Generation Interconnection

Feasibility Study Report

for

Queue Project AF1-235

SUNBURY 500 KV

617 MW Capacity / 617 MW Energy

January, 2020

1 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.

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

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.

2 General

The Interconnection Customer (IC) has proposed a Natural Gas generating facility located in Snyder County, Pennsylvania. The installed facilities will have a total capability of 617 MW with 617 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is May 1, 2023. This study does not imply a TO commitment to this in-service date.

Queue Number	AF1-235
Project Name	SUNBURY 500 KV
State	Pennsylvania
County	Snyder
Transmission Owner	PPL
MFO	617
MWE	617
MWC	617
Fuel	Natural Gas
Basecase Study Year	2023

2.1 Point of Interconnection

AF1-235 will interconnect with the PPL transmission system at the Sunbury 500 kV substation.

2.2 Cost Summary

The AF1-235 project will be responsible for the following costs for the physical interconnection:

Description	Total Cost
Attachment Facilities	$0
Direct Connection Network Upgrade	$0
Non Direct Connection Network Upgrades	$15,221,000
Total Costs	$15,221,000

In addition, the AF1-235 project may be responsible for a contribution to the following costs for any network upgrades identified in this report:

Description	Total Cost
System Upgrades	$220,504,000

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

3 Transmission Owner Scope of Work

PPL EU will modify the existing Sunbury 500kV Gas Insulated Switchgear (GIS) Substation to connect AF1-235 into a new 500kV GIS circuit breaker in the Sunbury 500kV Bay 3 South position.

Study Report Assumptions

- Existing Sunbury GIS Substation building, and Control House has space to accommodate the expansion
- IC AF1-235 will interconnect to Bay 3S
- IC is responsible for Attachment Facilities siting and ROW acquisition
- Outage feasibility not assessed until Facilities Study
- No major environmental, real estate, or permitting issues

3.1 Attachment Facilities

The Interconnection Customer is responsible for constructing the generator lead line from the Interconnection Customer Facility to the Point of Interconnection inside the Sunbury 500 kV substation.

3.2 Direct Connection Cost Estimate

None

3.3 Non-Direct Connection Cost Estimate

- Install a 500 kV GIS circuit breaker in 3S position (Bay 3, South)
  - Removable link to be installed at end
- Install (2) 48F ADSS Fiber Paths along the GIL path connecting the Gas Generation Plant to the 500kV control house.
  - One path is to be installed above ground in cable tray along the GIL Structure.
  - Another path is below ground in conduit along the GIL Pathway.
  - Terminate cables into the fiber interface rack in the 500 kV GIS control house and into the IC's gas generation plant control house
- Install all associated patch panels and conduit materials

The total preliminary cost estimate for the Non-Direct Connection work is **$15,221,000**. These costs do not include CIAC Tax Gross-up.

4 Schedule

The estimated time to complete the scope of work is 24 - 36 months after the PJM three-party Interconnection Service Agreement (ISA) and Interconnection Construction Service Agreement (ICSA) are signed and PPL EU receives Notice to Proceed from the IC.

5 Interconnection Customer Requirements

5.1 PPL EU Interconnection Requirements

PPL EU applicable technical standards that address requirements for interconnection of generation, transmission, and end user facilities can be found at the following link:

https://pjm.com/planning/design-engineering/to-tech-standards/private-ppl.aspx

5.2 IC Direct Transfer Trip (DTT) Requirements

PPL EU will require an independent communication path, for Direct Transfer Trip (DTT) of the IC Intertie Protective Relaying (IPR) Fault Interrupting Devices (FIDs), consisting of one communication circuit with the Sunbury 69kV Substation and one communication circuit with the Lock-Haven 69kV substation.

PPL EU does not have OPGW available on the Sunbury-Lock Haven 69 kV line available for DTT to the Sunbury and Lock Haven 69kV Substations. PPL EU assumes that the IC will procure the independent communication path through a third-party provider. Upon request, PPL EU will evaluate the feasibility of installing OPGW the Sunbury-Lock Haven 69 kV line for DTT.

To ensure reliable communication, the IC shall also provide DTT relaying equipment identical to the PPL EU DTT relaying equipment. All DTT relaying equipment shall connect to the respective communication path. All DTT relaying equipment should reside within the same location as the IPR and Point of Contact (POC) relaying equipment.

6 Revenue Metering and SCADA Requirements

6.1 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.

6.2 PPL Requirements

Installation of revenue grade Bi-directional Metering Equipment will be required in the vicinity of the POI to measure kWh and kVARh. PPL EU will design and supply the required metering equipment; all installation costs would be borne by the IC including CTs/PTs. All metering equipment must meet applicable PPL EU tariff

requirements as well as being compliant with all applicable requirements of the PJM agreements. The equipment must provide bidirectional revenue metering (kWh and kVARh) and real-time data (kW, kVAR, circuit breaker status, and generator bus voltages) for the IC's generating resource. The metering equipment should be housed in a control cabinet or similar enclosure and must be accessible to PPL EU metering personnel.

