Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AC1-051

South Greenwich-Willard 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.

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.

General

The Interconnection Customer proposes to install PJM Project #AC1-051, a 60.0 MW (7.8 MW capacity) wind generating facility. The proposed Point of Interconnection is on the Greenwich-South Greenwich section of AEP's South Greenwich-Willard 69 kV circuit (see Figure 1). The proposed generating facility is located in the vicinity of Greenwich, Ohio (see Figure 2).

The requested in service date is December 31, 2017.

Attachment Facilities

Point of Interconnection (South Greenwich-Willard 69 kV)

The proposed generating facility is to be tapped between the Greenwich and the South Greenwich stations on the South Greenwich-Willard 69 kV circuit. The generating facility will be separated from the tapping point by a circuit breaker. In addition, the Willard 69 kV station configuration must be modified to operate as a ring bus. A transfer trip relaying scheme will be required to open the wind farm breaker when the breakers at the Willard station open the Willard end of the Willard – South Greenwich 69 kV line (see Figure 1).

The existing Willard 69 kV station does not have enough space to accommodate the required reconfiguration. To achieve the required space, the Willard 69 kV station will need to be expanded to a dimension of 200 ft. by 200 ft. To attain the required space for the Willard 69 kV station expansion, a 3 acre plot of land will need to be added in the Northwest direction of the existing Willard 69 kV station. AEP to obtain the additional land required to expand the existing Willard 69 kV station and the costs will be reimbursable by The Interconnection Customer.

In addition, the proposed AC1-051 Wind generating facility will likely be required to be temporarily removed from service in the event of any facility outage (planned or unplanned) that leaves either of the 69 kV paths from Willard to Carrothers or Willard to Howard open, thereby leaving the Willard-S Greenwich 69 kV line part of an extended radial path (See Figure 1). To ensure that this removal occurs with minimal delay, AEP Operations will have Supervisory trip control for the AC1-051 project breaker.

The point of interconnection is also to include 69 kV metering, SCADA, and associated equipment. Protection relays in the surrounding area will need to be reset to accommodate the addition of the new project.

<u>New Switching Station Work:</u>

- Construct a new 69 kV switching station with one (1) 69 kV circuit breaker. Installation of associated protection and control equipment, 69 kV line risers, SCADA (see Figure 1).
    - **Estimated Station Cost: $2,000,000**

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
Greenwich-South Greenwich 69 kV T-Line Cut In	**$750,000**
Willard-Greenwich 69 kV T-Line Work	**$250,000**
Carrothers-Willard 69 kV T-Line Work	**$250,000**
Total	**$1,250,000**

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 Direct Connection cost estimates:

Description	Estimated Cost
69 kV Revenue Metering	**$150,000**
Expand Willard 69 kV Substation	**$1,000,000**
Total	**$1,150,000**

Table 2

It is understood that The Interconnection Customer is responsible for all costs associated with this interconnection. The costs above are reimbursable to AEP. 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 AC1-051 was evaluated as a 60.0 MW (Capacity 7.8 MW) injection tapping the Greenwich-North Greenwich 69kV line in the AEP area. Project AC1-051 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC1-051 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**
C2-CEI-345-001	CONTINGENCY 'C2-CEI-345-001' /* BREAKER FAILURE ON S145 BREAKER AT AVON 345KV DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 1 /* 02LAKEAVE 345 02AVON 345 DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 2 /* 02LAKEAVE 345 02AVON 345 END
C5-CEI-345-001	CONTINGENCY 'C5-CEI-345-001' /* AVON-BEAVER #1 AND #2 345KV LINE OUTAGES DISCONNECT BRANCH FROM BUS 238551 TO BUS 239725 CKT 1 /* 02AVON 345 02LAKEAVE 345 DISCONNECT BRANCH FROM BUS 238551 TO BUS 239725 CKT 2 /* 02AVON 345 02LAKEAVE 345 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)

AC1-051 Contribution to Previously Identified Overloads														
	Contingency				Bus				Loading		Rating			
#	Type	Name	Affected Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	MW Con.	FG App.
1	LFFB	C2-CEI-345-001	FE - FE	02BLKRVR-02USSTEEL 138 kV line	239728	239734	1	DC	189.08	189.73	ER	270	3.89	1
2	DCTL	C5-CEI-345-001	FE - FE	02BLKRVR-02USSTEEL 138 kV line	239728	239734	1	DC	189.08	189.73	ER	270	3.89	1
3	LFFB	C2-CEI-345-001	FE - FE	02USSTEEL-02LRN Q2 138 kV line	239734	238915	1	DC	177.23	177.87	ER	270	3.89	2
4	DCTL	C5-CEI-345-001	FE - FE	02USSTEEL-02LRN Q2 138 kV line	239734	238915	1	DC	177.23	177.87	ER	270	3.89	2

Table 4

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).

Light Load Analysis - 2020

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

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.

