Generation Interconnection

Feasibility Study Report

for

Queue Project AF1-295

BLAIN 115 KV II

12 MW Capacity / 12 MW Energy

January, 2020

Table of Contents

1 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 Mid-Atlantic Interstate Transmission (MAIT – Penelec zone).

2 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. Cost allocation rules for network upgrades can be found in PJM Manual 14A, Attachment B. 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.

PJM utilizes manufacturer models to ensure the performance of turbines is properly captured during the simulations performed for stability verification and, where applicable, for compliance with low voltage ride through requirements. Turbine manufacturers provide such models to their customers. The list of manufacturer models PJM has already validated is contained in Attachment B of Manual 14G. Manufacturer models may be updated from time to time, for various reasons such as to reflect changes to the control systems or to more accurately represent the capabilities turbines and controls which are currently available in the field. Additionally, as new turbine models are developed, turbine manufacturers provide such new models which must be used in the conduct of these studies. PJM needs adequate time to evaluate the new models in order to reduce delays to the System Impact Study process timeline for the Interconnection Customer as well as other Interconnection Customers in the study group. Therefore, PJM will require that any Interconnection Customer with a new manufacturer model must supply that model to PJM, along with a $10,000 fully refundable deposit, no later than three (3) months prior to the starting date of the System Impact Study (See Section 4.3 for starting dates) for the Interconnection Request which shall specify the use of the new model. The Interconnection Customer will be required to submit a completed dynamic model study request form (Attachment B-1 of Manual 14G) in order to document the request for the study.

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.

3 General

The Interconnection Customer (IC) has proposed a battery storage uprate to a planned solar generating facility located in Perry County, Pennsylvania. This battery storage project is an increase to the Interconnection Customer's AE2-215 solar project, which will share the same property and point of interconnection. The AF1-295 queue position is a 12 MW uprate (12 MW Capacity uprate) to the previous project. The total installed facilities will have a capability of 72 MW with 48 MW of this output being recognized by PJM as Capacity (see table below for clarity). The proposed in-service date for this uprate project is December 31, 2022. This study does not imply a TO commitment to this in-service date.

Queue	Maximum Facility Output (MFO) (MW)	Energy (MW)	Capacity (MW)
AE2-215	60	60	36
AF1-295	12	12	12
Total	**72**	**72**	**48**

Queue Number	**AF1-295**
Project Name	BLAIN 115 KV II
State	Pennsylvania
County	Perry
Transmission Owner	PENELEC
MFO	72
MWE	12
MWC	12
Fuel	Storage
Basecase Study Year	2023

3.1 Point of Interconnection

AF1-295 will interconnect with the PENELEC transmission system as an uprate to the AE2-215 project at the Blaine 115 kV substation. No modification of the FE connection facilities, other than those previously defined in the AE2-215 report, are required to accommodate this capacity increase.

Attachment 1 shows a one-line diagram of the proposed primary direct connection facilities for the AE2-215/AF1-295 generation project to connect to the FirstEnergy ("FE") transmission system. IC will be responsible for constructing the facilities on its side of the POI, including the attachment facilities which connect the generator to the FE transmission system's direct connection facilities.

3.2 Cost Summary

There are no direct or non-direct connection facility upgrades to accommodate the net energy output increase.

The AF1-295 project may be responsible for a contribution to the following costs:

Description	Total Cost
System Upgrades	**$187,605,050**

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

The costs provided above exclude the Contribution in Aid of Construction ("CIAC") Federal Income Tax Gross Up charge. If, at a future date, it is determined that the CIAC Federal Income Tax Gross charge is required, the Transmission Owner shall be reimbursed by the Interconnection Customer for such taxes.

4 Transmission Owner Scope of Work

AF1-295 will interconnect with the PENELEC transmission system as an uprate to the AE2-215 project at the Blaine 115 kV substation. No modification of the FE connection facilities, other than those previously defined in the AE2-215 report, are required to accommodate the connection facilities for this capacity increase. There are System Reinforcements required as identified in the Network Impacts section of the report.

4.1 Attachment Facilities

There is no Attachment Facility scope of work required.

4.2 Direct Connection Cost Estimate

There is no Direct Connection scope of work required.

4.3 Non-Direct Connection Cost Estimate

There is no Non-Direct Connection scope of work required.

5 Schedule

AF1-295 is an increase to the AE2-215 project. Therefore, there are no Attachment Facilities, Direct, and Non-Direct Connection facilities work to be completed outside of the scope of the AE2-215 project.

The schedule for the required Network Impact Reinforcements will be more clearly identified in future study phases. The estimate elapsed time to complete each of the required reinforcements is identified in the "System Reinforcements" section of the report.

6 Transmission Owner Analysis

6.1 Power Flow Analysis

FE performed an analysis of its underlying transmission <100 kV system. The AF1-295 project did not contribute to any overloads on the FE transmission <100 kV system.

7 Interconnection Customer Requirements

7.1 System Protection

The IC must design its Customer Facilities in accordance with all applicable standards, including the standards in FE's "Requirements for Transmission Connected Facilities" document located at: http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx.