7 Network Impacts

The Queue Project AF1-235 was evaluated as a 617.0 MW (Capacity 617.0 MW) injection at the Sunbury 500 kV substation in the PPL area. Project AF1-235 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-235 was studied with a commercial probability of 0.53. Potential network impacts were as follows:

Summer Peak Load Flow

8 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
41329508	200011	KEYSTONE	500	PJM	235104	01CABOT	500	AP	1	Base Case	single	2526	97.93	101.04	DC	78.51
42555535	200021	SUNBURY	500	PJM	200009	JUNIATA	500	PJM	1	PJM500_PL_P12_000080	single	3732	97.13	107.46	DC	385.46
42555538	200021	SUNBURY	500	PJM	200009	JUNIATA	500	PJM	1	Base Case	single	2939	95.2	106.93	DC	344.83
42555689	207973	FRAC	230	PPL	938390	AE1-058 TAP	230	PPL	1	PJM500_PL_P12_000083	single	628	91.96	100.7	DC	54.91

9 Multiple Facility Contingency

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

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
41646101	200009	JUNIATA	500.0	PJM	208005	JUNI BU2	230.0	PPL	2	PJM500_PL_P42_000140	breaker	1010.0	97.59	100.19	DC	58.29

10 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
41329503	200011	KEYSTONE	500	PJM	235104	01CABOT	500	AP	1	AP-P1-2-WP-500-008	single	2598	124.87	128.1	DC	116.14
49614430	200011	KEYSTONE	500	PJM	235104	01CABOT	500	AP	1	PJM_P1_APS_B_G693	single	2598	107.44	111.96	DC	117.29
42248523	200022	SUSQHANA	500	PJM	200023	WESCOVLE	500	PJM	1	PJM500_PL_P42_000923	breaker	3112	110.79	118.62	DC	251.66
42248524	200022	SUSQHANA	500	PJM	200023	WESCOVLE	500	PJM	1	PJM500_PL_P42_000922	breaker	3112	110.78	118.62	DC	251.66
42555370	200022	SUSQHANA	500	PJM	200023	WESCOVLE	500	PJM	1	PJM500_PL_P12_000083	single	3112	104.6	112.48	DC	248.02
42248465	200023	WESCOVLE	500	PJM	200075	BREI	500	PJM	1	PJM500_PL_P42_000923	breaker	3112	115.85	124.47	DC	270.62
42248466	200023	WESCOVLE	500	PJM	200075	BREI	500	PJM	1	PJM500_PL_P42_000922	breaker	3112	115.85	124.47	DC	270.61
42555314	200023	WESCOVLE	500	PJM	200075	BREI	500	PJM	1	PJM500_PL_P12_000083	single	3112	106.39	115.01	DC	267.99
42555324	938390	AE1-058 TAP	230	PPL	208072	SIEG	230	PPL	1	PJM500_PL_P12_000083	single	628	105.43	114.17	DC	54.91

11 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
42555532	200021	SUNBURY	500	PJM	200009	JUNIATA	500	PJM	1	PJM500_PL_P12_000080	operation	3732	102.48	112.78	DC	385.46
42555534	200021	SUNBURY	500	PJM	200009	JUNIATA	500	PJM	1	Base Case	operation	2939	101.14	112.81	DC	344.83
42555369	200022	SUSQHANA	500	PJM	200023	WESCOVLE	500	PJM	1	PJM500_PL_P12_000083	operation	3112	110.59	118.36	DC	248.02
42555313	200023	WESCOVLE	500	PJM	200075	BREI	500	PJM	1	PJM500_PL_P12_000083	operation	3112	115.75	124.28	DC	267.99
42555323	938390	AE1-058 TAP	230	PPL	208072	SIEG	230	PPL	1	PJM500_PL_P12_000083	operation	628	117.61	121.57	DC	54.91

