Generation Interconnection

Feasibility Study Report

for

Queue Project AF1-308

WAVERLY 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

The Interconnection Customer (IC), has proposed a Solar generating facility located in Pike County, Ohio. The installed facilities will have a total capability of 60 MW with 36 MW of this output being recognized by PJM as Capacity. The primary point of interconnection for the solar facility will be a direct connection to AEP's Waverly 138 kV substation. The secondary point of interconnection will be a new 138 kV switching station cut in to AEP's Waverly – Ware Road 138 kV circuit.

The proposed in-service date for this project is 12/31/2023. This study does not imply a TO commitment to this in-service date.

Queue Number	**AF1-308**
Project Name	WAVERLY 138 KV
State	Ohio
County	Pike
Transmission Owner	AEP
MFO	60
MWE	60
MWC	36
Fuel	Solar
Basecase Study Year	2023

2.1 Point of Interconnection

AF1-308 will interconnect with the AEP transmission system via a direct connection to the Waverly 138 kV substation (see Figure 1).

To accommodate the interconnection at the Waverly 138 kV substation, the substation will have to be expanded requiring the installation of one (1) 138 kV circuit breaker (see Figure 2). Installation of associated protection and control equipment, 138 kV line risers, SCADA and 138 kV revenue metering will also be required.

2.2 Cost Summary

The AF1-308 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$250,000
Direct Connection Network Upgrade	$1,250,000
Non Direct Connection Network Upgrades	$0
Total Costs	$1,500,000

In addition, the AF1-308 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	$9,150,000

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

3 Transmission Owner Scope of Work

4 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
138 kV Revenue Metering	$250,000
Total Attachment Facility Costs	$250,000

5 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
Expand the Waverly 138 kV substation: Install one (1) additional 138 kV circuit breaker. Installation of associated protection and control equipment, 138 kV line risers and SCADA will also be required.	$1,250,000
Total Direct Connection Facility Costs	$1,250,000

6 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
Total Non-Direct Connection Facility Costs	$0

7 Schedule

It is anticipated that the time between receipt of executed Agreements and Commercial Operation may range from 12 to 18 months if no line work is required. If line work is required, construction time would generally be between 24 to 36 months after Agreement execution.

8 Interconnection Customer Requirements

It is understood that the Interconnection Customer is responsible for all costs associated with this interconnection. The costs above are reimbursable to AEP. The cost of the Interconnection Customer's generating plant and the costs for the line connecting the generating plant to the Waverly 135 kV station are not included in this report; these are assumed to be the Interconnection Customer's responsibility.

The Generation Interconnection Agreement does not in or by itself establish a requirement for American Electric Power to provide power for consumption at the developer's facilities. A separate agreement may be reached with the local utility that provides service in the area to ensure that infrastructure is in place to meet this demand and proper metering equipment is installed. It is the responsibility of the developer to contact the local service provider to determine if a local service agreement is required.

In addition, if the Interconnection Customer considers use of the Option to Build, they should consult the guidance AEP has posted at:
https://www.aep.com/assets/docs/requiredpostings/TransmissionStudies/docs/2019/MerchantGenerationGuidelinesPJMoptiontoBuild.pdf

9 Revenue Metering and SCADA Requirements

9.1 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.

9.2 AEP Requirements

The Interconnection Customer will be required to comply with all AEP Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "Requirements for Connection of New Facilities or Changes to Existing Facilities Connected to the AEP Transmission System" document located at the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-aep/aep-interconnection-requirements.ashx

10 Network Impacts – Option 1

The Queue Project AF1-308 was evaluated as a 60.0 MW (Capacity 36.0 MW) injection at Waverly 138 kV substation. Project AF1-308 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-308 was studied with a commercial probability of 0.53. Potential network impacts were as follows:

Summer Peak Load Flow

11 Generation Deliverability

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

None

12 Multiple Facility Contingency

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

None

13 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	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
4402393	243522	05HARRISON	138.0	AEP	243593	05ZUBER	138.0	AEP	1	AEP_P4_#9679_05HARRISON 138_2E	breaker	167.0	141.54	142.5	DC	3.55
4402474	243522	05HARRISON	138.0	AEP	243593	05ZUBER	138.0	AEP	1	AEP_P7-1_#10921	tower	167.0	127.97	128.9	DC	3.44

