Generation Interconnection Impact Study Report

For

PJM Generation Interconnection Request Queue Position AD1-130

Hardin Switch 345 kV

February 2019

Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. 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. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

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 or merchant transmission upgrade, 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 System Impact Study is performed.

The System Impact 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

Invenergy Solar Development North America, LLC proposes to install PJM Project #AD1-130, a 170.0 MW (115.0 MW Capacity) solar generating facility in Hardin County, OH (see Figure 2). The point of interconnection for the generating facility will be to interconnect to the proposed Hardin Switch 345 kV switching station connecting to AEP's East Lima – Marysville 345 kV line being built for PJM Project #U2-041 (See Figure 1).

The requested in service date is December 31, 2019.

PJM has issued this System Impact Study without ICTR determinations. PJM will work with each customer to identify the Customer-Funded Upgrade(s) and LDAs (no more than three) for which the customer wants PJM to determine ICTRs. PJM will provide that determination as quickly as practicable following issuance of this System Impact Study.

Attachment Facilities

Point of Interconnection (Hardin Switch 345 kV)

Has been (or to be) constructed by PJM Project #U2-041.

Note: It is assumed that the 345 kV revenue metering and gen lead installed for #U2-041 will be adequate for the additional generation of AD1-130. Physical changes to the Protection and Control systems will be needed for either AB2-170 (Facilities Study now underway) or for AD1-130, whichever comes first. Settings changes will need to be reviewed for possible revisions for the second additional queue position if they are placed in-service separately. Assuming that the projects proceed in queue order, the estimated cost for relay setting review/revision for AD1-130 is $25,000. This is a non-direct connection and listed in the Table 1 below

In addition, the topology on the customer-side of the POI as submitted as part of the most recent interconnection request connecting at Hardin Switch (AE1-090) is no longer consistent with the configuration documented in the U2-041 and V3-028 Agreements. Construction of the U2-041 and V3-028 facilities is not yet completed. The scope and estimates provided for AD1-130 may be affected by resolution of the discrepancies.

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:

Type of Network Upgrade	Network Upgrade Number	Description	Estimated Cost
Non-Direct Connection Cost Estimate	**n5986**	Modify Relay Settings for Hardin Switch 345 kV	**$25,000**
		Total Estimated Cost for Project AD1-130	**$25,000**

Table 1

Interconnection Customer Requirements

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

The Queue Project AD1-130 was evaluated as a 170.0 MW (Capacity 115.0 MW) injection to the U2-041 345kV switching station in the AEP area. Project AD1-130 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional

Reliability Councils, and Transmission Owners). Project AD1-130 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Base case used

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

None

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None

Stability Analysis

No violations were identified in the Stability Analysis; however a data submission error by Invenergy was discovered during the analysis. The error has been corrected and Stability Analysis results will be confirmed during the Facilities Study.

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.

1. (AEP - FE) The 05HOWARD-02BRKSID 138 kV line (from bus 243024 to bus 238586 ckt 1) loads from 100.25% to 102.15% (AC power flow) of its normal rating (167 MVA) for non-contingency condition. This project contributes approximately 3.73 MW to the thermal violation.

System Reinforcements

None

Winter 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)

To be determined

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).

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Not Applicable

Winter Peak Load Flow Analysis Reinforcements

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.

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 Impact Study, the construction of Invenergy Solar's 170.0 MW (115.0 MW Capacity) solar generating facility (PJM Project #AD1-130) will the relay settings to be evaluated and modified at the Hardin Switch 345 kV Substation

Type of Network Upgrade	Network Upgrade Number	Description	Estimated Cost
Non-Direct Connection Cost Estimate	**n5986**	Modify Relay Settings for Hardin Switch 345 kV Substation	**$25,000**
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Table 2

Figure 1: Point of Interconnection (Hardin Switch 345 kV)

