Generation Interconnection

Feasibility Study Report

for

Queue Project AE2-192

ORRTANNA 115 KV

39 MW Capacity / 65 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 Adams County, Pennsylvania. The installed facilities will have a total capability of 65 MW with 39 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is 12/31/2022. This study does not imply a Transmission Owner (TO) commitment to this in-service date.

Queue Number	AE2-192
Project Name	ORRTANNA 115 KV
Interconnection Customer	
State	None
County	Adams
Transmission Owner	ME
MFO	65
MWE	65
MWC	39
Fuel	Solar
Basecase Study Year	2022

3 Point of Interconnection

3.1 Primary POI

The interconnection of the project at the Primary POI will be accomplished by constructing a new 115 kV line terminal and dead-end structure at the existing Orrtanna 115 kV substation. The project will not require any remote terminal upgrades.

Attachment 1 shows a one-line diagram of the proposed primary direct connection facilities for the AE2-192 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 AE2-192 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$404,100
Direct Connection Network Upgrade	$493,900
Non-Direct Connection Network Upgrade	$0
Total Costs	$898,000

In addition, the AE2-192 project may be responsible for a contribution to the following costs:

Description	Total Cost
System Upgrades	$8,060,000

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 AE2-192 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 115 kV line terminal and dead-end structure at the existing Orrtanna 115 kV substation. This project will not require any remote terminal upgrades.

Attachment 1 shows a one-line diagram of the proposed primary direct connection facilities for the AE2-192 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 new ring bus substation.	$404,100
Total Attachment Facility Costs	$404,100

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
Add one 115kV breaker and terminal equipment for AE2-192 developer interconnection @ Orrtanna SS	$493,900
Total Direct Connection Facility Costs	$493,900

8 Non-Direct Connection Cost Estimate

There is no Non-Direct Connection scope of work required.

9 System Reinforcements Cost Estimate

Facility	Upgrade Description	Cost
27LINC TAP 115.0 kV - 27LINCOLN 115.0 kV Ckt 1	**ME-0003a (354) : At Lincoln, replace 350 CU SCCIR.** **Project Type : FAC** **Cost : $2,860,000** **Time Estimate : 9.0 Months** **ME-0003b (355) : Reconductor 115 kV Line 963 from Lincoln to Lincoln TAP with 795 ACSR conductor (2.0 miles).** **Project Type : FAC** **Cost : $5,200,000** **Time Estimate : 18.0 Months**	$8,060,000
	TOTAL COST	**$8,060,000**

10 Schedule

Based on the scope of work for the Attachment Facilities and the Direct Connection facilities, it is expected to take a minimum of 12 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 Attachment Facilities and Direct Connection work. 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.

The schedule for the required Network Impact Reinforcements will be more clearly identified in future study phases. The estimated time to complete each of the required reinforcements is identified in the "System Reinforcements" section of the report. Full initial deposit will be required for the System Reinforcements.

11 Transmission Owner Analysis

11.1 Power Flow Analysis

FE performed an analysis of its underlying transmission <100 kV system. The AE2-192 project did not contribute to any overloads on the FE transmission system.

12 Interconnection Customer Requirements

12.1 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.

12.2 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 115 kV circuit breaker to protect the AE2-192 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 AE2-192 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.

12.3 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.

13 Revenue Metering and SCADA Requirements

13.1 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.

13.2 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

14 Network Impacts

The Queue Project AE2-192 was evaluated as a 65.0 MW (Capacity 39.0 MW) injection at the Orrtanna 115 kV substation in the ME area. Project AE2-192 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-192 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Load Flow

15 Generation Deliverability

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

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
7156746	204543	27LINC TAP	METED	204544	27LINCOLN	METED	1	ME-P1-2-ME-115-016-B	single	152.0	98.24	102.71	DC	6.8

16 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
7157550	204668	27TEX E TP	METED	204528	27GARDNERS	METED	1	ME-P7-1-ME-230-003	tower	185.0	81.71	87.67	DC	11.01
7157551	204668	27TEX E TP	METED	204528	27GARDNERS	METED	1	ME-P7-1-ME-230-004	tower	185.0	80.26	86.22	DC	11.02

17 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
7156745	204543	27LINC TAP	METED	204544	27LINCOLN	METED	1	ME-P1-2-ME-115-016-A	single	152.0	107.79	112.27	DC	6.8

