Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AA2-115

South Reading-Boyertown 230 kV

April 2016

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 Interconnected 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, if any, is included in the System Impact Study.

The 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 associated with them will be addressed when seeking an Interconnection Agreement as outlined below. Developer will also be responsible for providing and installing metering equipment in compliance with applicable PJM and Transmission Owner standards.

General

Birdsboro Power LLC ("Interconnection Customer" or "Birdsboro Power") has proposed a gas-steam combined-cycle generating facility located at approximately 3.2 miles east of the existing Metropolitan Edison 230 kV line on 1 Armorcast Road, Birdsboro, Berks County, Pennsylvania. The installed facilities will have a total capability of 450 MW with 450 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is July 1, 2019. **This study does not imply a Metropolitan Edison Company commitment to this in-service date.**

Point of Interconnection (POI)

For AA2-115 project, the connection from the METED transmission system to Birdsboro Power's facilities will be provided by connecting the POI with a new three breaker 230 kV ring bus substation as shown in Appendix 2.

Transmission Owner Scope of Work and Costs Estimation

The Transmission Owner attachment facilities and network upgrades as well as related costs estimates required for this project interconnection project are shown in below table. Please note that these costs do not include CIAC Tax Gross-up:

Project Costs Description	Amount
Attachment Facilities Inline facilities from tap point to POI: a. Ring Bus Construct a new three (3) breaker ring bus interconnection substation at South Reading - North Boyertown 230kV Line as shown in Appendix 2. Two third (2/3) of the ring bus substation costs are inline facilities from tap points at the transmission line to POI; (Total ring bus substation estimated cost is $7,671,200. Two third (2/3) is approximately $5,114,133). b. Install (1) fully rated disconnect switch in the attachment line between the ring bus substation and the POI. Cost estimate: $20,000 which is included in above costs. Metering to be installed in Interconnection Customer's facilities: Cost estimate: $150,000 which is included in above costs.	**$ 5,114,133**
Direct Connection Network Upgrades *NUN* — Description* *n4857 — Construct a new three (3) breaker ring bus interconnection substation at South Reading - North Boyertown 230kV Line as shown in Appendix 2. Only one third (1/3) of the ring bus substation costs are attributed to Direct Connect Network Upgrades.* *Cost estimate: $2,557,067* *n4861 — Loop the South Reading - North Boyertown 230 kV Line into the new AA2-115 interconnection substation (approximately 200 FT);* *Cost estimate: $679,600*	**$ 3,236,667**

Project Costs Description		Amount
Non-Direct Connection Network Upgrades		**$ 5,958,500**
*NUN**	*Description*	
n4858	*Upgrade line carrier and transfer trip relay equipment at South Reading 230kV Substation; Cost estimate: $454,600*	
n4859	*Upgrade line carrier and transfer trip relay equipment at Hosensack 230kV Substation. Cost estimate: $430,800*	
n4860	*Upgrade line carrier relay at North Boyertown 230kV Substation; Cost estimate: $419,000.*	
n4862	*<u>Contingency</u> at North Boyertown substation; Overloaded Element: North Boyertown 230/69kV #1 Bank; Replace the transformer with a new 168 MVA transformer and install a new 230 kV high side circuit breaker on the new transformer. Cost estimate $3,598,000*	
n4863	*<u>Contingency</u> at South Reading substation; Constraining Equipment: South Reading 230/69kV #7 Bank; Upgrade limiting OC facilities in order to increase thermal ratings of the bank. Cost estimate: $159,300*	
n4864	*<u>Contingency</u> at South Reading substation; Constraining Equipment:: South Reading 230/69kV #8 Bank; Upgrade limiting OC facilities (OC IBC51A) in order to increase the thermal ratings of the bank. Cost estimate: $159,300*	
n4865	*<u>Contingency</u> at South Reading Substation: Upgrade the overdutied circuit breaker. Cost estimate: $737,500*	
Contributions for Previously Identified Upgrades None.		$ 0
	Total Costs	**$ 14,309,300**

