Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AC2-035

Lick-Firebrick 69 kV

July 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 (IC) proposes to interconnect PJM Project #AC2-035, a 49.0 MW (29.40 MW Capacity) solar generating facility in Jackson County, Ohio (see Figure 2). The point of interconnection is to AEP's Lick – Firebrick 69 kV circuit (see Figure 1).

The requested in service date is June 1, 2019.

Attachment Facilities

Point of Interconnection (Lick – Firebrick 69 kV)

To accommodate the interconnection on the Lick – Firebrick 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 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.

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

- Construct 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. 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: $3,500,000**

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
Lick-Firebrick 69 kV T-Line Cut In	**$700,000**
Total	**$700,000**

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	**$200,000**
Upgrade line protection and controls at the Lick 69 kV substation to coordinate with the new 69 kV switching station.	**$200,000**
Upgrade line protection and controls at the Firebrick 69 kV substation to coordinate with the new 69 kV switching station.	**$200,000**
Total	**$600,000**

Table 2

It is understood that IC is responsible for all costs associated with this interconnection. The costs above are reimbursable to AEP. The cost of IC's generating plant and the costs for the line connecting the generating plant to the point of interconnection 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.

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 AC2-035 was evaluated as a 49.0 MW (Capacity 29.4 MW) injection tapping the Echo Valley – Black Fork 69 kV section of the Lick – Firebrick 69 kV circuit in the AEP area. Project AC2-035 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-035 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:

Contingency Name	Description
5923_B2_TOR10098A_MOAB	CONTINGENCY '5923_B2_TOR10098A_MOAB' OPEN BRANCH FROM BUS 243531 TO BUS 243555 CKT 1 / 243531 05KIMBRY 138 243555 05POSTON 138 1 END

Contingency Name	Description
5930_B2_TOR15138A_MOAB	CONTINGENCY '5930_B2_TOR15138A_MOAB' OPEN BRANCH FROM BUS 243501 TO BUS 243534 CKT 1 / 243501 05E.BEAV 138 243534 05LICK 138 1 OPEN BRANCH FROM BUS 243501 TO BUS 243034 CKT 1 / 243501 05E.BEAV 138 243034 05MARQUI 138 1 OPEN BRANCH FROM BUS 243501 TO BUS 243166 CKT 1 / 243501 05E.BEAV 138 243166 05E.BEAVER 69.0 1 OPEN BRANCH FROM BUS 243821 TO BUS 243166 CKT 1 / 243821 05BEAVER 69.0 243166 05E.BEAVER 69.0 1 OPEN BRANCH FROM BUS 244928 TO BUS 243166 CKT 1 / 244928 05BEAVER 8 69.0 243166 05E.BEAVER 69.0 1 END
7981_A	CONTINGENCY '7981_A' OPEN BRANCH FROM BUS 243019 TO BUS 931430 CKT 1 / 243019 05HILLSB 138 931430 AC2-061 TAP 138 1 OPEN BRANCH FROM BUS 243019 TO BUS 253111 CKT 1 / 243019 05HILLSB 138 253111 09MIDDLE 138 1 OPEN BRANCH FROM BUS 249995 TO BUS 250122 CKT 1 / 249995 08CLINCO 138 250122 08WARRN1 138 1 OPEN BRANCH FROM BUS 253111 TO BUS 253057 CKT 1 / 253111 09MIDDLE 138 253057 09OHH 138 1 END
7981_B	CONTINGENCY '7981_B' OPEN BRANCH FROM BUS 931430 TO BUS 249995 CKT 1 / 931430 AC2-061 TAP 138 249995 08CLINCO 138 1 OPEN BRANCH FROM BUS 243019 TO BUS 253111 CKT 1 / 243019 05HILLSB 138 253111 09MIDDLE 138 1 OPEN BRANCH FROM BUS 249995 TO BUS 250122 CKT 1 / 249995 08CLINCO 138 250122 08WARRN1 138 1 OPEN BRANCH FROM BUS 253111 TO BUS 253057 CKT 1 / 253111 09MIDDLE 138 253057 09OHH 138 1 END

Contingency Name	Description
8108_C2_05HILLSB 138-D_A	CONTINGENCY '8108_C2_05HILLSB 138-D_A' OPEN BRANCH FROM BUS 243019 TO BUS 931430 CKT 1 / 243019 05HILLSB 138 931430 AC2-061 TAP 138 1 OPEN BRANCH FROM BUS 243019 TO BUS 253111 CKT 1 / 243019 05HILLSB 138 253111 09MIDDLE 138 1 OPEN BRANCH FROM BUS 249995 TO BUS 250122 CKT 1 / 249995 08CLINCO 138 250122 08WARRN1 138 1 OPEN BRANCH FROM BUS 253111 TO BUS 253057 CKT 1 / 253111 09MIDDLE 138 253057 09OHH 138 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)

AC2-035 Multiple Facility Contingency												
	Contingency		Affected	Facility	Bus		Loading		Rating		MW	FG
#	Type	Name	Area	Description	From	To	Initial	Final	Type	MVA	Con.	App.
1	DCTL	7981_B	AEP - AEP	05MILLBR-05N PORT 138 kV line	243042	243047	62.03	62.63	ER	185	2.46	1
2	LFFB	8108_C2_05HILLSB 138-D_A	AEP - AEP	05MILLBR-05N PORT 138 kV line	243042	243047	62.03	62.63	ER	185	2.46	
3	DCTL	7981_A	AEP - AEP	05MILLBR-05N PORT 138 kV line	243042	243047	62.03	62.63	ER	185	2.46	

Table 4

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

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.