Single-Line Diagram

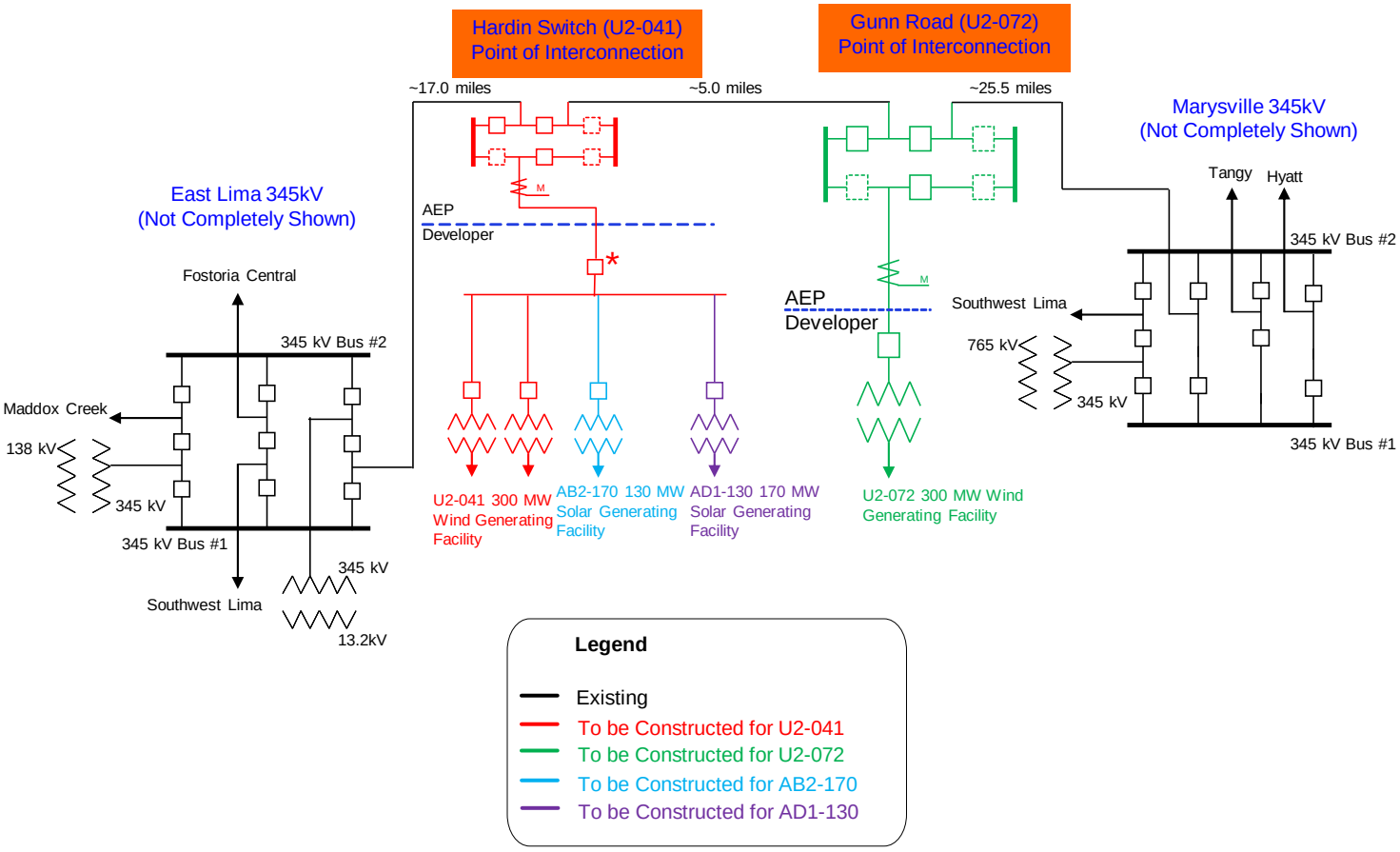

Figure 2: Point of Interconnection (Hardin Switch 345 kV)