**** NUN means Network Upgrade Number***

Interconnection Customer Requirements

Birdsboro Power will be responsible for meeting all criteria as specified in the applicable sections of the Interconnected Transmission Owner "Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of the minimum required Interconnected Transmission Owner generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.
2. The purchase and installation of a 230 kV interconnection metering instrument transformer. The Interconnected Transmission Owner will provide the ratio and accuracy specifications based on the customer load and generation levels.
3. The purchase and installation of a revenue class meter for each Birdsboro Power, LLC unit to measure the power delivered in compliance with the Interconnected Transmission Owner standards.
4. A compliance with the Interconnected Transmission Owner and PJM generator power factor and voltage control requirements.
5. The execution of a back-up retail service agreement with the electric distribution company to serve the customer load supplied from the AA2-115 generation project interconnection point when the units are out-of-service.
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. The RTU, the communications channel and all related equipment will be furnished and maintained by the Birdsboro Power, LLC. The RTU must communicate with the Interconnected Transmission Owner EMS via DNP 3.0 protocol.
7. The following status and metering points will be required:
   a. Interconnection breaker position.
   b. Generator real and reactive power output measured at the high-side of the generator step-up transformer.
   c. Generator voltage at the point of interconnection.

The above requirements are in addition to any metering or other requirements required by PJM.

Schedule of Work

Based on the scope of interconnection attachment facilities, direct and non-direct system upgrades, it is expected to take a minimum of twenty (20) months from the date of a fully executed Interconnection Construction Service Agreement to complete the installation. This includes a preliminary payment that compensates the Interconnected Transmission Owner for the first three months of the engineering design work that is related to the interconnection facilities of the Project. It also assumes that the Interconnection Customer will provide the property for the Project direct connection facilities 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 facilities and that transmission system outages will be possible when requested.

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 Interconnection Customer's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

Transmission Owner Requirements

The Interconnection Customer will be required to comply with all Interconnected Transmission Owner revenue metering requirements for generation interconnection customers. The Interconnected Transmission Owner revenue metering requirements may be found in the Interconnected Transmission Owner "Requirements for Transmission Connected Facilities" document located at the following links:

www.firstenergycorp.com/feconnect

www.pjm.com/planning/design-engineering/to-tech-standards.aspx

https://www.firstenergycorp.com/content/dam/feconnect/files/wholesale/Requirements-for-Transmission-Connected-Facilities.pdf

Network Impacts

The Queue Project AA2-115 was studied as a 450 MW (Capacity 450 MW) injection tapping the North Boyertown - South Reading 230 kV line in METED. Project AA2-115 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AA2-115 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Base Case Study Year Summer Peak Analysis - 2019

Generator Deliverability

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

1. (METED - METED) The 27N.BOYTWN 230/69 kV transformer (from bus 204505 to bus 204606 ckt 1) loads from 75.02% to 104.68% (AC power flow) of its emergency rating (103 MVA) for the single line contingency outage of 'B_ME230-SX-#32_A'. This project contributes approximately 35.46 MW to the thermal violation.

CONTINGENCY 'B_ME230-SX-#32_A' /* NORTH BOYERTOWN - AA2-115 TAP
DISCONNECT BRANCH FROM BUS 204512 TO BUS 920200 CKT 1
END

2. (METED - METED) The 27S.RDG 230/69 kV transformer (from bus 204512 to bus 204609 ckt 7) loads from 92.18% to 103.24% (AC power flow) of its emergency rating (250 MVA) for the single line contingency outage of 'B_ME230-SX-#39'. This project contributes approximately 32.19 MW to the thermal violation.

CONTINGENCY 'B_ME230-SX-#39' /* BERKS-S.READING 230 KV & S.READING BANK
DISCONNECT BRANCH FROM BUS 207905 TO BUS 204512 CKT 1
DISCONNECT BRANCH FROM BUS 204512 TO BUS 204609 CKT 8
DISCONNECT BUS 207905
END

Please refer to Appendix 3 for a table containing the generators having contribution to this flowgate.

