Generation Interconnection

System Impact Study Report

for

Queue Project AF1-049

BERRY HILL 138 KV

75 MW Capacity / 125 MW Energy

August 2020

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1 Introduction

This System Impact Study has been prepared in accordance with the PJM Open Access Transmission Tariff, 205, as well as the System Impact Study Agreement between the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is AEP

2 Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. 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 System Impact Study is performed.

The System Impact 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.

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.

3 General

The Interconnection Customer (IC) has proposed a Solar generating facility located in Pittsylvania, Virginia. The installed facilities will have a total capability of 125 MW with 75 MW of this output being recognized by PJM as Capacity.

The proposed in-service date for this project is November 25, 2022. This study does not imply a TO commitment to this in-service date.

Queue Number	**AF1-049**
Project Name	BERRY HILL 138 KV
Interconnection Customer	Berry Hill Solar, LLC
State	Virginia
County	Pittsylvania
Transmission Owner	AEP
MFO	125
MWE	125
MWC	75
Fuel	Solar
Basecase Study Year	2023

Any new service customers who can feasibly be commercially operable prior to June 1st of the basecase study year are required to request interim deliverability analysis.

3.1 Primary Point of Interconnection

AF1-049 will interconnect with the AEP transmission system via a direct connection to the proposed Berry Hill 138 kV station. See https://www.aeptransmission.com/virginia/BerryHill/ and Attachment 1.

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

Installation of the generator lead first span exiting the POI station, including the first structure outside the AEP fence, will also be included in AEP's scope. In the case where the generator lead is a single span, the structure in the customer station will be the customer's responsibility.

The Berry Hill station does not presently exist, but is part of a potential Supplemental project presently under development by AEP for other purposes. The potential project is still subject to PJM review, including Do No Harm Analysis. In addition, Supplemental projects are driven by other factors and the in-service date for the Berry Hill station has not been established. If the potential Supplemental project doesn't materialize, on a schedule compatible with the AF1-049 development, the proposed POI at Berry Hill would not exist. In the absence of the Berry Hill station, subject to Material Modification review by PJM, the project could connect to the existing Axton-Danville 138 kV circuit #2 at a point near where it would be cut to loop in and out of Berry Hill. In this instance, AF1-049 would be responsible for the full cost of a new greenfield 3-CB ring-bus station, as well as the generator lead from the project site to the new POI station site.

3.2 Cost Summary:

This project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$776,000
Direct Connection Network Upgrade	$643,000
Non Direct Connection Network Upgrades	$90,000
Allocation for New System Upgrades*	$0
Contribution to Previously Identified Upgrades*	$0
Total Costs	$1,509,000

*As your project progresses through the study process and other projects modify their request or withdraw, then your cost allocation could change.

The estimates provided in this report are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements. In addition, Stability analysis will be completed during the Facilities Study stage. It is possible that a need for additional upgrades could be identified by these studies.

This cost excludes a Federal Income Tax Gross Up charges. This tax may or may not be charged based on whether this project meets the eligibility requirements of IRS Notice 88-129. If at a future date it is determined that the Federal Income Tax Gross charge is required, the Transmission Owner shall be reimbursed by the Interconnection Customer for such taxes.

Note 1: PJM Open Access Transmission Tariff (OATT) section 217.3A outline cost allocation rules. The rules are further clarified in PJM Manual 14A Attachment B. The allocation of costs for a network upgrade will start with the first Queue project to cause the need for the upgrade. Later queue projects will receive cost allocation contingent on their contribution to the violation and are allocated to the queues that have not closed less than 5 years following the execution of the first Interconnection Service Agreement which identifies the need for this upgrade.

Note 2: For customers with System Reinforcements listed: If your present cost allocation to a System Reinforcement indicates $0, then please be aware that as changes to the interconnection process occur, such as prior queued projects withdrawing from the queue, reducing in size, etc, the cost responsibilities can change and a cost allocation may be assigned to your project. In addition, although your present cost allocation to a System Reinforcement is presently $0, your project may need this system reinforcement completed to be deliverable to the PJM system. If your project comes into service prior to completion of the system reinforcement, an interim deliverability study for your project will be required.