12 System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
41646101	4	JUNIATA 500.0 kV - JUNI BU2 230.0 kV Ckt 2	PPL R-PL-0004 (4) : Build new SUNB-DAUP 230kV Line and Rebuild DAUP 230kV Yard Project Type : CONTINGENCY Cost : $141,000,000 Time Estimate : 80.0 Months	$141,000,000
42555324	7	AE1-058 TAP 230.0 kV - SIEG 230.0 kV Ckt 1	PPL R-PL-0003 (13) : Rebuild FRACVILLE-SIEGFRIED 230kV Line Project Type : FACILITY Cost : $79,000,000 Time Estimate : 72.0 Months	$79,000,000
42555535, 42555538	2	SUNBURY 500.0 kV - JUNIATA 500.0 kV Ckt 1	PPL R-PL-0004 (4) : Build new SUNBURY-DAUPHIN 230kV Line and Rebuild DAUPIN 230kV Yard Project Type : CONTINGENCY Cost : $141,000,000 Time Estimate : 80 Months	Same as index 4 cost
49614430, 41329508, 41329503	1	KEYSTONE 500.0 kV - 01CABOT 500.0 kV Ckt 1	APS WP-AF1-F-0001 (1957) : Replace Wave Trap at Keystone Project Type : FACILITY Cost : $252,000 Time Estimate : 12.0 Months PJM-AF1-F-0003 (2082) : Replace 3000 Amp Generic Wave Trap at Keystone Project Type : FACILITY Cost : $252,000 Time Estimate : 9.0 Months	$504,000
42555314, 42248466, 42248465	6	WESCOVLE 500.0 kV - BREI 500.0 kV Ckt 1	PPL R-PL-0004 (4) : Build new SUNBURY-DAUPIN 230kV Line and Rebuild DAUP 230kV Yard Project Type : CONTINGENCY Cost : $141,000,000 Time Estimate : 80.0 Months	Same as index 4 cost
42248523 ,42555370, 42248524	5	SUSQHANA 500.0 kV - WESCOVLE 500.0 kV Ckt 1	PPL R-PL-0004 (4) : Build new SUNB-DAUP 230kV Line and Rebuild DAUP 230kV Yard Project Type : CON Cost : $141,000,000 Time Estimate : 80.0 Months	Same as index 4 cost
42555689	3	FRAC 230.0 kV - AE1-058 TAP 230.0 kV Ckt 1	PPL R-PL-0003 (3) : Rebuild FRACVILLE-SIEGFRIED 230kV Line Project Type : FAC Cost : $79,000,000 Time Estimate : 72.0 Months	Same as index 7 cost
			TOTAL COST	$220,504,000

13 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.

13.1 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
41329503	200011	KEYSTONE	PJM	235104	01CABOT	AP	1	AP-P1-2-WP-500-008	single	2598.0	124.87	128.1	DC	116.14

Bus #	Bus	MW Impact
200030	CONE G1	37.0780
200031	CONE G2	37.0518
200032	KEYS G1	46.9743
200033	KEYS G2	46.9853
200103	AA1-076 CT1	12.3096
200104	AA1-076 CT2	12.3096
200105	AA1-076 ST	16.4127
200809	26SITHE	0.9480
200833	26SEWRDB34	14.4755
200837	26HOMER C1	16.3269
200906	26KEYSTN#3	0.4194
208930	HUST 11	5.8590
208931	HUST 12	6.3582
208932	HUST 13	5.8590
208933	HUST 10	10.4044
235619	01SBEND1	8.7725
235620	01SBEND2	8.7670
235621	01SBEND3	8.8661
235622	01SBEND4	8.7836
920711	AA2-182 C	183.9007
926301	AC1-108	4.1032
934711	AD1-099	3.8524
936891	AD2-113 C	23.8934
936901	AD2-114 C	157.7120
942721	AE2-288	38.7754
945701	AF1-235	116.1379
DUCKCREEK	DUCKCREEK	12.6389
NEWTON	NEWTON	11.5928
FARMERCITY	FARMERCITY	0.5938
G-007A	G-007A	36.9311
VFT	VFT	99.6719
PRAIRIE	PRAIRIE	27.1680
COFFEEN	COFFEEN	5.7052
EDWARDS	EDWARDS	3.8595
CHEOAH	CHEOAH	4.5165
TILTON	TILTON	6.9413
MADISON	MADISON	0.9959
GIBSON	GIBSON	5.9383
CALDERWOOD	CALDERWOOD	4.5108
BLUEG	BLUEG	18.8912
TRIMBLE	TRIMBLE	6.0670

Bus #	Bus	MW Impact
CATAWBA	CATAWBA	2.6502
AC1-056	AC1-056	10.7760

13.2 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
42555535	200021	SUNBURY	PJM	200009	JUNIATA	PJM	1	PJM500_PL_P12_000080	single	3732.0	97.13	107.46	DC	385.46

