Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AC2-004

Meyersdale North 115 kV

July 2017

Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer 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 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 conduct of light load analysis as required under the PJM planning process is not performed during the Generation Interconnection Feasibility Study phase of the PJM study process. Additional reinforcement requirements for this Interconnection Request may be defined during the conduct of the light load analysis which shall be performed following execution of the System Impact Study agreement.

General

The Interconnection Customer (IC), has proposed an uprate to an existing wind and storage generating facility located Somerset County, PA. This projects requests an increase to the install capability of 50.75 MW with 6.6 MW of this output being recognized by PJM as capacity. The installed facilities will have a total capability of 98.75 MW with 11.7 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is December 13, 2019. **This study does not imply a Mid Atlantic Interstate Transmission (or "MAIT") commitment to this in-service date.**

Point of Interconnection

AC2-004 will interconnect with the Mid Atlantic Interstate Transmission (or "MAIT") transmission system at the Meyersdale North 115 kV Substation. The Project will connect behind the existing POI for projects G21 and Z2-108, which is currently a single breaker connection to the Meyersdale North 115 kV bus.

Cost Summary

The AC2-004 project will be responsible for the following costs:

Description	Cost	Tax (if applicable)	Total Cost
Attachment Facilities	$ 0	$ 0	$ 0
Direct Connection Network Upgrades	$ 2,548,600	$ 747,400	$ 1,801,200
Non Direct Connection Network Upgrades	$ 0	$ 0	$ 0
Total Costs	**$ 2,548,600**	**$ 747,400**	**$ 1,801,200**

In addition, the AC2-004 project may be responsible for a contribution to the following costs (not including Tax):

Description	Total Cost
New System Upgrades	$ 32,425,000
Previously Identified Upgrades	$ 0
Total Costs	**$ 32,425,000**

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

Attachment Facilities

No Attachment Facilities are required to support this interconnection request.

Direct Connection Cost Estimate

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	Activity Cost	Tax (if applicable)	Total Cost
Meyersdale - Install 2-115kv breakers to create a 3-breaker ring-bus	$ 2,548,600	$ 747,400	$ 1,801,200
Total Attachment Facility Costs	**$ 2,548,600**	**$ 747,400**	**$ 1,801,200**

Non-Direct Connection Cost Estimate

No Non-Direct Connection Facilities are required to support this interconnection request.

Transmission Owner Scope of Work

Since AC2-004 is an increase to the Maximum Facility Output ("MFO") to all projects behind the POI, AC2-004 is considered a material change and will require that the interconnection facilities be upgraded to FE's current standards. As such, interconnection of the Project will require connection facilities consisting of the installation of 2-115 kV breakers and associated facilities to form a new 115kV three breaker ring bus.

Transmission Owner Schedule

Based on the scope of the connection facilities, it is expected to take a minimum of 20 months from the signing of a Connection Service Agreement to complete the installation required for the Project. This assumes that the IC will provide the property for the expansion of Meyersdale North substation and all right-of-way, permits, easements, etc. that will be needed. A further assumption is that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined direct connection and network upgrades, and that PJM will allow all transmission system outages when requested.

Interconnection Customer Requirements

1. An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.

3. The Interconnection Customer seeking to interconnect a wind generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per item 5.iv. of Schedule H to the Interconnection Service Agreement.

4. The purchase and installation of the minimum required FE generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

5. The purchase and installation of an 115 kV interconnection metering instrument transformer. FE will provide the ratio and accuracy specifications based on the customer load and generation levels.

6. The purchase and installation of supervisory control and data acquisition (SCADA) equipment to provide information in a compatible format to the FE Transmission System Control Center.

7. The establishment of dedicated communication circuits for SCADA report to the FE Transmission System Control Center.

8. A compliance with the FE and PJM generator power factor and voltage control requirements.

9. The execution of a back-up retail service agreement with the electric distribution company to serve the customer load supplied from the AC2-004 generation project interconnection point when the units are out-of-service.

