

***Generation Interconnection
Feasibility Study Report***

For

***PJM Generation Interconnection Request
Queue Position AD2-092, AD2-093, and AD2-
096***

Marysville 345 kV

December 2018

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.

For Local and Network Upgrades which are required due to overloads associated with the System Impact Studies of an individual New Services Queue, and have a cost less than \$5,000,000, the cost of the Local and Network Upgrades will be shared by all proposed projects which have been assigned a Queue Position in the New Services Queue in which the need for the Local and Network Upgrades was identified. The Load Flow Cost Allocation methods discussed in this manual, including cutoffs, still apply to the individual projects.

For Local and Network Upgrades which are required due to the overloads associated with the System Impact Studies of an individual New Services Queue, and have a cost of \$5,000,000 or greater, the cost of the Local and Network Upgrades will be allocated according to the order of the New Service Requests in the New Services Queue and the MW contribution of each individual Interconnection Request for those projects which cause or contribute to the need for the Local or Network Upgrades. The Load Flow Cost Allocation methods discussed in this manual, including cutoffs, still apply to the individual projects.

Cost allocation rules 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.

PJM utilizes manufacturer models to ensure the performance of turbines is properly captured during the simulations performed for stability verification. Turbine manufacturers provide such models to their customers. The list of manufacturer models PJM has already validated is contained in Attachment G-2 of Manual 14A. Manufacturer models may be updated from time to time, for various reasons such as to reflect changes to the control systems or to more accurately represent the capabilities turbines and controls which are currently available in the field. Additionally, as new turbine models are developed, turbine manufacturers provide such new models which must be used in the conduct of these studies. PJM needs adequate time to evaluate the new models in order to reduce delays to the System Impact Study process timeline for the Interconnection Customer as well as other Interconnection Customers in the study group.

Therefore, PJM will require that any Interconnection Customer with a new manufacturer model must supply that model to PJM, along with a \$10,000 fully refundable deposit, no later than three (3) months prior to the starting date of the System Impact Study (See Section 2.2.2. of Manual 14A for starting dates) for the Interconnection Request which shall specify the use of the new model. The Interconnection Customer will be required to submit a completed dynamic model study request form (Attachment G-1 of Manual 14A) in order to document the request for the study.

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 (IC) proposes to install PJM Projects #AD2-092, #AD2-093 a combined 400.0MW (240.0MW) Solar Generating facility and #AD2-096, a 50.0 MW (50.0 MW Capacity) Storage facility in Union County, OH (see Figure 2). The primary point of interconnection will be a direct connection to AEP's Marysville 345 kV substation (see Figure 1). The Secondary Point of interconnection will be tapping the AEP's Marysville – Southwest Lima 345kV substation (See Figure 3). The following table lists the requested generation for the various queue requests:

| Queue Position | MFO | MWC | Fuel Type |
|----------------|-------|-------|-----------|
| AD2-092 | 175.0 | 105.0 | Solar |
| AD2-093 | 225.0 | 135.0 | Solar |
| AD2-096 | 50.0 | 50.0 | Storage |

Table 1

The requested in service date is December 31, 2020.

Attachment Facilities

Primary Point of Interconnection (Marysville 345 kV Substation)

To accommodate the interconnection at the Marysville 345 kV substation, the substation will have to be expanded requiring the installation of one (1) 345 kV circuit breaker (see Figure 1). Installation of associated protection and control equipment, 345 kV line risers, SCADA, and 345 kV revenue metering will also be required.

Marysville Station Work:

- Install one (1) new 345 kV circuit breaker and associated bus work. Installation of associated protection and control equipment, 345 kV line risers, SCADA, and 345 kV revenue metering will also be required.
- **Estimated Station Cost: \$2,500,000**

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 |
|-------------------------|------------------|
| 345 kV Revenue Metering | \$350,000 |
| Total | \$350,000 |

Table 2

Secondary Point of Interconnection (Marysville- Southwest Lima 345kV)

To accommodate the interconnection on the Marysville–Southwest Lima 345 kV circuit #1, install new one (3) circuit breaker 345 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus (see Figure 3). Installation of associated protection and control equipment, 345 kV line risers, SCADA, and 345 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.