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.

The IC has requested a non-standard GSU transformer winding configuration. This transformer is in violation of section 14.2.6 of FE's "Requirements for Transmission Connected Facilities" document and will not be accepted. The GSU transformer must have a grounded wye connection on the high (utility) side and a delta connection on the low (generator) side.

7.2 Compliance Issues and Interconnection Customer Requirements

The proposed Customer Facilities must be designed in accordance with FE's "Requirements for Transmission Connected Facilities" document located at: http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx. In particular, the IC is responsible for the following:

1. The purchase and installation of a fully rated 115 kV circuit breaker to protect the AE2-215/AF1-295 generator lead line. A single circuit breaker must be used to protect this line; if the project has several GSU transformers, the individual GSU transformer breakers cannot be used to protect this line.

2. 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.

3. 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.

4. Compliance with the FE and PJM generator power factor and voltage control requirements.

5. The execution of a back-up service agreement to serve the customer load supplied from the AE2-215/AF1-295 generation project metering point when the units are out-of-service. This assumes the intent of the IC is to net the generation with the load.

The IC will also be required to meet all PJM, ReliabilityFirst, 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 ReliabilityFirst 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 FE system.

7.3 Power Factor Requirements

The existing 60 MW portion of the Customer Facility shall retain 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. The increase of 12 MW to the Customer Facility associated with AF1-295 project shall be designed with the ability to maintain a power factor of at least 0.95 leading (absorbing VARs) to 0.95 lagging (supplying VARs) at the Point of Interconnection.

8 Revenue Metering and SCADA Requirements

8.1 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.

8.1.1 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

8.2 PENELEC Requirements

The IC will be required to comply with all FE revenue metering requirements for generation interconnection customers which can be found in FE's "Requirements for Transmission Connected Facilities" document located at: http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx

9 Network Impacts

The Queue Project AF1-295 was evaluated as a 12.1 MW (Capacity 12.0 MW) injection as an uprate to the AE2-215 project at the Blaine 115 kV substation in the PENELEC area. Project AF1-295 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-295 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Load Flow

10 Generation Deliverability

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

ID	FROM BUS#	FROM BUS	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
41393855	938380	AE1-071 TAP	115.0	PENELEC	200520	26ROXBURY	115.0	PENELEC	1	Base Case	single	133.0	98.4	101.09	DC	3.58
41393856	938380	AE1-071 TAP	115.0	PENELEC	200520	26ROXBURY	115.0	PENELEC	1	TS P1-2_#1	single	160.0	98.64	100.87	DC	3.57

11 Multiple Facility Contingency

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

None

12 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	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
41701135	200512	26LEWISTWN	115.0	PENELEC	200519	26REEDTAP	115.0	PENELEC	1	PL_P42_100548	breaker	225.0	112.07	115.44	DC	7.58
41897550	200513	26LEWISTWN	230.0	PENELEC	208005	JUNI BU2	230.0	PPL	1	PN-P2-2-PN-115-032	bus	624.0	139.09	140.13	DC	6.74
41393814	200519	26REEDTAP	115.0	PENELEC	200522	26SHADEGP	115.0	PENELEC	1	PL_P12_100618	single	225.0	108.88	110.85	DC	4.43
41393815	200519	26REEDTAP	115.0	PENELEC	200522	26SHADEGP	115.0	PENELEC	1	PN-P1-2-PN-230-103T	single	225.0	107.52	109.49	DC	4.43
41701033	200519	26REEDTAP	115.0	PENELEC	200522	26SHADEGP	115.0	PENELEC	1	PL_P42_100548	breaker	225.0	116.08	118.05	DC	4.42
41393480	200522	26SHADEGP	115.0	PENELEC	938380	AE1-071 TAP	115.0	PENELEC	1	PL_P12_100618	single	160.0	138.11	140.88	DC	4.43
41393481	200522	26SHADEGP	115.0	PENELEC	938380	AE1-071 TAP	115.0	PENELEC	1	PN-P1-2-PN-230-103T	single	160.0	136.2	138.97	DC	4.43
41701109	938380	AE1-071 TAP	115.0	PENELEC	200520	26ROXBURY	115.0	PENELEC	1	TS_P4_#3_RICE 500_CB 3	breaker	160.0	123.41	125.65	DC	3.58
41701112	938380	AE1-071 TAP	115.0	PENELEC	200520	26ROXBURY	115.0	PENELEC	1	TS_P4_#2_RICE 500_CB 2	breaker	160.0	123.35	125.59	DC	3.58
41897469	938380	AE1-071 TAP	115.0	PENELEC	200520	26ROXBURY	115.0	PENELEC	1	AP-P2-2-WP-230-001T	bus	160.0	123.71	125.98	DC	3.63
50709776	938380	AE1-071 TAP	115.0	PENELEC	200520	26ROXBURY	115.0	PENELEC	1	TS_P4_#1_RICE 500_CB 1	breaker	160.0	123.29	125.52	DC	3.58

