



# **Generation Interconnection**

## **Feasibility Study Report**

**for**

**Queue Project AE2-269**

**FAYETTEVILLE 138 KV**

**9.24 MW Capacity / 22 MW Energy**

July, 2019

# Table Of Contents

- 1 Preface..... 4
- 2 General..... 5
- 3 Point of Interconnection..... 6
  - 3.1 Primary POI..... 6
- 4 Cost Summary ..... 7
- 5 Transmission Owner Scope of Work..... 8
- 6 Attachment Facilities ..... 9
- 7 Direct Connection Cost Estimate..... 9
- 8 Non-Direct Connection Cost Estimate..... 9
- 9 Schedule.....10
- 10 Transmission Owner Analysis.....11
  - 10.1 Power Flow Analysis .....11
- 11 Interconnection Customer Requirements.....12
  - 11.1 System Protection.....12
  - 11.2 Compliance Issues and Interconnection Customer Requirements .....12
  - 11.3 Power Factor Requirements.....13
- 12 Revenue Metering and SCADA Requirements .....14
  - 12.1 PJM Requirements .....14
  - 12.2 FE Requirements.....14
- 13 Network Impacts.....15
- 14 Generation Deliverability .....17
- 15 Multiple Facility Contingency .....17
- 16 Contribution to Previously Identified Overloads .....17
- 17 Potential Congestion due to Local Energy Deliverability.....17
- 18 System Reinforcements.....18
- 19 Flow Gate Details .....19
  - 19.1 Index 1 .....20
- 20 Affected Systems .....23
  - 20.1 LG&E.....23
  - 20.2 MISO .....23
  - 20.3 TVA.....23

20.4 Duke Energy Progress.....23

20.5 NYISO .....23

21 Contingency Descriptions.....24

22 Short Circuit.....26

23 Attachment 1 – One Line.....27

24 Attachment 2 – Project Location .....28

## 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.

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.

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 Solar generating facility located in Franklin County, Pennsylvania. The installed facilities will have a total capability of 22 MW with 9.24 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is December 31, 2021. This study does not imply a Transmission Owner (TO) commitment to this in-service date.

<b>Queue Number</b>	<b>AE2-269</b>
<b>Project Name</b>	FAYETTEVILLE 138 KV
<b>Interconnection Customer</b>	
<b>State</b>	PA
<b>County</b>	Franklin
<b>Transmission Owner</b>	APS
<b>MFO</b>	22
<b>MWE</b>	22
<b>MWC</b>	9.24
<b>Fuel</b>	Solar
<b>Basecase Study Year</b>	2022

### 3 Point of Interconnection

#### 3.1 Primary POI

The interconnection of the project at the Primary POI will be accomplished by rebuilding Fayetteville substation into a 138 kV five breaker ring bus substation. The IC will be provided a new 138 kV terminal position at Fayetteville. The project will also require non-direct connection upgrades at West Waynesboro, Ringgold and Grand Point substations.

Attachment 1 shows a one-line diagram of the proposed primary direct connection facilities for the AE2-269 generation project to connect to the FirstEnergy (“FE”) transmission system. Attachment 2 provides the proposed location for the point of interconnection. IC will be responsible for constructing all of 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.

## 4 Cost Summary

The AE2-269 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	\$681,670
Direct Connection Network Upgrade	\$6,135,030
Non Direct Connection Network Upgrades	\$1,900,000
<b>Total Costs</b>	<b>\$8,716,700</b>

In addition, the AE2-269 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	\$0

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.

The required Attachment Facilities and Direct and Non-Direct Connection work for the interconnection of the AE2-269 generation project to the FE Transmission System is detailed in the following sections. The associated one-line with the generation project Attachment Facilities and the Primary Direct and Non-Direct Connection facilities are shown in Attachment 1.

## **5 Transmission Owner Scope of Work**

The interconnection of the project at the Primary POI will be accomplished by rebuilding Fayetteville substation into a 138 kV five breaker ring bus substation. The IC will be provided a new 138 kV terminal position at Fayetteville. The project will also require non-direct connection upgrades at West Waynesboro, Ringgold and Grand Point substations.