Bus #	Bus	MW Impact
200038	SUSQ 2	58.7191
200083	FRPO 1	28.1939
200084	FRPO 2	28.1939
203907	26Y2-042	3.5268
208911	MONT G1	50.7209
208912	**MONT G2 (Deactivation : 02/18/19)**	**51.3761**
208930	HUST 11	19.4463
208931	HUST 12	21.1031
208932	HUST 13	19.4463
208933	HUST 10	34.5324
208945	LOHA CT	0.9798
208948	WILL CT	1.9115
208981	FOWH IPP	2.8559
208982	GLBT IPP	5.0973
209006	**NEPC IPP (Deactivation : 10/24/18)**	**7.8570**
209013	SCEN IPP	5.3459
209018	SUNBIPCT	2.5808
209019	VIKI IPP	8.2174
209021	WEST IPP	2.1737
209022	**WHFR IPP (Deactivation : 03/01/20)**	**16.2772**
211418	BUMO	4.0576
211770	PEFO 1	10.4371
212099	BRMO IPP	0.4615
212174	INGE	0.4080
212369	PATRIOT 1	26.1923
212370	PATRIOT 2	26.1923
918521	AA1-066	5.0123
920651	AA2-171 E	23.1154
920711	AA2-182 C	610.3710
924291	AB2-074 C	31.2370
925951	AC1-071 C	2.2647
926081	AC1-087 C	0.6532
932691	AC2-092	29.1759
935071	AD1-143 C1	0.9832
935081	AD1-143 C2	0.0344
935091	AD1-143 C3	0.9832
935101	AD1-143 C4	0.0344
938331	AE1-051	2.6916
938391	AE1-058 C	88.4043
938401	AE1-059 C O1	73.8820
939521	AE1-181 C	8.1592
939891	AE1-225 C O1	4.8277
940561	AE2-042 C O1	24.1249

Bus #	Bus	MW Impact
940721	AE2-059 C	4.3301
940941	AE2-084 C	4.3301
941161	AE2-110 C	4.0454
941171	AE2-111 C	4.1075
941371	AE2-133 C	3.9075
942281	AE2-241 C	4.0454
942561	AE2-271 C O1	29.2233
942581	AE2-274	0.1375
942721	AE2-288	128.6964
942771	AE2-295 C O1	12.3260
943311	AF1-002 C	0.3928
943721	AF1-040 C	0.5136
945511	AF1-216 C1O1	21.4973
945521	AF1-216 C2O1	21.4978
945611	AF1-226 C	7.0794
945701	AF1-235	385.4646
945761	AF1-241 C	4.4339
946471	AF1-311 C O1	27.3070
946691	AF1-333 C O1	6.0947
946751	AF1-339 C O1	18.2840
946761	AF1-271A C	5.2386
DUCKCREEK	DUCKCREEK	5.0516
NEWTON	NEWTON	4.7095
FARMERCITY	FARMERCITY	0.2449
G-007A	G-007A	19.3358
VFT	VFT	59.7205
PRAIRIE	PRAIRIE	11.2929
COFFEEN	COFFEEN	2.3159
EDWARDS	EDWARDS	1.5358
CHEOAH	CHEOAH	2.1612
TILTON	TILTON	2.7657
MADISON	MADISON	0.0504
GIBSON	GIBSON	2.3953
CALDERWOOD	CALDERWOOD	2.1470
BLUEG	BLUEG	7.6210
TRIMBLE	TRIMBLE	2.4436
CATAWBA	CATAWBA	1.4899

13.3 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
42555689	207973	FRAC	PPL	938390	AE1-058 TAP	PPL	1	PJM500_PL_P12_000083	single	628.0	91.96	100.7	DC	54.91

Bus #	Bus	MW Impact
200038	SUSQ 2	6.4552
208911	MONT G1	10.1935
208912	**MONT G2 (Deactivation : 02/18/19)**	**10.3252**
208930	HUST 11	2.7700
208931	HUST 12	3.0060
208932	HUST 13	2.7700
208933	HUST 10	4.9189
208941	FISH CT	1.0794
208945	LOHA CT	0.1988
208948	WILL CT	0.3868
208981	FOWH IPP	1.3261
208982	GLBT IPP	3.1611
209013	SCEN IPP	3.3153
209018	SUNBIPCT	0.5323
209019	VIKI IPP	1.6949
209021	WEST IPP	1.0093
209022	**WHFR IPP (Deactivation : 03/01/20)**	**11.8757**
209027	LOR2_Q27	0.7710
212099	BRMO IPP	0.2143
212174	INGE	0.1894
212266	LOR1	0.2120
212369	PATRIOT 1	5.2819
212370	PATRIOT 2	5.2819
920651	AA2-171 E	3.2926
920711	AA2-182 C	86.9432
924291	AB2-074 C	4.4495
939891	AE1-225 C O1	0.9957
940561	AE2-042 C O1	4.8957
940721	AE2-059 C	0.8787
940941	AE2-084 C	0.8787
941161	AE2-110 C	0.9536
941171	AE2-111 C	0.8538
941371	AE2-133 C	0.8188
942281	AE2-241 C	0.9536
942561	AE2-271 C O1	5.8731
942721	AE2-288	18.3319
942771	AE2-295 C O1	5.6997
943311	AF1-002 C	0.1165
943721	AF1-040 C	0.1059
945511	AF1-216 C1O1	4.3556
945521	AF1-216 C2O1	4.3556