14 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
4402441	243522	05HARRISON	138.0	AEP	243593	05ZUBER	138.0	AEP	1	AEP_P1-2_#5764	operation	167.0	126.97	127.9	DC	3.44

15 System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
44023938,44024742	1	05HARRIS 138.0 kV - 05ZUBER 138.0 kV Ckt 1	AEPO0015a (101) : Replace six 300 Cu jumpers at Harrison Project Type : FAC Cost : $600,000 Time Estimate : 12-18 Months AEPO0015b (102) : Replace 600 Amp Sw at Harrison Project Type : FAC Cost : $200,000 Time Estimate : 12-18 Months AEPO0015c (103) : Reconductor 5.5 miles of ACSR ~ 336.4 ~ 30/7 ~ ORIOLE Harrison - Zuber conductor with 795 ACSR or equivalent Project Type : FAC Cost : $8,250,000 Time Estimate : 24-36 Months AEPO0015d (104) : Replace 800 Amp wavetrap at Harrison Project Type : FAC Cost : $100,000 Time Estimate : 12.18 Months	$9,150,000
			TOTAL COST	$9,150,000

16 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.

16.1 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
4402393 8	24352 2	05HARRISO N	AEP	24359 3	05ZUBE R	AEP	1	AEP_P4_#9679_05HARRIS ON 138_2E	breake r	167.0	141.54	142.5	DC	3.55

Bus #	Bus	MW Impact
924351	AB2-083 C O1	4.8413
924352	AB2-083 E O1	2.2783
925341	AC1-001 C O1	9.6827
925342	AC1-001 E O1	4.5565
927061	AC1-194 C O1	3.0673
927062	AC1-194 E O1	5.0045
932201	AC2-029 C	10.4448
932202	AC2-029 E	17.0414
932311	AC2-045 C	0.2826
932312	AC2-045 E	0.4611
932411	AC2-059 C	15.4525
932412	AC2-059 E	15.9470
934481	AD1-072 C	3.3946
934482	AD1-072 E	1.5502
936111	AD2-016 C	15.4525
936112	AD2-016 E	15.9470
937231	AD2-162 C	21.5518
937232	AD2-162 E	10.5671
938711	AE1-093	2.7121
943041	AE2-327 C	9.1539
943042	AE2-327 E	6.0880
946441	AF1-308 C O1	0.9601
946442	AF1-308 E O1	0.6401
DUCKCREEK	DUCKCREEK	0.1405
LGEE	LGEE	0.0325
NEWTON	NEWTON	0.0269
CPLE	CPLE	0.1462
FARMERCITY	FARMERCITY	0.0029
G-007A	G-007A	0.0048
VFT	VFT	0.0064
CBM-W2	CBM-W2	0.2785
NY	NY	0.0044
TVA	TVA	0.1974
PRAIRIE	PRAIRIE	0.0207
COFFEEN	COFFEEN	0.0264
CBM-S2	CBM-S2	1.3410
EDWARDS	EDWARDS	0.0476
CBM-S1	CBM-S1	1.0735
TILTON	TILTON	0.0510
MADISON	MADISON	0.1794
GIBSON	GIBSON	0.0104