There is actually a more severe N-1 condition which was (probably) not studied. Loss of the S. Greenwich load should be considered a valid N-1 condition, simulating outage of either the 69/12 kV transformer (which could be cleared by operation of the 69 circuit switcher) or operation of the breaker on the single 12 kV feeder. This contingency exposure will increase the risk of curtailment.

Contingency			Affected Area	Facility Description	Bus		Cir.	PF	Loading		Rating		MW Con.
#	Type	Name			From	To			Initial	Final	Type	MVA	
1	Non	Non	AEP - AEP	05GREENWIC-05BOUGHTN8 69 kV line	245662	245651	1	DC	17.6	102.4	NR	50	60
2	Non	Non	AEP - AEP	AC1-051 TAP-05GREENWIC 69 kV line	925750	245662	1	DC	11.4	108.6	NR	50	60

Table 5

New System Reinforcements

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)

PJM baseline project (b2559) will eliminate the identified overloads below. The scheduled in service date **b2559** is 06/01/2017.

1. (FE - FE) The 02BLKRVR-02USSTEEL 138 kV line (from bus 239728 to bus 239734 ckt 1) loads from 189.08% to 189.73% (**DC power flow**) of its emergency rating (270 MVA) for the line fault with failed breaker contingency outage of 'C2-CEI-345-001'. This project contributes approximately 3.89 MW to the thermal violation.

Reinforcement: Replace approx. 3.4 miles of 795 ACSS/TW Drake line conductor between Black-River & Charleston (US Steel) substations with a bundle 795Kcmil ACSS conductor in conjunction with **b2559**.
Cost: $6,664,901
Time: 24 months

This contingency is no longer valid once the topology in the model is updated to reflect the reconductor of the Black River - Lorain 138 kV line and upgrade Black River and Lorain substation terminal end equipment updated once **b2559** is in service in conjunction with the aforementioned upgrade. The new rating will 489/572 SN/SE.

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

2. (FE - FE) The 02BLKRVR-02USSTEEL 138 kV line (from bus 239728 to bus 239734 ckt 1) loads from 189.08% to 189.73% (**DC power flow**) of its emergency rating (270 MVA) for the tower line contingency outage of 'C5-CEI-345-001'. This project contributes approximately 3.89 MW to the thermal violation.

Same as Contribution to Previously Identified Overload #1

3. (FE - FE) The 02USSTEEL-02LRN Q2 138 kV line (from bus 239734 to bus 238915 ckt 1) loads from 177.23% to 177.87% (**DC power flow**) of its emergency rating (270 MVA) for the line fault with failed breaker contingency outage of 'C2-CEI-345-001'. This project contributes approximately 3.89 MW to the thermal violation.

This contingency is no longer valid once the topology in the model is updated to reflect the reconductor of the Black River - Lorain 138 kV line and upgrade Black River and Lorain substation terminal end equipment updated once **b2559** is in service. New rating will be 435/500 SN/SE.

Please refer to Appendix 2 for a table containing the generators having contribution to this flowgate.

4. (FE - FE) The 02USSTEEL-02LRN Q2 138 kV line (from bus 239734 to bus 238915 ckt 1) loads from 177.23% to 177.87% (**DC power flow**) of its emergency rating (270 MVA) for the tower line contingency outage of 'C5-CEI-345-001'. This project contributes approximately 3.89 MW to the thermal violation.

Same as Contribution to Previously Identified Overload #3

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 60.0 MW (7.8 MW Capacity) wind generating facility of The Interconnection Customer (PJM Project #AC1-051) will require the following additional interconnection charges. This plan of service will interconnect the proposed wind generating facility in a manner that will provide operational reliability and flexibility to both the AEP system and the The Interconnection Customer generating facility.

Cost Breakdown for Point of Interconnection (South Greenwich-Willard 69 kV)		
Attachment Cost	New 69 kV Switching Station	**$2,000,000**
Direct Connection Cost Estimate	Greenwich-South Greenwich 69 kV T-Line Cut In	**$750,000**
	Willard-Greenwich 69 kV T-Line Work	**$250,000**
	Carrothers-Willard 69 kV T-Line Work	**$250,000**
Non-Direct Connection Cost Estimate	69 kV Revenue Metering	**$150,000**
	Expand Willard 69 kV Substation	**$1,000,000**
	Total Estimated Cost for Project AC1-051	**$4,400,000**

Table 6

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.

Appendices

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

(FE - FE) The 02BLKRVR-02USSTEEL 138 kV line (from bus 239728 to bus 239734 ckt 1) loads from 189.08% to 189.73% (**DC power flow**) of its emergency rating (270 MVA) for the line fault with failed breaker contingency outage of 'C2-CEI-345-001'. This project contributes approximately 3.89 MW to the thermal violation.

