*	*1.25*
926741	*AC1-159*	*62.13*
926751	*AC1-161 C*	*27.16*
926752	*AC1-161 E*	*11.59*
926771	*AC1-163 C*	*1.63*
926772	*AC1-163 E*	*0.76*
926781	*AC1-164 C*	*58.41*
926782	*AC1-164 E*	*26.24*
927041	*AC1-191 C*	*17.46*
927042	*AC1-191 E*	*8.7*
927111	*AC1-206 C*	*9.15*
927112	*AC1-206 E*	*4.32*
927221	*AC1-216 C O1*	*12.11*
927222	*AC1-216 E O1*	*9.53*