Attachment 1 shows a one-line diagram of the proposed primary direct connection facilities for the AE2-269 generation project to connect to the FirstEnergy (“FE”) transmission system. Attachment 2 provides the proposed location for the point of interconnection. IC will be responsible for constructing all of 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.

## 6 Attachment Facilities

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

Description	Total Cost
Install Dead-End Structure, Foundation and Disconnect Switch for AE2-269 Terminal	\$681,670
<b>Total Attachment Facility Costs</b>	<b>\$681,670</b>

## 7 Direct Connection Cost Estimate

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

Description	Total Cost
Rebuild Fayetteville Substation as 5 Breaker Ring Bus	\$6,135,030
<b>Total Direct Connection Facility Costs</b>	<b>\$6,135,030</b>

## 8 Non-Direct Connection Cost Estimate

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
Re-terminate the Existing 138 kV Lines into the Fayetteville Substation	\$465,900
Upgrade Fayetteville Line Terminal Relays and Wavetrap at West Waynesboro Substation	\$371,500
Upgrade Line Relays and Wavetrap at Ringgold Substation	\$371,500
Upgrade Line Relays and Wavetrap at Grand Point Substation	\$371,500
Upgrade E. Waynesboro Line Terminal Relays and Wavetrap at West Waynesboro Substation	\$319,600
<b>Total Non-Direct Connection Facility Cost</b>	<b>\$1,900,000</b>

## 9 Schedule

Based on the scope of work for the Attachment Facilities and the Direct and Non-Direct Connection facilities, it is expected to take a minimum of 19 months after the signing of an Interconnection Construction Service Agreement to complete the installation. This includes the requirement for the IC to make a preliminary payment that compensates FE for the first three months of the engineering design work that is related to the expansion of the interconnection substation. This assumes 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 and network upgrades, and that all transmission system outages will be allowed when requested.

## 10 Transmission Owner Analysis

### 10.1 Power Flow Analysis

FE performed an analysis of its underlying transmission <100 kV system. The AE2-269 project did not contribute to any overloads on the FE transmission <100 kV system.

## 11 Interconnection Customer Requirements

### 11.1 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.

### 11.2 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 138 kV circuit breaker to protect the AE2-269 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 AE2-269 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.

### **11.3 Power Factor Requirements**

The IC shall design its non-synchronous Customer Facility with 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.

## 12 Revenue Metering and SCADA Requirements

### 12.1 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.

### 12.2 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>

### **13 Network Impacts**

The Queue Project AE2-269 was evaluated as a 22.0 MW (Capacity 9.2 MW) injection at the Fayetteville 138kV substation in the APS area. Project AE2-269 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-269 was studied with a commercial probability of 53%. Potential network impacts were as follows:

# Summer Peak Load Flow

## 14 Generation Deliverability

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

None

## 15 Multiple Facility Contingency

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

None

## 16 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	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
7320370	200532	26ROXBURY	PENELEC	200520	26ROXBURY	PENELEC	2	ME_P4-500-002H	breaker	150.0	118.42	121.23	DC	4.21

## 17 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	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
7321439	200532	26ROXBURY	PENELEC	200520	26ROXBURY	PENELEC	2	AP-P1-2-WP-138-109	operation	150.0	105.02	108.71	DC	5.52
7321440	200532	26ROXBURY	PENELEC	200520	26ROXBURY	PENELEC	2	Base Case	operation	124.0	104.84	108.17	DC	4.13

## 18 System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
7320370	1	26ROXBURY 138.0 kV - 26ROXBURY 115.0 kV Ckt 2	<a href="#">7320370</a> No Violation - Ratings Increased <sup>1</sup>	\$0
			TOTAL COST	\$0

<sup>1</sup> If “No Reinforcement Needed. Not a valid violation” was provided as the Upgrade Description for a facility in the System Reinforcements table then that facility met one of the following conditions:

- a. The loading on the facility at your queue position was less than 100%; therefore, the facility is not yet overloaded, but may be overloaded by end of the AE2 queue.
- b. The TO reviewed their ratings on the facility and determined that the current rating was greater than the rating in PJM’s model. This new rating was greater than the loading at your queue position making the violation invalid.
- c. The TO reviewed the contingency and determined that contingency was not valid; therefore the violation is invalid. Any contingency corrections will be assessed and corrected in the AE2 impact study phase.

