Generation Interconnection

Revised Impact Study Report

for

Queue Project AE1-093

ELK 138 KV

42 MW Capacity / 42 MW Energy

July 2022

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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.

General

Invenergy Solar Development North America LLC has proposed to install PJM Project #AE1-093, a Storage facility located in Vinton County, Ohio (See Figure 2) The installed facilities will have a capability of 42 MW with 42 MW of this output being recognized by PJM as capacity. This project is an increase to the Interconnection customer's previous AC1-194 project, a 125.0 MW (47.5 MW) solar facility.

Note: The AE1-093 project will share the same connection point with AC1-194 project. The point of interconnection will be AEP's Elk 138 kV substation (see Figure 1).

The proposed in-service date for this project is December 31, 2021. This study does not imply AEP's commitment to this in-service date.

The objective of this System Impact Study is to determine budgetary cost estimates and approximate construction timelines for identified transmission facilities required to connect the proposed generating facilities to the AEP transmission system. These reinforcements include the Attachment Facilities, Local Upgrades, and Network Upgrades required for maintaining the reliability of the AEP transmission system.

Queue Number	**AE1-093**
Project Name	ELK 138 KV
Interconnection Customer	Invenergy Solar Development North America LLC
State	Ohio
County	Vinton
Transmission Owner	AEP
MFO	42
MWE	42
MWC	42
Fuel	Storage
Basecase Study Year	2022

Point of Interconnection

The Point of Interconnection for AE1-093 will be the AEP transmission system at the Elk 138 kV substation to be constructed by the Interconnection customer's previous PJM Project # AC1-094.

Note: It is assumed that the 138kV revenue metering system and gen lead installed for #AC1-194 will be adequate for the additional generation connection requested in AE1-093.

Cost Summary

The AE1-093 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$
Direct Connection Network Upgrade	$
Non Direct Connection Network Upgrades	$
Total Costs	$

In addition, the AE1-093 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	$

Transmission Owner Scope of Work

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
	$
	$
	$
Total Attachment Facility Costs	$

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
	$
	$
	$
Total Direct Connection Facility Costs	$

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	$

Interconnection Customer Requirements

It is understood that Invenergy Solar Development North America is responsible for all costs associated with this interconnection. The costs above are reimbursable to AEP. The cost of Invenergy Solar Development North America's generating plant and the costs for the line connecting the generating plant to the Elk 138 kV line are not included in this report; these are assumed to be Invenergy Solar Development North America'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.

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.

Revenue Metering and SCADA Requirements

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.

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

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 signing Agreement execution.

Conclusion

Based upon the results of this System Impact Study, the 42.0 MW (42.0 MW Capacity) storage facility requested in PJM queue position AE1-093 which is an increase to the Interconnection Customer's previous AC1-194 project, a 125.0 MW (47.5 MW) will not require additional interconnection charges.

Network Impacts

The Queue Project AE1-093 was evaluated as a 42.0 MW (Capacity 42.0 MW) injection into the Elk 138 kV substation in the AEP area. Project AE1-093 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-093 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

Generation Deliverability

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

None

Multiple Facility Contingency

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

None

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)

1. (AEP - AEP) The 05HARRIS-05ZUBER 138 kV line (from bus 243522 to bus 243593 ckt 1) loads from 111.62% to 113.22% (AC power flow) of its emergency rating (167 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#9679_05HARRISON 138_2E'. This project contributes approximately 3.13 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#9679_05HARRISON 138_2E'
OPEN BRANCH FROM BUS 243522 TO BUS 243550 CKT 1 / 243522 05HARRIS 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 05HARRIS 138 246706 05HARRISON 69.0 1
END

Please refer to Appendix 1 for a table containing the generators having contribution to this flowgate.

2. (AEP - AEP) The 05HARRIS-05ZUBER 138 kV line (from bus 243522 to bus 243593 ckt 1) loads from 104.39% to 105.98% (AC power flow) of its emergency rating (167 MVA) for the tower line contingency outage of 'AEP_P7-1_#10921'. This project contributes approximately 3.13 MW to the thermal violation.

CONTINGENCY 'AEP_P7-1_#10921'
OPEN BRANCH FROM BUS 243522 TO BUS 243550 CKT 1 / 243522 05HARRIS 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

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.