Interconnection Customer Requirements

It is understood that The Interconnection Customer (IC) is responsible for all costs associated with this interconnection. The IC's generating/storage facility and the costs for the line connecting the generating/storage facility to the Marysville 345 kV substation are not included in this report; these are assumed to be the IC's responsibility. It is also assumed that any metering or other operational data PJM may require for the new generation/storage facility to participate in the desired PJM Markets can be accommodated by the existing telecommunications equipment. If any modification of metering or telecommunications equipment is required, that would also be the IC'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.

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 – Option 1

Summer Peak Analysis – 2021

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

(Results of the steady-state voltage studies should be inserted here)

None

Short Circuit

(Summary of impacted circuit breakers)

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.

| Option 1 AD2-096 Delivery of Energy Portion of Interconnection Request | | | | | | | | | | | | | |
|--|-------------|------------------|---------------|-------------------------------|--------|--------|------|----|---------|--------|--------|-----|---------|
| # | Contingency | | Affected Area | Facility Description | Bus | | Ckt. | PF | Loading | | Rating | | MW Con. |
| | Type | Name | | | From | To | | | Initial | Final | Type | MVA | |
| 1 | N-1 | 'AEP_P1-2_#6705' | AEP - AEP | U2-041 C-05E LIMA 345 kV line | 247506 | 242935 | 1 | DC | 116.12 | 119.27 | NR | 897 | 28.26 |
| 2 | Non | Non | AEP - AEP | U2-041 C-05E LIMA 345 kV line | 247506 | 242935 | 1 | DC | 99.95 | 100.84 | NR | 897 | 17.42 |

Table 2

Note: FERC 715 part 4 was updated to eliminate the normal rating requirement for single contingencies on EHV facilities. The Summer Emergency rating for the above overloaded facilities is 1186MVA.

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

None

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

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 Construction Service Agreement (ICSA).

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 IC's 400.0 MW (240.0 MW Capacity) Solar generating facility (PJM Project #AD2-092, #AD2-093) and 50.0MW storage facility of Solar Development (PJM Project #AD2-096) will require the following additional interconnection charges. This plan of service will interconnect the proposed generating/storage facility in a manner that will provide operational reliability and flexibility to both the AEP system and the generating facility.

| Cost Breakdown for Point of Interconnection (Marysville 345 kV Substation) | | |
|---|--|--------------------|
| Attachment Cost | Install One (1) 345kV Circuit Breaker at the Marysville 345kV Substation and associated equipment, including upgrades to line protection and controls. | \$2,500,000 |
| Non-Direct Connection Cost Estimate | 345 kV Revenue Metering | \$350,000 |
| | Total Estimated Cost for Project AD2-092,AD2-093, AD2-096 | \$2,850,000 |

Table 4

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.

Network Impacts – Option 2

The Queue Project AD2-092, AD2-093, and AD2-096 was evaluated as a 450.0 MW (Capacity 290.0 MW) injection as a tap of Marysville – Southwest Lima 345 kV line in the AEP area. The projects were evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). The Project was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Analysis - 2021

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

(Results of the steady-state voltage studies should be inserted here)

None

Short Circuit

(Summary of impacted circuit breakers)

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.

Only the most severely overloaded conditions are listed. 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 will study all overload conditions associated with the overloaded element(s) identified.

| Option 1 AD2-093 Delivery of Energy Portion of Interconnection Request | | | | | | | | | | | | | |
|--|------|------------------|---------------|----------------------------------|--------|--------|-----|----|---------|--------|-------------|-----|---------|
| # | Type | Contingency | Affected Area | Facility Description | Bus | | | PF | Loading | | Rating Type | MVA | MW Con. |
| | | Name | | | From | To | Ckt | | Initial | Final | | | |
| 1 | N-1 | 'AEP_P1-2_#6705' | AEP - AEP | U2-041 C-05E LIMA 345 kV line | 247506 | 242935 | 1 | DC | 113.67 | 116.11 | NR | 897 | 21.91 |

Table 5

Note: FERC 715 part 4 was updated to eliminate the normal rating requirement for single contingencies on EHV facilities. The Summer Emergency rating for the above overloaded facilities is 1186MVA.