Generation Interconnection

Feasibility Study Report

for

Queue Project AE2-318

FORD-CEDARVILLE 138 KV

67.2 MW Capacity / 100 MW Energy

July, 2019

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 Clermont County, Ohio. The installed facilities will have a total capability of 100 MW with 67.2 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is December 1, 2022. This study does not imply a TO commitment to this in-service date.

Queue Number	AE2-318
Project Name	FORD-CEDARVILLE 138 KV
State	Ohio
County	Clermont
Transmission Owner	DEOK
MFO	100
MWE	100
MWC	67.2
Fuel	Solar
Basecase Study Year	2022

2.1 Point of Interconnection

AE2-318 will interconnect with the Duke Energy transmission system by direct injection into a new 138 kV substation bus located on the feeder between the Ford and Cedarville substations. The new substation will have a three breaker ring bus configuration. The Point of Interconnection is located where Duke Energy's overhead line from the new substation terminates to the Interconnection Customer's pole mounted switch, approximately 25 feet outside the new substation fence. Please refer to the facilities location map in Attachment 1 and the single-line diagram in Attachment 2.

2.2 Cost Summary

The AE2-318 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$401,582
Direct Connection Network Upgrade	$7,261,972
Non Direct Connection Network Upgrades	$806,886
Total Costs	**$8,470,440**

In addition, the AE2-318 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	$6,890,000

Cost allocations for these upgrades will be provided in the System Impact Study Report.

3 Attachment Facilities

Duke Energy will install a revenue metering package, a take-off structure, and overhead conductors from the new substation to the Interconnect Customer's pole mounted switch.

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
Revenue metering package, a take-off structure, and overhead conductors from the new substation to the Interconnect Customer's pole mounted switch.	$401,582
Total Attachment Facility Costs	**$401,582**

4 Direct Connection Cost Estimate

Duke Energy will build a new 138 kV substation on Interconnection Customer supplied land. The substation will include, but is not limited to, a three breaker ring bus configuration, three 138 kV breakers, nine disconnect switches, relaying, metering, control building, two take-off structures, lighting, fencing, gravel, and foundations as necessary to form a complete substation installation. Duke Energy will install overhead conductors from the new substation to the Interconnect Customer's pole mounted switch.

Duke Energy facilities and network upgrades costs required to support the AE2-318 project are listed below. It is also assumed there will be no issues obtaining Transmission Line easement for station power.

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
Construct a new 138 kV substation on Interconnection Customer supplied land	$7, 261,972
Total Direct Connection Facility Costs	**$7, 261, 972**

5 Non-Direct Connection Cost Estimate

Transmission: Duke Energy will reconfigure the Ford to Cedarville 138 kV feeder to loop through the new 138 KV Interconnection substation.

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
Reconfigure the Ford to Cedarville 138 kV feeder to loop through the new 138 KV Interconnection substation.	$806,886
Total Non-Direct Connection Facility Costs	**$806,886**

6 Schedule

The estimated time to complete this work is approximately 24 months from a signed ISA and CSA. This assumes no issues getting a PJM outage on the line or adjacent line on tower and no major interruptions for weather.

NOTE: CIAC Tax Gross Up charges will be charged to the project if it does not meet the eligibility requirements of IRS Notice 88-129.

7 Interconnection Customer Requirements

Interconnection Customer will be required to procure and provide land for the new substation. The land will be ceded to Duke Energy prior to construction of the new substation. The land must be near the Ford - Cedarville 138 kV feeder path and have direct access to publicly maintained roadway. The land shall be environmentally permitted, graded and ready for construction. Final size and location is to be approved by Duke Energy.

Interconnection Customer will be required to engineer, procure, and construct the connecting circuit from the Interconnection Customer's substation to the Point of Interconnection. This includes, but is not limited to, a pole and switch to be installed approximately 25 feet outside the new substation fence.

Interconnection Customer will be responsible for meeting all criteria as specified in the applicable sections of the "Duke Energy Midwest transmission systems Facility Connection Requirements" document, Version 7, effective October 31, 2018, which can be found under this link:

http://www.pjm.com/~/media/planning/plan-standards/deok/deok-facility-connection-requirements.ashx.

8 Revenue Metering and SCADA Requirements

8.1 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.

8.2 DEOK Requirements

The Interconnection Customer will be required to comply with all Duke Energy revenue metering requirements for generation interconnection customers. The revenue metering requirements may be found within the "Duke Energy Midwest transmission systems Facility Connection Requirements" document, Version 7, effective October 31, 2018.