10. 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 FE transmission system.

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.

MAIT Requirements

The Interconnection Customer will be required to comply with all FE Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "FirstEnergy Requirements for Transmission Connected Facilities" document located at the following links:

http://www.firstenergycorp.com/feconnect
http://www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Network Impacts

The Queue Project AC2-004 was evaluated as a 50.7 MW (Capacity 6.6 MW) injection at the Meyersdale 115 kV substation in the Penelec area. Project AC2-004 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-004 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Analysis - 2020

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
B2-PN-115-068	CONTINGENCY 'B2-PN-115-068' /* ROCKWOOD - SOMERSET 115KV DISCONNECT BRANCH FROM BUS 200744 TO BUS 200746 CKT 1 /* 26SOMERST 115 26ROCKWOOD 115 DISCONNECT BRANCH FROM BUS 200746 TO BUS 200773 CKT 1 /* 26ROCKWOOD 115 26ROCKWOOD 23 END
B2-PN-230-025	CONTINGENCY 'B2-PN-230-025' /* CONEMAUGH - SEWARD 230KV DISCONNECT BRANCH FROM BUS 200912 TO BUS 200793 CKT 1 /* 26CONEMAGH 230 26SEWARD 2 230 END
B3-PN-115-010	CONTINGENCY 'B3-PN-115-010' /* GARRETT 138/115KV XFMR FAULT OPEN BRANCH FROM BUS 235469 TO BUS 235470 CKT 1 /* 01GARRET 138.00 01GARRET 115.00 END
B3-PN-230-001	CONTINGENCY 'B3-PN-230-001' /* CONEMAUGH #1 500/230KV XFMR DISCONNECT BRANCH FROM BUS 200005 TO BUS 200912 CKT 3 /* CONEM-GH 500 26CONEMAGH 230 END

Contingency Name	Description
C2_PN115-SB-35E	CONTINGENCY 'C2_PN115-SB-35E' /* 649 DISCONNECT BRANCH FROM BUS 200734 TO BUS 200743 CKT 1 /* 26SCALP L. 115 26HOOVERSV 115 DISCONNECT BRANCH FROM BUS 200743 TO BUS 200802 CKT 1 /* 26HOOVERSV 115 26RALPHTON 115 DISCONNECT BRANCH FROM BUS 200743 TO BUS 200796 CKT 3 /* 26HOOVERSV 115 26HOOVRSVL 230 DISCONNECT BRANCH FROM BUS 200743 TO BUS 200836 CKT 1 /* 26HOOVERSV 115 26STATHILL 115 DISCONNECT BRANCH FROM BUS 200799 TO BUS 200800 CKT 1 /* 26CEN.CTY 115 26C.CITY W 23 DISCONNECT BRANCH FROM BUS 200799 TO BUS 200836 CKT 1 /* 26CEN.CTY 115 26STATHILL 115 DISCONNECT BRANCH FROM BUS 200836 TO BUS 200846 CKT 1 /* 26STATHILL 115 26FORWARD 35 DISCONNECT BRANCH FROM BUS 200743 TO BUS 200776 CKT 1 /* 26HOOVERSV 115 26HOOVER#1 23 DISCONNECT BRANCH FROM BUS 200743 TO BUS 200744 CKT 1 /* 26HOOVERSV 115 26SOMERST 115 DISCONNECT BRANCH FROM BUS 200742 TO BUS 200743 CKT 1 /* 26TOWER 51 115 26HOOVERSV 115 DISCONNECT BRANCH FROM BUS 200743 TO BUS 200789 CKT 2 /* 26HOOVERSV 115 26HOOVER#2 23 END
C2-PN-500-001A	CONTINGENCY 'C2-PN-500-001A' /* KEYSTONE 500KV BKR 1 DISCONNECT BRANCH FROM BUS 200011 TO BUS 200810 TO BUS 200906 CKT 3/* KEYSTONE 500 26KEYSTONE 230 26KEYSTN#3 20.00 REMOVE MACHINE H FROM BUS 200033 /* KEYS G2 20 REMOVE MACHINE L FROM BUS 200033 /* KEYS G2 20 DISCONNECT BUS 200033 /* KEYS G2 20 END
C2-PN-500-001D	CONTINGENCY 'C2-PN-500-001D' /* KEYSTONE 500KV BKR 4 DISCONNECT BRANCH FROM BUS 200011 TO BUS 200810 TO BUS 200906 CKT 3/* KEYSTONE 500 26KEYSTONE 230 26KEYSTN#3 20.00 REMOVE MACHINE H FROM BUS 200032 /* KEYS G1 20 REMOVE MACHINE L FROM BUS 200032 /* KEYS G1 20 DISCONNECT BUS 200032 /* KEYS G1 20 END
C2-PN-500-002A	CONTINGENCY 'C2-PN-500-002A' /* CONEMAUGH 500KV BKR 1 DISCONNECT BRANCH FROM BUS 200005 TO BUS 200912 CKT 3 /* CONEM-GH 500 26CONEMAGH 230 DISCONNECT BUS 200031 /* CONE G2 22 END