AC2-035 Delivery of Energy Portion of Interconnection Request												
	Contingency				Bus		Loading		Rating			FG
#	Type	Name	Affected Area	Facility Description	From	To	Initial	Final	Type	MVA	MW Con.	App.
1	N-1	5923_B2_TOR1 0098A_MOAB	AEP - AEP	05SPENCR-05CROOKS 138 kV line	243107	242986	91.37	92.5	ER	134	3.35	
2	N-1	5930_B2_TOR1 5138A_MOAB	AEP - AEP	AC2-035 TAP-05ECHO 8 69 kV line	931230	243603	60.2	113.2	ER	50	26.49	

Table 5

New System Reinforcements

#	Overloaded Facility	Upgrade Description	Schedule	Estimated Cost
#1	05MILLBR-05N PORT 138 kV line	A Sag Study will be required on the 3.40 mile section of line to mitigate the overload on the Millbrook Park – North Portsmouth 138 kV line to determine if the line can be operated above its emergency rating of 185 MVA. The result could prove that no additional upgrades are necessary, that some upgrades on the circuit are necessary, or that the entire 3.40 mile section of line would need to be rebuilt. Note: AC2-035 does not overload this facility but may receive cost allocation because the AC2 Queue overloads this facility.	Sag Study: 6 to 12 months. Rebuild: The standard time required for construction differs from state to state. An approximate construction time would be 24 to 36 months after signing an interconnection agreement.	**$15,000**
			Total New Network Upgrades	**$15,000**

Table 6

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 49.0 MW (29.4 MW Capacity) solar generating facility of the IC (PJM Project #AC2-035) 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 IC generating facility.

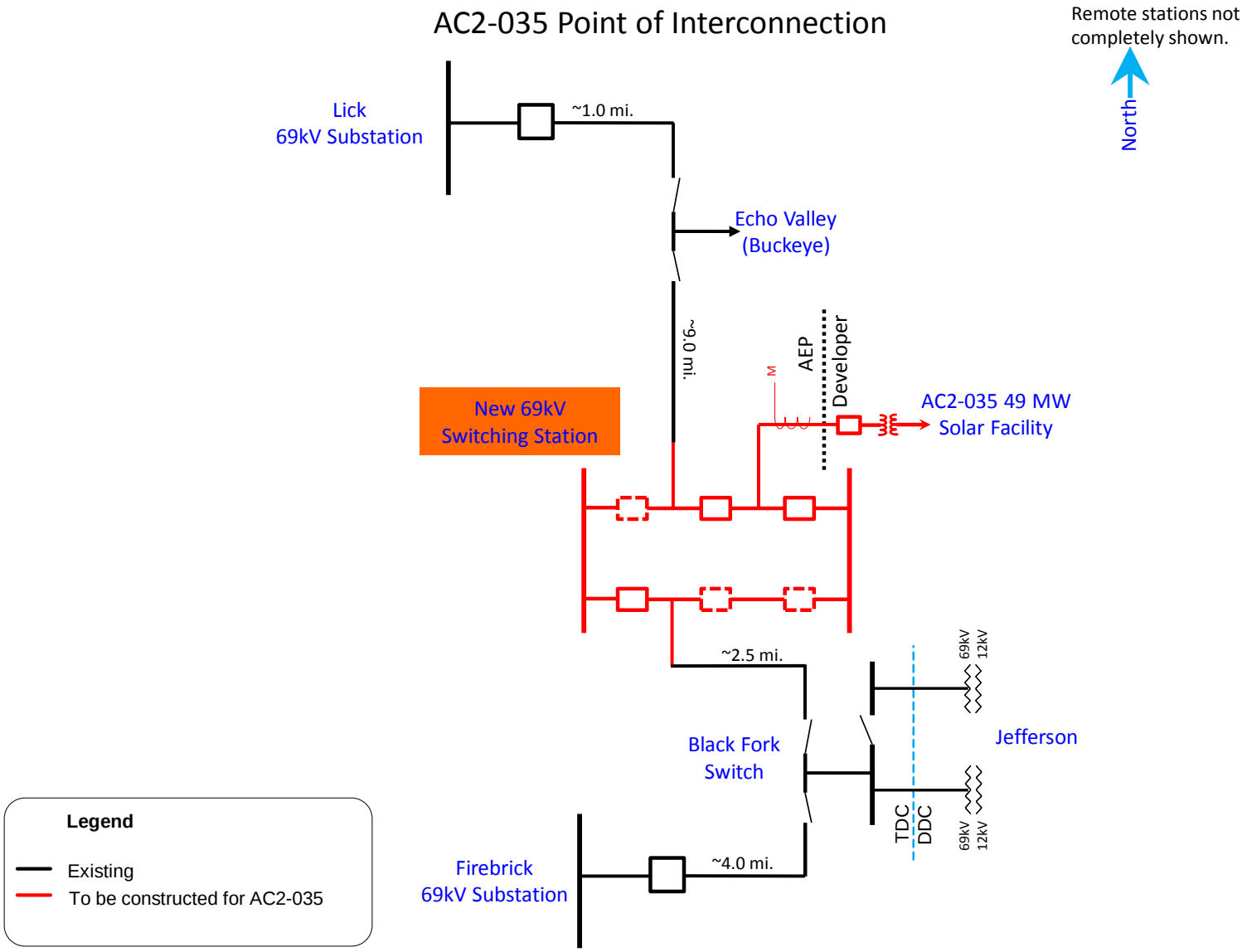
Cost Breakdown for Point of Interconnection (Lick-Firebrick 69 kV)		
Attachment Cost	New 69 kV Switching Station	**$3,500,000**
Direct Connection Cost Estimate	Lick-Firebrick 69 kV T-Line Cut In	**$700,000**
Non-Direct Connection Cost Estimate	69 kV Revenue Metering	**$200,000**
	Upgrade line protection and controls at the Lick 69 kV substation to coordinate with the new 69 kV switching station.	**$200,000**
	Upgrade line protection and controls at the Firebrick 69 kV substation to coordinate with the new 69 kV switching station.	**$200,000**
	A Sag Study will be required on the 3.40 mile section of line to mitigate the overload on the Millbrook Park – North Portsmouth 138 kV line to determine if the line can be operated above its emergency rating of 185 MVA. The result could prove that no additional upgrades are necessary, that some upgrades on the circuit are necessary, or that the entire 3.40 mile section of line would need to be rebuilt.	**$15,000**
	Total Estimated Cost for Project AC2-035	**$4,815,000**