3. (METED - METED) The 27S.RDG 230/69 kV transformer (from bus 204512 to bus 204609 ckt 7) loads from 89.61% to 101.87% (AC power flow) of its emergency rating (250 MVA) for the single line contingency outage of 'PL100791_A'. This project contributes approximately 39.95 MW to the thermal violation.

CONTINGENCY 'PL100791_A' /* SAKR-SREA #1 230KV LINE, SREA T8

DISCONNECT BRANCH FROM BUS 204512 TO BUS 204609 CKT 8
DISCONNECT BRANCH FROM BUS 208045 TO BUS 204512 CKT 1
END

4. (METED - METED) The 27S.RDG 230/69 kV transformer (from bus 204512 to bus 204609 ckt 8) loads from 95.29% to 105.73% (AC power flow) of its emergency rating (250 MVA) for the single line contingency outage of 'B_ME230-SX-#43'. This project contributes approximately 26.37 MW to the thermal violation.

CONTINGENCY 'B_ME230-SX-#43' /* SOUTH READING 7 BANK 230/69 KV
DISCONNECT BRANCH FROM BUS 204512 TO BUS 204609 CKT 7
END

Please refer to Appendix 4 for a table containing the generators having contribution to this flowgate.

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

None

Contribution to Previously Identified Overloads
(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)
None

Transient Stability Requirements

Transient stability is maintained for all contingencies tested. AA2-115 queue project is transiently stable and meets the applicable criteria.

Delivery of Energy Portion of Interconnection Request
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.
Only the most severely overloaded conditions are listed. 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 will study all overload conditions associated with the overloaded element(s) identified.

Not Applicable

Light Load Analysis - 2019

None

System Reinforcements

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

1. In order to mitigate the North Boyertown 230/69 kV #1 transformer: Replacing the transformer with a new 168 MVA rating and installing a new 230 kV high side circuit breaker on the new transformer are required (n4862). The estimated cost is $3,598,000, and it will take 14 months to complete.

Queue	MW contribution	Percentage of Cost	Cost
AA2-115	4.82	100%	$3,598,000

2 and 3. In order to mitigate the South Reading 230/69 kV #7 transformer: Upgrading limiting OC facilities are required (n4863). The estimated cost is $159,300, and it will take 9 months to complete.

Queue	MW contribution	Percentage of Cost	Cost
AA2-115	8.1	100%	$159,300

4. In order to mitigate the South Reading 230/69 kV #8 transformer: Upgrading limiting OC facilities are required (n4864). The estimated cost is $159,300, and it will take 9 month to complete.

Queue	MW contribution	Percentage of Cost	Cost
AA2-115	14.325	100%	$159,300

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)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

None

Short Circuit
(Summary form of Cost allocation for breakers will be inserted here if any)