Contingency Name	Description
C2-PN-500-002F	CONTINGENCY 'C2-PN-500-002F' /* CONEMAUGH 500KV BKR 6 DISCONNECT BRANCH FROM BUS 200005 TO BUS 200912 CKT 3 /* CONEM-GH 500 26CONEMAGH 230 DISCONNECT BUS 200030 /* CONE G1 22 END
P12_DQE_167B	CONTINGENCY 'P12_DQE_167B' DISCONNECT BRANCH FROM BUS 200769 TO BUS 235129 CKT 1 END

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)

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Circuit	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
1	LFFB	C2-PN-500-001D	PENELEC	26KEYSTONE 230/1 kV transformer	200810	999435	4	DC	99.79	100.3	ER	634	7.16	1
2	LFFB	C2-PN-500-001A	PENELEC	26KEYSTONE 230/1 kV transformer	200810	999435	4	DC	99.71	100.22	ER	634	7.16	
3	LFFB	C2_PN115-SB-35E	PENELEC	26PRIDE-26ALLEGHEN 115 kV line	202637	200745	1	DC	87.5	100.76	ER	160	21.22	2

Note: Please see Attachment 1 for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper table in the Attachment.

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 Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Circuit	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
4	LFFB	C2-PN-500-002A	PENELEC	26HOMER CT-26SHELOCTA 230 kV line	200767	200795	1	DC	141.59	142.2	ER	917	12.36	3

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Circuit	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
5	LFFB	C2-PN-500-002F	PENELEC	26HOMER CT-26SHELOCTA 230 kV line	200767	200795	1	DC	141.55	142.15	ER	917	12.36	
6	LFFB	C2-PN-500-002A	PENELEC	26SHELOCTA-26KEYSTONE 230 kV line	200795	200810	1	DC	134.49	135.16	ER	917	13.49	4
7	LFFB	C2-PN-500-002F	PENELEC	26SHELOCTA-26KEYSTONE 230 kV line	200795	200810	1	DC	134.44	135.11	ER	917	13.49	
8	LFFB	C2_PN115-SB-35E	PENELEC	26NEW BALT-26BDFORD N 115 kV line	200884	200501	1	DC	103.77	117.03	ER	160	21.21	5

Note: Please see Attachment 1 for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper table in the Attachment.

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

#	Area	Bus No.	Bus	Breaker	Rating Type	Duty Percent Without AC2-004	Duty Percent With AC2-004	Duty Percent Difference
9	Penelec	200743	HOOVRSVL 115 115.kV	C CITY W	S	99.75%	100.31%	0.57%

Contributions to previously identified circuit breakers found to be over-duty:

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 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.