None

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

None

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

System Reinforcements – Summer Peak

Facility	Upgrade Description	Cost	Cost Allocation	Upgrade Number
05HARRIS-05ZUBER 138 kV line (from bus 243522 to bus 243593 ckt 1)	**AEP** AEP SE rating is 167 MVA. AEP Reinforcement: **Project ID**: s1665.2 **Description**: Replace six 300 Cu jumpers at Harrison. **Type**: FAC **Cost:** $600,000 **Time Estimate**: 6-12 Months **Ratings**: 180 MVA SE AEP Reinforcement: **Project ID**: N6263.2 **Description**: Replace 600 Amp Sw at Harrison. **Type**: FAC **Cost:** $200,000 **Time Estimate**: 12-18 Months **Ratings**: 219 MVA SE **Notes:** 1. Since the cost of the upgrade is less than $5M, based on PJM cost allocation criteria, AE1-093 currently does not receive cost allocation towards this upgrade. 2. As changes to the PJM queue process occur (such as prior queued projects withdrawing from the queue, reducing in size, etc.) AE1-093 could receive cost allocation. 3. Although Queue Project AE1-093 may not presently have cost responsibility for this upgrade, Queue Project AE1-093 may need this upgrade in-service to be deliverable to the PJM system. 4. If Queue Project AE1-093 comes into service prior to completion of the upgrade, Queue Project AE1-093 will need an interim study.	$600,000 + $200,000	$0 + $0	s1665.2 N6263.2
	Total	**$0**	**$0**	

This constraint is driven by a prior queue.
Per PJM cost allocation rules, Queue Project AE1-093 presently does not receive cost allocation for this upgrade.

Note 1: As changes to the interconnection process occur, such as prior queued projects withdrawing from the queue, reducing in size, etc, Queue Project AE1-093 could receive cost allocation.

Note 2: Although Queue Project AE1-093 may not have cost responsibility for this upgrade, Queue Project AE1-093 may need this upgrade in-service to be deliverable to the PJM system. If Queue Project AE1-093 comes into service prior to completion of the upgrade, Queue Project AE1-093 will need an interim study.

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.

Appendix 1

(AEP - AEP) The 05HARRIS-05ZUBER 138 kV line (from bus 243522 to bus 243593 ckt 1) loads from 111.62% to 113.22% (AC power flow) of its emergency rating (167 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#9679_05HARRISON 138_2E'. This project contributes approximately 3.13 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#9679_05HARRISON 138_2E'
OPEN BRANCH FROM BUS 243522 TO BUS 243550 CKT 1 / 243522 05HARRIS 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 05HARRIS 138 246706 05HARRISON 69.0 1
END

Bus Number	*Bus Name*	*Full Contribution*
932201	*AC2-029 C*	*10.46*
932202	*AC2-029 E*	*17.07*
932411	*AC2-059 C*	*15.47*
932412	*AC2-059 E*	*15.96*
934481	*AD1-072 C*	*3.4*
934482	*AD1-072 E*	*1.55*
936111	*AD2-016 C*	*15.47*
936112	*AD2-016 E*	*15.96*
937231	*AD2-162 C*	*21.58*
937232	*AD2-162 E*	*10.58*
938711	*AE1-093 C*	*3.13*
LTF	*CBM-N*	*< 0.01*
LTF	*CBM-S1*	*0.44*
LTF	*CBM-S2*	*0.4*
LTF	*CBM-W2*	*1.04*
LTF	*COFFEEN*	*0.02*
LTF	*CPLE*	*0.15*
LTF	*DUCKCREEK*	*0.13*
LTF	*EDWARDS*	*0.07*
LTF	*FARMERCITY*	*0.02*
LTF	*G-007A*	*0.06*
LTF	*GIBSON*	*< 0.01*
LTF	*LGEE*	*0.05*
LTF	*NEWTON*	*0.02*
LTF	*NYISO*	*< 0.01*
LTF	*TATANKA*	*0.05*
LTF	*TILTON*	*0.04*

LTF	*VFT*	*0.15*
925341	*AC1-001 C O1*	*9.68*
925342	*AC1-001 E O1*	*4.55*
927061	*AC1-194 C O1*	*3.54*
927062	*AC1-194 E O1*	*5.77*

Light Load Analysis

Network Impacts

The Queue Project AE1-245 was evaluated as a 150.0 MW (Capacity 19.5 MW) injection at the Haviland 138kV substation in the AEP area. Project AE1-245 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-245 was studied with a commercial probability of 1.0. Potential network impacts were as follows:

Generation Deliverability

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

None

Multiple Facility Contingency

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

None

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

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.

