Generation Interconnection

System Impact Study Report

for

Queue Project AE2-295

ELDRED 230 KV

25.7 MW Capacity / 174.8 MW Energy

February 2020

1 Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation will be deferred until the System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

The Interconnection Customer seeking to interconnect a wind or solar generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per Schedule H to the Interconnection Service Agreement and Section 8 of Manual 14D.

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

2 General

The Interconnection Customer (IC), has proposed a Wind generating facility located in Schuylkill County, Pennsylvania. The installed facilities will have a total capability of 174.8 MW with 25.7 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is May 31, 2022. **This study does not imply a TO commitment to this in-service date.**

Queue Number	AE2-295
Project Name	ELDRED 230 KV
Interconnection Customer	Clean Air Generation LLC
State	Pennsylvania
County	Schuylkill
Transmission Owner	PPL
MFO	174.8
MWE	174.8
MWC	25.7
Fuel	Wind
Basecase Study Year	2022

2.1 Point of Interconnection

AE2-295 will interconnect with the PPL transmission system via a direct connection into the Eldred 230 kV Substation. The Point of Interconnection (POI) will be at the dead-end structure inside the PPL EU Eldred 230 kV Substation.

2.2 Cost Summary

The AE2-295 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	$ 16,558,000
Total Costs	$ 16,558,000

In addition, the AE2-295 project may be responsible for a contribution to the following costs for Network Upgrades to mitigate overloads identified in this report:

Description	Total Cost
System Upgrades [1]	$ 39,358,326

[1] Stability analysis will be performed during the Facilities Study. Additional system upgrades may be identified to mitigate stability concerns.

3 Transmission Owner Scope of Work

PPL EU will expand the Eldred 230/69 kV substation to accommodate the interconnection of AE2-295. This requires the installation of two new 230 kV substation bays with (5) circuit breakers and the relocation of (2) existing 230 kV transmission lines.

3.1 Attachment Facilities

It is assumed that the Interconnection Customer will construct the generator lead line from the customer facility to the point of interconnection at the Eldred 230 kV substation.

3.2 Direct Connection Cost Estimate

None.

3.3 Non-Direct Connection Cost Estimate

IC will connect directly into the PPL EU Eldred 230/69kV substation. AE2-295 is requesting a 230kV line connection into Eldred Substation. The 230/69kV Eldred Substation will require an expansion to support the AE2-295 interconnection, resulting in a (2) bay, (5) circuit breaker arrangement.

Eldred Substation Expansion – Physical/Electrical:

- Removal of existing 230 kV Breakers and associated bay equipment along with structures.
- Removal of existing fence (~850 Feet).
- Bay 4 shall be installed with 3 circuit breakers leaving two line positions.
- The AE2-295 line from the east will be terminated in the east line position in Bay 4 and the SUNB-ELDR from west will also be terminated in Bay 4 in the west line position.
- Bay 3 shall be installed with 2 circuit breakers creating one line position for ELDR-FRAC 230 kV line from the east.
- Install all required foundations, support structures, termination structures, cabling, raceway, bus work, grounding, and yard lighting.
- Install new control cubicle and associated equipment.
- Provide testing, commissioning and start-up of all newly installed metering equipment.
- Develop all engineering packages including Bill of Material, construction support and close-out in compliance with PPL EU Standards and Specifications.

Eldred Substation Expansion - Fiber:

- Install fiber cable splice box mounted on the A-frame inside the Eldred Substation
- Terminate all fiber optic protection circuits from the IC to A-frame in the Eldred Substation
- Install fiber optic cable between control cubicle fiber rack and relay and communication panels
- Install 1-1/4” inner duct within 3” conduit and new cable trench.
- Install new Patch Panel FOP of new fiber entry rack Install fiber optic cable between yard splice boxes and control cubicle fiber rack.
- Install fiber splicing and testing of fiber cable at both ends (PPL EU and IC).
-

Eldred Substation Expansion - Protection and Control:

Develop all engineering packages including BOM, construction support and close-out in compliance with PPL EU Standards and Specs:

- Model IC in CAPE and conduct a wide area short-circuit study two busses away from the IC facilities. Identify affected relays and revise settings as needed.
- Develop relay protection scheme documents at Eldred Substation to allow for IC direct connection.
- Develop relay settings for the new bay interconnection line at Eldred Substation.
- Modify existing SCADA RTU to add new alarm points for IC connection.
- Review and coordinate all relay settings from the IC.
- Revise protective relay settings at Frackville Substation as needed
- Revise protective relay settings at Sunbury Substation as needed
- Provide testing, commissioning and start-up of all metering equipment.

