Generation Interconnection

Feasibility Study Report

for

Queue Project AF1-315

CEDARVILLE-FORD 138 KV

36 MW Capacity / 60 MW Energy

January, 2020

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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.

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

Project AF1-315 is a request that proposes a 60 MW solar generator to be built near State Road OH-276, Clermont County, Ohio; please refer to the facilities location map in Appendix 1(Please note this POI location is not official). The proposed in-service date for this project is December 31, 2023. **This study does not imply a Duke Energy commitment to this in-service date.**

Queue Number	AF1-315
Project Name	CEDARVILLE-FORD 138 KV
State	Ohio
County	Clermont
Transmission Owner	DEOK
MFO	60
MWE	60
MWC	36
Fuel	Solar
Basecase Study Year	2023

2.1 Point of Interconnection

AF1-315 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 the AE2-318/AF1-045 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 switches, approximately 25 feet outside the new substation fence; please refer to the single-line diagram in Appendix 2.

2.2 Cost Summary

The AF1-315 project will be responsible for the following costs:

Duke Energy facilities and network upgrades costs required to support the AF1-315 project are listed below. Please note this is a class 5 estimate, with a band range of (-50% to +100 %). It is also assumed there will be no issues obtaining Transmission Line easement for station power.

Description	Total Cost
Attachment Facilities	$ 425,411
Direct Connection Network Upgrade	$7,475,413
Non Direct Connection Network Upgrades	$1,152,888
Total Costs	$9,053,712

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.

In addition, the AF1-315 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	$14,540,000

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

3 Transmission Owner Scope of Work

4 Attachment Facilities

Duke Energy will install a revenue metering package, equipment for protection and relaying, a take-off structure, a set of disconnect switches, and overhead conductors from the new substation to the Interconnect Customer's pole mounted switches.

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
	$425,411
Total Attachment Facility Costs	$425,411

5 Direct Connection Cost Estimate

Duke Energy will build a new 138 kV substation on Interconnect Customer supplied land. The substation will include, but is not limited to, a three breaker ring bus configuration, three 145 kV breakers, eight sets of disconnect switches, associated buswork, relaying, metering, control building, take-off structures, lighting, fencing, gravel, and foundations as necessary to form a complete substation installation.

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
	$7,475,413
Total Direct Connection Facility Costs	$7,475,413

6 Non-Direct Connection Cost Estimate

Duke Energy will reconfigure the Ford to the AE2-318/AF1-045 POI 138 kV feeder to loop through the new substation and perform any work needed at the other substations on the terminal ends of the line.

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
	$1,152,888
Total Non-Direct Connection Facility Costs	$1,152,888

7 Schedule

The estimated time to complete this work is approximately 29 months from a signed ISA and CSA. This assumes no issues getting right of way, a PJM outage on the line or adjacent line on tower, and no major interruptions for weather.

8 Transmission Owner Analysis

A Summer Peak 2023 load flow study was performed evaluating AF1-315 for compliance with applicable reliability planning criteria (NERC, NERC Regional Reliability Council, and Transmission Owner). For the load flow case, PJM queue project AE2-318 was modeled on the 138 kV line between Ford and Cedarville. Also, AF1-045 was modeled on this line. Due to this, AF1-315 was studied as a 60 MW injection onto the 138 kV line between Ford and the AE2-318/AF1-045 POI. Previous queued generation and other AF1 queued generation within the DEOK footprint only were modeled as well. An impact was found on the system caused by the combination of this generation interconnection and AF1-045. The impact was that the line from the AE2-318/AF1-045 POI to Cedarville becomes overloaded for contingencies elsewhere on the DEOK system. The scope and cost estimate are given below in the Network Upgrades section.

9 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 (POI). This includes, but is not limited to, a pole and disconnect switches to be installed approximately 25 feet outside the new substation fence at the POI.

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.

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 Section 8 of Attachment O.

10.2 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.

