



# **Generation Interconnection**

## **Feasibility Study Report**

**for**

### **Queue Project AE2-256**

**COPPERSTONE-NORTH LEBANON 230 KV**

**29.4 MW Capacity / 70 MW Energy**

July, 2019

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## 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 Lebanon County, Pennsylvania. The installed facilities will have a total capability of 70 MW with 29.4 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is June 30, 2022. This study does not imply a Transmission Owner (TO) commitment to this in-service date.

<b>Queue Number</b>	<b>AE2-256</b>
<b>Project Name</b>	<b>COPPERSTONE-NORTH LEBANON 230 KV</b>
<b>Interconnection Customer</b>	
<b>State</b>	PA
<b>County</b>	Lebanon
<b>Transmission Owner</b>	ME
<b>MFO</b>	70
<b>MWE</b>	70
<b>MWC</b>	29.4
<b>Fuel</b>	Solar
<b>Basecase Study Year</b>	2022

### 3 Point of Interconnection (POI)

#### 3.1 Primary POI

The interconnection of the project at the Primary POI will be accomplished by constructing a new 230 kV three (3) breaker ring bus substation and looping the North Lebanon - Copperstone 230 kV line into the new station. The new substation will be located approximately 7.5 miles from North Lebanon substation. The IC will be responsible for acquiring all easements, properties, and permits that may be required to construct both the new interconnection switching station and the associated facilities. The IC will also be responsible for the rough grade of the property and an access road to the proposed three breaker ring bus site. The project will also require non-direct connection relay upgrades at both North Lebanon (FE) and Copperstone (PPL) substations.

Attachment 1 shows a one-line diagram of the proposed primary direct connection facilities for the AE2-256 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.

#### 3.2 Secondary POI

The interconnection of the project at a Secondary POI can be accomplished by constructing a new 230 kV three (3) breaker ring bus substation and looping the North Hershey – North Temple 230 kV line into the new station. The new substation would be located approximately 4 miles from North Hershey substation. A full scope of work or estimated cost is not provided for the proposed Secondary POI. Only network impacts are provided for the Secondary POI which can be found under the “Network Impacts – Secondary Point of Interconnection” section of this report.

## 4 Cost Summary

The AE2-256 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	\$ 827,480
Direct Connection Network Upgrade	\$7,447,320
Non Direct Connection Network Upgrades (FE)	\$ 251,000
Non Direct Connection Network Upgrades (PPL)	\$ 114,000
<b>Total Costs</b>	<b>\$8,639,800</b>

In addition, the AE2-256 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 AE2-256 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 constructing a new 230 kV three (3) breaker ring bus substation and looping the North Lebanon - Copperstone 230 kV line into the new station. The new substation will be located approximately 7.5 miles from North Lebanon substation. The IC will be responsible for acquiring all easements, properties, and permits that may be required to construct both the new interconnection switching station and the associated facilities. The IC will also be responsible for the rough grade of the property and an access road to the proposed three breaker ring bus site. The project will also require non-direct connection relay upgrades at North Lebanon (FE) and Copperstone (PPL) substations.

Attachment 1 shows a one-line diagram of the proposed primary direct connection facilities for the AE2-256 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 line exit take-off structure, foundations, disconnect switch and associated equipment at ring bus substation	\$827,480
<b>Total Attachment Facility Costs</b>	<b>\$827,480</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
Build new (3) breaker 230kV ring bus ~7.5 miles from North Lebanon substation for AE2-256 developer interconnection @ AE2-256	\$7,447,320
<b>Total Direct Connection Facility Costs</b>	<b>\$7,447,320</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
(FE) North Lebanon Substation: Replace Line relaying for existing Copperstone (PPL) 230kV line exit and rename due to AE2-256 developer interconnection @ North Lebanon SS	\$251,000
(PPL) Copperstone Substation: Relay upgrades for existing North Lebanon Substation (FE) 230 kV line exit and rename due to AE2-256 developer interconnection @ Copperstone SS	\$114,000
<b>Total Non-Direct Connection Facility Costs</b>	<b>\$365,000</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 30 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 construction of the interconnection substation. Full initial deposit will be required for the non-direct connection work identified. 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 AE2-256 project did not contribute to any overloads on the FE transmission 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 230 kV circuit breaker to protect the AE2-256 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 AE2-256 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 solar-powered 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 ME 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- Primary Point of Interconnection**