13 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	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
41393885	200512	26LEWISTWN	115.0	PENELEC	200519	26REED TAP	115.0	PENELEC	1	PL_P12_100618	operation	225.0	110.63	113.99	DC	7.57
41393400	200513	26LEWISTWN	230.0	PENELEC	208005	JUNI BU2	230.0	PPL	1	PN-P1-2-PN-115-094-A	operation	624.0	139.06	140.09	DC	6.74
41393812	200519	26REED TAP	115.0	PENELEC	200522	26SHADE GP	115.0	PENELEC	1	PL_P12_100618	operation	225.0	114.64	116.61	DC	4.43
41393478	200522	26SHADE GP	115.0	PENELEC	938380	AE1-071 TAP	115.0	PENELEC	1	PL_P12_100618	operation	160.0	146.21	148.98	DC	4.43
41393850	938380	AE1-071 TAP	115.0	PENELEC	200520	26ROXBURY	115.0	PENELEC	1	Base Case	operation	133.0	123.7	126.39	DC	3.58
41393851	938380	AE1-071 TAP	115.0	PENELEC	200520	26ROXBURY	115.0	PENELEC	1	TS P1-2_#1	operation	160.0	119.36	121.59	DC	3.57

14 System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
41897550	3	26LEWISTWN 230.0 kV - JUNI BU2 230.0 kV Ckt 1	**PENELEC** **PN-AF1-F-0003a (260) :Lewistown-Juniata 230 kV Line: PPL would need to replace their section of the limiting conductor/ equipment and provide estimates for their replacement. Their replacement conductor/ equipment should at least be rated above 660 MVA (Rate B) to not remain as the limiting element.** **Project Type : FAC** **Cost : $0** **Time Estimate : Months** **PN-AF1-F-0003b (261) : Reconductor Lewistown – Juniata 230 kV Line (~24.5 miles).** **Project Type : FAC** **Cost : $102,042,500** **Time Estimate : 6.0 Months** **PN-AF1-F-0003c (262) : Replace relays at Lewistown Substation** **Project Type : FAC** **Cost : $297,500** **Time Estimate : 12.0 Months** **PN-AF1-F-0003d (263) : Replace Wave Trap at Lewistown Substation** **Project Type : FAC** **Cost : $119,000** **Time Estimate : 9.0 Months** **PPL** **R-PL-0006 (427) : Re-conductor PPL's ~0.9mi Lewistown-Juniata 230kV Line** **Project Type : FAC** **Cost : $900,000** **Time Estimate : 24.0 Months**	$103,359,000

ID	Index	Facility	Upgrade Description	Cost
41393480,41393481	5	26SHADE GP 115.0 kV - AE1-071 TAP 115.0 kV Ckt 1	PENELEC PN-AF1-F-0005a (268) : Reconductor Shade Gap - AE1-071 115 kV Line (~7.2 miles). Project Type : FAC Cost : $12,852,000 Time Estimate : 6.0 Months PN-AF1-F-0005b (269) : Replace substation conductor at Roxbury and Shade Gap Substations Replace Wave Trap at Shade Gap Substation Project Type : FAC Cost : $119,000 Time Estimate : 6.0 Months PN-AF1-F-0005c (270) : Replace CT at Roxbury Substation Project Type : FAC Cost : $0 Time Estimate : 12.0 Months	$12,971,000
41393856,41393855,41701109,50709776,41897469,41701112	1	AE1-071 TAP 115.0 kV - 26ROXBURY 115.0 kV Ckt 1	PENELEC PN-AF1-F-0066a (196) : Reconductor AE1-071 - Roxbury 115 kV Line (~6 miles) Project Type : FAC Cost : $11,424,000 Time Estimate : 6.0 Months PN-AF1-F-0066b (197) : Replace Wave Trap at Shade Gap Substation Replace substation conductor at Roxbury Substation Project Type : FAC Cost : $119,000 Time Estimate : 9.0 Months	$11,543,000
41701135	2	26LEWISTWN 115.0 kV - 26REED TAP 115.0 kV Ckt 1	PENELEC PN-AF1-F-0002a (264) : Reconductor Lewistown - Shade Gap 115 kV Line (~10 miles). Project Type : FAC Cost : $17,850,000 Time Estimate : 30.0 Months PN-AF1-F-0002b (265) : Reconductor Lewistown - Shade Gap 115 kV Line (~0.2 mile). Project Type : FAC Cost : $766,360 Time Estimate : 24.0 Months	$18,616,360

ID	Index	Facility	Upgrade Description	Cost
41393815,41393814,41701033	4	26REED TAP 115.0 kV - 26SHADE GP 115.0 kV Ckt 1	**PENELEC** **PN-AF1-F-0004a (264) : Reconductor Reeds Tap - Shade Gap 115 kV Line (~22.4 miles).** **Project Type : FAC** **Cost : $39,984,000** **Time Estimate : 6.0 Months** **PN-AF1-F-0004b (265) : Replace CTs at Shade Gap Substation** **Reconductor Reeds Tap - Shade Gap 115 kV Line (~0.2 miles).** **Project Type : FAC** **Cost : $1,042,440** **Time Estimate : 12.0 Months** **PN-AF1-F-0004c (266) : Replace substation conductor at Shade Gap Substation** **Project Type : FAC** **Cost : $89,250** **Time Estimate : 6.0 Months**	$41,115,690
			TOTAL COST	**$187,605,050**

15 Flow Gate Details

The following indices contain additional information about each flowgate presented in the body of the report. For each index, 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.

