

***Generation Interconnection
Feasibility Study Report***

For

***PJM Generation Interconnection Request
Queue Position AD2-178***

Wurno 138 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.

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 Project #AD2-178, a 120 MW (72 MW Capacity) solar facility in Pulaski County, Virginia (see Figure 2). The primary point of interconnection will be a direct connection to AEP's Wurno 138 kV substation (see Figure 1). The secondary point of interconnection will be to the AEP's Wurno – Westglow 138 kV section of the Claytor – Peak Creek 138 kV circuit (see Figure 3).

The requested in service date is June 1, 2021.

The objective of this Feasibility 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. Stability analysis is not included as part of this study.

Attachment Facilities

Primary Point of Interconnection (Wurno 138 kV)

To accommodate the interconnection at the Wurno 138 kV substation, the Wurno substation will have to be expanded to a new five (5) circuit breaker 138 kV substation physically configured in a breaker and half bus arrangement (see Figure 1). 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.

Expansion of Wurno 138 kV Substation Work and Cost:

- Expand the Wurno 138 kV substation to a new five (5) circuit breaker 138 kV substation physically configured in a breaker and half bus arrangement (see Figure 1). Installation of associated protection and control equipment, 138 kV line risers, SCADA, and 138 kV revenue metering will also be required. (See Figure 1).
- **Estimated Station Cost: \$7,000,000**

Direct Connection Cost Estimate

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

For AEP building Direct Connection cost estimates:

Description	Total Cost
Peak Creek - Claytor 138 kV T-Line Cut In	\$1,000,000
Total	\$1,000,000

Table 1

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 Non-Direct Connection cost estimates:

Description	Total Cost
138 kV Revenue Metering	\$250,000
Upgrade line protection and controls at the Peak Creek 138 kV substation	\$250,000
Upgrade line protection and controls at Claytor 138 kV substation	\$250,000
Total	\$750,000

Table 2

Secondary Point of Interconnection (Wurno - Westglow 138 kV)

To accommodate the interconnection on the Wurno – Westglow 138 kV section of the Claytor – Peak Creek 138 kV circuit, 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 (see 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.

Interconnection Customer Requirements

It is understood that The IC is responsible for all costs associated with this interconnection. The costs above are reimbursable to AEP. The cost of The IC generating plant and the costs for the line connecting the generating plant to the Wurno 138 kV substation are not included in this report; these are assumed to be 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.
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 – Option 1

The Queue Project AD2-178 was evaluated as a 120.0 MW (Capacity 72.0 MW) injection at the Wurno 138kV substation in the AEP area. Project AD2-178 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD2-178 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Base Case Used

Summer Peak Analysis – 2021 Case

Contingency Descriptions

The following contingencies resulted in overloads:

Option 1	
Contingency Name	Description
'AEP_P1-2_#5387'	CONTINGENCY 'AEP_P1-2_#5387' OPEN BRANCH FROM BUS 242609 TO BUS 934750 CKT 1 / 242609 05CLYTR2 138 934750 AD1-102 TAP 138 1 END
'AEP_P1-2_#311'	CONTINGENCY 'AEP_P1-2_#311' OPEN BRANCH FROM BUS 242512 TO BUS 242514 CKT 1 / 242512 05CLOVRD 765 242514 05J.FERR 765 1 END

Table 3

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.

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.

AD2-178 Delivery of Energy Portion of Interconnection Request – Option 1														
#	Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	PF	Loading Initial	Loading Final	Rating Type	Rating MVA	MW Con.	FG App.
1	N-1	'AEP_P1-2_#5387	AEP –AEP	05WURNO-05W GLOW 138 kV line	242853	242841	1	DC	60.87	107.93	ER	255	120	
2	N-1	'AEP_P1-2_#311'	AEP-AEP	05WURNO-AD1-102 TAP 138 kV line	242853	934750	1	DC	77.78	102.74	ER	251	62.65	
3	N-1	'AEP_P1-2_#311'	AEP-AEP	AD1-102 TAP-05CLYTR2 138 kV line	934750	242609	1	DC	124.9	149.86	ER	251	62.65	
4	-	None	AEP-AEP	AD1-102 TAP-05CLYTR2 138 kV line	934750	242609	1	DC	84.63	109.53	NR	251	62.49	

Table 4

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 agreement.

Conclusion

Based upon the results of this Feasibility Study, the construction of the IC's 120 MW (72 MW Capacity) solar generating facility (PJM Project #AD2-178) 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 generating facility.

Cost Breakdown for Primary Point of Interconnection (Wurno 138 kV Substation)		
Attachment Cost	Expand the Wurno 138 kV Substation to accommodate the interconnection of PJM Project #AD2-178.	\$7,000,000
Direct Connection Cost Estimate	Peak Creek - Claytor 138 kV T-Line Cut In	\$1,000,000
Non-Direct Connection Cost Estimate	138 kV Revenue Metering	\$250,000
	Upgrade line protection and controls at the Peak Creek 138 kV substation	\$250,000
	Upgrade line protection and controls at the Claytor 138 kV substation	\$250,000
Total Estimated Cost for Project AD2-178		\$8,750,000

Table 5

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 AD2-178 was evaluated as a 120.0 MW (Capacity 72.0 MW) injection tapping the Wurno to Westglow 138kV line in the AEP area. Project AD2-178 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD2-178 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Base Case Used

Summer Peak Analysis – 2021 Case

Contingency Descriptions

The following contingencies resulted in overloads:

Option 2	
Contingency Name	Description
'AEP_P1-2_#311'	OPEN BRANCH FROM BUS 242512 TO BUS 242514 CKT 1 / 242512 05CLOVRD 765 242514 05J.FERR 765 1 END
'AEP_P1-2_#5387'	OPEN BRANCH FROM BUS 242609 TO BUS 934750 CKT 1 / 242609 05CLYTR2 138 934750 AD1-102 TAP 138 1 END

Table 6

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.

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.

AD2-178 Delivery of Energy Portion of Interconnection Request – Option 2														
#	Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	PF	Loading Initial	Loading Final	Rating Type	Rating MVA	MW Con.	FG App.
1	N-1	'AEP_P1-2_#311'	AEP – AEP	05WURNO-AD1-102 TAP 138 kV	242853	934750	1	DC	77.78	102.09	ER	251	61.03	
2	N-1	'AEP_P1-2_#311'	AEP-AEP	AD1-102 TAP-05CLYTR2 138 kV	934750	242609	1	DC	124.9	149.21	ER	251	61.03	
3	-	None	AEP-AEP	AD1-102 TAP-05CLYTR2 138 kV	934750	242609	1	DC	84.63	108.86	NR	251	60.82	
4	N-1	'AEP_P1-2_#5387'	AEP-AEP	AD2-178 TAP-05W GLOW 138 kV	937340	242841	1	DC	60.87	107.93	ER	255	120.0	
5	N-1	'AEP_P1-2_#311'	AEP – AEP	AD2-178 TAP-05WURNO 138 kV	937340	242853	1	DC	86.43	110.37	ER	255	61.03	

Table 6