# *Generation Interconnection Feasibility Study Report*

# *For*

# *PJM Generation Interconnection Request Queue Position AD1-140*

# *Greene-Clark 138 kV*

**April 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.

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.

The conduct of light load analysis as required under the PJM planning process is not performed during the Generation Interconnection Feasibility Study phase of the PJM study process. Additional reinforcement requirements for this Interconnection Request may be defined during the conduct of the light load analysis which shall be performed following execution of the System Impact Study agreement.

# General

The Interconnection Customer (IC), has proposed a Solar generating facility located in Greene County, Ohio. The installed facilities will have a total capability of 200 MW with 102 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is May 29, 2020. **This study does not imply a ATSI commitment to this in-service date.**

## Point of Interconnection

AD1-140 will interconnect with the ATSI transmission system at one of the following:

Primary POI:
Along the Clark-Greene 138kV line
10.9 Miles from Greene Substation (39.782, -83.830)

Secondary POI:
Cost Along the Clark-Greene 138kV line
15.8 Miles from Greene Substation (39.833, -83.781)

## Summary

The AD1-140 project will be responsible for the following costs:

| Description | Total Cost |
|---|---|
| Attachment Facilities | $ 0 |
| Direct Connection Network Upgrades | $ 5,021,800 |
| Non Direct Connection Network Upgrades | $ 5,548,700 |
| **Total Costs** | **$ 10,570,500** |

In addition, the AD1-140 project may be responsible for a contribution to the following costs:

| Description | Total Cost |
|---|---|
| New System Upgrades | $ 0 |
| Previously Identified Upgrades | $ 3,368,000 |
| **Total Costs** | **$ 3,368,000** |

Cost allocations for these upgrades will be provided in the System Impact Study Report.

## Attachment Facilities

No Attachment Facilities are required to support this interconnection request.

## Direct Connection Cost Estimate

The total preliminary cost estimate for the Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

| Description | Activity Cost | Tax (if applicable) | Total Cost |
|---|---|---|---|
| Install a new 138kV 3 breaker ring bus switchyard for 200MW of solar generation. The new switchyard will cut the Greene and Clark lines. @ AD1-140 Interconnect | $ 4,543,300 | $ 620,500 | $ 5,163,800 |
| Install one (1) span from the AD1-140 Interconnection sub to customer owned wood monopole strain structure. @ AD1-140 Interconnection Sub Customer Span | $ 451,100 | $ 59,400 | $ 510,500 |
| Modify substation and switchboard nameplates as well as drawings. @ AD1-140 Collector Substation | $ 27,400 | $ 3,700 | $ 31,100 |
| **Total Direct Connection Facility Costs** | **$ 5,021,800** | **$ 683,600** | **$ 5,705,400** |

## Non-Direct Connection Cost Estimate

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

| Description | Activity Cost | Tax (if applicable) | Total Cost |
|---|---|---|---|
| Loop the Clark-Greene 138kV circuit into the AD1-140 ring bus. The proposed location of the new ring bus is near structure #5604. @ Clark-Greene 138kV Loop to AD1-140 Ring Bus | $ 390,600 | $ 51,500 | $ 442,100 |
| Install OPGW on the Clark-Greene 138kV line between Clark Substation and the AD1-140 Ring Bus Loop, 16.5 miles. The proposed location of the new ring bus is near structure #5604. @ Clark-Greene (DPL) 138kV OPGW Installation | $ 4,682,000 | $ 609,900 | $ 5,291,900 |
| Adjust remote, relaying, and metering settings at Clark Substation. | $ 451,100 | $ 59,400 | $ 510,500 |

| Description | Activity Cost | Tax (if applicable) | Total Cost |
|---|---|---|---|
| Adjust remote, relaying, and metering settings at Greene Substation. | $ 25,000 | $ 3,292 | $ 28,292 |
| **Total Non-Direct Connection Facility Costs** | **$ 5,548,700** | **$ 724,092** | **$ 6,272,792** |

# Transmission Owner Scope of Work

The primary Point of Interconnection (POI) for the AD1-140 generation project is located one span outside of the proposed ATSI ring bus switch station which will be located on the Clark-Greene 138kV line. The direct connection of AD1-140 generation project will be accomplished by utilizing a three (3) breaker ring bus to connect to the Clark-Greene 138 kV Line. A conceptual one-line diagram of the proposed connection of AD1-140 generation project to the FE / ATSI transmission system is provided in the attachments. The Interconnection Customer will be responsible for constructing all the facilities on their side of the POI, including the 138 kV Line extension to its generation facilities. Interconnection Customer may not install above ground equipment within any FirstEnergy right-of-way unless permission to do so is expressly granted by FirstEnergy.