Bus #	Bus	MW Impact
945611	AF1-226 C	1.6687
945701	AF1-235	54.9068
945761	AF1-241 C	0.8946
946471	AF1-311 C O1	5.4880
946691	AF1-333 C O1	1.2503
946751	AF1-339 C O1	3.7508
946761	AF1-271A C	1.0805
DUCKCREEK	DUCKCREEK	0.2844
NEWTON	NEWTON	0.2654
FARMERCITY	FARMERCITY	0.0138
PRAIRIE	PRAIRIE	0.6406
COFFEEN	COFFEEN	0.1305
EDWARDS	EDWARDS	0.0864
CHEOAH	CHEOAH	0.1251
TILTON	TILTON	0.1556
GIBSON	GIBSON	0.1349
CALDERWOOD	CALDERWOOD	0.1242
BLUEG	BLUEG	0.4305
TRIMBLE	TRIMBLE	0.1380
CATAWBA	CATAWBA	0.0879

13.4 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
41646101	200009	JUNIATA	PJM	208005	JUNI BU2	PPL	2	PJM500_PL_P42_000140	breaker	1010.0	97.59	100.19	DC	58.29

Bus #	Bus	MW Impact
208769	SISO	-0.1572
209022	**WHFR IPP (Deactivation : 03/01/20)**	**2.2325**
235007	AC1-025 BAT	0.2499
236828	01GRAYMONT	-0.5426
920651	AA2-171 E	2.9711
920711	AA2-182 C	78.4526
921653	AA2-008 E	3.2127
924291	AB2-074 C	4.0150
924292	AB2-074 E	5.0589
932691	AC2-092	2.9841
933973	AD1-020 BAT	1.5950
937271	AD2-166	-8.2101
938391	AE1-058 C	12.1359
938392	AE1-058 E	12.1359
940561	AE2-042 C O1	2.8128
940562	AE2-042 E O1	1.3944
940721	AE2-059 C	0.5049
940722	AE2-059 E	0.6972
940941	AE2-084 C	0.5049
940942	AE2-084 E	0.6972
941161	AE2-110 C	0.4659
941162	AE2-110 E	0.6434
942281	AE2-241 C	0.4659
942282	AE2-241 E	0.6434
942561	AE2-271 C O1	3.3474
942562	AE2-271 E O1	2.2280
942721	AE2-288	8.7671
942771	AE2-295 C O1	1.4446
942772	AE2-295 E O1	8.3810
943311	AF1-002 C	0.0509
943312	AF1-002 E	0.0702
944313	AF1-099 BAT	5.3273
944323	AF1-100 BAT	8.6918
944773	AF1-142 BAT	8.4983
944841	AF1-149 C	-1.6268
944842	AF1-149 E	-1.0845
945483	AF1-213 BAT	3.6603
945511	AF1-216 C1O1	1.2670
945512	AF1-216 E1O1	0.8437
945521	AF1-216 C2O1	1.2670
945522	AF1-216 E2O1	0.8437
945611	AF1-226 C	0.4321

Bus #	Bus	MW Impact
945612	AF1-226 E	0.5967
945701	AF1-235	26.2587
945761	AF1-241 C	0.2701
945762	AF1-241 E	0.1801
946312	AF1-295 BAT	2.5318
946423	AF1-306 BAT	22.4431
946471	AF1-311 C O1	1.6578
946472	AF1-311 E O1	2.7048
999904	U1-067 2	-0.0943
LGEE	LGEE	0.1500
G-007A	G-007A	2.3783
VFT	VFT	7.6561
WEC	WEC	0.0895
CBM-W2	CBM-W2	1.5152
CBM-W1	CBM-W1	3.7655
TVA	TVA	0.1596
CBM-S1	CBM-S1	1.2013
MEC	MEC	0.3909
CATAWBA	CATAWBA	0.0445

13.5 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
42248524	200022	SUSQHANA	PJM	200023	WESCOVLE	PJM	1	PJM500_PL_P42_000922	breaker	3112.0	110.78	118.62	DC	251.66