	Contingency		Affected		Bus			Power	Loading %		Rating		MW	
#	Type	Name	Area	Facility Description	From	To	Circuit	Flow	Initial	Final	Type	MVA	Contribution	Ref
10	N-1	B3-PN-115-010	PENELEC	26ROCKWOOD-26SOMERST 115 kV line	200746	200744	1	DC	125.02	153.35	ER	179	50.73	
11	Non	Non	PENELEC	26ROCKWOOD-26SOMERST 115 kV line	200746	200744	1	DC	106.8	130.75	NR	148	35.44	
12	N-1	B2-PN-115-068	PENELEC	26ROCKWOOD-Y1-033 TAP 115 kV line	200746	913140	1	DC	100.64	129.8	ER	174	50.74	
13	N-1	B2-PN-115-068	PENELEC	26PENN-MAR-26GARRETT 115 kV line	200747	200762	1	DC	126.89	157.27	ER	167	50.73	
14	Non	Non	PENELEC	26ARNOLD R-26LICK RUN 115 kV line	200761	200856	1	DC	91.43	125.71	NR	148	50.74	
15	N-1	B2-PN-115-068	PENELEC - AP	26GARRETT-01GARRET 115 kV line	200762	235470	1	DC	144.74	176.44	ER	160	50.73	
16	Non	Non	PENELEC - AP	26GARRETT-01GARRET 115 kV line	200762	235470	1	DC	94.61	106.1	NR	133	15.29	
17	Non	Non	PENELEC - AP	26GARRETT-01GARRET 115 kV line	200762	235470	1	DC	94.61	106.1	NR	133	15.29	
18	N-1	B2-PN-230-025	PENELEC	26HOMER CT-26SHELOCTA 230 kV line	200767	200795	1	DC	137.29	137.9	ER	917	12.37	
19	Non	Non	PENELEC	26HOMER CT-26SHELOCTA 230 kV line	200767	200795	1	DC	135.56	136.09	NR	731	8.72	

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Circuit	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
20	N-1	B3-PN-230-001	PENELEC	26SHELOCTA-26KEYSTONE 230 kV line	200795	200810	1	DC	129.5	130.16	ER	917	13.5	
21	Non	Non	PENELEC	26SHELOCTA-26KEYSTONE 230 kV line	200795	200810	1	DC	123.09	123.69	NR	731	9.65	
22	Non	Non	PENELEC	26LICK RUN-26ROCKWOOD 115 kV line	200856	200746	1	DC	127.89	164.92	NR	137	50.74	
23	Non	Non	PENELEC	26BIGBY-26ARNOLD R 115 kV line	200881	200761	1	DC	71.75	106.03	NR	148	50.74	
24	N-1	P12_DQE_167B	PENELEC	26BLAIRVLE+-26BLRSVL E 115 kV line	202643	200740	1	DC	109.78	110.55	ER	190	3.24	
25	Non	Non	PENELEC	26BLAIRVLE+-26BLRSVL E 115 kV line	202643	200740	1	DC	101.73	102.54	NR	164	2.95	
26	N-1	B2-PN-115-068	AP	01GARRET-01ALBRIG 138 kV line	235469	235120	1	DC	100.41	119.05	ER	191	35.6	
27	N-1	B2-PN-115-068	AP	01GARRET 138/115 kV transformer	235470	235469	1	DC	118.15	144.03	ER	196	50.73	
28	N-1	B2-PN-115-068	PENELEC	Y1-033 TAP-26PENN-MAR 115 kV line	913140	200747	1	DC	122.62	151.78	ER	174	50.73	