15.1 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
50709776	938380	AE1-071 TAP	PENELEC	200520	26ROXBURY	PENELEC	1	TS_P4_#1_RICE 500_CB 1	breaker	160.0	123.29	125.52	DC	3.58

Bus #	Bus	MW Impact
235003	AC1-025 E	0.0763
236828	01GRAYMONT	0.1967
934361	AD1-060 C	-0.2680
934362	AD1-060 E	-0.4372
938381	AE1-071 C	38.9299
938382	AE1-071 E	23.8218
939171	AE1-147 C	0.5868
939172	AE1-147 E	0.3912
940201	AE2-001 C	0.5886
940202	AE2-001 E	0.3924
940681	AE2-055 C	0.6165
940682	AE2-055 E	0.4110
941231	AE2-117 C	0.6487
941232	AE2-117 E	0.4325
941241	AE2-118 C	0.6487
941242	AE2-118 E	0.4325
941261	AE2-120 C	0.5896
941262	AE2-120 E	0.3930
941271	AE2-121 C	0.3103
941272	AE2-121 E	0.2072
942031	AE2-215 C	10.7251
942032	AE2-215 E	7.1501
942351	AE2-248 C	0.4839
942352	AE2-248 E	0.3226
942511	AE2-264 C	2.1575
942512	AE2-264 E	1.4383
944001	AF1-068 C O1	0.3439
944002	AF1-068 E O1	0.1934
944471	AF1-112 C	0.3190
944472	AF1-112 E	0.2126
944671	AF1-132 C O1	0.3234
944672	AF1-132 E O1	0.2156
944731	AF1-138 C O1	0.3438
944732	AF1-138 E O1	0.2292
944841	AF1-149 C	0.5898
944842	AF1-149 E	0.3932
945491	AF1-214 C	0.3125
945492	AF1-214 E	0.2083
946311	AF1-295	3.5750
DUCKCREEK	DUCKCREEK	0.1359
NEWTON	NEWTON	0.1418

Bus #	Bus	MW Impact
FARMERCITY	FARMERCITY	0.0080
G-007A	G-007A	0.9518
VFT	VFT	2.6961
PRAIRIE	PRAIRIE	0.3874
COFFEEN	COFFEEN	0.0692
EDWARDS	EDWARDS	0.0403
CHEOAH	CHEOAH	0.1236
TILTON	TILTON	0.0737
GIBSON	GIBSON	0.0699
CALDERWOOD	CALDERWOOD	0.1213
BLUEG	BLUEG	0.2239
TRIMBLE	TRIMBLE	0.0712
CATAWBA	CATAWBA	0.1183

15.2 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
41701135	200512	26LEWISTWN	PENELEC	200519	26REED TAP	PENELEC	1	PL_P42_100548	breaker	225.0	112.07	115.44	DC	7.58

Bus #	Bus	MW Impact
200812	26ALY HYDR	0.3760
200852	26WARR RDG	0.1074
235003	AC1-025 E	0.1809
236828	01GRAYMONT	0.4655
290086	Q-036 E	2.0611
293301	N-039 E	3.5812
294515	O38_P22	3.1335
919491	AA2-000	26.2577
930511	AB1-092	0.9641
936421	AD2-055	1.9849
936991	AD2-133 C	0.9275
936992	AD2-133 E	4.2422
939171	AE1-147 C	1.3885
939172	AE1-147 E	0.9257
940201	AE2-001 C	1.3931
940202	AE2-001 E	0.9287
940681	AE2-055 C	1.4624
940682	AE2-055 E	0.9750
941231	AE2-117 C	1.5395
941232	AE2-117 E	1.0263
941241	AE2-118 C	1.5395
941242	AE2-118 E	1.0263
941251	**AE2-119 C (Withdrawn : 12/16/2019)**	**0.7308**
941252	**AE2-119 E (Withdrawn : 12/16/2019)**	**0.4872**
941261	AE2-120 C	1.3956
941262	AE2-120 E	0.9304
941271	AE2-121 C	0.7340
941272	AE2-121 E	0.4901
941321	AE2-126 C	0.6666
941322	AE2-126 E	0.4444
941331	AE2-129 C	0.6690
941332	AE2-129 E	0.4460
941351	AE2-131 C	0.6690
941352	AE2-131 E	0.4460
942351	AE2-248 C	1.1468
942352	AE2-248 E	0.7645
942491	AE2-262 C	4.1025
942492	AE2-262 E	2.7569
942501	AE2-263 C	3.8564
942502	AE2-263 E	2.5747
942511	AE2-264 C	5.0630
942512	AE2-264 E	3.3754