Bus #	Bus	MW Impact
200038	SUSQ 2	58.0391
200083	FRPO 1	27.7769
200084	FRPO 2	27.7769
200823	26MHP_X3-003	2.8796
203907	26Y2-042	3.1724
203909	26Z1-038	2.8816
203910	26Z1-091	2.3081
208930	HUST 11	12.6958
208931	HUST 12	13.7775
208932	HUST 13	12.6958
208933	HUST 10	22.5450
209006	**NEPC IPP (Deactivation : 10/24/18)**	**6.1239**
209019	VIKI IPP	4.6720
209022	**WHFR IPP (Deactivation : 03/01/20)**	**11.4701**
211369	W1-111 BAT	0.0236
211375	BEAC	4.7107
211418	BUMO	3.2038
211770	PEFO 1	6.7356
211771	PEFO 2	6.7356
292935	U2-015E OP1	21.4411
294573	P-028 E	17.2778
917662	Z2-107 E	2.3337
918521	AA1-066	4.9381
918602	AA1-077 E	18.4360
918682	AA1-082 E	6.3938
919201	AA1-144 OP	17.7940
920651	AA2-171 E	12.8275
920711	AA2-182 C	398.4890
921653	AA2-008 E	17.0597
923673	AB1-182 E	5.1903
924291	AB2-074 C	17.3345
924292	AB2-074 E	25.6958
925951	AC1-071 C	1.9160
925952	AC1-071 E	12.8268
932691	AC2-092	28.7443
938331	AE1-051	2.3337
938391	AE1-058 C	61.5591
938392	AE1-058 E	61.5591
938401	AE1-059 C O1	62.2965
938402	AE1-059 E O1	62.2965
939521	AE1-181 C	6.3594
939522	AE1-181 E	4.2396

Bus #	Bus	MW Impact
939891	AE1-225 C O1	2.7448
939892	AE1-225 E O1	3.0368
940561	AE2-042 C O1	14.2114
940562	AE2-042 E O1	7.0450
940592	AE2-046 E	6.1239
940721	AE2-059 C	2.5508
940722	AE2-059 E	3.5225
940941	AE2-084 C	2.5508
940942	AE2-084 E	3.5225
941161	AE2-110 C	2.5308
941162	AE2-110 E	3.4949
941171	AE2-111 C	2.3447
941172	AE2-111 E	3.2379
941371	AE2-133 C	2.2403
941372	AE2-133 E	3.0938
942281	AE2-241 C	2.5308
942282	AE2-241 E	3.4949
942561	AE2-271 C O1	18.1428
942562	AE2-271 E O1	12.0754
942721	AE2-288	84.0212
942771	AE2-295 C O1	7.2174
942772	AE2-295 E O1	41.8720
943311	AF1-002 C	0.3131
943312	AF1-002 E	0.4323
943721	AF1-040 C	0.1548
943722	AF1-040 E	2.9404
945511	AF1-216 C1O1	6.8215
945512	AF1-216 E1O1	4.5424
945521	AF1-216 C2O1	6.8215
945522	AF1-216 E2O1	4.5424
945611	AF1-226 C	2.3473
945612	AF1-226 E	3.2415
945701	AF1-235	251.6558
945761	AF1-241 C	1.4292
945762	AF1-241 E	0.9528
946471	AF1-311 C O1	8.9852
946472	AF1-311 E O1	14.6600
946691	AF1-333 C O1	1.8686
946692	AF1-333 E O1	1.2458
946751	AF1-339 C O1	5.6059
946752	AF1-339 E O1	3.7373
946761	AF1-271A C	1.5786
946762	AF1-271A E	1.0524
DUCKCREEK	DUCKCREEK	2.4619
NEWTON	NEWTON	2.3112
FARMERCITY	FARMERCITY	0.1209
G-007A	G-007A	2.9058
VFT	VFT	15.4155
PRAIRIE	PRAIRIE	5.5922
COFFEEN	COFFEEN	1.1363
EDWARDS	EDWARDS	0.7473
CHEOAH	CHEOAH	1.1236

Bus #	Bus	MW Impact
TILTON	TILTON	1.3469
GIBSON	GIBSON	1.1728
CALDERWOOD	CALDERWOOD	1.1148
BLUEG	BLUEG	3.7324
TRIMBLE	TRIMBLE	1.1959
CATAWBA	CATAWBA	0.8109

13.6 Index 6

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
42248466	200023	WESCOVLE	PJM	200075	BREI	PJM	1	PJM500_PL_P42_000922	breaker	3112.0	115.85	124.47	DC	270.61

Bus #	Bus	MW Impact
200038	SUSQ 2	60.4519
200083	FRPO 1	28.9584
200084	FRPO 2	28.9584
200823	26MHP_X3-003	3.1827
203907	26Y2-042	3.5142
203909	26Z1-038	3.1853
203910	26Z1-091	2.5433
208930	HUST 11	13.6520
208931	HUST 12	14.8152
208932	HUST 13	13.6520
208933	HUST 10	24.2430
209006	**NEPC IPP (Deactivation : 10/24/18)**	**7.8475**
209019	VIKI IPP	5.2269
209022	**WHFR IPP (Deactivation : 03/01/20)**	**13.9325**
211369	W1-111 BAT	0.0302
211375	BEAC	6.0365
211418	BUMO	3.9931
211770	PEFO 1	12.4388
211771	PEFO 2	12.4388
292935	U2-015E OP1	26.7233
294573	P-028 E	19.0964
917662	Z2-107 E	2.5922
918521	AA1-066	5.1482
918602	AA1-077 E	20.4787
920651	AA2-171 E	13.7937
920711	AA2-182 C	428.5024
921653	AA2-008 E	19.3122
923673	AB1-182 E	5.9473
924291	AB2-074 C	18.6401
924292	AB2-074 E	27.6312
925951	AC1-071 C	2.1808
925952	AC1-071 E	14.5993
926081	AC1-087 C	0.8027
926082	AC1-087 E	1.3096
932691	AC2-092	29.9670
935071	AD1-143 C1	1.2083
935072	AD1-143 E1	7.2411
935081	AD1-143 C2	0.0422
935082	AD1-143 E2	1.0139
935091	AD1-143 C3	1.2083
935092	AD1-143 E3	7.2411
935101	AD1-143 C4	0.0422
935102	AD1-143 E4	1.0139

