Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AE1-160

Venango 34.5 kV

May 2019

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), has proposed a solar generating facility located in Venango County, PA. The installed facilities will have a total capability of 20 MW with 12.7 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is January 4, 2021. **This study does not imply a Penelec commitment to this in-service date.**

Point of Interconnection

AE1-160 will interconnect with the Penelec distribution system along the Venango 34.5kV circuit.

Cost Summary

The AE1-160 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 176,200
Direct Connection Network Upgrades	$ 0
Non Direct Connection Network Upgrades	$ 14,500
Total Costs	**$ 176,200**

The transmission and substation costs given above exclude the Contribution in Aid of Construction ("CIAC") Federal Income Tax Gross up charge. If at a future date Federal CIAC taxes are deemed necessary by the IRS for this project, ATSI shall be reimbursed by the Interconnection Customer for such taxes. ATSI estimates the tax, if applicable, would be approximately $33,800.

In addition, the AE1-160 project may be responsible for a contribution to the following costs:

Description	Total Cost
System Upgrades	$ 109,300

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

Attachment Facilities

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

Description	Total Cost
Tap on the Colonel Drake 34.5 kV line and associated 34.5 kV metering package	$ 176,200
Total Attachment Facility Costs	**$ 176,200**

Direct Connection Cost Estimate

No Direct Connection Facilities are required to support this interconnection request.

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	Total Cost
Titusville 34.5kV SS. Remote Relay and Metering Settings at Titusville 34.5kV.	$ 14,500
Total Non-Direct Connection Facility Costs	**$ 14,500**

Transmission Owner Scope of Work

The IC has submitted a "Generation Interconnection Feasibility Study Agreement" that identifies their proposal for the connection of a 20 MW (12.7 MW Capacity) solar generation project on the 34.5kV the First Energy distribution system via a tap on the 34.5 kV Colonel Drake circuit at pole # T1-35751. The IC's proposed generating unit site is approximately 3.8 miles south of Titusville, PA., off William Flinn Highway.

This project is being studied for a single point of interconnection (POI). The POI is a 34.5kV interconnection via the Colonel Drake circuit at the Penelec-owned Titusville substation.

The IC is responsible for constructing all of the facilities on its side of the point of interconnection, on the line to the generating plant.

The 34.5kV interconnection point will require the installation of a Penelec installed/owned disconnect switch (which will act as the disconnect point between First Energy and the generator interconnection, POI).

Below are conceptual estimates for the engineering/construction associated with Direct Connection requirements.

Conceptual Estimate: $224,500
Estimated Lead Time: 1.0 year from signed IA

Notes:

- Detailed Engineering & Construction Estimates TBD via Facility Study
- The above estimates do not include 1) property costs and site development up to rough grade which is to be provided by the developer, and 2) generation SCADA to be provided by the developer.

Conceptual estimates are provided for the assumption that the point of interconnection would be a connection on the 34.5kV Colonel Drake line and that the customer interconnection substation would be at a site approximately 3.8 miles south of Titusville, PA.

Based on the scope of the FE direct connection, it is expected to take approximately one (1) year from the signing of a Construction Service Agreement to complete the direct and non-direct connection construction installation required for the Venango 34.5kV (AE1-160) Project.

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 wind generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per item 5.iv. of Schedule H to the Interconnection Service Agreement.

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

5. The installation of a Penelec provided 34.5 kV interconnection metering instrument transformer. FE will provide the ratio and accuracy specifications based on the customer load and generation levels.

6. The installation of a Penelec provided revenue class meter for each unit to measure the power delivered in compliance with the FE standards.

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 report 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 retail service agreement with the electric distribution company to serve the customer load supplied from the AE1-160 generation project interconnection point when the units are out-of-service. This assumes the intent of The IC is to net the generation with the load.

11. The rough grade of the property for the AE1-160 Interconnection 34.5 kV tap pole and an access road for the delivery of equipment to this site. The above requirements are in addition to any metering and telecommunications required by PJM as specified in PJM Manuals M-01 and M-14D

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.

Metering

Interconnection metering is also required for this generation connection. The 34.5 kV revenue quality metering equipment shall be designed, furnished and installed by FirstEnergy. The Interconnection Customer will be responsible for designing, furnishing and installing a SCADA RTU in their generation substation and obtaining the telecommunication circuits from the RTU to the Penelec Data Center. The connection to the Penelec Data Center will be to provide MW, MVAR and 34.5kV voltage at customers generation substation. Please reference the FirstEnergy Metering Requirements for Interconnection Customers, for more details on the metering requirements for FirstEnergy. This document can be found on the FE website at:

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

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

System Protection

An analysis was conducted to assess the impact of the Venango 34.5 kV (AE1-160) Project on the system protection requirements in the area. The results of this review show that the following relay additions will be required:

Proposed single line diagrams show The IC (Developer) constructing a generation facility they call "Venango" tapping Penelec's Titusville-34.5kV Colonel Drake at pole T1-35751.