New System Reinforcements

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

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
#1, 2, 4, 5, 6, 7, 8	26KEYSTONE 230/1 kV transformer	In order to mitigate the overloads of facilities above, the following reinforcements are required: • At the Homer City substation, there will be a 500/345 kV transformer addition with a 500 kV breaker and a half layout. Total with Tax: $37,451,600; Tax: $11,022,400; Total Cost: $26,429,200 • Install a loop, approximately 1200' in length, to the proposed Homer City 500 kV substation expansion. The new structures shall be steel with concrete foundations. Loop the Conemaugh – Keystone 500 kV line into the Homer City 500 kV expanded substation. Total with Tax: $5,464,300; Tax: $1,563,900; Total Cost: $3,900,400 • At the Keystone substation, replace the 500 kV wave traps on the Conemaugh line (future Homer City). Total with Tax: $360,300; Tax: $104,800; Total Cost: $255,500 • At the Conemaugh substation, replace the 500 kV wave traps on the Keystone line (future Homer City). Total with Tax: $360,300; Tax: $104,800; Total Cost: $255,500 • Estimate Time: 28 months		**$ 30,840,600**
#3	26PRIDE-26ALLEGHEN 115 kV line	In order to mitigate the overloads of facilities above, the following reinforcements are required: • At the Hooversville substation, install a second 115 kV bus tie breaker and new 115 kV line position. Relocate the Ralphton line to the new terminal. Remove the old Ralphton line terminal. Total with Tax: $1,982,900; Tax: $581,500; Total Cost: $1,401,400; Estimate Time: 14 months		**$ 1,401,400**
#9	HOOVRSVL 115kV CB	In order to mitigate the overloads of facilities above, the following reinforcements are required: • Replace 115kV Circuit Breaker at Hooversville 115kV Sub. Estimated Cost: Total with Tax: $259,000; Tax: $76,000; Total Cost: $183,000; Estimated Time: 18 months		**$ 183,000**
			Total New Network Upgrades	**$ 32,425,000**

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

Included in New System Reinforcements section

Stability and Reactive Power Requirement

Stability and Reactive study to be completed during later study phases

Steady-State Voltage Requirements

Steady-State Voltage study to be completed during later study phases

Affected System Analysis & Mitigation

NYISO Impacts:

NYISO Impacts to be determined during later study phases (as applicable)

Attachment 1. Flowgate Details

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

(PENELEC - PENELEC) The 26KEYSTONE 230/1 kV transformer (from bus 200810 to bus 999435 ckt 4) loads from 99.79% to 100.3% (**DC power flow**) of its emergency rating (634 MVA) for the line fault with failed breaker contingency outage of 'C2-PN-500-001D'. This project contributes approximately 7.16 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
236828	01GRAYMONT	0.35
200886	26ARWF_N39	0.47
200890	26BF_G21_K23	5.92
200503	26C.SLOPE	4.28
200805	26COLVER13	3.45
202158	26CON.GEN1	0.12
202160	26CON.GEN2	0.08
200945	26CT_V3-030	0.16
200846	26FORWARD	4.3
200888	26HIGHLAND	0.41
200837	26HOMER C1	27.63
200838	26HOMER C2	23.08
200839	26HOMER C3	24.43
200636	26IUP CO-G	0.51
200894	26K02	6.38
200823	26MHP_X3-003	4.07
203034	26NA_O38_P22	0.42
200925	26R32	0.47

Bus Number	Bus Name	Full Contribution
290086	Q-036 E	5.71
200883	Q-053 E	7.95
296332	R-032 E	10.77
293432	R-040 E	0.25
297050	V2-019 E	0.06
293393	V3-030E	4.85
903643	W3-099 C OP1	1.15
903644	W3-099 E OP1	7.73
907462	X1-109 E	6.92
910522	X3-003 E	1.37
913142	Y1-033 E OP1	3.92
915951	Y3-092	69.53
LTF	Z1-019	66.52
916051	Z1-038	1.33
920573	Z1-066 E	1.47
916202	Z1-069 E	7.26
916311	Z1-087	1.97
916351	Z1-091	1.68