11 Network Impacts

The Queue Project AF1-315 was evaluated as a 60.0 MW (Capacity 36.0 MW) injection tapping the Cedarville to Ford 138 kV line in the DEOK area. Project AF1-315 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-315 was studied with a commercial probability of 0.53. 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)

ID	FROM BUS#	FROM BUS	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
43627012	244022	05COLE	345.0	AEP	243457	05HAYDEN	345.0	AEP	1	AEP_P4_#8094_05BIXBY 345_C	breaker	1429.0	99.83	100.0	DC	5.2
41719693	943200	AE2-318 TAP	138.0	DEO&K	249993	08CDRVL2	138.0	DEO&K	1	DEOK_P2-3_C2 1425_HILLCREST	breaker	298.0	98.35	111.91	DC	40.42
41719694	943200	AE2-318 TAP	138.0	DEO&K	249993	08CDRVL2	138.0	DEO&K	1	DEOK_P2-3_C2 1423_HILLCREST	breaker	298.0	98.35	111.91	DC	40.42
41719695	943200	AE2-318 TAP	138.0	DEO&K	249993	08CDRVL2	138.0	DEO&K	1	DEOK_P2-3_C2 1427_HILLCREST	breaker	298.0	98.21	111.78	DC	40.42

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)

None

15 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	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
4141553 2	943200	AE2-318 TAP	138.0	DEO&K	249993	08CDRVL 2	138.0	DEO&K	1	DEOK_P1-3_B3 HILLCREST 345/138 TB21	operation	298.0	96.03	109.6	DC	40.43

16 System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
43627012	1	05COLE 345.0 kV - 05HAYDEN 345.0 kV Ckt 1	**AEP** **AEPO0041a : A Sag Study will be required on the 7.7 miles of bundled ACSR ~ 954 ~ 45/7 ~ RAIL- Conductor section 1 to mitigate the overload. Depending on the sag study results, the cost for this upgrade is expected to be between $40,000 (no remediations required, just sag study) and $11.55 million (complete line reconductor/rebuild). New rating after sag study: S/N: 1409 S/E: 1887. Time Estimate: a) Sag Study: 6-12 months b) Rebuild: The standard time required for construction differs from state to state. An approximate construction time would be 24 to 36 months after signing an interconnection agreement.** **Project Type : FAC** **Cost : $40,000** **Time Estimate : 6-12 Months**	$40,000
41719693,41719695, 41719694	2	AE2-318 TAP 138.0 kV - 08CDRVL2 138.0 kV Ckt 1	**DEOK** **n2986 (2783) : Rebuild the line, Replace equipment at Cedarville** **Project Type : FAC** **Cost : $14,500,000** **Time Estimate : 30.0 Months**	$12,722,939
			TOTAL COST	**$12,722,979**

17 Flow Gate Details

The following indices contain additional information about each flowgate presented in the body of the report. For each index, 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.

17.1 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
43627012	244022	05COLE	AEP	243457	05HAYDEN	AEP	1	AEP_P4_#8094_05BIXBY 345_C	breaker	1429.0	99.83	100.0	DC	5.2

Bus #	Bus	MW Impact
251827	WILLYESP	0.3438
251828	CLNTESP1	0.3672
251829	CLNTESP2	0.2448
253077	**09STUART (Deativation : 09/30/17)**	**151.9788**
253110	09ADKINS	21.6442
902531	**W2-040 C (Withdrawn : 01/23/2020)**	**0.6370**
902532	**W2-040 E (Withdrawn : 01/23/2020)**	**1.0392**
904722	V4-073 E	0.1407
913222	Y1-054 E	1.1296
918802	AA1-099 E	0.2448
923522	AB1-169 C OP	97.7355
925921	AC1-068 C	9.0185
925922	AC1-068 E	4.2175
925931	AC1-069 C	9.0185
925932	AC1-069 E	4.2175
926011	AC1-078 C O1	5.5017
926012	AC1-078 E O1	9.1695
926061	AC1-085 C	17.6046
926062	AC1-085 E	28.7234
926101	AC1-089 C O1	3.3721
926102	AC1-089 E O1	5.5019
926791	AC1-165 C	8.9124
926792	AC1-165 E	4.3236
926801	AC1-166 C	8.9124
926802	AC1-166 E	4.3236
926951	AC1-182	1.3350
930062	AB1-014 E	6.0038
932201	AC2-029 C	1.5189
932202	AC2-029 E	2.4783
932381	AC2-055 C	1.9694
932382	AC2-055 E	3.2133
932421	AC2-060 C	6.9830
932422	AC2-060 E	3.9280
932431	AC2-061 C	3.4372
932432	AC2-061 E	3.4845
932461	AC2-066 C	2.2079
932462	AC2-066 E	3.6023
932481	AC2-068 C	2.1417
932482	AC2-068 E	3.5075
932651	**AC2-087 C O1 (Withdrawn : 01/15/2020)**	**5.1718**
932652	**AC2-087 E O1 (Withdrawn : 01/15/2020)**	**4.1025**
932661	AC2-088 C O1	3.0447