9 Network Impacts

The Queue Project AE2-318 was evaluated as a 100.0 MW (Capacity 67.2 MW) injection tapping the Ford to Cedarville 138kV line in the DEOK area. Project AE2-318 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-318 was studied with a commercial probability of 0.53. Potential network impacts were as follows:

Summer Peak Load Flow

10 Generation Deliverability

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

None

11 Multiple Facility Contingency

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

None

12 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
9692431	253038	09KILLEN	DAY	242938	05MARQUI	AEP	1	AEP_P4_#2866_05BEATTY 345_304W	breaker	1372.0	100.36	100.81	DC	13.74
9692432	253038	09KILLEN	DAY	242938	05MARQUI	AEP	1	AEP_P4_#2085_05BEATTY 345_304C	breaker	1372.0	100.2	100.66	DC	13.93
9693621	253038	09KILLEN	DAY	242938	05MARQUI	AEP	1	DAY_P7_BEATTY-S. CHARLESTON 34542_1-A	tower	1372.0	113.45	113.95	DC	15.15
9693622	253038	09KILLEN	DAY	242938	05MARQUI	AEP	1	DAY_P7_BEATTY-S. CHARLESTON 34542_1-B	tower	1372.0	111.36	111.85	DC	15.15

13 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
9693340	253038	09KILLEN	DAY	242938	05MARQUI	AEP	1	AEP_P1-2_#762	operation	1372.0	100.15	100.6	DC	13.73

14 System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
9692432, 9693621, 9693622, 9692431	1	09KILLEN 345.0 kV - 05MARQUI 345.0 kV Ckt 1	**AEPO0007a (116)** : Perform sag study on Don Marquis-Killen 345kV circuit, 32.1 miles of 2-983.1 ACAR 30/7 Rail 5 conductor. Since Killen will be retired, the conductor between Don Marquis and Stuart will become a complete circuit and the whole circuit will need to be sag studied. Perform sag study on Killen-Stuart 345kV circuit, 15.2 miles of 2-983.1 ACAR 30/7 Rail5 conductor. **Project Type** : FACILITY **Cost** : $190,000 **Time Estimate** : 6-12 Months **r190008 (336)** : Reconductor line with 795 ACCR high temperature conductor in a twin bundle **Project Type** : FACILITY **Cost** : $6,500,000 **Time Estimate** : 18.0 Months **r190009 (337)** : Replace 2000A wave trap with 3000A **Project Type** : FACILITY **Cost** : $100,000 **Time Estimate** : 12.0 Months **r190010 (338)** : Replace substation riser conductor with 2-1024.5 ACAR 30x7 **Project Type** : FACILITY **Cost** : $100,000 **Time Estimate** : 12.0 Months	$6,890,000
			TOTAL COST	**$6,890,000**

15 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.

15.1 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
9693621	253038	09KILLEN	DAY	242938	05MARQUI	AEP	1	DAY_P7_BEATTY-S. CHARLESTON 34542_1-A	tower	1372.0	113.45	113.95	DC	15.15

Bus #	Bus	MW Impact
253038	09KILLEN	298.51
253077	09STUART	478.92
902531	W2-040 C	0.7
902532	W2-040 E	1.13
904722	V4-073 E	0.15
913222	Y1-054 E	1.77
914372	Y2-111 E	1.12
915582	Y3-080 E	0.75
915662	Y3-099 E	0.16
915672	Y3-100 E	0.16
916182	Z1-065 E	0.54
916272	Z1-080 E	0.47
918802	AA1-099 E	0.31
925242	AB2-178 E	1.56
925921	AC1-068 C	7.92
925922	AC1-068 E	3.71
925931	AC1-069 C	7.92
925932	AC1-069 E	3.71
925981	AC1-074 C O1	7.04
925982	AC1-074 E O1	3.02
926061	AC1-085 C O1	34.6
926062	AC1-085 E O1	56.44
926101	AC1-089 C O1	4.35
926102	AC1-089 E O1	7.1
926791	AC1-165 C	7.83
926792	AC1-165 E	3.8
926801	AC1-166 C	7.83
926802	AC1-166 E	3.8
930062	AB1-014 E	13.64
931181	AB1-169	301.62
932462	AC2-066 E	0.44
932481	AC2-068 C	2.36
932482	AC2-068 E	3.86
932551	AC2-075 C	1.67
932552	AC2-075 E	0.84
932661	AC2-088 C O1	7.58
932662	AC2-088 E O1	6.24
935011	AD1-134	7.68
935031	AD1-136 C	1.07
935032	AD1-136 E	0.91
935041	AD1-140 C O1	7.32