4 Transmission Owner Scope of Work

5 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	$376,000
Generator lead first span exiting the POI station, including the first structure outside the fence	$400,000
Total Attachment Facility Costs	$776,000

6 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
The Berry Hill 138 kV substation will have to be expanded requiring the installation of one (1) 138 kV circuit breaker. Installation of associated protection and control equipment, 138 kV line risers, and SCADA will also be required.	$643,000
Total Direct Connection Facility Costs	$643,000

7 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
Review and revise the P&C relay settings at Axton 138 kV station	$45,000
Review and revise the P&C relay settings at Danville #2 138 kV station	$45,000
Total Non-Direct Connection Facility Costs	$90,000

8 Incremental Capacity Transfer Rights (ICTRs)

None

9 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.

10 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 the Interconnected Transmission Owner. The cost of the Interconnection Customer's generating plant and the costs for the line connecting the generating plant to the Interconnected Transmission Owner's Transmission circuit 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 the Interconnected Transmission Owner 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.

Requirement from the PJM Open Access Transmission Tariff:

1. An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.
2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.

11 Revenue Metering and SCADA Requirements

11.1 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.

11.2 Meteorological Data Reporting Requirements

The solar generation facility shall provide the Transmission Provider with site-specific meteorological data including:

- Back Panel temperature (Fahrenheit)
- Irradiance (Watts/meter^2)
- Ambient air temperature (Fahrenheit) – (Accepted, not required)
- Wind speed (meters/second) – (Accepted, not required)
- Wind direction (decimal degrees from true north) – (Accepted, not required)

11.3 Interconnected Transmission Owner Requirements

The IC will be required to comply with all Interconnected Transmission Owner's revenue metering requirements for generation interconnection customers located at the following link:

http://www.pjm.com/planning/design-engineering/to-tech-standards/

12 Summer Peak Analysis

The Queue Project AF1-049 was evaluated as a 125.0 MW (Capacity 75.0 MW) injection tapping the Axton to Danville 138 kV line in the AEP area. Project AF1-049 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-049 was studied with a commercial probability of 100.0 %. Potential network impacts were as follows:

13 Generation Deliverability

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

None

14 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
43703370	242620	05DANVL2	138.0	AEP	242631	05EDAN 1	138.0	AEP	1	AEP_P4_#2916_05J.FERR 765_A	breaker	402.0	87.98	107.56	AC	80.82

15 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

16 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	TO BUS#	TO BUS	kV	TO BUS	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT	POST PROJECT	AC|DC	MW IMPACT

				AREA				AREA					LOADING %	LOADING %		
43703810	242555	05BLAINE	138.0	AEP	242773	05ROANO1	138.0	AEP	1	AEP_P1-2_#PMS_73	operation	223.0	108.41	112.48	AC	8.73
43703807	242620	05DANVL2	138.0	AEP	242631	05EDAN1	138.0	AEP	1	AEP_P1-2_#1370	operation	402.0	87.31	106.88	AC	80.7
43703808	242620	05DANVL2	138.0	AEP	242631	05EDAN1	138.0	AEP	1	Base Case	operation	275.0	90.07	111.57	AC	59.88
43703790	242631	05EDAN1	138.0	AEP	242632	05EDAN2	138.0	AEP	Z1	AEP_P1-3_#8675_05EDANV1 230_5-B	operation	296.0	103.5	122.27	AC	55.59
43703726	242711	05MARTN1	138.0	AEP	242744	05PATCTR	138.0	AEP	1	AEP_P1-2_#5459	operation	202.0	107.71	114.44	AC	13.95

17 System Reinforcements

ID	Idx	Facility	Upgrade Description	Cost	Cost Allocated to AF1-049	Upgrade Number
43703370	1	**05DANVL2 138.0 kV - 05EDAN 1 138.0 kV Ckt 1**	1. 2.78 miles of ACSR ~ 336/556 Six Wire conductor will need to be rebuilt/reconductored. Estimated cost: $4,275,000. PJM Network Upgrade N6124.1 2. 0.03 miles of ACSR ~ 1351.5 ~ 45/7 ~ DIPPER - Conductor Section 3 will need to be rebuilt/reconductored. Estimated cost: 36,000. PJM Network Upgrade N6124.2 3. 0.03 miles of ACSR ~ 1351.5 ~ 45/7 ~ DIPPER - Conductor Section 1 will need to be rebuilt/reconductored. Estimated cost: 36,000. PJM Network Upgrade N6124.3 Total cost estimate: $4,347,000. Time estimate: 24-36 months after signing an interconnection agreement The new expected SE rating on the line after these upgrades will be 498 MVA. This line is overloaded in a prior queue cycle for flows in the opposite direction. Note 1: Queue Project AF1-049 presently does not receive cost allocation for these upgrades. As changes to the interconnection process occur, such as prior queued projects withdrawing from the queue, reducing in size, etc, Queue Project AF1-049 could receive cost allocation. Note 2: Although Queue Project AF1-049 may not have cost responsibility for these upgrades, Queue Project AF1-049 may need this upgrade in-service to be deliverable to the PJM system. If Queue Project AF1-049 comes into service prior to completion of the upgrades, Queue Project AF1-049 will need an interim study.	$4.347 M	$0	N6124.1 N6124.2 N6124.3
			TOTAL COST	$4.347 M	$0	