Bus #	Bus	MW Impact
943751	AF1-043	3.1560
944001	AF1-068 C O1	1.5383
944002	AF1-068 E O1	0.8653
944311	AF1-099 C	3.3006
944312	AF1-099 E	2.2004
944321	AF1-100 C O1	5.6135
944322	AF1-100 E O1	3.7423
944471	AF1-112 C	1.4258
944472	AF1-112 E	0.9506
944671	AF1-132 C O1	1.4471
944672	AF1-132 E O1	0.9647
944691	AF1-134 C O1	0.2510
944692	AF1-134 E O1	0.2510
944701	AF1-135 C	0.3012
944702	AF1-135 E	0.2008
944731	AF1-138 C O1	1.5395
944732	AF1-138 E O1	1.0263
944771	AF1-142 C	5.2810
944772	AF1-142 E	3.5207
944841	AF1-149 C	1.3958
944842	AF1-149 E	0.9306
944881	AF1-153 C O1	0.3383
944882	AF1-153 E O1	0.2255
944901	AF1-155 C	0.3363
944902	AF1-155 E	0.2242
945071	AF1-172 C	4.9350
945072	AF1-172 E	3.2900
945161	AF1-181	0.0299
945171	AF1-182	0.1497
945181	AF1-183	0.0349
945481	AF1-213 C	2.6018
945482	AF1-213 E	1.7345
945491	AF1-214 C	1.3954
945492	AF1-214 E	0.9302
945551	AF1-220 C	2.5011
945552	AF1-220 E	1.6683
945771	AF1-242 C	0.3363
945772	AF1-242 E	0.2242
946091	AF1-274 C	1.4725
946092	AF1-274 E	0.9817
946312	AF1-295 BAT	7.5751
946421	AF1-306 C	1.7269
946422	AF1-306 E	6.9075
LGEE	LGEE	0.0650
WEC	WEC	0.0435
CBM-W2	CBM-W2	0.5897
CBM-W1	CBM-W1	2.0892
TVA	TVA	0.0364
O-066	O-066	1.5456
CHEOAH	CHEOAH	0.0070
CBM-S1	CBM-S1	0.3578
G-007	G-007	0.2735

Bus #	Bus	MW Impact
MEC	MEC	0.1796
CALDERWOOD	CALDERWOOD	0.0050
CATAWBA	CATAWBA	0.0399

15.3 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
41897550	200513	26LEWISTWN	PENELEC	208005	JUNI BU2	PPL	1	PN-P2-2-PN-115-032	bus	624.0	139.09	140.13	DC	6.74

Bus #	Bus	MW Impact
200665	26SHAWVL 3	6.2354
200666	26SHAWVL 4	6.1364
200715	26SHAWVL 1	4.0803
200722	26SHAWVL 2	4.1849
200812	26ALY HYDR	1.1764
200852	26WARR RDG	0.3361
200883	Q-053 E	5.9286
200886	26ARWF_N39	0.4537
200894	26K02	6.4807
200913	26SHAW-D	0.1853
201477	26Y2-055	2.7694
203034	26NA_O38_P22	0.3970
235003	AC1-025 E	0.5646
236828	01GRAYMONT	1.4514
290086	Q-036 E	6.3498
293301	N-039 E	13.0022
293393	V3-030E	2.8273
293603	O-018 E	4.7771
294515	O38_P22	11.3770
296332	R-032 E	5.5121
919491	AA2-000	93.7344
922932	AB1-082 OP	1.8074
930511	AB1-092	2.9254
936421	AD2-055	6.0229
936991	AD2-133 C	2.8574
936992	AD2-133 E	13.0696
938381	AE1-071 C	34.7356
938382	AE1-071 E	21.2553
939171	AE1-147 C	4.3286
939172	AE1-147 E	2.8858
940201	AE2-001 C	4.3432
940202	AE2-001 E	2.8954
940681	AE2-055 C	4.5641
940682	AE2-055 E	3.0427
940861	AE2-074 C	1.3723
940862	AE2-074 E	1.8065
941191	AE2-113 C	7.8165
941192	AE2-113 E	8.4159
941231	AE2-117 C	4.8158
941232	AE2-117 E	3.2106
941241	AE2-118 C	4.8158