18 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
7156743	204543	27LINC TAP	METED	204544	27LINCOLN	METED	1	ME-P1-2-ME-115-016-A	operation	152.0	108.51	115.97	DC	11.34
7157104	204544	27LINCOLN	METED	204538	27STRABAN	METED	1	RICE RINGGOLD 230 KV	operation	223.0	89.48	94.11	DC	10.31
7157105	204544	27LINCOLN	METED	204538	27STRABAN	METED	1	RICE_TRANSFORMERS	operation	223.0	89.48	94.11	DC	10.31
1610052	939100	AE1-139 TAP	METED	204543	27LINC TAP	METED	1	Base Case	operation	126.0	51.17	102.76	DC	64.99

19 System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
7157551,7157550	2	27TEX E TP 115.0 kV - 27GARDNERS 115.0 kV Ckt 1	No Reinforcement Needed. Not a valid violation[1]	$0
7156746,7156745	1	27LINC TAP 115.0 kV - 27LINCOLN 115.0 kV Ckt 1	ME-0003a (354) : At Lincoln, replace 350 CU SCCIR. Project Type : FAC Cost : $2,860,000 Time Estimate : 9.0 Months ME-0003b (355) : Reconductor 115 kV Line 963 from Lincoln to Lincoln TAP with 795 ACSR conductor (2.0 miles). Project Type : FAC Cost : $5,200,000 Time Estimate : 18.0 Months	$8,060,000
			TOTAL COST	$8,060,000

[1] 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.

20 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.

21 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
7156745	204543	27LINC TAP	METED	204544	27LINCOLN	METED	1	ME-P1-2-ME-115-016-A	single	152.0	107.79	112.27	DC	6.8

Bus #	Bus	MW Impact
204639	27GLATFLTR	0.34
204642	27YK SOLID	0.19
204646	27HAM CT	0.23
204647	27HUNTR CT	0.95
204648	27MOUNT CT	0.4
204649	27ORTAN CT	0.41
204650	27TOLNA CT	0.25
204660	27YK H STA	0.07
933973	AD1-020 BAT	15.51
936921	AD2-116 C O1	0.71
939001	AE1-129 C O1	2.43
939021	AE1-131 C O1	4.29
939091	AE1-138 C O1	1.26
939101	AE1-139 C O1	6.8
939561	AE1-185 C	0.72
939661	AE1-196 C	0.7
941871	AE2-192 C	6.8
942391	AE2-252 C	1.02
942631	AE2-279 C O2	3.04
943161	AE2-345 C O2	6.76
BLUEG	BLUEG	2.74
CALDERWOOD	CALDERWOOD	0.35
CANNELTON	CANNELTON	0.17
CATAWBA	CATAWBA	0.25
CBM-N	CBM-N	0.77
CHEOAH	CHEOAH	0.32
CHILHOWEE	CHILHOWEE	0.11
COFFEEN	COFFEEN	0.29
COTTONWOOD	COTTONWOOD	1.27
DUCKCREEK	DUCKCREEK	0.62
EDWARDS	EDWARDS	0.28
ELMERSMITH	ELMERSMITH	0.29
FARMERCITY	FARMERCITY	0.2
G-007A	G-007A	3.01
GIBSON	GIBSON	0.11
HAMLET	HAMLET	0.42
NEWTON	NEWTON	0.76
NYISO	NYISO	3.35
PRAIRIE	PRAIRIE	1.46
SANTEETLA	SANTEETLA	0.09

Bus #	Bus	MW Impact
SMITHLAND	SMITHLAND	0.12
TATANKA	TATANKA	0.35
TILTON	TILTON	0.34
TRIMBLE	TRIMBLE	0.3
TVA	TVA	1.07
UNIONPOWER	UNIONPOWER	0.48
VFT	VFT	8.15

22 Index 2

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
7157550	204668	27TEX E TP	METED	204528	27GARDNERS	METED	1	ME-P7-1-ME-230-003	tower	185.0	81.71	87.67	DC	11.01