Sunbury – Eldred 230 kV Line Relocation

- Relocate the Sunbury-Eldred 230 kV line to the new west bus of the rebuilt Eldred 230 kV Substation.
    - Remove structures 36238S51054, 36229S51020, 36231S51018, and 36227S51022.
    - Route the SUNB-ELDR 230 kV into the new west bus position of Bay 4
    - Install new three pole structure with custom foundation poles to tap the SUNB-ELDR 230 kV line.
    - Install new full dead-end 90-degree foundation dead-end structure.
    - Install 0.15 miles of new single circuit 230 kV line utilizing 1590 ACSR and dual 48 count OPGW.
    - Tie new fiber into existing fiber on the ELDR-FRAC 230 kV line and Eldred Substation.

Eldred – Frackville 230 kV Line Relocation

- Relocate the Eldred- Frackville 230kV line to the new east bus of the rebuilt Eldred Substation.
    - Remove structures 36247S51020, 36249S51022, 36251S51024, and 36251S51048.
    - Route the ELDR-FRAC 230 kV line into the new west bus position of Bay 3
    - Install new three pole structure with custom foundation poles to tap the ELDR-FRAC 230 kV line.
    - Install new full dead-end 90-degree foundation dead-end structure.
    - Install 0.15 miles of new single circuit 230 kV line utilizing 1590 ACSR and dual 48 count OPGW.
    - Tie new fiber into existing fiber on the SUNB-ELDR 230 kV line and Eldred Substation.

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	**Total Cost**
Eldred Substation Expansion	$ 13,676,000
230 kV Transmission Line Relocations	$ 2,882,000
	$ 0
Total Non-Direct Connection Facility Costs	$ 16,558,000

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

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 AE2-295 was evaluated as a 174.8 MW (Capacity 25.7 MW) injection at the **Eldred 230kV** substation in the PPL area. Project AE2-295 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-295 was studied with a commercial probability of 1.00. 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)

None

9 Multiple Facility Contingency

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

None

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
8524729	938390	AE1-058 TAP	230.0	PPL	208072	SIEG	230.0	PPL	1	PL:1A:P42:000922	breaker	628.0	104.16	110.14	AC	38.12
8524730	938390	AE1-058 TAP	230.0	PPL	208072	SIEG	230.0	PPL	1	PL:1A:P42:000923	breaker	628.0	104.16	110.14	AC	38.12
8524731	938390	AE1-058 TAP	230.0	PPL	208072	SIEG	230.0	PPL	1	PL:18:P42:000129	breaker	628.0	104.75	109.77	AC	37.2
8524732	938390	AE1-058 TAP	230.0	PPL	208072	SIEG	230.0	PPL	1	PL:08:P42:000130	breaker	628.0	104.75	109.77	AC	37.2
8524733	938390	AE1-058 TAP	230.0	PPL	208072	SIEG	230.0	PPL	1	PL:10:P42:100576	breaker	628.0	104.75	109.77	AC	37.2

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
7378499	200021	SUNBURY	500.0	PJM	200009	JUNIATA	500.0	PJM	1	PL:28:P12:000080	operation	3112.0	114.11	116.39	AC	84.27
7378504	200021	SUNBURY	500.0	PJM	200009	JUNIATA	500.0	PJM	1	Base Case	operation	2707.0	100.32	102.54	AC	72.92
7378691	200022	SUSQHANA	500.0	PJM	200023	WESCOVLE	500.0	PJM	1	PL:08:P12:000083	operation	3112.0	107.71	109.48	AC	59.4
7378685	200023	WESCOVLE	500.0	PJM	200075	BREI	500.0	PJM	1	PL:08:P12:000083	operation	3112.0	108.21	110.16	AC	66.02
8525135	938390	AE1-058 TAP	230.0	PPL	208072	SIEG	230.0	PPL	1	PL:08:P12:000083	operation	628.0	104.7	109.72	AC	37.2

12 Stability and Reactive Power Requirement for Low Voltage Ride Through

Stability Analysis will be performed during the Facilities Study. **Additional reinforcements may be identified to mitigate stability concerns.**

13 Light Load Analysis

No mitigations are required

14 Affected Systems

None

15 System Reinforcements

<table>
<tr><th>ID</th><th>Index</th><th>Facility</th><th>Upgrade Description</th><th>Cost</th><th>AE2-295 Cost Allocation</th><th>Network Upgrade Number</th></tr>
<tr><td>8524732, 8524730, 8524731, 8524729, 8524733</td><td>1</td><td>AE1-058 TAP 230.0 kV - SIEG 230.0 kV Ckt 1</td><td>Reinforcement: Rebuild AE1-058-Siegfried 230kV line segment of the Frackville – Siegfried 230 kV line
Estimated Schedule: 72 Months
Ratings after Reinforcement: 665/821/821