None

System Reinforcements – Light Load

None

Affected Systems

Affected Systems

LG&E

None

MISO

The Preliminary MISO Affect System Report did not identify any impacts AE1-093, but the FINAL MISO report for this project will be required to confirm that they will have no impacts.

TVA

None

Duke Energy Progress

None

NYISO

None

Short Circuit

Short Circuit

The following Breakers are overduty

None

Figure 1:

AE1-093 Point of Interconnection (Elk 138 kV)
Single-Line Diagram

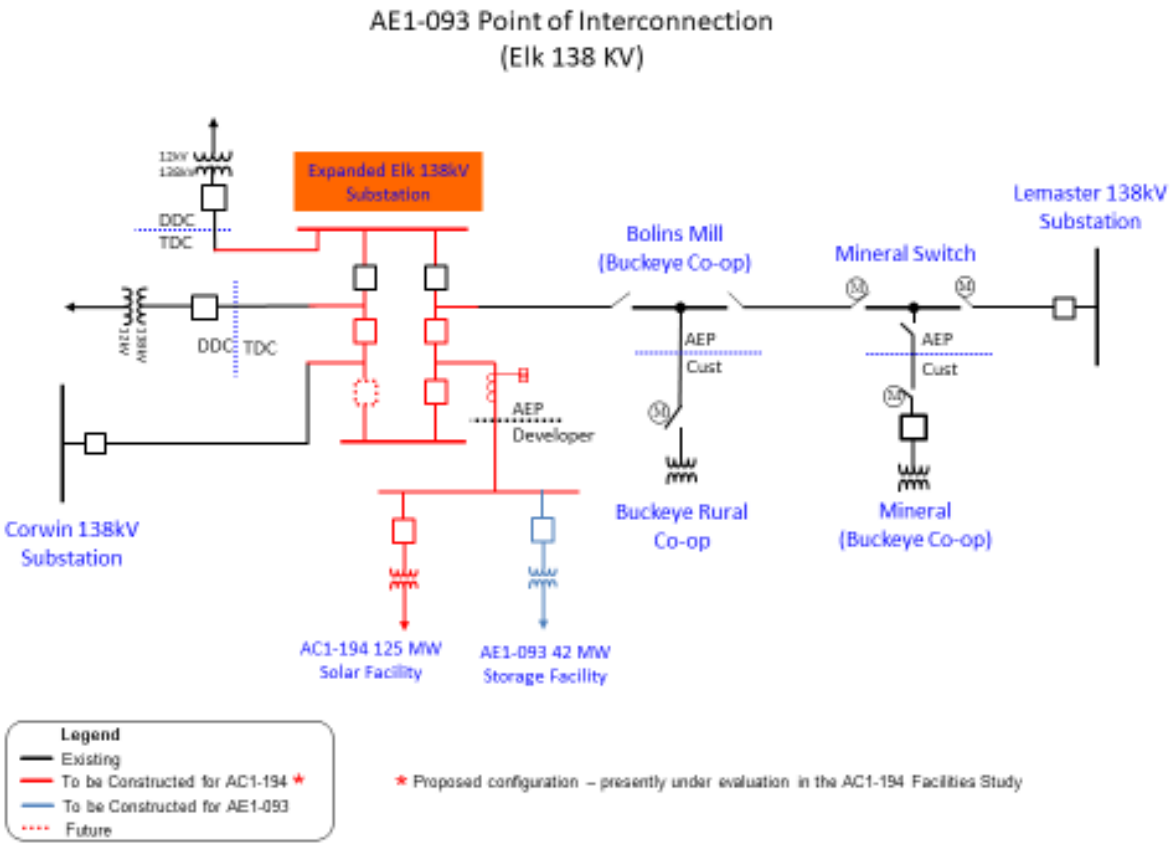

Figure 2:

Point of Interconnection (Elk 138 kV Substation)