Generation Interconnection

System Impact Study Report

for

Queue Project AD2-110

Guilford 138 kV

12 MW Capacity / 12 MW Energy

October, 2019

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1 Introduction

This System Impact Study (SIS) has been prepared in accordance with the PJM Open Access Transmission Tariff, 205, as well as the System Impact Study Agreement between Chambersburg Energy, LLC, the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is West Penn Power (Mid-Atlantic Interstate Transmission, LLC or "MAIT").

2 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.

3 General

Interconnection Customer has proposed an uprate to its existing Guilford natural gas generating facility located 225 Alleman Road, Chambersburg, Franklin County, Pennsylvania. This project requests an increase to the install capability of 12 MW Energy and 12 MW Capacity Interconnection Rights ("CIR"). The installed facilities will have a total capability of 100 MW with 100 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 5/31/2022. **This study does not imply a West Penn Power (Transmission Owner) commitment to this in-service date.**

Queue Number	**AD2-110**
Project Name	Guilford 138 kV
Interconnection Customer	Chambersburg Energy, LLC
State	Pennsylvania
County	Franklin
Transmission Owner	West Penn Power
MFO	100
MWE	12
MWC	12
Fuel	Natural Gas
Basecase Study Year	2021

3.1 Generator Capability

The Guilford units are two (2) combustion turbines; the uprate is achieved by software optimization that will affect the firing capability of the units.

3.1.1 MFO

The following table shows the MW unit contributions as related to the Maximum Facility Output ("MFO") by unit and Queue No.:

	Queue No.	Unit 1	Unit 2	Total MW
	E04_W20	44 (winter)	44 (winter)	88
	AD2-110	6	6	12
Total MFO MW		50	50	**100**

3.1.2 Capacity

The following table shows the Capacity Interconnection Rights MWs by unit and Queue No.:

	Queue No.	Unit 1	Unit 2	Total MW
	E04_W20	44	44	88
	Please Note: Above CIR numbers are based on 2017 Summer Capability Test, as reported to PJM by Guilford Energy power plant. The units achieved 88.0 MW CIRs as of 9/1/2018 @0000 hours.			
	AD2-110	6	6	12
Total MFO MW		50	50	**100**

4 Point of Interconnection (POI)

The AD2-110 uprate project will utilize the existing Guilford units' POI, assigned Queue No. E04_W20. The existing POI will remain unchanged. AD2-110 is interconnecting with the West Penn Power transmission system by direct injection of power into Guilford switching station.

Attachment 1 shows a one-line diagram of the E04_W20 and AD2-110 generation project interconnection with the FirstEnergy ("FE") transmission system. Attachment 2 shows the project location.

5 Cost Summary

The AD2-110 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$0
Direct Connection Network Upgrade	$0
Non Direct Connection Network Upgrades	$0
New System Upgrades	$0
Contribution to Previously Identified Upgrades	$0[1]
Total Costs	$0

The required Attachment Facilities and Direct and Non-Direct Connection work for the interconnection of the AD2-110 generation project to the FE Transmission System is detailed in the following sections. The associated one-line with the generation project is shown in Attachment 1.

[1] This project contributes to an overload of the Roxbury 139/115 kV transformer (See Network Impacts Section 11). There is an existing Supplemental RTEP Upgrade s1643 to replace the Roxbury 100 MVA 138/115 kV transformer with a 224 MVA unit and convert the Roxbury 115 kV Substation into a four breaker ring bus. The current expected in-service date for this project is December 31, 2019. The AD2-110 project does not have cost responsibility for this upgrade. Queue AD2-110 may need this upgrade in-service to be deliverable to the PJM system. If Queue Project AD2-110 desires to come into service prior to completion of the upgrade, they will need an interim deliverability study.

6 Transmission Owner Scope of Work

There is no transmission owner work associated with this queue request.

6.1 Attachment Facilities

There is no Attachment Facilities work required to accommodate this project.

6.2 Direct Connection Cost Estimate

There is no Direct Connection work required to accommodate this project.

6.3 Non-Direct Connection Cost Estimate

There is no Non-Direct Connection work required to accommodate this project.

7 Schedule

This project contributes to an overload of the Roxbury 139/115 kV transformer (See Network Impacts Section). There is an existing Supplemental RTEP Upgrade s1643 to replace the Roxbury 100 MVA 138/115 kV transformer with a 224 MVA unit and convert the Roxbury 115 kV Substation into a four breaker ring bus. The current expected in-service date for this project is December 31, 2019. The AD2-110 project does not have cost responsibility for this upgrade. Queue AD2-110 may need this upgrade in-service to be deliverable to the PJM system. If Queue Project AD2-110 desires to come into service prior to completion of the upgrade, they will need an interim deliverability study.

8 Transmission Owner Analysis

8.1 Power Flow Analysis

PJM performed a power flow analysis of the transmission system using a 2021 summer peak load flow model and the results were verified by FE. Additionally, FE performed an analysis of its underlying transmission <100 kV system. The AD2-110 project did not contribute to any overloads on the FE transmission system.