Bus #	Bus	MW Impact
941242	AE2-118 E	3.2106
941251	**AE2-119 C (Withdrawn : 12/16/2019)**	**2.6548**
941252	**AE2-119 E (Withdrawn : 12/16/2019)**	**1.7698**
941261	AE2-120 C	4.3511
941262	AE2-120 E	2.9007
941271	AE2-121 C	2.2880
941272	AE2-121 E	1.5277
941321	AE2-126 C	2.0533
941322	AE2-126 E	1.3688
941331	AE2-129 C	2.0636
941332	AE2-129 E	1.3757
941351	AE2-131 C	2.0636
941352	AE2-131 E	1.3757
942031	AE2-215 C	20.2144
942032	AE2-215 E	13.4762
942121	AE2-224 C	6.6917
942122	AE2-224 E	4.4611
942351	AE2-248 C	3.5775
942352	AE2-248 E	2.3850
942491	AE2-262 C	14.9815
942492	AE2-262 E	10.0676
942501	AE2-263 C	14.0826
942502	AE2-263 E	9.4024
942511	AE2-264 C	15.7915
942512	AE2-264 E	10.5277
942961	AE2-316 C	5.1918
942962	AE2-316 E	7.4035
943751	AF1-043	21.2572
944001	AF1-068 C O1	4.7996
944002	AF1-068 E O1	2.6998
944181	AF1-086 C O1	1.2363
944182	AF1-086 E O1	5.3787
944311	AF1-099 C	22.7419
944312	AF1-099 E	15.1613
944321	AF1-100 C O1	38.5635
944322	AF1-100 E O1	25.7090
944381	AF1-103 O1	1.0116
944471	AF1-112 C	4.4478
944472	AF1-112 E	2.9652
944671	AF1-132 C O1	4.5152
944672	AF1-132 E O1	3.0102
944691	AF1-134 C O1	0.7713
944692	AF1-134 E O1	0.7713
944701	AF1-135 C	0.9256
944702	AF1-135 E	0.6171
944731	AF1-138 C O1	4.8158
944732	AF1-138 E O1	3.2106
944751	AF1-140 C	0.5384
944752	AF1-140 E	0.3590
944771	AF1-142 C	36.3871
944772	AF1-142 E	24.2580
944841	AF1-149 C	4.3519

Bus #	Bus	MW Impact
944842	AF1-149 E	2.9013
944881	AF1-153 C O1	1.0424
944882	AF1-153 E O1	0.6950
944901	AF1-155 C	1.0362
944902	AF1-155 E	0.6908
945071	AF1-172 C	33.5190
945072	AF1-172 E	22.3460
945121	AF1-177	0.2529
945161	AF1-181	0.2052
945171	AF1-182	1.0284
945181	AF1-183	0.2396
945481	AF1-213 C	8.0167
945482	AF1-213 E	5.3445
945491	AF1-214 C	4.3506
945492	AF1-214 E	2.9004
945551	AF1-220 C	7.6899
945552	AF1-220 E	5.1294
945771	AF1-242 C	1.0362
945772	AF1-242 E	0.6908
945901	AF1-255 C	0.2845
945902	AF1-255 E	0.3928
946091	AF1-274 C	4.5335
946092	AF1-274 E	3.0224
946131	AF1-278	9.5340
946241	AF1-289 C O1	1.3011
946242	AF1-289 E O1	0.8674
946311	AF1-295	6.7381
946381	AF1-302 C	1.2016
946382	AF1-302 E	1.6021
946421	AF1-306 C	11.8158
946422	AF1-306 E	47.2630
LGEE	LGEE	0.6515
CPLE	CPLE	0.3433
WEC	WEC	0.3761
CBM-W2	CBM-W2	8.6732
CBM-W1	CBM-W1	15.7376
TVA	TVA	1.3524
O-066	O-066	20.4826
CBM-S2	CBM-S2	3.7859
CBM-S1	CBM-S1	8.5115
G-007	G-007	3.1990
MEC	MEC	1.8146

15.4 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
41701033	200519	26REED TAP	PENELEC	200522	26SHADE GP	PENELEC	1	PL_P42_100548	breaker	225.0	116.08	118.05	DC	4.42

Bus #	Bus	MW Impact
200812	26ALY HYDR	0.3760
200852	26WARR RDG	0.1074
235003	AC1-025 E	0.1809
236828	01GRAYMONT	0.4655
290086	Q-036 E	2.0611
293301	N-039 E	3.5812
294515	O38_P22	3.1335
919491	AA2-000	26.2577
930511	AB1-092	0.9641
936421	AD2-055	1.9849
936991	AD2-133 C	0.9275
936992	AD2-133 E	4.2422
939171	AE1-147 C	1.3885
939172	AE1-147 E	0.9257
940201	AE2-001 C	1.3931
940202	AE2-001 E	0.9287
940681	AE2-055 C	1.4624
940682	AE2-055 E	0.9750
941231	AE2-117 C	1.5395
941232	AE2-117 E	1.0263
941241	AE2-118 C	1.5395
941242	AE2-118 E	1.0263
941251	**AE2-119 C (Withdrawn : 12/16/2019)**	**0.7308**
941252	**AE2-119 E (Withdrawn : 12/16/2019)**	**0.4872**
941261	AE2-120 C	1.3956
941262	AE2-120 E	0.9304
941271	AE2-121 C	0.7340
941272	AE2-121 E	0.4901
941321	AE2-126 C	0.6666
941322	AE2-126 E	0.4444
941331	AE2-129 C	0.6690
941332	AE2-129 E	0.4460
941351	AE2-131 C	0.6690
941352	AE2-131 E	0.4460
942031	AE2-215 C	13.2746
942032	AE2-215 E	8.8498
942351	AE2-248 C	1.1468
942352	AE2-248 E	0.7645
942491	AE2-262 C	4.1025
942492	AE2-262 E	2.7569
942501	AE2-263 C	3.8564
942502	AE2-263 E	2.5747