Bus Number	Bus Name	Full Contribution
202225	26SCI_S29B	1.15
200833	26SEWRDB34	16.7
200913	26SHAW-D	0.72
200715	26SHAWVL 1	12.87
200722	26SHAWVL 2	13.19
200665	26SHAWVL 3	17.85
200666	26SHAWVL 4	17.84
200809	26SITHE	1.6
200889	26STNY CRK	0.32
200834	26SW_E13_K22	0.29
931001	AC2-004 C	0.93
931002	AC2-004 E	6.23
931571	AC2-077	2.61
203997	B14E K18E	1.17
200864	K-013 E	0.22
292340	K-022	0.05
292542	L-013 1	4.51
293301	N-039 E	10.79
293603	O-018 E	9.34
293802	O-038 E	6.74
293902	O-048 E	4.06
294515	P-022 E	2.7
294573	P-028 E	8.23
203999	P-047 E	8.99
294903	P-060 E	7.18

Bus Number	Bus Name	Full Contribution
920632	Z2-014	0.04
920853	Z2-108 E	2.82
921072	AA1-046 C	1.75
921073	AA1-046 E	11.72
921283	AA1-082 E	4.68
921302	AA1-085 C	0.99
921303	AA1-085 E	6.62
921412	AA1-106	1.87
921612	AA1-144 OP	13.33
921642	AA2-000	43.82
921932	AA2-081	2.54
922062	AA2-112	1.8
922242	AA2-132	1.83
922252	AA2-133	1.5
922932	AB1-082 OP	2.69
923032	AB1-092	1.61
LTF	AB1-100	71.55
923442	AB1-160 C	0.5
923443	AB1-160 E	2.13
925512	AC1-025 E	0.13
926991	AC1-186 C OP	3.29
926992	AC1-186 E OP	22.08
927001	AC1-187 C	2
927002	AC1-187 E	13.62

Appendix 2

(PENELEC - PENELEC) The 26PRIDE-26ALLEGHEN 115 kV line (from bus 202637 to bus 200745 ckt 1) loads from 87.5% to 100.76% (**DC power flow**) of its emergency rating (160 MVA) for the line fault with failed breaker contingency outage of 'C2_PN115-SB-35E'. This project contributes approximately 21.22 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
200890	26BF_G21_K23	17.56
200891	26CSLMN_L13	0.59
200840	26DEEPCRK1	0.29
200841	26DEEPCRK2	0.29
200835	26DSGENWIN	1.1
200892	26LOOKOUT	0.56
202225	26SCI_S29B	3.38

Bus Number	Bus Name	Full Contribution
292340	K-022	0.16
292350	K-023	0.44
292542	L-013 1	13.38
293902	O-048 E	12.04
293432	R-040 E	0.75
913141	Y1-033 C OP1	0.33
913142	Y1-033 E OP1	11.78

Bus Number	Bus Name	Full Contribution
200834	26SW_E13_K22	0.86
200813	26YOUGH	0.31
931001	AC2-004 C	2.76
931002	AC2-004 E	18.46
203997	B14E K18E	3.47

Bus Number	Bus Name	Full Contribution
920573	Z1-066 E	4.35
920853	Z2-108 E	8.36
921072	AA1-046 C	5.59
921073	AA1-046 E	37.41