8.2 Short Circuit Analysis

PJM performed a short circuit analysis and the results were verified by FE. The connection of AD2-110 project to the system does not result in any newly overdutied circuit breakers on the FE transmission system and does not have a significant fault current contribution to existing overdutied circuit breakers.

8.3 Stability Analysis

A dynamic stability analysis was completed by FE and the results were reviewed by PJM. There were no stability concerns identified.

9 Interconnection Customer Requirements

9.1 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.

9.2 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. If not already existing, the IC is responsible for the following:

1. The purchase and installation of a fully rated 138 kV circuit breaker to protect the AD2-110 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 AD2-110 generation project metering point when the units are out-of-service.

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.

9.3 Power Factor Requirements

The existing Customer Facility shall retain its ability to maintain a power factor of at least 0.95 leading (absorbing VARs) to 0.90 lagging (supplying VARs) measured at the generator's terminals. The increase of 12 MW to the Customer Facilities associated with the AD2-110 project shall be designed with the ability to maintain a Power Factor of at least 1.0 (unity) to 0.90 lagging (supplying VARs) measured at the Point of Interconnection.

FE performed a reactive capability analysis of the proposed incremental increase using the D-Curve provided by the IC. The following table(s) show the reactive power requirements and capabilities for both the existing and additional output.

Queue	Size	Leading PF	Lagging PF	Leading MVARs	Lagging MVARs
E04_W20	88	0.95	0.90	-29	42
AD2-110	12	1.00	0.90	0	6
Total	**-**	**-**		**-29**	**48**
Reactive Capability at 100 MW				**-31**	**88**
MVAR Surplus/Deficiency				**2**	**40**

Based on the FE review, the IC is capable of meeting the Power Factor requirements.

10 Revenue Metering and SCADA Requirements

10.1 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 Attachment O, Appendix 2, Section 8.

10.2 FE 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

11 Network Impacts

The Queue Project AD2-110 was evaluated as a 12.0 MW (Capacity 12.0 MW) injection at the Guilford 138kV substation in the APS (West Penn Power) area. Project AD2-110 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD2-110 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

12 Generation Deliverability

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

None

13 Multiple Facility Contingency

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

None

14 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)

1. (PENELEC - PENELEC) The 26ROXBURY 138/115 kV transformer (from bus 200532 to bus 200520 ckt 2) loads from 100.02% to 101.35% (AC power flow) of its emergency rating (150 MVA) for the line fault with failed breaker contingency outage of 'ME_P4-500-002H'. This project contributes approximately 1.89 MW to the thermal violation.

```
CONTINGENCY 'ME_P4-500-002H'                    /* HUNTERSTOWN 500 KV STUCK CB - CBB11392
  DISCONNECT BRANCH FROM BUS 200026 TO BUS 200004 CKT 1      /* HUNTERTN 500 CNASTONE 500
  DISCONNECT BRANCH FROM BUS 200026 TO BUS 204501 CKT 1      /* HUNTERTN 500 27HUNTRSTN 230
  END
```

Please refer to Appendix 1 for a table containing the generators having contribution to this flowgate.

14.1 Overload Summary Table:

Contingency Description	Overloaded Element	Emergency Rating (MVA)	% Loading After AD2-110	FE Comments/Reinforcements
Hunterstown Stuck Breaker	Roxbury 138/115 kV Transformer	150	101.35%	Supplemental Project s1643 will resolve overload

15 Steady State Voltage Requirements

None.

16 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.

None.

17 System Reinforcements

To Relieve the ROXBURY 138/115 kV transformer overload (ckt 2):

- **Existing PJM Supplemental Upgrade s1643** - Replace the existing Roxbury 100 MVA 138/115 kV transformer with a 224 MVA unit. Convert Roxbury 115 kV substation into a four (4) breaker ring bus.

- **Expected In-Service Date:** 12/31/2019

Note: AD2-110 does not have cost responsibility for this upgrade. AD2-110 will need this upgrade in-service to be deliverable to the PJM system. If AD2-110 intends to come into service prior to completion of the upgrade, they will need an interim study.

18 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.

18.1 Appendix 1

(PENELEC - PENELEC) The 26ROXBURY 138/115 kV transformer (from bus 200532 to bus 200520 ckt 2) loads from 100.02% to 101.35% (AC power flow) of its emergency rating (150 MVA) for the line fault with failed breaker contingency outage of 'ME_P4-500-002H'. This project contributes approximately 1.89 MW to the thermal violation.