Bus #	Bus	MW Impact
938331	AE1-051	2.5922
938391	AE1-058 C	78.2701
938392	AE1-058 E	78.2701
938401	AE1-059 C O1	70.4947
938402	AE1-059 E O1	70.4947
939521	AE1-181 C	8.1493
939522	AE1-181 E	5.4329
939712	**AE1-202 E (Withdrawn : 11/04/2019)**	**1.0319**
939891	AE1-225 C O1	3.0708
939892	AE1-225 E O1	3.3975
940561	AE2-042 C O1	16.0059
940562	AE2-042 E O1	7.9345
940592	AE2-046 E	7.8475
940721	AE2-059 C	2.8729
940722	AE2-059 E	3.9673
940941	AE2-084 C	2.8729
940942	AE2-084 E	3.9673
941161	AE2-110 C	2.8669
941162	AE2-110 E	3.9591
941171	AE2-111 C	2.6219
941172	AE2-111 E	3.6207
941371	AE2-133 C	2.5041
941372	AE2-133 E	3.4580
941751	AE2-175 C O1	11.2518
941752	AE2-175 E O1	7.5012
942281	AE2-241 C	2.8669
942282	AE2-241 E	3.9591
942561	AE2-271 C O1	20.5896
942562	AE2-271 E O1	13.7039
942581	AE2-274	0.1690
942721	AE2-288	90.3495
942771	AE2-295 C O1	8.5143
942772	AE2-295 E O1	49.3962
943311	AF1-002 C	0.3612
943312	AF1-002 E	0.4988
943721	AF1-040 C	0.1731
943722	AF1-040 E	3.2897
945191	AF1-184	0.0738
945511	AF1-216 C1O1	7.7001
945512	AF1-216 E1O1	5.1274
945521	AF1-216 C2O1	7.7001
945522	AF1-216 E2O1	5.1274
945611	AF1-226 C	2.6591
945612	AF1-226 E	3.6721
945701	AF1-235	270.6100
945761	AF1-241 C	1.6172
945762	AF1-241 E	1.0781
946471	AF1-311 C O1	10.1969
946472	AF1-311 E O1	16.6371
946691	AF1-333 C O1	2.0968
946692	AF1-333 E O1	1.3978
946751	AF1-339 C O1	6.2903

Bus #	Bus	MW Impact
946752	AF1-339 E O1	4.1935
946761	AF1-271A C	1.7660
946762	AF1-271A E	1.1774
DUCKCREEK	DUCKCREEK	2.9352
NEWTON	NEWTON	2.7550
FARMERCITY	FARMERCITY	0.1441
G-007A	G-007A	5.2769
VFT	VFT	23.0007
PRAIRIE	PRAIRIE	6.6667
COFFEEN	COFFEEN	1.3545
EDWARDS	EDWARDS	0.8908
CHEOAH	CHEOAH	1.3418
TILTON	TILTON	1.6052
GIBSON	GIBSON	1.3978
CALDERWOOD	CALDERWOOD	1.3310
BLUEG	BLUEG	4.4494
TRIMBLE	TRIMBLE	1.4258
CATAWBA	CATAWBA	0.9699

13.7 Index 7

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
42555324	938390	AE1-058 TAP	PPL	208072	SIEG	PPL	1	PJM500_PL_P12_000083	single	628.0	105.43	114.17	DC	54.91