Appendix 3

(PENELEC - PENELEC) The 26HOMER CT-26SHELOCTA 230 kV line (from bus 200767 to bus 200795 ckt 1) loads from 141.59% to 142.2% (**DC power flow**) of its emergency rating (917 MVA) for the line fault with failed breaker contingency outage of 'C2-PN-500-002A'. This project contributes approximately 12.36 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
236828	01GRAYMONT	0.57
200886	26ARWF_N39	0.9
200890	26BF_G21_K23	10.23
200503	26C.SLOPE	7.38
200846	26FORWARD	7.41
200888	26HIGHLAND	0.72
200837	26HOMER C1	48.22
200838	26HOMER C2	39.94
200839	26HOMER C3	42.28
200894	26K02	10.34
200823	26MHP_X3-003	6.73
203034	26NA_O38_P22	0.78
200925	26R32	0.83
202225	26SCI_S29B	1.99
200833	26SEWRDB34	34.19
200913	26SHAW-D	1.07
200715	26SHAWVL 1	19.97
200722	26SHAWVL 2	20.47
200665	26SHAWVL 3	28.06
200666	26SHAWVL 4	28.06
200809	26SITHE	2.8
200889	26STNY CRK	0.54
200834	26SW_E13_K22	0.51
931001	AC2-004 C	1.61
931002	AC2-004 E	10.75
931571	AC2-077	4.4
203997	B14E K18E	2.02
200864	K-013 E	0.38

Bus Number	Bus Name	Full Contribution
296332	R-032 E	18.77
293432	R-040 E	0.44
297050	V2-019 E	0.09
293393	V3-030E	6.24
903643	W3-099 C OP1	1.92
903644	W3-099 E OP1	12.86
907462	X1-109 E	11.49
910522	X3-003 E	2.27
913142	Y1-033 E OP1	6.78
915951	Y3-092	115.86
LTF	Z1-019	112.14
916051	Z1-038	2.2
920573	Z1-066 E	2.53
916202	Z1-069 E	12.26
916311	Z1-087	3.27
916351	Z1-091	2.8
920853	Z2-108 E	4.87
921072	AA1-046 C	3.02
921073	AA1-046 E	20.22
921283	AA1-082 E	7.77
921302	AA1-085 C	1.6
921303	AA1-085 E	10.63
921412	AA1-106	3.11
921612	AA1-144 OP	22.13
921642	AA2-000	70.39
921932	AA2-081	4.3
922062	AA2-112	3.01
922242	AA2-132	3.07

Bus Number	Bus Name	Full Contribution
292340	K-022	0.09
292542	L-013 1	7.79
293301	N-039 E	20.39
293603	O-018 E	16.27
293802	O-038 E	12.74
293902	O-048 E	7.01
294515	P-022 E	5.1
294573	P-028 E	13.62
203999	P-047 E	15.18
294903	P-060 E	12.38
290086	Q-036 E	9.23
200883	Q-053 E	13.56

Bus Number	Bus Name	Full Contribution
922252	AA2-133	2.5
LTF	AA2-300	36.96
922932	AB1-082 OP	4.53
923032	AB1-092	2.58
LTF	AB1-100	122.36
923442	AB1-160 C	0.84
923443	AB1-160 E	3.59
925512	AC1-025 E	0.21
926991	AC1-186 C OP	5.68
926992	AC1-186 E OP	38.08
927001	AC1-187 C	3.38
927002	AC1-187 E	22.96

Appendix 4

(PENELEC - PENELEC) The 26SHELOCTA-26KEYSTONE 230 kV line (from bus 200795 to bus 200810 ckt 1) loads from 134.49% to 135.16% (**DC power flow**) of its emergency rating (917 MVA) for the line fault with failed breaker contingency outage of 'C2-PN-500-002A'. This project contributes approximately 13.49 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
236828	01GRAYMONT	0.63
200886	26ARWF_N39	0.93
200890	26BF_G21_K23	11.16
200503	26C.SLOPE	8.31
200915	26CHSTN_FL	0.56
200805	26COLVER13	6.16
202158	26CON.GEN1	0.19
200945	26CT_V3-030	0.3
200846	26FORWARD	8.06
200888	26HIGHLAND	0.79
200837	26HOMER C1	46.65
200838	26HOMER C2	39.08
200839	26HOMER C3	41.37
200636	26IUP CO-G	0.85
200894	26K02	11.04
200823	26MHP_X3-003	6.76
203034	26NA_O38_P22	0.81
200925	26R32	0.91
202225	26SCI_S29B	2.16
200833	26SEWRDB34	35.58