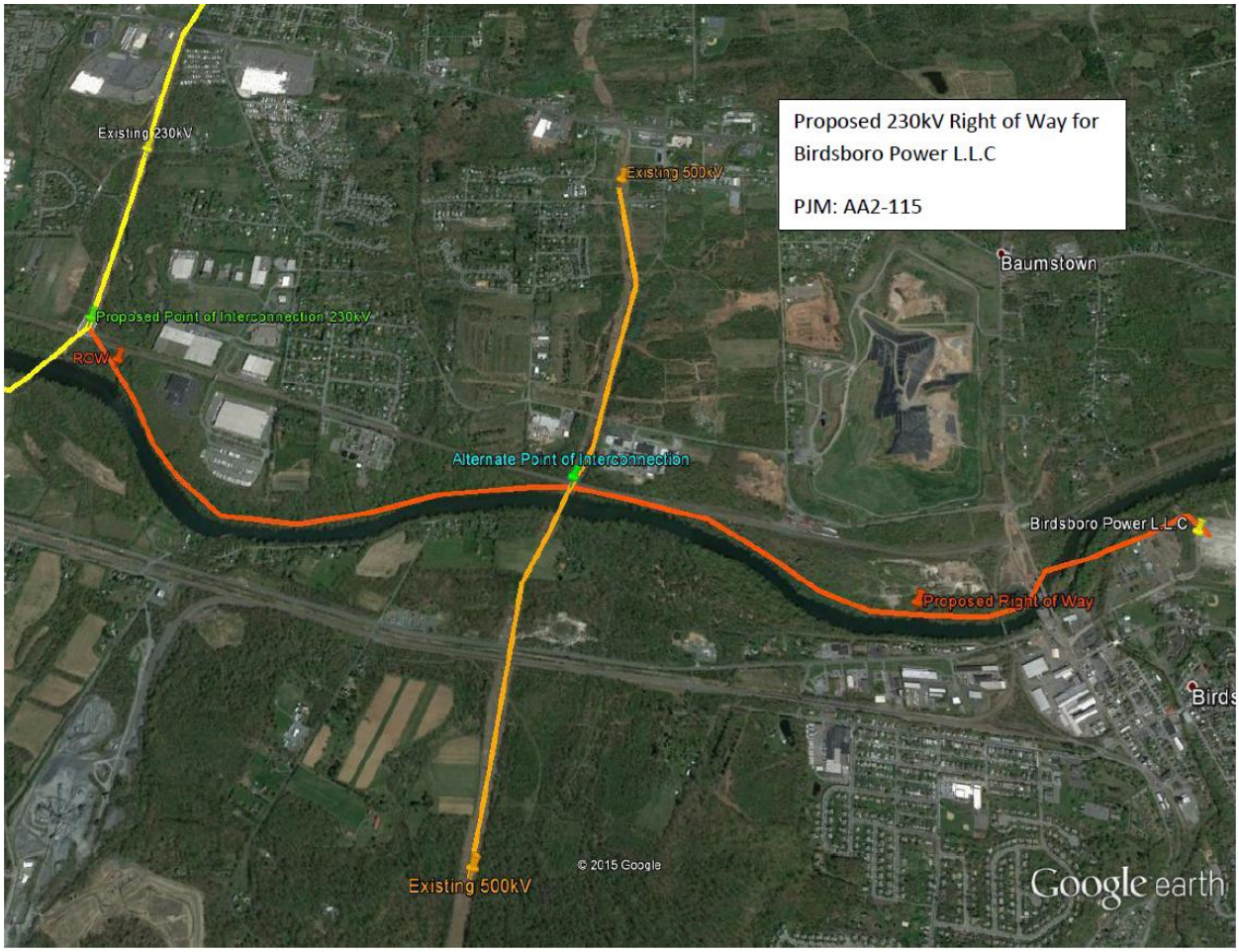
None

Stability and Reactive Power Requirement
(Results of the dynamic studies should be inserted here)

