

***Generation Interconnection  
Feasibility Study Report***

***For***

***PJM Generation Interconnection Request  
Queue Position AC1-210***

***Madison 69 kV***

**April 2017**

## 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. 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 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.

## General

The Interconnection Customer proposes to install PJM Project #AC1-210, a 45.0 MW (31.0 MW Capacity) solar generating facility in Madison County, Ohio (see Figure 2). The primary point of interconnection will be a direct connection to AEP's Madison 69 kV substation (see Figure 1). The secondary point of interconnection is to AEP's Madison – Texas Eastern 69 kV section of the Madison – Harrison 69 kV circuit (see Figure 4).

The requested Backfeed date is March 31, 2019.

The requested in service date is June 1, 2019.

## Attachment Facilities

### Primary Point of Interconnection (Madison 69 kV Substation)

To accommodate the interconnection at Madison 69 kV substation, Madison substation will have to be expanded to a new three (3) circuit breaker 69 kV substation physically configured in a breaker and half bus arrangement (see Figure 1). Installation of associated protection and control equipment, 69 kV line risers, SCADA, and 69 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.

#### Station Work:

- Expand Madison 69 kV substation to a new three (3) circuit breaker 69 kV substation physically configured in a breaker and half bus arrangement (see Figure 1). Installation of associated protection and control equipment, 69 kV line risers, SCADA, and 69 kV revenue metering will also be required. (see Figure 1).
- **Estimated Station Cost: \$3,000,000**

### Non-Direct Connection Cost Estimate

The total preliminary cost estimate for Non-Direct Connection work is given in the following tables below:

For AEP building Direct Connection cost estimates:

| Description   | Estimated Cost   |
|---|------------------|
| 69 kV Revenue Metering  | <b>\$150,000</b> |
| Upgrade line protection and controls at the expanded Madison 69 kV substation.  | <b>\$150,000</b> |
| Upgrade line protection and controls at the Harrison 69 kV substation to coordinate with the expanded Madison 69 kV substation. | <b>\$150,000</b> |

|  |                  |
|--|------------------|
| Upgrade line protection and controls at the East Lima 69 kV substation to coordinate with the expanded Madison 69 kV substation. | <b>\$150,000</b> |
| <b>Total</b>   | <b>\$600,000</b> |

**Table 1**

### **Secondary Point of Interconnection (Madison – Texas Eastern 69 kV Substation)**

To accommodate the interconnection on the Madison – Texas Eastern 69 kV section of the Madison – Harrison 69 kV circuit, a new three (3) circuit breaker 69 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus will be constructed (see Figure 3). Installation of associated protection and control equipment, 69 kV line risers, SCADA, and 69 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.

It is understood that The Interconnection Customer is responsible for all costs associated with this interconnection. The cost of The Interconnection Customer's generating plant and the costs for the line connecting the generating plant to The Interconnection Customer's switching 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.

## **Interconnection Customer Requirements**

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 Sections 24.1 and 24.2.

## **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>

## **Network Impacts**

The Queue Project AC1-210 was evaluated as a 45.0 MW (Capacity 31.0 MW) injection at the Madison 69kV substation in the AEP area. Project AC1-210 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC1-210 was studied with a commercial probability of 53%. Potential network impacts were as follows:

## **Base Case Used**

Summer Peak Analysis – 2020 Case

## **Contingency Descriptions**

The following contingencies resulted in overloads:

None

## **Generator 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

## **Steady-State Voltage Requirements**

None

## **Short Circuit**

*(Summary of impacted circuit breakers)*

New circuit breakers found to be over-duty:

None

## **Affected System Analysis & Mitigation**

### **LGEE Impacts:**

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

### **MISO Impacts:**

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

### **Duke, Progress & TVA Impacts:**

Duke Carolina, Progress, & TVA Impacts to be determined during later study phases (as applicable).