Bus #	Bus	MW Impact
942511	AE2-264 C	5.0630
942512	AE2-264 E	3.3754
943751	AF1-043	3.1560
944001	AF1-068 C O1	1.5383
944002	AF1-068 E O1	0.8653
944311	AF1-099 C	3.3006
944312	AF1-099 E	2.2004
944321	AF1-100 C O1	5.6135
944322	AF1-100 E O1	3.7423
944471	AF1-112 C	1.4258
944472	AF1-112 E	0.9506
944671	AF1-132 C O1	1.4471
944672	AF1-132 E O1	0.9647
944691	AF1-134 C O1	0.2510
944692	AF1-134 E O1	0.2510
944701	AF1-135 C	0.3012
944702	AF1-135 E	0.2008
944731	AF1-138 C O1	1.5395
944732	AF1-138 E O1	1.0263
944771	AF1-142 C	5.2810
944772	AF1-142 E	3.5207
944841	AF1-149 C	1.3958
944842	AF1-149 E	0.9306
944881	AF1-153 C O1	0.3383
944882	AF1-153 E O1	0.2255
944901	AF1-155 C	0.3363
944902	AF1-155 E	0.2242
945071	AF1-172 C	4.9350
945072	AF1-172 E	3.2900
945161	AF1-181	0.0299
945171	AF1-182	0.1497
945181	AF1-183	0.0349
945481	AF1-213 C	2.6018
945482	AF1-213 E	1.7345
945491	AF1-214 C	1.3954
945492	AF1-214 E	0.9302
945551	AF1-220 C	2.5011
945552	AF1-220 E	1.6683
945771	AF1-242 C	0.3363
945772	AF1-242 E	0.2242
946091	AF1-274 C	1.4725
946092	AF1-274 E	0.9817
946311	AF1-295	4.4249
946421	AF1-306 C	1.7269
946422	AF1-306 E	6.9075
LGEE	LGEE	0.0650
WEC	WEC	0.0435
CBM-W2	CBM-W2	0.5897
CBM-W1	CBM-W1	2.0892
TVA	TVA	0.0364
O-066	O-066	1.5456
CHEOAH	CHEOAH	0.0070

Bus #	Bus	MW Impact
CBM-S1	CBM-S1	0.3578
G-007	G-007	0.2735
MEC	MEC	0.1796
CALDERWOOD	CALDERWOOD	0.0050
CATAWBA	CATAWBA	0.0399

15.5 Index 5

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
41393480	200522	26SHADE GP	PENELEC	938380	AE1-071 TAP	PENELEC	1	PL_P12_100618	single	160.0	138.11	140.88	DC	4.43

Bus #	Bus	MW Impact
200649	26PENNTECH	0.3546
200665	26SHAWVL 3	2.0128
200666	26SHAWVL 4	1.9806
200715	26SHAWVL 1	1.3184
200722	26SHAWVL 2	1.3520
200812	26ALY HYDR	0.3758
200852	26WARR RDG	0.1074
200886	26ARWF_N39	0.1468
200905	26Q36	0.0845
200913	26SHAW-D	0.0599
203034	26NA_O38_P22	0.1284
919491	AA2-000	30.8497
930511	AB1-092	1.1327
936421	AD2-055	2.3320
936991	AD2-133 C	1.0894
939171	AE1-147 C	1.3877
940201	AE2-001 C	1.3922
940681	AE2-055 C	1.4616
941231	AE2-117 C	1.5386
941241	AE2-118 C	1.5386
941251	**AE2-119 C (Withdrawn : 12/16/2019)**	**0.8587**
941261	AE2-120 C	1.3948
941271	AE2-121 C	0.7336
941321	AE2-126 C	0.7831
941331	AE2-129 C	0.7860
941351	AE2-131 C	0.7860
942031	AE2-215 C	13.2754
942351	AE2-248 C	1.1461
942491	AE2-262 C	4.8230
942501	AE2-263 C	4.5336
942511	AE2-264 C	5.0592
943751	AF1-043	6.9961
944001	AF1-068 C O1	1.5374
944311	AF1-099 C	7.3213
944321	AF1-100 C O1	12.4470
944471	AF1-112 C	1.4251
944671	AF1-132 C O1	1.4462
944691	AF1-134 C O1	0.5562
944701	AF1-135 C	0.6674
944731	AF1-138 C O1	1.5386
944771	AF1-142 C	11.7141

Bus #	Bus	MW Impact
944841	AF1-149 C	1.3950
944881	AF1-153 C O1	0.7498
944901	AF1-155 C	0.7454
945071	AF1-172 C	10.9410
945161	AF1-181	0.0662
945171	AF1-182	0.3319
945181	AF1-183	0.0774
945481	AF1-213 C	5.7672
945491	AF1-214 C	1.3945
945551	AF1-220 C	5.5437
945771	AF1-242 C	0.7454
946091	AF1-274 C	3.2640
946311	AF1-295	4.4251
946421	AF1-306 C	3.8280
LGEE	LGEE	0.0633
WEC	WEC	0.0425
CBM-W2	CBM-W2	0.5651
CBM-W1	CBM-W1	2.0391
TVA	TVA	0.0336
CHEOAH	CHEOAH	0.0080
CBM-S1	CBM-S1	0.3408
MEC	MEC	0.1748
CALDERWOOD	CALDERWOOD	0.0060
CATAWBA	CATAWBA	0.0403

Affected Systems

16 Affected Systems

16.1 LG&E

LG&E Impacts to be determined during later study phases (as applicable).