Bus #	Bus	MW Impact
200038	SUSQ 2	6.4552
208911	MONT G1	10.1935
208912	**MONT G2 (Deactivation : 02/18/19)**	**10.3252**
208930	HUST 11	2.7700
208931	HUST 12	3.0060
208932	HUST 13	2.7700
208933	HUST 10	4.9189
208941	FISH CT	1.0794
208945	LOHA CT	0.1988
208948	WILL CT	0.3868
208981	FOWH IPP	1.3261
208982	GLBT IPP	3.1611
209013	SCEN IPP	3.3153
209018	SUNBIPCT	0.5323
209019	VIKI IPP	1.6949
209021	WEST IPP	1.0093
209022	**WHFR IPP (Deactivation : 03/01/20)**	**11.8757**
209027	LOR2_Q27	0.7710
212099	BRMO IPP	0.2143
212174	INGE	0.1894
212266	LOR1	0.2120
212369	PATRIOT 1	5.2819
212370	PATRIOT 2	5.2819
920651	AA2-171 E	3.2926
920711	AA2-182 C	86.9432
924291	AB2-074 C	4.4495
938391	AE1-058 C	89.1925
939891	AE1-225 C O1	0.9957
940561	AE2-042 C O1	4.8957
940721	AE2-059 C	0.8787
940941	AE2-084 C	0.8787
941161	AE2-110 C	0.9536
941171	AE2-111 C	0.8538
941371	AE2-133 C	0.8188
942281	AE2-241 C	0.9536
942561	AE2-271 C O1	5.8731
942721	AE2-288	18.3319
942771	AE2-295 C O1	5.6997
943311	AF1-002 C	0.1165
943721	AF1-040 C	0.1059
945511	AF1-216 C1O1	4.3556

Bus #	Bus	MW Impact
945521	AF1-216 C2O1	4.3556
945611	AF1-226 C	1.6687
945701	AF1-235	54.9068
945761	AF1-241 C	0.8946
946471	AF1-311 C O1	5.4880
946691	AF1-333 C O1	1.2503
946751	AF1-339 C O1	3.7508
946761	AF1-271A C	1.0805
DUCKCREEK	DUCKCREEK	0.2844
NEWTON	NEWTON	0.2654
FARMERCITY	FARMERCITY	0.0138
PRAIRIE	PRAIRIE	0.6406
COFFEEN	COFFEEN	0.1305
EDWARDS	EDWARDS	0.0864
CHEOAH	CHEOAH	0.1251
TILTON	TILTON	0.1556
GIBSON	GIBSON	0.1349
CALDERWOOD	CALDERWOOD	0.1242
BLUEG	BLUEG	0.4305
TRIMBLE	TRIMBLE	0.1380
CATAWBA	CATAWBA	0.0879

Affected Systems

14 Affected Systems

14.1 LG&E

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

14.2 MISO

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

14.3 TVA

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

14.4 Duke Energy Progress

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

14.5 NYISO

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

Contingency Name	Contingency Definition
PJM500_PL_P12_000083	CONTINGENCY 'PJM500_PL_P12_000083' /* JUNI-SUNB 500KV LINE DISCONNECT BRANCH FROM BUS 200009 TO BUS 200021 CKT 1 /* JUNIATA-SUNBURY 500 END
PJM500_PL_P12_000080	CONTINGENCY 'PJM500_PL_P12_000080' /* SUSQ-WESC 500KV LINE DISCONNECT BRANCH FROM BUS 200022 TO BUS 200023 CKT 1 /* SUSQHANA-WESCOVLE 500 END
AP-P1-2-WP-500-008	CONTINGENCY 'AP-P1-2-WP-500-008' /* SOUTH BEND
PJM_P1_APS_B_G693	CONTINGENCY 'PJM_P1_APS_B_G693' / 200011 KEYSTONE 500 235118 01SOBEND
PJM500_PL_P42_000140	CONTINGENCY 'PJM500_PL_P42_000140' /* JUNI-TMIS 500KV STUCK BREAKER CONNECTED TO JUNI TR1 DISCONNECT BRANCH FROM BUS 200009 TO BUS 200016 CKT 1 /* JUNIATA-3 MILE I 500 DISCONNECT BRANCH FROM BUS 200009 TO BUS 208004 CKT 1 /* JUNIATA-JUNI BU1 500-230 DISCONNECT BRANCH FROM BUS 200009 TO BUS 200183 CKT 1 /* 500 CAP BANK END
PJM500_PL_P42_000922	CONTINGENCY 'PJM500_PL_P42_000922' /* SUNBURY 500KV YARD 3N BF DISCONNECT BRANCH FROM BUS 200021 TO BUS 208109 CKT 24 /* /* T24 DISCONNECT BRANCH FROM BUS 200021 TO BUS 200009 CKT 1 /* /* JUNIATA-SUNBURY 500KV LINE END
PJM500_PL_P42_000923	CONTINGENCY 'PJM500_PL_P42_000923' /* SUNBURY 500KV YARD 3T BF DISCONNECT BRANCH FROM BUS 200021 TO BUS 208109 CKT 25 /* /* T25 DISCONNECT BRANCH FROM BUS 200021 TO BUS 200009 CKT 1 /* /* JUNIATA-SUNBURY 500KV LINE END
Base Case	

Short Circuit

15 Short Circuit

The following Breakers are over duty

None