Bus Number	Bus Name	Full Contribution
290086	Q-036 E	10.67
200883	Q-053 E	15.25
296332	R-032 E	20.71
293432	R-040 E	0.48
297050	V2-019 E	0.1
293393	V3-030E	9.01
903643	W3-099 C OP1	2
903644	W3-099 E OP1	13.4
907462	X1-109 E	11.64
910522	X3-003 E	2.28
913142	Y1-033 E OP1	7.42
915951	Y3-092	121.91
LTF	Z1-019	112.96
916051	Z1-038	2.21
920573	Z1-066 E	2.76
916202	Z1-069 E	12.38
916311	Z1-087	3.42
916351	Z1-091	2.82
920632	Z2-014	0.08
920853	Z2-108 E	5.32

Bus Number	Bus Name	Full Contribution
200913	26SHAW-D	1.3
200715	26SHAWVL 1	22.91
200722	26SHAWVL 2	23.49
200665	26SHAWVL 3	31.7
200666	26SHAWVL 4	31.69
200809	26SITHE	2.71
200889	26STNY CRK	0.6
200834	26SW_E13_K22	0.55
931001	AC2-004 C	1.75
931002	AC2-004 E	11.73
931571	AC2-077	4.44
203997	B14E K18E	2.21
200864	K-013 E	0.42
292340	K-022	0.1
292542	L-013 1	8.51
293301	N-039 E	21.1
293603	O-018 E	17.95
293802	O-038 E	13.19
293902	O-048 E	7.65
294515	P-022 E	5.28
294573	P-028 E	13.68
203999	P-047 E	15.21
294903	P-060 E	13.54

Bus Number	Bus Name	Full Contribution
921072	AA1-046 C	3.29
921073	AA1-046 E	22.05
921283	AA1-082 E	7.87
921302	AA1-085 C	1.77
921303	AA1-085 E	11.79
921412	AA1-106	3.18
921612	AA1-144 OP	22.45
921642	AA2-000	76.61
921932	AA2-081	4.32
922062	AA2-112	3.03
922242	AA2-132	3.08
922252	AA2-133	2.51
LTF	AA2-300	34.77
922932	AB1-082 OP	4.6
923032	AB1-092	2.81
LTF	AB1-100	121.2
923442	AB1-160 C	0.85
923443	AB1-160 E	3.63
925512	AC1-025 E	0.23
926991	AC1-186 C OP	6.18
926992	AC1-186 E OP	41.46
927001	AC1-187 C	3.42
927002	AC1-187 E	23.27

Appendix 5

(PENELEC - PENELEC) The 26NEW BALT-26BDFORD N 115 kV line (from bus 200884 to bus 200501 ckt 1) loads from 103.77% to 117.03% (**DC power flow**) of its emergency rating (160 MVA) for the line fault with failed breaker contingency outage of 'C2_PN115-SB-35E'. This project contributes approximately 21.21 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
200890	26BF_G21_K23	17.56
200891	26CSLMN_L13	0.59
200840	26DEEPCRK1	0.29
200841	26DEEPCRK2	0.29
200835	26DSGENWIN	1.1
200892	26LOOKOUT	0.56
202225	26SCI_S29B	3.38
200889	26STNY CRK	1.14
200834	26SW_E13_K22	0.86
200813	26YOUGH	0.3

Bus Number	Bus Name	Full Contribution
292340	K-022	0.15
292350	K-023	0.44
292542	L-013 1	13.38
293902	O-048 E	12.04
294903	P-060 E	26
293432	R-040 E	0.75
913141	Y1-033 C OP1	0.33
913142	Y1-033 E OP1	11.78
920573	Z1-066 E	4.35
920853	Z2-108 E	8.36

931001	AC2-004 C	2.76
931002	AC2-004 E	18.46
203997	B14E K18E	3.47

921072	AA1-046 C	5.59
921073	AA1-046 E	37.41