Bus #	Bus	MW Impact
935042	AD1-140 E O1	6.06
936251	AD2-031 C O1	2.3
936252	AD2-031 E O1	3.76
936281	AD2-036 C	5.03
936282	AD2-036 E	2.51
936381	AD2-048 C	5.59
936382	AD2-048 E	2.79
936571	AD2-072 C O1	4.96
936572	AD2-072 E O1	2.43
937111	AD2-147 C O1	4.65
937112	AD2-147 E O1	6.41
937151	AD2-151 C O1	7.55
937152	AD2-151 E O1	10.43
938051	AE1-007 C	0.68
938052	AE1-007 E	1.1
938271	AE1-040 C O1	2.56
938272	AE1-040 E O1	1.29
938921	AE1-120	7.75
939141	AE1-144 C O1	13.3
939142	AE1-144 E O1	6.6
940531	AE2-038 C O1	8.87
940532	AE2-038 E O1	4.39
941411	AE2-138 C	26.57
941412	AE2-138 E	9.83
941511	AE2-148 C	43.93
941512	AE2-148 E	19.87
941981	AE2-210 C O1	9.04
941982	AE2-210 E O1	3.4
942061	AE2-218 C	8.21
942062	AE2-218 E	5.58
942091	AE2-221 C	32.57
942092	AE2-221 E	21.71
942231	AE2-235 C O1	6.33
942232	AE2-235 E O1	2.73
942411	AE2-254 C O1	2.36
942412	AE2-254 E O1	1.57
942521	AE2-267 C O1	2.99
942522	AE2-267 E O1	1.85
942591	AE2-275 C O1	6.97
942592	AE2-275 E O1	2.62
942781	AE2-296 O1	9.52
942891	AE2-308 C O1	11.94
942892	AE2-308 E O1	4.34
942951	AE2-315	2.31
942981	AE2-320 C O1	15.59
942982	AE2-320 E O1	7.71
943111	AE2-339 C	4.02
943112	AE2-339 E	1.98
943191	AE2-318 C	10.18
943192	AE2-318 E	4.97
943201	AE2-319 C O1	15.59
943202	AE2-319 E O1	7.71

Bus #	Bus	MW Impact
CARR	CARR	0.47
CATAWBA	CATAWBA	0.07
CBM-S1	CBM-S1	8.51
CBM-W1	CBM-W1	10.07
CBM-W2	CBM-W2	56.95
CIN	CIN	9.04
G-007	G-007	1.37
HAMLET	HAMLET	0.22
IPL	IPL	6.18
LGEE	LGEE	3.95
MEC	MEC	9.91
MECS	MECS	3.8
O-066	O-066	8.76
RENSSELAER	RENSSELAER	0.37
WEC	WEC	1.35

Affected Systems

16 Affected Systems

16.1 LG&E

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

16.2 MISO

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

16.3 TVA

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

16.4 Duke Energy Progress

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

16.5 NYISO

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

Contingency Name	Contingency Definition
DAY_P7_BEATTY-S. CHARLESTON 34542_1-B	CONTINGENCY 'DAY_P7_BEATTY-S. CHARLESTON 34542_1-B' OPEN BRANCH FROM BUS 243453 TO BUS 253110 CKT 1 / 243453 05BEATTY 345 253110 09ADKINS 345 1 OPEN BRANCH FROM BUS 941510 TO BUS 253248 CKT 1 / 941510 AE2-148 TAP 345 253248 09SCHARL 345 1 END
DAY_P7_BEATTY-S. CHARLESTON 34542_1-A	CONTINGENCY 'DAY_P7_BEATTY-S. CHARLESTON 34542_1-A' OPEN BRANCH FROM BUS 243453 TO BUS 253110 CKT 1 / 243453 05BEATTY 345 253110 09ADKINS 345 1 OPEN BRANCH FROM BUS 243453 TO BUS 941510 CKT 1 / 243453 05BEATTY 345 941510 AE2-148 TAP 345 1 END
AEP_P1-2_#762	CONTINGENCY 'AEP_P1-2_#762' OPEN BRANCH FROM BUS 243453 TO BUS 253110 CKT 1 / 243453 05BEATTY 345 253110 09ADKINS 345 1 END
AEP_P4_#2085_05BEATTY 345_304C	CONTINGENCY 'AEP_P4_#2085_05BEATTY 345_304C' OPEN BRANCH FROM BUS 243453 TO BUS 243454 CKT 1 / 243453 05BEATTY 345 243454 05BIXBY 345 1 OPEN BRANCH FROM BUS 243453 TO BUS 253110 CKT 1 / 243453 05BEATTY 345 253110 09ADKINS 345 1 END
AEP_P4_#2866_05BEATTY 345_304W	CONTINGENCY 'AEP_P4_#2866_05BEATTY 345_304W' OPEN BRANCH FROM BUS 243453 TO BUS 253110 CKT 1 / 243453 05BEATTY 345 253110 09ADKINS 345 1 OPEN BRANCH FROM BUS 243453 TO BUS 243469 CKT 3 / 243453 05BEATTY 345 243469 05BEATTY 138 3 END

Short Circuit

17 Short Circuit

The following Breakers are over duty

None