## 19 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.

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## 19.1 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
7320370	200532	26ROXBURY	PENELEC	200520	26ROXBURY	PENELEC	2	ME_P4-500-002H	breaker	150.0	118.42	121.23	DC	4.21

Bus #	Bus	MW Impact
235723	01GUILF1	0.83
235724	01GUILF2	0.83
237329	01CHBRG_I12	0.77
905554	W4-102 E	0.64
918731	AA1-092 C	0.52
918732	AA1-092 E	0.26
918761	AA1-095 C	0.36
918762	AA1-095 E	0.18
923871	AB2-027 C	0.17
923872	AB2-027 E	0.29
924482	AB2-097 E	0.61
930781	AB1-123 C O1	0.38
930782	AB1-123 E O1	0.62
930821	AB1-127 C	1.02
930822	AB1-127 E	1.66
930831	AB1-128 C	1.02
930832	AB1-128 E	1.66
933251	AC2-136 C	0.32
933252	AC2-136 E	0.36
933973	AD1-020 BAT	1.13
934362	AD1-060 E	0.85
934371	AD1-061 C	0.85
934372	AD1-061 E	1.39
936061	AD2-009 C	5.79
936062	AD2-009 E	2.64
936471	AD2-062 C O1	20.79
936472	AD2-062 E O1	10.42
936871	AD2-110	1.85
938751	AE1-101 C	13.54
938752	AE1-101 E	6.67
939031	AE1-132 C O1	6.14
939032	AE1-132 E O1	4.09
939591	AE1-188 C	1.55
939592	AE1-188 E	0.91
940671	AE2-054 C	1.33
940672	AE2-054 E	0.89
942541	AE2-269 C	1.77
942542	AE2-269 E	2.44
CARR	CARR	0.44
CBM-S1	CBM-S1	1.76
CBM-S2	CBM-S2	1.09

<b>CBM-W1</b>	CBM-W1	2.71
<b>CBM-W2</b>	CBM-W2	12.47
<b>CIN</b>	CIN	1.21
<b>CPLE</b>	CPLE	0.47
<b>G-007</b>	G-007	1.26
<b>IPL</b>	IPL	0.77
<b>LGEE</b>	LGEE	0.35
<b>MEC</b>	MEC	2.32
<b>MECS</b>	MECS	1.45
<b>O-066</b>	O-066	8.22
<b>RENSSELAER</b>	RENSSELAER	0.35
<b>WEC</b>	WEC	0.32

## Affected Systems

## **20 Affected Systems**

### **20.1 LG&E**

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

### **20.2 MISO**

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

### **20.3 TVA**

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

### **20.4 Duke Energy Progress**

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

### **20.5 NYISO**

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

## 21 Contingency Descriptions

Contingency Name	Contingency Definition
Base Case	
AP-P1-2-WP-138-109	CONTINGENCY 'AP-P1-2-WP-138-109' /* GUILFORD - REID 138KV DISCONNECT BRANCH FROM BUS 235189 TO BUS 235136 CKT 1 /* 01GUILFD 138 01ANTRIM 138 DISCONNECT BRANCH FROM BUS 235136 TO BUS 235503 CKT 1 /* 01ANTRIM 138 01REID 138 REMOVE LOAD 1 FROM BUS 235136 /* 01ANTRIM 138 END
ME_P4-500-002H	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

## Short Circuit

## 22 Short Circuit

The following Breakers are overduty:

None

## 23 Attachment 1 – One Line

## 24 Attachment 2 – Project Location