None

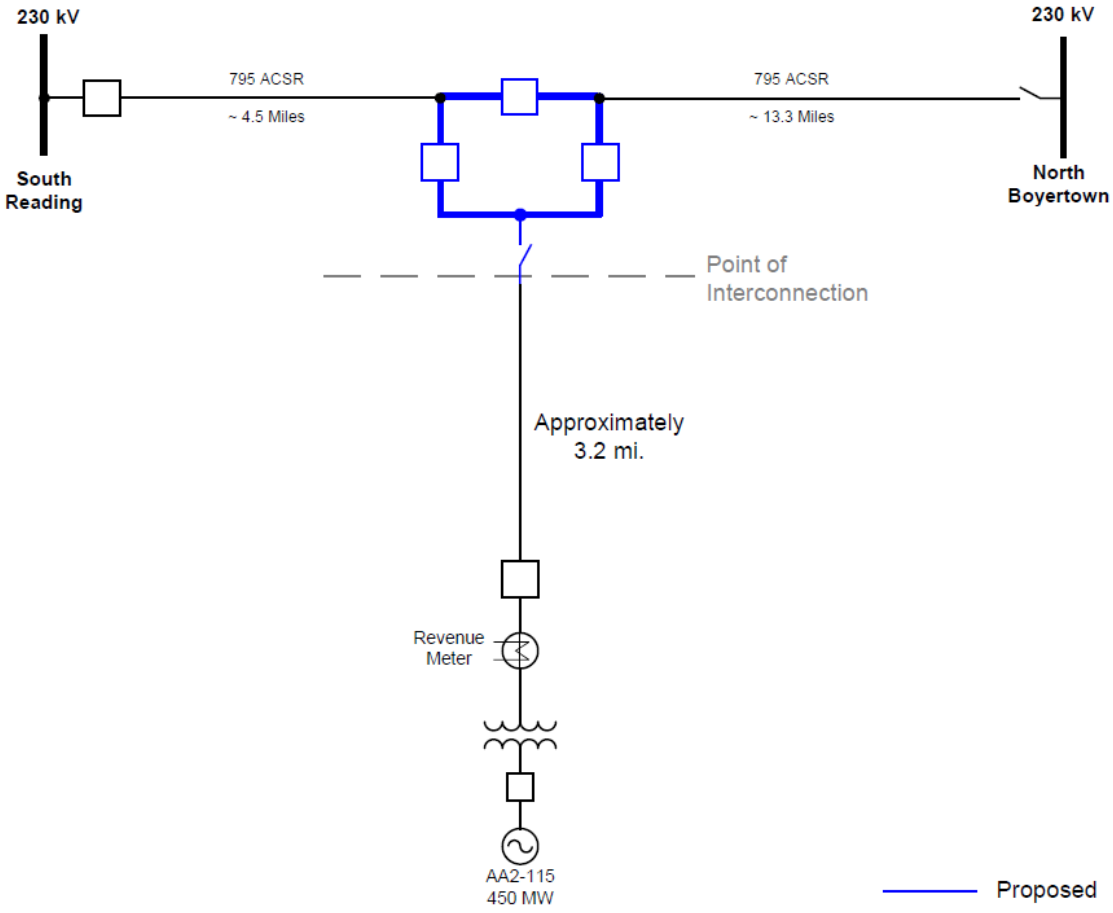
Appendix 1

Project Location



Appendix 2

System Configuration – Single Line Diagram



Appendix 3

The purpose of this appendix is to provide information about 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.

(METED - METED) The 27S.RDG 230/69 kV transformer (from bus 204512 to bus 204609 ckt 7) loads from 92.18% to 103.24% (AC power flow) of its emergency rating (250 MVA) for the single line contingency outage of 'B_ME230-SX-#39'. This project contributes approximately 32.19 MW to the thermal violation.

```
CONTINGENCY 'B_ME230-SX-#39'  /* BERKS-S.READING 230 KV & S.READING BANK
  DISCONNECT BRANCH FROM BUS 207905 TO BUS 204512 CKT 1
  DISCONNECT BRANCH FROM BUS 204512 TO BUS 204609 CKT 8
  DISCONNECT BUS 207905
  END
```

Bus Number	*Bus Name*	*Full Contribution*
920201	*AA2-115 OP*	*32.19*

Appendix 4

The purpose of this appendix is to provide information about 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.

(METED - METED) The 27S.RDG 230/69 kV transformer (from bus 204512 to bus 204609 ckt 8) loads from 95.29% to 105.73% (AC power flow) of its emergency rating (250 MVA) for the single line contingency outage of 'B_ME230-SX-#43'. This project contributes approximately 26.37 MW to the thermal violation.

CONTINGENCY 'B_ME230-SX-#43' /* SOUTH READING 7 BANK 230/69 KV
DISCONNECT BRANCH FROM BUS 204512 TO BUS 204609 CKT 7
END

Bus Number	*Bus Name*	*Full Contribution*
920201	*AA2-115 OP*	*26.37*