<table>
<tr><th>Queue</th><th>MW contribution</th><th>% Cost</th><th>Cost ($69 Million)</th><th>Contingency Name</th><th>Contingency Type</th></tr>
<tr><td>AE2-110</td><td>1.314</td><td>1.97</td><td>$1,357,397.37</td><td>PL:18:P42:000 129</td><td>breaker</td></tr>
<tr><td>AE2-271</td><td>9.51</td><td>14.24</td><td>$9,824,086.00</td><td>PL:18:P42:000 129</td><td>breaker</td></tr>
<tr><td>AE2-288</td><td>17.87</td><td>26.75</td><td>$18,460,191.04</td><td>PL:18:P42:000 129</td><td>breaker</td></tr>
<tr><td>AE2-295</td><td>38.1</td><td>57.04</td><td>$39,358,325.60</td><td>PL:1A:P42:000 922</td><td>breaker</td></tr>
</table></td><td>$69,000,000</td><td>$39,358,326</td><td>N6406</td></tr>
<tr><td></td><td></td><td></td><td>TOTAL COST</td><td>$69,000,000</td><td>$39,358,326</td><td></td></tr>
</table>

16 Flow Gate Details

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact. It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

16.1 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
8524730	938390	AE1-058 TAP	PPL	208072	SIEG	PPL	1	PL:1A:P42:000923	breaker	628.0	104.16	110.14	AC	38.12

Bus #	Bus	MW Impact
208941	FISH CT	0.8903
208981	FOWH IPP	1.2369
209013	SCEN IPP	2.7344
209021	WEST IPP	0.9414
209022	**WHFR IPP (Deactivation : 03/01/20)**	**1.3672**
211064	PSPA	0.6521
212099	BRMO IPP	0.3766
212174	INGE	0.2317
918431	AA1-057	1.5406
919512	AA2-008 E	4.9138
920711	AA2-182 C	68.1716
920712	AA2-182 E	3.6982
924291	AB2-074 C	3.4888
924292	AB2-074 E	4.3959
926081	AC1-087 C	0.2478
926082	AC1-087 E	0.4043
935071	AD1-143 C1	0.4043
935072	AD1-143 E1	2.4231
935081	AD1-143 C2	0.0166
935082	AD1-143 E2	0.3992
935091	AD1-143 C3	0.3694
935092	AD1-143 E3	2.2139
935101	AD1-143 C4	0.0152
935102	AD1-143 E4	0.3647
938391	AE1-058 C	87.6175
938392	AE1-058 E	87.6175
939712	**AE1-202 E (Withdrawn : 11/04/2019)**	**0.2349**
939891	AE1-225 C O1	0.9216
939892	AE1-225 E O1	1.0196
940561	AE2-042 C	4.4009
940562	AE2-042 E	2.1816
940721	AE2-059 C	0.7899
940722	AE2-059 E	1.0908
940941	AE2-084 C	0.7899
940942	AE2-084 E	1.0908
941161	AE2-110 C	0.8095
941162	AE2-110 E	1.1178
941171	AE2-111 C	0.8097
941172	AE2-111 E	1.1182
941371	AE2-133 C	0.8286
941372	AE2-133 E	1.1443

Bus #	Bus	MW Impact
942281	AE2-241 C	0.8095
942282	AE2-241 E	1.1178
942561	AE2-271 C	5.0795
942562	AE2-271 E	3.3863
942581	AE2-274	0.0522
942721	AE2-288	14.3740
942771	AE2-295 C	5.6047
942772	AE2-295 E	32.5157
DUCKCREEK	DUCKCREEK	0.2430
NEWTON	NEWTON	0.2931
CHILHOWEE	CHILHOWEE	0.0402
G-007	G-007	0.6331
TVA	TVA	0.3868
PRAIRIE	PRAIRIE	0.5528
O-066	O-066	5.2023
COFFEEN	COFFEEN	0.1120
EDWARDS	EDWARDS	0.1102
CHEOAH	CHEOAH	0.1126
TILTON	TILTON	0.1329
SANTEETLA	SANTEETLA	0.0332
SMITHLAND	SMITHLAND	0.0448
CBM-N	CBM-N	0.1155
COTTONWOOD	COTTONWOOD	0.4620
HAMLET	HAMLET	0.1380
BLUEG	BLUEG	1.0621
UNIONPOWER	UNIONPOWER	0.1741
CANNELTON	CANNELTON	0.0652
GIBSON	GIBSON	0.0439
CALDERWOOD	CALDERWOOD	0.1228
FARMERCITY	FARMERCITY	0.0749
TRIMBLE	TRIMBLE	0.1180
CATAWBA	CATAWBA	0.0822
NYISO	NYISO	0.4847