16.2 MISO

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

16.3 TVA

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

16.4 Duke Energy Progress

Duke Energy Progress Impacts to be determined during later study phases (as applicable).

16.5 NYISO

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

17 Contingency Descriptions

Contingency Name	Contingency Definition
PN-P1-2-PN-115-094-A	CONTINGENCY 'PN-P1-2-PN-115-094-A' /* ROXBURY - SHADE GAP 115KV DISCONNECT BRANCH FROM BUS 200520 TO BUS 938380 CKT 1 /* 26ROXBURY 115 AE1-071 TAP 115 END
PN-P2-2-PN-115-032	CONTINGENCY 'PN-P2-2-PN-115-032' /* ROXBURY 115KV BUS FAULT DISCONNECT BUS 200520 /* 26ROXBURY 115 END
PN-P1-2-PN-230-103T	CONTINGENCY 'PN-P1-2-PN-230-103T' /** 26LEWISTWN - JUNI BU2 230.00 LINE DISCONNECT BRANCH FROM BUS 200513 TO BUS 208005 CKT 1 /* 26LEWISTWN - JUNI BU2 230.00 LINE END
PL_P42_100548	CONTINGENCY 'PL_P42_100548' /* AT JUNIATA SUB 230KV BUS TIE CB FAILED" DISCONNECT BUS 208005 /* DISCONNECT BUS 208004 /* END
AP-P2-2-WP-230-001T	CONTINGENCY 'AP-P2-2-WP-230-001T' /* ELKO #2 230KV BUS DISCONNECT BRANCH FROM BUS 235175 TO BUS 235158 CKT 1 /* 01ELKO 230 01CARB 230 DISCONNECT BRANCH FROM BUS 235175 TO BUS 235236 CKT 1 /* 01ELKO 230 01QUEHAN 230 DISCONNECT BRANCH FROM BUS 235175 TO BUS 200726 CKT 1 /* 01ELKO 230 26SHAWVL 2 230 REDUCE BUS 237007 SHUNT BY 100 PERCENT /* 01ELKO CAP 138 DISCONNECT BUS 237007 /* 01ELKO CAP 138 END
TS_P4_#2_RICE 500_CB 2	CONTINGENCY 'TS_P4_#2_RICE 500_CB 2' OPEN BRANCH FROM BUS 270070 TO BUS 270071 CKT 1 /*RICE 500/230 KV TRANSFORMER #1 OPEN BRANCH FROM BUS 270070 TO BUS 270071 CKT 2 /*RICE 500/230 KV TRANSFORMER #2 OPEN BRANCH FROM BUS 270070 TO BUS 200101 CKT 1 /*RICE AA1-076 500 END
TS_P4_#3_RICE 500_CB 3	CONTINGENCY 'TS_P4_#3_RICE 500_CB 3' OPEN BRANCH FROM BUS 270070 TO BUS 200101 CKT 1 /*RICE AA1-076 500 OPEN BRANCH FROM BUS 270070 TO BUS 200026 CKT 1 /*RICE HUNTERTOWN 500 END
PL_P12_100618	CONTINGENCY 'PL_P12_100618' /* JUNIATA 230/69KV TR4 OUT" DISCONNECT BRANCH FROM BUS 208005 TO BUS 209997 CKT 4 /* DISCONNECT BRANCH FROM BUS 208005 TO BUS 207955 CKT 1 /* DISCONNECT BRANCH FROM BUS 208005 TO BUS 200009 CKT 2 /* DISCONNECT BRANCH FROM BUS 208005 TO BUS 208006 CKT 1 /* DISCONNECT BRANCH FROM BUS 208005 TO BUS 208004 CKT 1 /* DISCONNECT BRANCH FROM BUS 208005 TO BUS 200513 CKT 1 /* END

Contingency Name	Contingency Definition
TS_P4_#1_RICE 500_CB 1	CONTINGENCY 'TS_P4_#1_RICE 500_CB 1' OPEN BRANCH FROM BUS 270070 TO BUS 270071 CKT 1 /*RICE 500/230 KV TRANSFORMER #1 OPEN BRANCH FROM BUS 270070 TO BUS 270071 CKT 2 /*RICE 500/230 KV TRANSFORMER #2 OPEN BRANCH FROM BUS 270070 TO BUS 200026 CKT 1 /*RICE HUNTERSTOWN END
Base Case	
TS P1-2_#1	CONTINGENCY 'TS P1-2_#1' OPEN BRANCH FROM BUS 270071 TO BUS 235506 CKT 1 / 270071 RICE_230 230 TO 235506 01RINGLD 230 1 END

Short Circuit

18 Short Circuit

The following Breakers are overduty:

None

19 Attachment One: One Line Diagram