The 34.5kV interconnection proposal will require Developer to meet applicable "Technical Requirements" as outlined in First Energy's document titled "Technical Requirements for the Interconnection of Customer-Owned Generation to the FirstEnergy Distribution System".

Protection requirements are included in the "Technical Requirements" document.

General Concerns

It is to be understood, for abnormal operation of the Penelec system, which could cause Developer's generation facility to be electrically isolated from the Penelec system synchronous source via the tripping of a interconnecting primary voltage line or device, Developer will, via Penelec's direction, be required to disconnect the generation from Penelec's system and remain disconnected (units are required to be OFF LINE), until the Penelec system normal circuitry is restored. These abnormal conditions will be reviewed by Penelec system operators as to the need for the generation facility to be disconnected.

Requirements for Owner's/Developer's generation IPP Facility

The proposed interconnection Owner's/Developer's facilities must be designed in accordance with the document titled FirstEnergy Distribution Engineering Practices Interconnection of Customer-Owned Generation to the FirstEnergy Distribution System dated 11/17/14 located at the following link:

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

The document is referred to as engineering practice EP(# 02-280) with section 4 part C specifically referencing the "interconnection technical requirements". Certain protection requirement are shown.

Additionally, Owner/Developer is responsible to provide adequate protection (for their equipment) under any distribution system operating condition' - which includes 'Separation from supply' (i.e. tripping of F.E. circuit breakers) and 'Re-synchronizing the generation after electric restoration of the supply' (i.e. reclosing of F.E. circuit breakers).

Owner's/Developer's protection must be designed to coordinate with the reclosing practices of FirstEnergy line protective devices. The generator must cease to energize the FirstEnergy circuit to which it is connected prior to reclosing of any (FE) automatic reclosing devices.

Owners/Developer's electrical protection and control schematics shall be provided to FE for consideration. FE may request modifications, if required, to meet the technical requirements.

Compliance Issues

The IC will be responsible for meeting a power factor between 0.90 lagging (producing MVARs) to 0.95 leading (absorbing MVARs) and assure that voltage deviation will be less than 1.0 volt as measured at the POI under all Solar Gen operating conditions due to the inherent dynamic reactive power capability of this solar facility.

Generators with no inherent VAR (reactive power) control capability, or those that have a restricted VAR capability less than the defined requirements, must provide dynamic supplementary reactive support located at the generation facility with electrical characteristics equivalent to that provided by a similar sized synchronous generator. A Dynamic Reactive Compensation (either Static VAR Compensator (SVC) or STATCOM) or other method be applied in order to maintain the required specifications at the POI. The IC is responsible for the installation of equipment on its side of the POI in order to adhere to the criteria stated above by FirstEnergy.

Network Impacts

The Queue Project AE1-160 was evaluated as a 20 MW (Capacity 12.7 MW) injection at the Titusville 34.5kV substation in the PENELEC area. Project AE1-160 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-160 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Analysis – 2022