Short Circuit

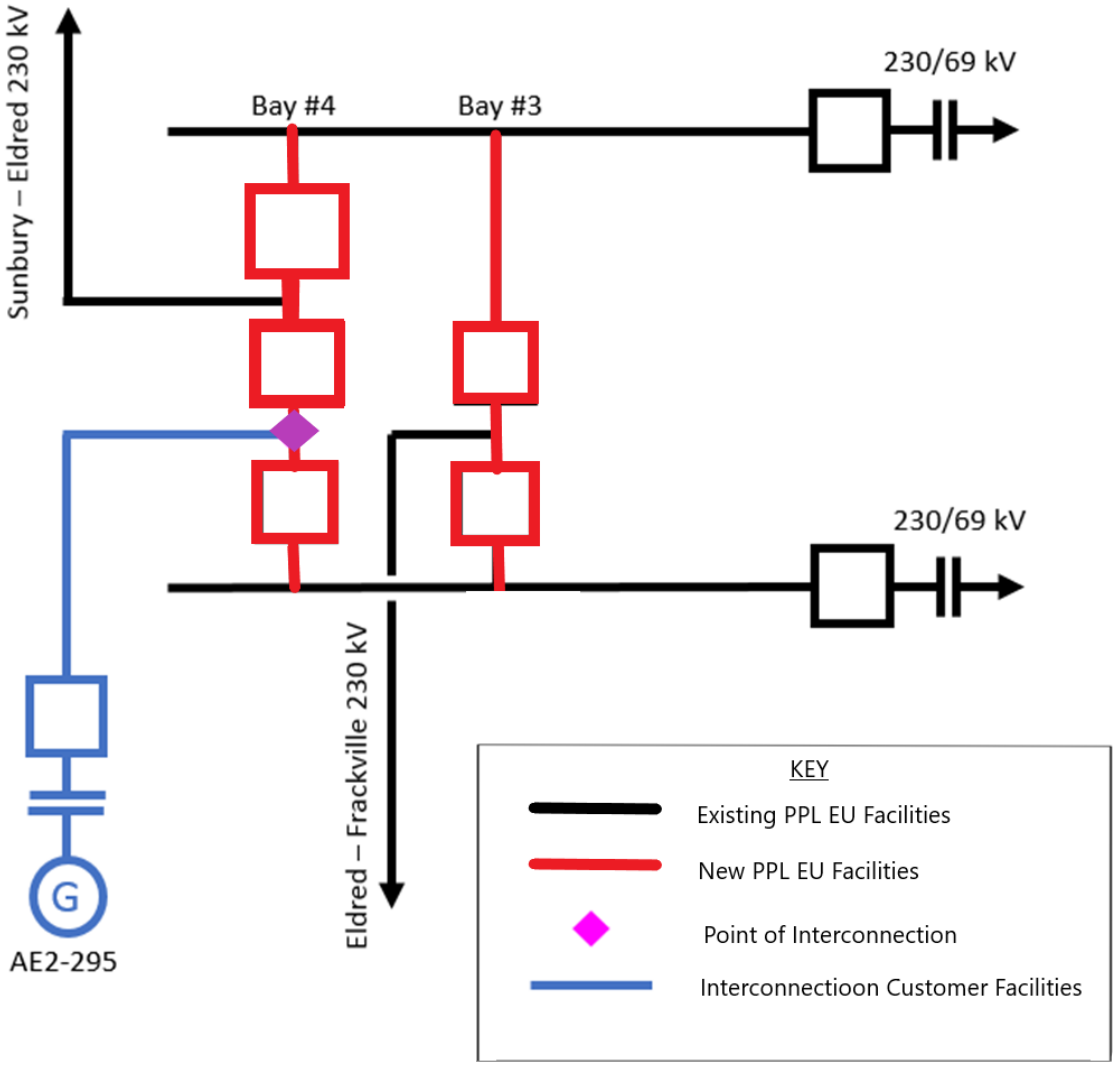
17 Short Circuit

The following Breakers are over duty:

None

Attachment 1

Single Line Diagram



Attachment 2

Project Location