Bus #	Bus	MW Impact
932662	AC2-088 E O1	2.5055
934491	AD1-073 C	1.4403
934492	AD1-073 E	0.7419
934561	AD1-081 C	1.1003
934562	AD1-081 E	0.5668
935031	AD1-136 C	0.4282
935032	AD1-136 E	0.3647
935041	AD1-140 C O1	7.5486
935042	AD1-140 E O1	6.2406
936251	AD2-031 C O1	2.1276
936252	AD2-031 E O1	3.4714
938051	AE1-007 C	0.6142
938052	AE1-007 E	1.0021
938271	AE1-040 C O1	4.0119
938272	AE1-040 E O1	2.0187
938921	AE1-120	3.4086
939141	AE1-144 C O1	5.2641
939142	AE1-144 E O1	2.6124
940531	AE2-038 C O1	3.5116
940532	AE2-038 E O1	1.7394
941411	AE2-138 C	10.7123
941412	AE2-138 E	3.9621
941511	AE2-148 C	131.8281
941512	AE2-148 E	59.6263
941981	AE2-210 C O1	3.6912
941982	AE2-210 E O1	1.3884
942021	AE2-214 C	66.6492
942022	AE2-214 E	44.4328
942061	AE2-218 C	6.8737
942062	AE2-218 E	4.6689
942091	AE2-221 C	21.8322
942092	AE2-221 E	14.5548
942521	AE2-267 C O1	1.0468
942522	AE2-267 E O1	0.6471
942951	AE2-315	2.1333
942981	AE2-320 C O1	17.7452
942982	AE2-320 E O1	8.7798
943191	AE2-319 C O1	17.7452
943192	AE2-319 E O1	8.7798
943201	AE2-318 C	4.9163
943202	AE2-318 E	2.3996
943771	AF1-045	2.0240
944521	AF1-117 C	37.8168
944522	AF1-117 E	11.6492
944941	AF1-159	1.2318
945631	AF1-228 C	32.6095
945632	AF1-228 E	21.7397
945681	AF1-233 C O1	5.2587
945682	AF1-233 E O1	2.5979
945821	AF1-247 C	1.0468
945822	AF1-247 E	0.6471
945841	AF1-249 C	0.4559

Bus #	Bus	MW Impact
945842	AF1-249 E	0.2145
945861	AF1-251 C	3.9200
945862	AF1-251 E	2.6133
945911	AF1-256 C	1.6938
945912	AF1-256 E	1.1292
946101	AF1-275	27.7705
946171	AF1-282 C	6.9492
946172	AF1-282 E	4.6328
946181	AF1-283 C	9.0340
946182	AF1-283 E	6.0226
946511	AF1-315 C O1	1.4067
946512	AF1-315 E O1	0.9378
LGEE	LGEE	2.3607
CPLE	CPLE	0.2944
WEC	WEC	0.3604
CBM-W2	CBM-W2	16.2572
NY	NY	0.6531
CBM-W1	CBM-W1	9.4451
TVA	TVA	2.6054
O-066	O-066	7.7482
CBM-S2	CBM-S2	4.3523
CBM-S1	CBM-S1	19.4597
G-007	G-007	1.1929
MEC	MEC	2.3168