CONTINGENCY 'C2-CEI-345-001' /* BREAKER FAILURE ON S145 BREAKER AT AVON 345KV
DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 1 /* 02LAKEAVE 345 02AVON 345
DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 2 /* 02LAKEAVE 345 02AVON 345
END

Bus Number	*Bus Name*	*Full Contribution*
238571	*02BEAVGA*	*2.02*
238572	*02BEAVGB*	*2.1*
240968	*02BG2 GEN*	*0.62*
240969	*02BG4 G1*	*0.15*
240970	*02BG4 G2&3*	*0.31*
240971	*02BG4 G4&5*	*0.31*
240950	*02BG5*	*1.88*
240973	*02BG6 AMPO*	*2.75*
239276	*02COLLW 11*	*-2.85*
239297	*02CPPW41*	*-3.63*
238979	*02NAPMUN*	*2.92*
240975	*02PGE GEN*	*4.25*
239175	*02WLORG-6*	*3.33*
247542	*U4-001 C*	*1.54*
247934	*U4-001 E*	*10.32*
247551	*U4-028 C*	*0.98*
247940	*U4-028 E*	*6.57*
247552	*U4-029 C*	*0.98*
247941	*U4-029 E*	*6.57*
247567	*V2-006 C*	*1.04*
247961	*V2-006 E*	*6.93*
247548	*V4-010 C*	*2.13*
247947	*V4-010 E*	*14.25*
901803	*W1-072A*	*3.44*
907062	*X1-027A E1*	*14.32*
907065	*X1-027A E2*	*14.32*
907067	*X1-027A E3*	*14.32*
907069	*X1-027A E4*	*14.32*

Bus Number	*Bus Name*	*Full Contribution*
LTF	*Y3-032*	*18.52*
921102	*AA1-056*	*4.05*
922573	*AA2-186 E*	*1.06*
923092	*AB1-107 CT1*	*24.08*
923094	*AB1-107 CT2*	*23.74*
923093	*AB1-107 CTE1*	*2.66*
923095	*AB1-107 CTE2*	*2.62*
923096	*AB1-107 ST1*	*28.29*
923097	*AB1-107 STE*	*3.13*
923821	*AB2-019*	*1.77*
925751	*AC1-051 C*	*0.51*
925752	*AC1-051 E*	*3.39*

Appendix 2

(FE - FE) The 02USSTEEL-02LRN Q2 138 kV line (from bus 239734 to bus 238915 ckt 1) loads from 177.23% to 177.87% (**DC power flow**) of its emergency rating (270 MVA) for the line fault with failed breaker contingency outage of 'C2-CEI-345-001'. This project contributes approximately 3.89 MW to the thermal violation.

CONTINGENCY 'C2-CEI-345-001' /* BREAKER FAILURE ON S145 BREAKER AT AVON 345KV
DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 1 /* 02LAKEAVE 345 02AVON 345
DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 2 /* 02LAKEAVE 345 02AVON 345
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Bus Number	*Bus Name*	*Full Contribution*
238571	*02BEAVGA*	*2.02*
238572	*02BEAVGB*	*2.1*
240968	*02BG2 GEN*	*0.62*
240969	*02BG4 G1*	*0.15*
240970	*02BG4 G2&3*	*0.31*
240971	*02BG4 G4&5*	*0.31*
240950	*02BG5*	*1.88*
240973	*02BG6 AMPO*	*2.75*
239276	*02COLLW 11*	*-2.85*
239297	*02CPPW41*	*-3.63*
238979	*02NAPMUN*	*2.92*
240975	*02PGE GEN*	*4.25*
239175	*02WLORG-6*	*3.33*
247542	*U4-001 C*	*1.54*
247934	*U4-001 E*	*10.32*
247551	*U4-028 C*	*0.98*
247940	*U4-028 E*	*6.57*
247552	*U4-029 C*	*0.98*
247941	*U4-029 E*	*6.57*
247567	*V2-006 C*	*1.04*
247961	*V2-006 E*	*6.93*
247548	*V4-010 C*	*2.13*
247947	*V4-010 E*	*14.25*
901803	*W1-072A*	*3.44*
907062	*X1-027A E1*	*14.32*
907065	*X1-027A E2*	*14.32*
907067	*X1-027A E3*	*14.32*
907069	*X1-027A E4*	*14.32*

Bus Number	*Bus Name*	*Full Contribution*
LTF	*Y3-032*	*18.52*
921102	*AA1-056*	*4.05*
922573	*AA2-186 E*	*1.06*
923092	*AB1-107 CT1*	*24.08*
923094	*AB1-107 CT2*	*23.74*
923093	*AB1-107 CTE1*	*2.66*
923095	*AB1-107 CTE2*	*2.62*
923096	*AB1-107 ST1*	*28.29*
923097	*AB1-107 STE*	*3.13*
923821	*AB2-019*	*1.77*
925751	*AC1-051 C*	*0.51*
925752	*AC1-051 E*	*3.39*