Table 7

The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. The cost of remediation for sag limited conductors is not included in this estimate. Final estimates will require an on-site review and coordination to determine final construction requirements.

Figure 1: Point of Interconnection (Lick – Firebrick 69 kV)

Single-Line Diagram



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

(AEP - AEP) The 05MILLBR-05N PORT 138 kV line (from bus 243042 to bus 243047 ckt 1) loads from 62.03% to 62.63% (**DC power flow**) of its emergency rating (185 MVA) for the tower line contingency outage of '7981_B'. This project contributes approximately 2.46 MW to the thermal violation.

CONTINGENCY '7981_B'

OPEN BRANCH FROM BUS 931430 TO BUS 249995 CKT 1 / 931430 AC2-061 TAP 138 249995 08CLINCO 138 1

OPEN BRANCH FROM BUS 243019 TO BUS 253111 CKT 1 / 243019 05HILLSB 138 253111 09MIDDLE 138 1

OPEN BRANCH FROM BUS 249995 TO BUS 250122 CKT 1 / 249995 08CLINCO 138 250122 08WARRN1 138 1

OPEN BRANCH FROM BUS 253111 TO BUS 253057 CKT 1 / 253111 09MIDDLE 138 253057 09OHH 138 1

END

Bus Number	*Bus Name*	*Full Contribution*
342948	*1LOVE HYDRO*	*2.67*
931022	*AC2-008 E*	*0.86*
931121	*AC2-019 C*	*0.21*
931122	*AC2-019 E*	*0.34*
931192	*AC2-027 E*	*0.55*
931221	*AC2-031 C*	*7.33*
931222	*AC2-031 E*	*3.61*
931231	*AC2-035 C*	*1.48*
931232	*AC2-035 E*	*0.99*
931281	*AC2-042 C*	*22.91*
931282	*AC2-042 E*	*15.28*

Bus Number	*Bus Name*	*Full Contribution*
931351	*AC2-049 C*	*6.96*
931352	*AC2-049 E*	*4.64*
931431	*AC2-061 C*	*6.36*
931432	*AC2-061 E*	*6.45*
931441	*AC2-062 C OP*	*1.1*
931442	*AC2-062 E OP*	*1.79*
931451	*AC2-064 C*	*16.35*
931452	*AC2-064 E*	*10.9*
247613	*X4-025*	*4.36*
926061	*AC1-085 C*	*16.63*
926062	*AC1-085 E*	*27.14*
926101	*AC1-089 C*	*5.58*
926102	*AC1-089 E*	*9.11*
926631	*AC1-144 C*	*7.36*
926632	*AC1-144 E*	*3.58*