17.2 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
41719695	943200	AE2-318 TAP	DEO&K	249993	08CDRVL2	DEO&K	1	DEOK_P2-3_C2 1427_HILLCREST	breaker	298.0	98.21	111.78	DC	40.42

Bus #	Bus	MW Impact
250166	HLCRST AB114	3.8724
251830	BIOENGRY	0.2790
930062	AB1-014 E	45.2639
932461	AC2-066 C	16.6454
932462	AC2-066 E	27.1583
932661	AC2-088 C O1	15.9878
932662	AC2-088 E O1	13.1567
935031	AD1-136 C	2.2483
935032	AD1-136 E	1.9152
938921	AE1-120	25.6982
943201	AE2-318 C	46.5998
943202	AE2-318 E	22.7452
943771	AF1-045	36.1981
946511	AF1-315 C O1	24.2543
946512	AF1-315 E O1	16.1695
DUCKCREEK	DUCKCREEK	0.1762
NEWTON	NEWTON	0.1816
CPLE	CPLE	0.0245
FARMERCITY	FARMERCITY	0.0068
G-007A	G-007A	0.0887
VFT	VFT	0.2386
PRAIRIE	PRAIRIE	0.3255
COFFEEN	COFFEEN	0.0835
CBM-S2	CBM-S2	0.1965
EDWARDS	EDWARDS	0.0543
TILTON	TILTON	0.1235
MADISON	MADISON	2.4837
GIBSON	GIBSON	0.1141
BLUEG	BLUEG	0.3559
TRIMBLE	TRIMBLE	0.1213

Affected Systems

18 Affected Systems

18.1 LG&E

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

18.2 MISO

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

18.3 TVA

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

18.4 Duke Energy Progress

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

18.5 NYISO

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

Contingency Name	Contingency Definition
DEOK_P2-3_C2 1425_HILLCREST	CONTINGENCY 'DEOK_P2-3_C2 1425_HILLCREST' OPEN BRANCH FROM BUS 249566 TO BUS 249578 CKT 1 / 249566 08FOSTER 345 249578 08HILCRT 345 1 OPEN BRANCH FROM BUS 249578 TO BUS 250136 CKT 1 / 249578 08HILCRT 345 250136 08HILCRT 138 1 END
AEP_P4_#8094_05BIXBY 345_C	CONTINGENCY 'AEP_P4_#8094_05BIXBY 345_C' OPEN BRANCH FROM BUS 243453 TO BUS 243454 CKT 1 / 243453 05BEATTY 345 243454 05BIXBY 345 1 OPEN BRANCH FROM BUS 941520 TO BUS 243454 CKT 1 / 941520 AE2-149 TAP 345 243454 05BIXBY 345 1 END
DEOK_P1-3_B3 HILLCREST 345/138 TB21	CONTINGENCY 'DEOK_P1-3_B3 HILLCREST 345/138 TB21' OPEN BRANCH FROM BUS 249578 TO BUS 250136 CKT 1 / 249578 08HILCRT 345 250136 08HILCRT 138 1 END
DEOK_P2-3_C2 1423_HILLCREST	CONTINGENCY 'DEOK_P2-3_C2 1423_HILLCREST' OPEN BRANCH FROM BUS 249578 TO BUS 253077 CKT 1 / 249578 08HILCRT 345 253077 09STUART 345 1 OPEN BRANCH FROM BUS 249578 TO BUS 250136 CKT 1 / 249578 08HILCRT 345 250136 08HILCRT 138 1 END
DEOK_P2-3_C2 1427_HILLCREST	CONTINGENCY 'DEOK_P2-3_C2 1427_HILLCREST' OPEN BRANCH FROM BUS 249578 TO BUS 253077 CKT 1 / 249578 08HILCRT 345 253077 09STUART 345 1 OPEN BRANCH FROM BUS 249566 TO BUS 249578 CKT 1 / 249566 08FOSTER 345 249578 08HILCRT 345 1 END

19 Short Circuit

No Breakers were identified as overdutied