18 Flow Gate Details

The following indices contain additional information about each facility presented in the body of the report. For each index, a description of the flowgate and its contingency was included for convenience. The intent of the indices is to provide more details on which projects/generators have contributions to the flowgate in question. All New Service Queue Requests, through the end of the Queue under study, that are contributors to a flowgate will be listed in the indices. Please note that there may be contributors that are subsequently queued after the queue under study that are not listed in the indices. Although this information is not used "as is" for cost allocation purposes, it can be used to gage the impact of other projects/generators. It should be noted the project/generator MW contributions presented in the body of the report are Full MW Impact contributions which are also noted in the indices column named "Full MW Impact", whereas the loading percentages reported in the body of the report, take into consideration the PJM Generator Deliverability Test rules such as commercial probability of each project as well as the ramping impact of "Adder" contributions. The MW Impact found and used in the analysis is shown in the indices column named "Gendeliv MW Impact".

18.1 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
4370337 0	24262 0	05DANVL 2	AEP	24263 1	05EDA N 1	AEP	1	AEP_P4_#2916_05J.FER R 765_A	breake r	402.0	87.98	107.56	AC	80.82

Bus #	Bus	Gendeliv MW Impact	Type	Full MW Impact
244012	05PINNACLE	3.3862	50/50	3.3862
247723	05PHILPOTT	0.7292	50/50	0.7292
926461	**AC1-117 C (Suspended)**	**3.8677**	**50/50**	**3.8677**
926462	**AC1-117 E (Suspended)**	**6.3105**	**50/50**	**6.3105**
938741	AE1-100 C O1	23.5390	50/50	23.5390
938742	AE1-100 E O1	13.5391	50/50	13.5391
938931	AE1-121 O1	271.3446	50/50	271.3446
939441	AE1-176	0.1363	Adder	0.16
940083	AE1-250 BAT	12.3810	Merchant Transmission	12.3810
940601	AE2-047 C O1	9.3105	50/50	9.3105
940602	AE2-047 E O1	5.0575	50/50	5.0575
941431	AE2-140 C O1	70.5028	50/50	70.5028
941432	AE2-140 E O1	47.0019	50/50	47.0019
941671	AE2-166 C	27.4811	50/50	27.4811
941672	AE2-166 E	18.3208	50/50	18.3208
942321	AE2-245	3.5166	50/50	3.5166
942641	AE2-280 C O1	4.0787	Adder	4.8
942642	AE2-280 E O1	2.7497	Adder	3.23
943811	AF1-049 C O1	48.4890	50/50	48.4890
943812	AF1-049 E O1	32.3260	50/50	32.3260
WEC	WEC	0.0838	Confirmed LTF	0.0838
LGEE	LGEE	0.1808	Confirmed LTF	0.1808
NY	NY	0.0238	Confirmed LTF	0.0238
O-066	O-066	0.6653	Confirmed LTF	0.6653
CHEOAH	CHEOAH	0.2873	Confirmed LTF	0.2873
G-007	G-007	0.1071	Confirmed LTF	0.1071
MEC	MEC	0.2177	Confirmed LTF	0.2177
CALDERWOOD	CALDERWOOD	0.2644	Confirmed LTF	0.2644
CATAWBA	CATAWBA	0.6041	Confirmed LTF	0.6041
CBM-W1	CBM-W1	3.3277	Confirmed LTF	3.3277

19 Queue Dependencies

The Queue Projects below are listed in one or more indices for the overloads identified in your report. These projects contribute to the loading of the overloaded facilities identified in your report. The percent overload of a facility and cost allocation you may have towards a particular reinforcement could vary depending on the action of these earlier projects. The status of each project at the time of the analysis is presented in the table. This list may change as earlier projects withdraw or modify their requests.