Based on the extent of the ATSI primary direct connection required to support the AD1-140 generation project, it is expected to take a minimum of twenty-three (23) months from the date of a fully executed Interconnection Construction Service Agreement to complete the installation. This includes the requirement for Interconnection Customer to make a preliminary payment to ATSI which funds the first three months of engineering design that is related to the construction of the direct connection facilities. It further assumes that Interconnection Customer will provide all rights-of-way, permits, easements, etc. that will be needed. A further assumption is that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined direct connection and facility upgrades, and that all system outages will be allowed when requested.

Note that the FE findings were made from a conceptual review of this project. A more detailed review of the connection facilities and their cost will be identified in the System Impact Study. Further note that the cost estimate data contained in this document should be considered high level estimates since it was produced without a detailed engineering review. The applicant will be responsible for the actual cost of construction. FE herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the transmission or sub-transmission systems.

# Interconnection Customer Requirements

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.

3. The Interconnection Customer seeking to interconnect a solar generation facility larger than 3MW shall maintain meteorological data facilities as well as provide that meteorological data which is required per PJM Manual 3 and the Interconnection Service Agreement.

4. The AD1-140 generation facility shall design its solar facility with the ability to maintain a power factor of at least 0.95 leading to 0.95 lagging power factor measured at the high-side of the facility substation transformers.

5. The purchase and installation of fully rated 138 kV circuit breakers on the high side of the AD1-140 step-up transformer.

6. The purchase and installation of the minimum required ATSI generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

7. The purchase and installation of supervisory control and data acquisition (SCADA) equipment to provide information in a compatible format to the FE Transmission System Control Center.

8. The establishment of dedicated communication circuits for SCADA to the FE Transmission System Control Center.

9. A compliance with the FE and PJM generator power factor and voltage control requirements.

10. The execution of a back-up service agreement to serve the customer load supplied from the AD1-140 generation project metering point when the units are out-of-service. This assumes the intent of Interconnection Customer is to net the generation with the load.

# 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.

## FE Requirements

The Interconnection Customer will be required to comply with all FE Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "FirstEnergy Requirements for Transmission Connected Facilities" document located at the following links:

http://www.firstenergycorp.com/feconnect
http://www.pjm.com/planning/design-engineering/to-tech-standards.aspx

## Compliance Issues

The proposed interconnection facilities must be designed in accordance with the FE "Requirements for Transmission Connected Facilities" located at:

http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx

Interconnection Customer will be responsible for following the requirements of the "FE Approved Vendors and Contractors" documents which is also located at the above link.

Interconnection Customer will also be required to meet all PJM, ReliabilityFirst and NERC reliability criteria and operating procedures for standards compliance. For example, Interconnection Customer will need to properly locate and report the over and under voltage and over and under frequency system protection elements for its units as well as the submission of the generator model and protection data required to satisfy the PJM and ReliabilityFirst audits. Failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the ATSI system.

# Network Impacts

## Option 1

The Queue Project AD1-140 was evaluated as a 200.0 MW (Capacity 102.0 MW) injection tapping Clark to Greene 138kV line in the Dayton area. Project AD1-140 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD1-140 was studied with a commercial probability of 53%. Potential network impacts were as follows:

# Summer Peak Analysis - 2021

## Contingency Descriptions

The following contingencies resulted in overloads:

| Contingency Name | Description |
|---|---|
| AEP_P1-2_#349 | CONTINGENCY 'AEP_P1-2_#349'<br><br>OPEN BRANCH FROM BUS 242528 TO BUS 248005 CKT 1 / 242528 05SPORN 345 248005 06KYGER 345 1<br><br>END |
| AEP_P7-1_#468 | CONTINGENCY 'AEP_P7-1_#468'<br><br>OPEN BRANCH FROM BUS 239133 TO BUS 243458 CKT 1 / 239133 02TANGY 345 243458 05HYATT 345 1<br><br>OPEN BRANCH FROM BUS 239133 TO BUS 242939 CKT 1 / 239133 02TANGY 345 242939 05MARYSV 345 1<br><br>END |