### **OVEC Impacts:**

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

## **Delivery of Energy Portion of Interconnection Request**

*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.*

| AC1-210 Delivery of Energy Portion of Interconnection Request |      |      |               |                                   |        |        |      |    |         |       |        |     |         |         |
|---|------|------|---------------|-----------------------------------|--------|--------|------|----|---------|-------|--------|-----|---------|---------|
| Contingency   |      |      | Affected Area | Facility Description              | Bus    |        | Cir. | PF | Loading |       | Rating |     | MW Con. | FG App. |
| #   | Type | Name |               |                                   | From   | To     |      |    | Initial | Final | Type   | MVA |         |         |
| 1   | Non  | Non  | AEP - AEP     | 05DARBY Z-05PICWAY 69 kV line     | 246680 | 246716 | 1    | DC | 59.2    | 120.8 | NR     | 25  | 45      |         |
| 2   | Non  | Non  | AEP - AEP     | 05TX-EAST SS-05DARBY Z 69 kV line | 246685 | 246680 | 1    | DC | 58.8    | 121.2 | NR     | 25  | 45      |         |

**Table 2**

## **New System Reinforcements**

None

## **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 be between 24 to 36 months after signing an interconnection agreement.

**Note: The time provided between anticipated normal completion of System Impact, Facilities Studies, subsequent execution of ISA and ICSA documents, and the proposed Backfeed Date is shorter than usual and may be difficult to achieve.**

## **Conclusion**

Based upon the results of this Feasibility Study, the construction of the 45.0 MW (31.0 MW Capacity) solar generating facility of The Interconnection Customer (PJM Project #AC1-210) will require the following additional interconnection charges. This plan of service will interconnect the proposed solar generating facility in a manner that will provide operational reliability and flexibility to both the AEP system and the The Interconnection Customer generating facility.

| <b>Cost Breakdown for Primary Point of Interconnection (Madison 69 kV Substation)</b> |  |                    |
|---|--|--------------------|
| <b>Attachment Cost</b>  | Expand Madison 69 kV Substation  | <b>\$3,000,000</b> |
| <b>Non-Direct Connection Cost Estimate</b>  | 69 kV Revenue Metering   | <b>\$150,000</b>   |
|   | Upgrade line protection and controls at the expanded Madison 69 kV substation.   | <b>\$150,000</b>   |
|   | Upgrade line protection and controls at the Harrison 69 kV substation to coordinate with the expanded Madison 69 kV substation.  | <b>\$150,000</b>   |
|   | Upgrade line protection and controls at the East Lima 69 kV substation to coordinate with the expanded Madison 69 kV substation. | <b>\$150,000</b>   |
|   | <b>Total Estimated Cost for Project AC1-210</b>  | <b>\$3,600,000</b> |

**Table 3**

The estimates 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.



## **Option 2**

### **Network Impacts**

The Queue Project AC1-210 was evaluated as a 45.0 MW (Capacity 31.0 MW) injection tapping the Madison-Texas East 69kV line in the AEP area. Project AC1-210 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC1-210 was studied with a commercial probability of 53%. Potential network impacts were as follows:

### **Base Case Used**

Summer Peak Analysis – 2020 Case

### **Contingency Descriptions**

The following contingencies resulted in overloads:

| Option 1                   |  |
|----------------------------|--|
| Contingency Name           | Description  |
| 6763_B2_TOR5200548_B       | CONTINGENCY '6763_B2_TOR5200548_B'<br>OPEN BRANCH FROM BUS 926180 TO BUS 243454 CKT 1 / 926180 AC1-096 TAP 345 243454 05BIXBY 345 1<br>END   |
| 6783_B                     | CONTINGENCY '6783_B'<br>OPEN BRANCH FROM BUS 243453 TO BUS 243454 CKT 1 / 243453 05BEATTY 345 243454 05BIXBY 345 1<br>OPEN BRANCH FROM BUS 926180 TO BUS 243454 CKT 1 / 926180 AC1-096 TAP 345 243454 05BIXBY 345 1<br>END                     |
| 8094_C2_05BIXBY 345-303C_A | CONTINGENCY '8094_C2_05BIXBY 345-303C_A'<br>OPEN BRANCH FROM BUS 243453 TO BUS 243454 CKT 1 / 243453 05BEATTY 345 243454 05BIXBY 345 1<br>OPEN BRANCH FROM BUS 926180 TO BUS 243454 CKT 1 / 926180 AC1-096 TAP 345 243454 05BIXBY 345 1<br>END |