Queue Number	Project Name	Status
AC1-117	Stockton 34.5kV	Suspended
AE1-100	Axton 138 kV	Active
AE1-121	Axton 138 kV	Active
AE1-176	Roanoke-Vinton 12 kV (Niagara Hydro)	In Service
AE1-250	Smith Mountain-E. Danville 138 kV	Active
AE2-047	Ridgeway-Solite 69 kV	Active
AE2-140	Axton-Danville 138 kV	Active
AE2-166	Stockton 138 kV	Active
AE2-245	Stockton 34.5 kV	Active
AE2-280	Claytor Lake-Edgemont 138 kV	Active
AF1-049	Berry Hill 138 kV	Active

20 Contingency Descriptions

Contingency Name	Contingency Definition
AEP_P1-2_#5459	CONTINGENCY 'AEP_P1-2_#5459' OPEN BRANCH FROM BUS 242544 TO BUS 242712 CKT 1 / 242544 05AXTON 138 242712 05MARTN2 138 1 OPEN BRANCH FROM BUS 242614 TO BUS 242638 CKT 1 / 242614 05COLLIN 138 242638 05FIELDALE1 138 1 OPEN BRANCH FROM BUS 242614 TO BUS 242712 CKT 1 / 242614 05COLLIN 138 242712 05MARTN2 138 1 OPEN BRANCH FROM BUS 242712 TO BUS 243977 CKT 1 / 242712 05MARTN2 138 243977 05MART 115 34.5 1 OPEN BRANCH FROM BUS 243977 TO BUS 243979 CKT Z1 / 243977 05MART 115 34.5 243979 05MART2-30 34.5 Z1 OPEN BRANCH FROM BUS 243977 TO BUS 243980 CKT 1 / 243977 05MART 115 34.5 243980 05MORRIS-N 34.5 1 END
AEP_P1-2_#PMS_73	CONTINGENCY 'AEP_P1-2_#PMS_73' OPEN BRANCH FROM BUS 247499 TO BUS 242802 CKT Z1 / 247499 05SMITHMTN2 242802 05SMITHMTN1 Z1 END
AEP_P1-2_#1370	CONTINGENCY 'AEP_P1-2_#1370' OPEN BRANCH FROM BUS 242509 TO BUS 242514 CKT 1 / 242509 05AXTON 765 242514 05J.FERR 765 1 OPEN BRANCH FROM BUS 242509 TO BUS 242545 CKT 1 / 242509 05AXTON 765 242545 05AXTONX 138 1 OPEN BRANCH FROM BUS 242544 TO BUS 242545 CKT SR / 242544 05AXTON 138 242545 05AXTONX 138 SR OPEN BRANCH FROM BUS 242544 TO BUS 242545 CKT ZB / 242544 05AXTON 138 242545 05AXTONX 138 ZB END
AEP_P4_#2916_05J.FERR 765_A	CONTINGENCY 'AEP_P4_#2916_05J.FERR 765_A' OPEN BRANCH FROM BUS 242509 TO BUS 242514 CKT 1 / 242509 05AXTON 765 242514 05J.FERR 765 1 OPEN BRANCH FROM BUS 242511 TO BUS 242514 CKT 1 / 242511 05BROADF 765 242514 05J.FERR 765 1 OPEN BRANCH FROM BUS 242509 TO BUS 242545 CKT 1 / 242509 05AXTON 765 242545 05AXTONX 138 1 OPEN BRANCH FROM BUS 242544 TO BUS 242545 CKT SR / 242544 05AXTON 138 242545 05AXTONX 138 SR OPEN BRANCH FROM BUS 242544 TO BUS 242545 CKT ZB / 242544 05AXTON 138 242545 05AXTONX 138 ZB OPEN BRANCH FROM BUS 242566 TO BUS 242567 CKT ZB / 242566 05BROADF 138 242567 05BROADX 138 ZB END
Base Case	

AEP_P1-3_#8675_05EDANV1 230_5-B	CONTINGENCY 'AEP_P1-3_#8675_05EDANV1 230_5-B' OPEN BRANCH FROM BUS 936160 TO BUS 304024 CKT 1 / 936160 AD2-022 TAP 230 304024 6ROXSEP230 T 230 1 END

21 Light Load Analysis

Not Required

22 Short Circuit Analysis

The following Breakers are overdutied

None

23 Stability and Reactive Power Requirements for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

To be evaluated during the Facilities Study Phase

24 Affected Systems

24.1 TVA

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

24.2 Duke Energy Progress

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

24.3 MISO

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

24.4 LG&E

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

25 Attachment 1: One- Line Diagram and Point of Interconnection Map