| Contingency Name | Description |
|---|---|
| ATSI-P7-1-OES-345-68T | CONTINGENCY 'ATSI-P7-1-OES-345-68T' /* TANGY-HYATT & TANGY-MARYSVILLE COMMON TOWER<br><br>DISCONNECT BRANCH FROM BUS 239133 TO BUS 243458 CKT 1 /* 02TANGY 345 05HYATT 345<br><br>DISCONNECT BRANCH FROM BUS 239133 TO BUS 242939 CKT 1 /* 02TANGY 345 05MARYSV 345<br><br>DISCONNECT BRANCH FROM BUS 239133 TO BUS 239134 CKT 3 /* 02TANGY 345 02TANGY 138<br><br>DISCONNECT BRANCH FROM BUS 239133 TO BUS 239134 CKT 4 /* 02TANGY 345 02TANGY 138<br><br>DISCONNECT BRANCH FROM BUS 239133 TO BUS 239134 CKT 5 /* 02TANGY 345 02TANGY 138<br><br>DISCONNECT BUS 239133 /* 02TANGY 345<br><br>END |

## 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)*

| | Contingency | | Affected | | Bus | | | Power | Loading % | | Rating | | MW | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Type | Name | Area | Facility Description | From | To | Circuit | Flow | Initial | Final | Type | MVA | Contribution | Ref |
| 1 | DCTL | ATSI-P7-1-OES-345-68T | AEP - FE | AC1-078 TAP-02LONDON 138 kV line | 926010 | 238908 | 1 | DC | 106.89 | 107.95 | ER | 242 | 4.83 | 1 |
| 2 | DCTL | AEP_P7-1_#468 | AEP - FE | AC1-078 TAP-02LONDON 138 kV line | 926010 | 238908 | 1 | DC | 106.89 | 107.95 | ER | 242 | 4.83 | |

*Note: Please see Attachment 3 for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper table in the Attachment.*

## Short Circuit

*(Summary of impacted circuit breakers)*

None.

## Potential Congestion due to Local Energy Deliverability

*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.*

| | Contingency | | Affected | | Bus | | | Power | Loading % | | Rating | | MW | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Type | Name | Area | Facility Description | From | To | Circuit | Flow | Initial | Final | Type | MVA | Contribution | Ref |
| 3 | N-1 | AEP_P1-2_#349 | OVEC - AEP | 06KYGER-05SPORN 345 kV line | 248005 | 242528 | 2 | DC | 130.53 | 131.2 | NR | 971 | 14.38 | |

### Steady-State Voltage Requirements

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

To be determined

## 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).

### OVEC Impacts:

OVEC Impacts to be determined during later study phases (as applicable).

## Light Load Analysis - 2021

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

## 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)*

| Violation # | Overloaded Facility | Upgrade Description | Network Upgrade Number | Upgrade Cost |
|---|---|---|---|---|
| #1, 2 | AC1-078 TAP-02LONDON 138 kV line | AEP:<br>Non-AEP element is limiting this line.<br><br>ATSI:<br>Reconductor approximately 8 miles of transmission line from the "London-Beatty 138 kV (AD1-081) Generation Project" point of interconnection to the London substation. Estimated Cost: $3,368,000. Estimated Schedule: minimum of twenty-three (23) months from the date of a fully executed Interconnection Construction Service Agreement to complete the installation | | **$ 3,368,000** |
| | | | **Total New Network Upgrades** | **$ 3,368,000** |

## Option 2

The Queue Project AD1-140 was evaluated as a 200.0 MW (Capacity 102.0 MW) injection tapping Clark to Greene 138kV line in the Dayton area. Project AD1-140 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD1-140 was studied with a commercial probability of 53%. Potential network impacts were as follows:

# Summer Peak Analysis - 2021

### Contingency Descriptions

The following contingencies resulted in overloads:

| Contingency Name | Description |
|---|---|
| AEP_P1-2_#349 | CONTINGENCY 'AEP_P1-2_#349'<br><br>OPEN BRANCH FROM BUS 242528 TO BUS 248005 CKT 1 / 242528 05SPORN 345 248005 06KYGER 345 1<br><br>END |
| AEP_P7-1_#468 | CONTINGENCY 'AEP_P7-1_#468'<br><br>OPEN BRANCH FROM BUS 239133 TO BUS 243458 CKT 1 / 239133 02TANGY 345 243458 05HYATT 345 1<br><br>OPEN BRANCH FROM BUS 239133 TO BUS 242939 CKT 1 / 239133 02TANGY 345 242939 05MARYSV 345 1<br><br>END |
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## 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)*

| | Contingency | | Affected | | Bus | | | Power | Loading % | | Rating | | MW | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Type | Name | Area | Facility Description | From | To | Circuit | Flow | Initial | Final | Type | MVA | Contribution | Ref |
| 1 | DCTL | ATSI-P7-1-OES-345-68T | AEP - FE | AC1-078 TAP-02LONDON 138 kV line | 926010 | 238908 | 1 | DC | 106.89 | 109.48 | ER | 242 | 6.27 | 1 |
| 2 | DCTL | AEP_P7-1_#468 | AEP - FE | AC1-078 TAP-02LONDON 138 kV line | 926010 | 238908 | 1 | DC | 106.89 | 109.48 | ER | 242 | 6.27 | |