**Table 4**

### **Generator 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)

| AC1-210 Multiple Facility Contingency |             |                               |               |                                     |        |        |      |    |         |        |        |     |         |         |
|---------------------------------------|-------------|-------------------------------|---------------|-------------------------------------|--------|--------|------|----|---------|--------|--------|-----|---------|---------|
| #                                     | Contingency |                               | Affected Area | Facility Description                | Bus    |        | Cir. | PF | Loading |        | Rating |     | MW Con. | FG App. |
|                                       | Type        | Name                          |               |                                     | From   | To     |      |    | Initial | Final  | Type   | MVA |         |         |
| 1                                     | LFFB        | 8094_C2_05BIXBY<br>345-303C_A | AEP -<br>AEP  | 05HARRIS-<br>05OBETZ<br>138 kV line | 243522 | 243550 | 1    | DC | 95.87   | 103.09 | ER     | 179 | 12.93   |         |
| 2                                     | DCTL        | 6783_B                        | AEP -<br>AEP  | 05HARRIS-<br>05OBETZ<br>138 kV line | 243522 | 243550 | 1    | DC | 95.87   | 103.09 | ER     | 179 | 12.93   |         |

Table 5

## 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)

| AC1-210 Contribution to Previously Identified Overloads |             |                      |               |                                     |        |        |      |    |         |        |        |     |         |         |
|---|-------------|----------------------|---------------|-------------------------------------|--------|--------|------|----|---------|--------|--------|-----|---------|---------|
| #   | Contingency |                      | Affected Area | Facility Description                | Bus    |        | Cir. | PF | Loading |        | Rating |     | MW Con. | FG App. |
|   | Type        | Name                 |               |                                     | From   | To     |      |    | Initial | Final  | Type   | MVA |         |         |
| 1   | N-1         | 6763_B2_TOR5200548_B | AEP - AEP     | 05HARRIS-<br>05OBETZ 138 kV<br>line | 243522 | 243550 | 1    | DC | 105.49  | 110.42 | ER     | 179 | 8.83    | 1       |

Table 6

## Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None

## Affected System Analysis & Mitigation

### LGEE Impacts:

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

### MISO Impacts:

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

**Duke, Progress & TVA Impacts:**

Duke Carolina, Progress, & TVA Impacts to be determined during later study phases (as applicable).

**OVEC Impacts:**

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

**Delivery of Energy Portion of Interconnection Request**

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*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.*

AC1-210 Delivery of Energy Portion of Interconnection Request

| # | Contingency |      | Affected Area | Facility Description              | Bus    |        |      |    | Loading |       | Rating |     | MW Con. | FG App. |
|---|-------------|------|---------------|-----------------------------------|--------|--------|------|----|---------|-------|--------|-----|---------|---------|
|   | Type        | Name |               |                                   | From   | To     | Cir. | PF | Initial | Final | Type   | MVA |         |         |
| 1 | Non         | Non  | AEP - AEP     | 05DARBY Z-05PICWAY 69 kV line     | 246680 | 246716 | 1    | DC | 59.2    | 120.8 | NR     | 25  | 45      |         |
| 2 | Non         | Non  | AEP - AEP     | 05TX-EAST SS-05DARBY Z 69 kV line | 246685 | 246680 | 1    | DC | 58.8    | 121.2 | NR     | 25  | 45      |         |

**Table 7**