Bus #	Bus	MW Impact
204646	27HAM CT	0.41
204647	27HUNTR CT	1.27
204649	27ORTAN CT	0.4
903051	W2-094 C	0.17
903052	W2-094 E	0.3
925721	AC1-048 C	1.67
925722	AC1-048 E	2.73
932371	AC2-053 C	0.96
932372	AC2-053 E	1.56
933971	AD1-020 C	9.06
933972	AD1-020 E	4.46
933973	AD1-020 BAT	3.38
938041	AE1-006 C	0.96
938042	AE1-006 E	1.56
939021	AE1-131 C O1	12.61
939022	AE1-131 E O1	8.4
939091	AE1-138 C O1	2.29
939092	AE1-138 E O1	1.53
939101	AE1-139 C O1	6.61
939102	AE1-139 E O1	4.41
941871	AE2-192 C	6.61
941872	AE2-192 E	4.41
942631	AE2-279 C O2	3.53
942632	AE2-279 E O2	2.35
943161	AE2-345 C O2	16.49
943162	AE2-345 E O2	10.99
CARR	CARR	0.07
CBM-S1	CBM-S1	0.11
CBM-S2	CBM-S2	0.1
CBM-W1	CBM-W1	0.08
CBM-W2	CBM-W2	0.66
CIN	CIN	0.05
CPLE	CPLE	0.05
G-007	G-007	0.1
IPL	IPL	0.03
LGEE	LGEE	0.01
MEC	MEC	0.1
O-066	O-066	0.79
RENSSELAER	RENSSELAER	0.06
WEC	WEC	0.01

Affected Systems

23 Affected Systems

23.1 LG&E

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

23.2 MISO

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

23.3 TVA

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

23.4 Duke Energy Progress

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

23.5 NYISO

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

24 Contingency Descriptions

Contingency Name	Contingency Definition
RICE_TRANSFORMERS	CONTINGENCY 'RICE_TRANSFORMERS' /RICE TRANSFORMER #1 AND #2 500/230KV DISCONNECT BRANCH FROM BUS 270070 TO BUS 270071 CKT 1 DISCONNECT BRANCH FROM BUS 270070 TO BUS 270071 CKT 2 END
ME-P7-1-ME-230-003	CONTINGENCY 'ME-P7-1-ME-230-003' /* HUNTERSTOWN-JACKSON 230 KV & HAMILTON-JACKSON 115 KV DISCONNECT BRANCH FROM BUS 204575 TO BUS 204502 CKT 1 /* 27HUNTRST1 230 27JACKSON 230 DISCONNECT BRANCH FROM BUS 204535 TO BUS 204700 CKT 1 /* 27HAMILTON 115 27JACKSON6 115 END
ME-P7-1-ME-230-004	CONTINGENCY 'ME-P7-1-ME-230-004' /* HUNTRSTWN-JACKSN 230 KV & HUNTRSTWN-HAMILTON 115 KV DISCONNECT BRANCH FROM BUS 204575 TO BUS 204502 CKT 1 /* 27HUNTRST1 230 27JACKSON 230 DISCONNECT BRANCH FROM BUS 204535 TO BUS 204539 CKT 1 /* 27HAMILTON 115 27HUNTRSTN 115 END
RICE RINGGOLD 230 KV	CONTINGENCY 'RICE RINGGOLD 230 KV' /*RICE TO RINGGOLD 230 KV DISCONNECT BRANCH FROM BUS 270071 TO BUS 235506 CKT 1 DISCONNECT BRANCH FROM BUS 270071 TO BUS 235506 CKT 2 END
Base Case	
ME-P1-2-ME-115-016-B	CONTINGENCY 'ME-P1-2-ME-115-016-B' /* HUNTERSTOWN - LINCOLN 115 KV DISCONNECT BRANCH FROM BUS 933970 TO BUS 204544 CKT 1 /* AD1-020 TAP 115 27LINCOLN 115 REMOVE LOAD 3 FROM BUS 204544 /* 27LINCOLN 115 END
ME-P1-2-ME-115-016-A	CONTINGENCY 'ME-P1-2-ME-115-016-A' /* HUNTERSTOWN - LINCOLN 115 KV DISCONNECT BRANCH FROM BUS 204539 TO BUS 933970 CKT 1 /* 27HUNTRSTN 115 AD1-020 TAP 115 END

Short Circuit

25 Short Circuit

The following Breakers are overduty:

None

26 Attachment 1 – One Line Diagram

27 Attachment 2 – Project Location