*Note: Please see Attachment 3 for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper table in the Attachment.*

## Short Circuit

*(Summary of impacted circuit breakers)*

None.

### Steady-State Voltage Requirements

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

To be determined

## 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).

### OVEC Impacts:

OVEC Impacts to be determined during later study phases (as applicable).

# Light Load Analysis - 2021

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

## Potential Congestion due to Local Energy Deliverability

*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.*

| | Contingency | | Affected | | Bus | | | Power | Loading % | | Rating | | MW | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Type | Name | Area | Facility Description | From | To | Circuit | Flow | Initial | Final | Type | MVA | Contribution | Ref |
| 3 | N-1 | AEP_P1-2_#349 | OVEC - AEP | 06KYGER-05SPORN 345 kV line | 248005 | 242528 | 2 | DC | 130.54 | 131.16 | NR | 971 | 13.41 | |

**Attachment 1. Flowgate Details – Option 1**

# 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 - FE) The AC1-078 TAP-02LONDON 138 kV line (from bus 926010 to bus 238908 ckt 1) loads from 106.89% to 107.95% (**DC power flow**) of its emergency rating (242 MVA) for the tower line contingency outage of 'ATSI-P7-1-OES-345-68T'. This project contributes approximately 4.83 MW to the thermal violation.

| Bus Number | Bus Name | Full Contribution |
|---|---|---|
| 934561 | AD1-081 C | 4.87 |
| 934562 | AD1-081 E | 2.51 |
| 935043 | AD1-140 BAT | 4.83 |

| Bus Number | Bus Name | Full Contribution |
|---|---|---|
| 926011 | AC1-078 C | 24.35 |
| 926012 | AC1-078 E | 40.59 |

## Attachment 2. Flowgate Details – Option 2

# 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 - FE) The AC1-078 TAP-02LONDON 138 kV line (from bus 926010 to bus 238908 ckt 1) loads from 106.89% to 109.48% (**DC power flow**) of its emergency rating (242 MVA) for the tower line contingency outage of 'ATSI-P7-1-OES-345-68T'. This project contributes approximately 6.27 MW to the thermal violation.

| Bus Number | Bus Name | Full Contribution |
|---|---|---|
| 934561 | AD1-081 C | 4.87 |
| 934562 | AD1-081 E | 2.51 |
| 935043 | AD1-140 BAT | 6.27 |
| LTF | AMIL | 0.04 |
| LTF | BAYOU | 0.06 |
| LTF | BIG_CAJUN1 | 0.08 |
| LTF | BIG_CAJUN2 | 0.17 |
| LTF | BLUEG | 0.34 |
| LTF | CANNELTON | 0.05 |
| LTF | CBM-N | < 0.01 |
| LTF | CBM-S2 | 0.15 |
| LTF | CHOCTAW | 0.05 |
| LTF | CLIFTY | 0.17 |
| LTF | COTTONWOOD | 0.25 |
| LTF | CPLE | 0.05 |
| LTF | DEARBORN | 0.49 |
| LTF | EDWARDS | 0.08 |
| LTF | ELMERSMITH | 0.13 |
| LTF | FARMERCITY | 0.04 |
| LTF | G-007A | 0.15 |
| LTF | GIBSON | 0.11 |
| LTF | MORGAN | 0.07 |
| LTF | NEWTON | 0.2 |
| LTF | NYISO | 0.02 |
| LTF | O-066A | 0.07 |
| LTF | PRAIRIE | 0.33 |
| LTF | SMITHLAND | 0.02 |
| LTF | TATANKA | 0.09 |
| LTF | TILTON | 0.11 |
| LTF | TRIMBLE | 0.07 |
| LTF | TVA | 0.03 |
| LTF | VFT | 0.41 |
| LTF | X1-078 | 0.12 |
| 926011 | AC1-078 C | 24.35 |
| 926012 | AC1-078 E | 40.59 |