CONTINGENCY 'ME_P4-500-002H' /* HUNTERSTOWN 500 KV STUCK CB - CBB11392
DISCONNECT BRANCH FROM BUS 200026 TO BUS 200004 CKT 1 /* HUNTERTN 500 CNASTONE 500
DISCONNECT BRANCH FROM BUS 200026 TO BUS 204501 CKT 1 /* HUNTERTN 500 27HUNTRSTN 230
END

Bus Number	*Bus Name*	*Full Contribution*
237329	*01CHBRG_I12*	*1.31*
235723	*01GUILF1*	*1.42*
235724	*01GUILF2*	*1.42*
933251	*AC2-136 C*	*0.34*
933252	*AC2-136 E*	*0.39*
933974	*AD1-020 BAT*	*1.24*
934361	*AD1-060 C*	*0.54*
934362	*AD1-060 E*	*0.88*
934371	*AD1-061 C*	*0.87*
934372	*AD1-061 E*	*1.41*
936061	*AD2-009 C*	*5.92*
936062	*AD2-009 E*	*2.7*
936471	*AD2-062 C O1*	*20.92*
936472	*AD2-062 E O1*	*10.48*
936871	*AD2-110*	*1.89*
LTF	*CARR*	*0.42*
LTF	*CBM-S1*	*1.59*
LTF	*CBM-S2*	*1.71*
LTF	*CBM-W1*	*5.12*
LTF	*CBM-W2*	*9.19*
LTF	*CIN*	*1.17*
LTF	*CPLE*	*0.45*
LTF	*G-007*	*1.24*
LTF	*IPL*	*0.75*

LTF	*LGEE*	*0.25*
LTF	*MEC*	*2.25*
LTF	*MECS*	*1.4*
LTF	*O-066*	*8.07*
LTF	*RENSSELAER*	*0.33*
905554	*W4-102 E*	*0.68*
LTF	*WEC*	*0.31*
918731	*AA1-092 C*	*0.55*
918732	*AA1-092 E*	*0.28*
918761	*AA1-095 C*	*0.33*
918762	*AA1-095 E*	*0.17*
930781	*AB1-123 C*	*0.41*
930782	*AB1-123 E*	*0.67*
930821	*AB1-127 C*	*1.04*
930822	*AB1-127 E*	*1.7*
930831	*AB1-128 C*	*1.04*
930832	*AB1-128 E*	*1.7*
923871	*AB2-027 C*	*0.18*
923872	*AB2-027 E*	*0.3*
924482	*AB2-097 E*	*0.64*

Affected Systems

19 Affected Systems

19.1 NYISO Impacts:

None

Short Circuit

20 Short Circuit

The following Breakers are overduty:

None

Stability

21 Stability Analysis and Reactive Power Assessment

No mitigations required. See executive summary from Stability Study Analysis below:

21.1 Stability Analysis Executive Summary

Generator Interconnection Request AD2-110 project (the "Project") is for an uprate to the existing natural gas facility located at the Guilford 138 kV substation. The existing facilities will operate at 100 MW Maximum Facility Output (MFO), which includes a 12 MW Energy and 12 MW Capacity Interconnection Rights (CIR) increase to the installed capability. The Project will be connected to the West Penn Power 138 kV transmission system with a Point of Interconnection (POI) at the Guilford substation located at 225 Alleman Road, Chambersburg, Franklin County, Pennsylvania.

The Project has a proposed in-service date of 05/31/2022.

This report describes a dynamic simulation analysis of AD2-110 as part of the System Impact Study (SIS).

The Study utilized the updated RTEP 2021 Light Load case, modified to include applicable queue projects (AD2-108, AD2-109, AD2-110 & AD2-112). The Study Area for the Study includes buses and generators located seven buses away from the POI.

The analysis was conducted in compliance with the applicable NERC and PJM reliability and design standards; and in accordance with applicable FirstEnergy study guidelines, procedures and practices.

Transient stability analysis was conducted to assess the dynamic performance of the system under transient conditions within the Study Area. This analysis evaluated the performance of the system under normal criteria contingencies in the Study Area and analyzed issues including, but not limited to, transient stability, control systems, and performance of any Special Protection Systems that may have been affected.

The results of the transient stability analysis showed that all monitored elements were stable following all studied faults and indicated that the AD2-110 interconnection would not have an adverse impact on the existing system's transient stability.

No mitigations were found to be required.

21.2 Reactive Power Assessment

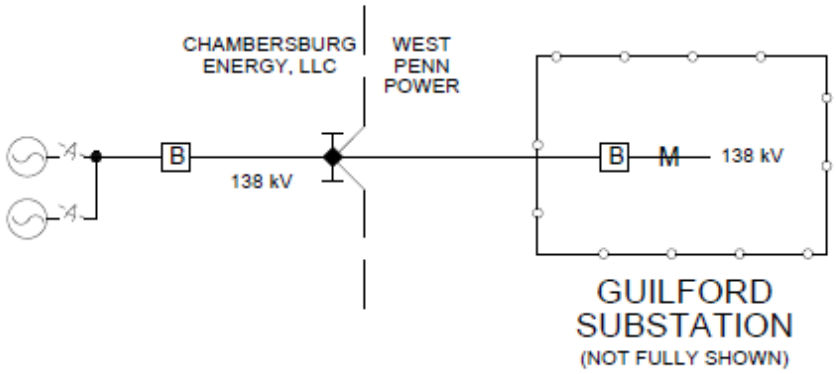
No reactive deficiencies were identified.

Light Load

22 Light Load Analysis

No impacts.

23 Attachment 1 – One Line



◆ = POI (POINT OF INTERCONNECTION) LOCATED AT CHAMBERSBURG, LLC DEAD-END STRUCTURE, WHERE WEST PENN POWER TRANSMISSION LINE TERMINATES

M = REVENUE METERING

24 Attachment 2 – Project Location