16.2 Queue Dependencies

Queue Number	Project Name	Status
AB2-083	Delano 138kV	Active
AF1-308	Waverly 138 kV	Active
AD1-072	Biers Run-Circleville 138 kV	Active
AE1-093	Elk 138 kV	Active
AD1-072	Biers Run-Circleville 138 kV	Active
G-007A	N/A	N/A
AC1-001	Delano 138kV	Active
AD2-162	Biers Run-Circleville 138kV	Active
AD2-162	Biers Run-Circleville 138kV	Active
AF1-308	Waverly 138 kV	Active
AC1-194	Elk 138kV	Active
AC1-194	Elk 138kV	Active
AD2-016	Biers Run-Circleville 138 kV	Active
AD2-016	Biers Run-Circleville 138 kV	Active
AC2-029	Circleville 138kV	Active
AC2-029	Circleville 138kV	Active
AC2-059	Biers Run-Circleville 138kV	Active
AC2-059	Biers Run-Circleville 138kV	Active
AC1-001	Delano 138kV	Active
AE2-327	Biers Run-Circleville 138 kV	Active
AE2-327	Biers Run-Circleville 138 kV	Active
AB2-083	Delano 138kV	Active
AC2-045	Clark 12kV	Suspended
AC2-045	Clark 12kV	Suspended

Affected Systems

17 Affected Systems

17.1 LG&E

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

17.2 MISO

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

17.3 TVA

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

17.4 Duke Energy Progress

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

17.5 NYISO

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

Contingency Name	Contingency Definition
AEP_P4_#9679_05HARRISON 138_2E	CONTINGENCY 'AEP_P4_#9679_05HARRISON 138_2E' OPEN BRANCH FROM BUS 243522 TO BUS 243550 CKT 1 / 243522 05HARRISON 138 243550 05OBETZ 138 1 OPEN BRANCH FROM BUS 243539 TO BUS 243550 CKT 1 / 243539 05MARION 138 243550 05OBETZ 138 1 OPEN BRANCH FROM BUS 243522 TO BUS 246706 CKT 1 / 243522 05HARRISON 138 246706 05HARRISON 69.0 1 END
AEP_P7-1_#10921	CONTINGENCY 'AEP_P7-1_#10921' OPEN BRANCH FROM BUS 243522 TO BUS 243550 CKT 1 / 243522 05HARRISON 138 243550 05OBETZ 138 1 OPEN BRANCH FROM BUS 243536 TO BUS 243539 CKT 1 / 243536 05LS-II 138 243539 05MARION 138 1 OPEN BRANCH FROM BUS 243539 TO BUS 243550 CKT 1 / 243539 05MARION 138 243550 05OBETZ 138 1 END
AEP_P1-2_#5764	CONTINGENCY 'AEP_P1-2_#5764' OPEN BRANCH FROM BUS 243522 TO BUS 243550 CKT 1 / 243522 05HARRISON 138 243550 05OBETZ 138 1 OPEN BRANCH FROM BUS 243539 TO BUS 243550 CKT 1 / 243539 05MARION 138 243550 05OBETZ 138 1 END

Short Circuit

18 Short Circuit

The following Breakers are overduty

Bus Number	Bus Name	BREAKER	Type	Capacity (Amps)	Duty Percentage Post Queue	Duty Percentage Pre Queue

18.1 Secondary Point of Interconnection

AF1-308 will interconnect with the AEP transmission system at a new 138kV switching station cut into AEP's Waverly–Ware Road 138 kV circuit.

To accommodate the interconnection on the AEP-owned Waverly-Ware Road Station, a new three (3) circuit breaker 138 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus will be constructed (Figure 3). Installation of associated protection and control equipment, 138 kV line risers, SCADA, and 138 kV revenue metering will also be required. AEP reserves the right to specify the final acceptable configuration considering design practices, future expansion, and compliance requirements.

19 Network Impacts – Option 2

The Queue Project AF1-308 was evaluated as a 60.0 MW (Capacity 36.0 MW) injection at Waverly – Ware Road 138 kV substation. Project AF1-308 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-308 was studied with a commercial probability of 0.53. Potential network impacts were as follows:

Summer Peak Load Flow

20 Generation Deliverability

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

None

21 Multiple Facility Contingency

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

None

22 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	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
4402393	243522	05HARRISON	138.0	AEP	243593	05ZUBER	138.0	AEP	1	AEP_P4_#9679_05HARRISON 138_2E	breaker	167.0	141.77	142.71	DC	3.5
4402474	243522	05HARRISON	138.0	AEP	243593	05ZUBER	138.0	AEP	1	AEP_P7-1_#10921	tower	167.0	128.26	129.18	DC	3.39

23 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
4402441	243522	05HARRISON	138.0	AEP	243593	05ZUBER	138.0	AEP	1	AEP_P1-2_#5764	operation	167.0	127.2	128.12	DC	3.39

24 Flow Gate Details

The following indices 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.