The Queue Project AE2-256 was evaluated as a 70.0 MW (Capacity 29.4 MW) tapping the Copperstone to North Lebanon 230kV line in the ME area. Project AE2-256 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-256 was studied with a commercial probability of 53%. Potential network impacts were as follows:

# Summer Peak Load Flow

### **13.1 Generation Deliverability**

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

None

### **13.2 Multiple Facility Contingency**

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

None

### **13.3 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

### **13.4 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

### 13.5 System Reinforcements:

None

### 13.6 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.

None

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## Affected Systems

## **13.7 Affected Systems**

### **13.7.1 LG&E**

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

### **13.7.2 MISO**

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

### **13.7.3 TVA**

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

### **13.7.4 Duke Energy Progress**

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

### **13.7.5 NYISO**

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

# Short Circuit

### 13.8 Short Circuit

The following Breakers are overduty:

None

## **14 Network Impacts- Secondary Point of Interconnection**

The Queue Project AE2-256 was evaluated as a 70.0 MW (Capacity 29.4 MW) injection tapping the North Hershey to South Lebanon Tap 230kV line in the ME area. Project AE2-256 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-256 was studied with a commercial probability of 53%. Potential network impacts were as follows:

# Summer Peak Load Flow

### 14.1 Generation Deliverability

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

None

### 14.2 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	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
11814672	204518	27IRONWOOD	METED	204511	27S.LEB	METED	1	PL:11:P42:000588	breaker	817.0	93.78	102.31	DC	69.72

### 14.3 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

### 14.4 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

## 14.5 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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## 14.6 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
11814672	204518	27IRONWOOD	METED	204511	27S.LEB	METED	1	PL:11:P42:000588	breaker	817.0	93.78	102.31	DC	69.72

Bus #	Bus	MW Impact
204662	27AES GEN1	16.46
204663	27AES GEN2	16.46
204664	27AES GEN3	16.46
925601	AC1-035	3.64
937271	AD2-166	89.45
942431	AE2-256 C O2	29.28
942432	AE2-256 E O2	40.44
BLUEG	BLUEG	1.99
CALDERWOOD	CALDERWOOD	0.22
CANNELTON	CANNELTON	0.12
CARR	CARR	0.15
CATAWBA	CATAWBA	0.14
CHEOAH	CHEOAH	0.2
CHILHOWEE	CHILHOWEE	0.07
COFFEEN	COFFEEN	0.21
COTTONWOOD	COTTONWOOD	0.84
DUCKCREEK	DUCKCREEK	0.46
EDWARDS	EDWARDS	0.21
ELMERSMITH	ELMERSMITH	0.21
FARMERCITY	FARMERCITY	0.14
G-007	G-007	0.42
GIBSON	GIBSON	0.08
HAMLET	HAMLET	0.23
NEWTON	NEWTON	0.55
O-066	O-066	2.68
PRAIRIE	PRAIRIE	1.03
RENSELAER	RENSELAER	0.12
SANTEETLA	SANTEETLA	0.06
SMITHLAND	SMITHLAND	0.08
TATANKA	TATANKA	0.25
TILTON	TILTON	0.25
TRIMBLE	TRIMBLE	0.22
TVA	TVA	0.7
UNIONPOWER	UNIONPOWER	0.31

# Affected Systems

## **14.7 Affected Systems**

### **14.7.1 LG&E**

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

### **14.7.2 MISO**

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

### **14.7.3 TVA**

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

### **14.7.4 Duke Energy Progress**

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

### **14.7.5 NYISO**

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

## 14.8 Contingency Descriptions

Contingency Name	Contingency Definition
<b>PL:11:P42:000588</b>	CONTINGENCY 'PL:11:P42:000588' /* HUMM-NHER 230KV STUCK BREAKER CONNECTED TO NHER-NTEM LINE DISCONNECT BRANCH FROM BUS 204506 TO BUS 942430 CKT 1 /* 27N.HERSHY 230 AE2-256 TAP 230 DISCONNECT BRANCH FROM BUS 204506 TO BUS 204602 CKT 1 /* N.HERSHY-N.HERSHY 230-69 DISCONNECT BRANCH FROM BUS 204508 TO BUS 204517 CKT 1 /* N.TEMPLE-S.LEBTAP 230 END

# Short Circuit

## 14.9 Short Circuit

The following Breakers are overduty:

None

**15 Attachment 1 – One Line**

**16 Attachment 2 – Project Location**