24.1 Index 1

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Bus #	Bus	MW Impact
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924352	AB2-083 E O1	2.2781
925341	AC1-001 C O1	9.6821
925342	AC1-001 E O1	4.5563
927061	AC1-194 C O1	3.0669
927062	AC1-194 E O1	5.0039
932201	AC2-029 C	10.4448
932202	AC2-029 E	17.0414
932311	AC2-045 C	0.2826
932312	AC2-045 E	0.4610
932411	AC2-059 C	15.4519
932412	AC2-059 E	15.9463
934481	AD1-072 C	3.3945
934482	AD1-072 E	1.5501
936111	AD2-016 C	15.4519
936112	AD2-016 E	15.9463
937231	AD2-162 C	21.5510
937232	AD2-162 E	10.5668
938711	AE1-093	2.7118
943041	AE2-327 C	9.1536
943042	AE2-327 E	6.0878
946441	AF1-308 C O2	0.9465
946442	AF1-308 E O2	0.6310
DUCKCREEK	DUCKCREEK	0.1416
LGEE	LGEE	0.0319
NEWTON	NEWTON	0.0279
CPLE	CPLE	0.1455
FARMERCITY	FARMERCITY	0.0030
G-007A	G-007A	0.0072
VFT	VFT	0.0129
CBM-W2	CBM-W2	0.2703
NY	NY	0.0039
TVA	TVA	0.1960
PRAIRIE	PRAIRIE	0.0232
COFFEEN	COFFEEN	0.0270
CBM-S2	CBM-S2	1.3352
EDWARDS	EDWARDS	0.0479
CBM-S1	CBM-S1	1.0650
TILTON	TILTON	0.0517
MADISON	MADISON	0.1794
GIBSON	GIBSON	0.0115

Affected Systems

25 Affected Systems

25.1 LG&E

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

25.2 MISO

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

25.3 TVA

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

25.4 Duke Energy Progress

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

25.5 NYISO

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

Contingency Name	Contingency Definition
AEP_P4_#9679_05HARRISON 138_2E	CONTINGENCY 'AEP_P4_#9679_05HARRISON 138_2E' OPEN BRANCH FROM BUS 243522 TO BUS 243550 CKT 1 / 243522 05HARRISON 138 243550 05OBETZ 138 1 OPEN BRANCH FROM BUS 243539 TO BUS 243550 CKT 1 / 243539 05MARION 138 243550 05OBETZ 138 1 OPEN BRANCH FROM BUS 243522 TO BUS 246706 CKT 1 / 243522 05HARRISON 138 246706 05HARRISON 69.0 1 END
AEP_P7-1_#10921	CONTINGENCY 'AEP_P7-1_#10921' OPEN BRANCH FROM BUS 243522 TO BUS 243550 CKT 1 / 243522 05HARRISON 138 243550 05OBETZ 138 1 OPEN BRANCH FROM BUS 243536 TO BUS 243539 CKT 1 / 243536 05LS-II 138 243539 05MARION 138 1 OPEN BRANCH FROM BUS 243539 TO BUS 243550 CKT 1 / 243539 05MARION 138 243550 05OBETZ 138 1 END
AEP_P1-2_#5764	CONTINGENCY 'AEP_P1-2_#5764' OPEN BRANCH FROM BUS 243522 TO BUS 243550 CKT 1 / 243522 05HARRISON 138 243550 05OBETZ 138 1 OPEN BRANCH FROM BUS 243539 TO BUS 243550 CKT 1 / 243539 05MARION 138 243550 05OBETZ 138 1 END

Short Circuit

26 Short Circuit

The following Breakers are overduty

Bus Number	Bus Name	BREAKER	Type	Capacity (Amps)	Duty Percentage Post Queue	Duty Percentage Pre Queue