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Contingency Definition
ATSI-P2-3-CEI-138-124	CONTINGENCY 'ATSI-P2-3-CEI-138-124' /* AT BUS 138KV_ BRKR FAILURE - Q-8-AT-T_ Q-3-AT-C_ (OR BUS FAULT - SECT. 3) DISCONNECT BRANCH FROM BUS 238544 TO BUS 239082 CKT 8 /* 02ASH_3 138 02S8-ATT 345 DISCONNECT BRANCH FROM BUS 238544 TO BUS 238543 CKT ZB /* 02ASH_3 138 02ASH_2 138 DISCONNECT BRANCH FROM BUS 238544 TO BUS 239098 CKT 1 /* 02ASH_3 138 02SBRNQ4 138 DISCONNECT BRANCH FROM BUS 238544 TO BUS 239182 CKT 1 /* 02ASH_3 138 02ZNQ-16 138 DISCONNECT BUS 238544 /* 02ASH_3 138 DISCONNECT BUS 238692 /* 02ELKEM 138 END
PN-P2-3-PN-345-004J	CONTINGENCY 'PN-P2-3-PN-345-004J' /* ERIE WEST STUCK BKR B 79 DISCONNECT BRANCH FROM BUS 200599 TO BUS 200595 CKT 1 /* 26ERIE W 345 26WAYNE 345 END
ATSI-P2-4-CEI-138-125	CONTINGENCY 'ATSI-P2-4-CEI-138-125' /* AT BUS 138KV_ BRKR FAILURE - Q-2-3-AT-TIE DISCONNECT BRANCH FROM BUS 238544 TO BUS 239082 CKT 8 /* 02ASH_3 138 02S8-ATT 345 DISCONNECT BRANCH FROM BUS 238544 TO BUS 238543 CKT ZB /* 02ASH_3 138 02ASH_2 138 DISCONNECT BRANCH FROM BUS 238544 TO BUS 239098 CKT 1 /* 02ASH_3 138 02SBRNQ4 138 DISCONNECT BRANCH FROM BUS 238544 TO BUS 239182 CKT 1 /* 02ASH_3 138 02ZNQ-16 138 DISCONNECT BRANCH FROM BUS 238543 TO BUS 238542 CKT ZB /* 02ASH_2 138 02ASH_1 138 DISCONNECT BRANCH FROM BUS 238543 TO BUS 239096 CKT 1 /* 02ASH_2 138 02SBRNQ2 138 DISCONNECT BRANCH FROM BUS 238543 TO BUS 239097 CKT 1 /* 02ASH_2 138 02SBRNQ3 138 DISCONNECT BRANCH FROM BUS 238543 TO BUS 238545 CKT 1 /* 02ASH_2 138 02ASHTG5 18 DISCONNECT BUS 238543 /* 02ASH_2 138 DISCONNECT BUS 238545 /* 02ASHTG5 18 DISCONNECT BUS 238544 /* 02ASH_3 138 DISCONNECT BUS 238692 /* 02ELKEM 138 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)

ID	FROM BUS#	FROM BUS	FROM BUS AREA	TO BUS#	TO BUS	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
753639	200585	26TITUSVIL	PENELEC	200571	26UNION CY	PENELEC	1	PN-P2-3-PN-345-004J	breaker	120.0	79.02	85.08	DC	7.27
149976	238547	02AT	ATSI	239036	02PERRY	ATSI	1	ATSI-P2-4-CEI-138-125	breaker	1891.0	99.99	100.35	DC	6.82
149977	238547	02AT	ATSI	239036	02PERRY	ATSI	1	ATSI-P2-3-CEI-138-124	breaker	1891.0	99.99	100.35	DC	6.82

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.

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

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.

None

System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation) (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)

ID	Index	Facility	Upgrade Description	Cost
753639	1	**26TITUSVIL 115.0 kV - 26UNION CY 115.0 kV Ckt 1**	**PENELEC** Description : No Violation. Facility loading does not exceed 100%.	$0
149976,149977	2	**02AT 345.0 kV - 02PERRY 345.0 kV Ckt 1**	**ATSI** Description : Replace terminal equipment at Perry substation to increase the Perry-Ashtabula-Erie West 345kV line ratings Time Estimate : 6.0 Months Cost : $109,300	$109,300
			TOTAL COST	**$109,300**

Attachment 3. Flowgate Details

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.

Index 1

ID	FROM BUS#	FROM BUS	FROM BUS AREA	TO BUS#	TO BUS	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
753639	200585	26TITUSVIL	PENELEC	200571	26UNION CY	PENELEC	1	PN-P2-3-PN-345-004J	breaker	120.0	79.02	85.08	DC	7.27

Bus #	Bus	MW Impact
200662	26SCRUB GR	1.69
935191	AD1-154	1.14
938951	AE1-123	1.46
939291	AE1-160 C	4.62
939292	AE1-160 E	2.65
939381	AE1-169 C O1	16.06
939382	AE1-169 E O1	10.71
BAYOU	BAYOU	0.17
BIG_CAJUN1	BIG_CAJUN1	0.26
BIG_CAJUN2	BIG_CAJUN2	0.53
BLUEG	BLUEG	0.98
CALDERWOOD	CALDERWOOD	0.08
CANNELTON	CANNELTON	0.06
CARR	CARR	0.07
CATAWBA	CATAWBA	0.04
CHEOAH	CHEOAH	0.07
CHILHOWEE	CHILHOWEE	0.03
CHOCTAW	CHOCTAW	0.17
COFFEEN	COFFEEN	0.11
COTTONWOOD	COTTONWOOD	0.69
DEARBORN	DEARBORN	0.31
DUCKCREEK	DUCKCREEK	0.24

Bus #	Bus	MW Impact
EDWARDS	EDWARDS	0.11
ELMERSMITH	ELMERSMITH	0.1
FARMERCITY	FARMERCITY	0.07
G-007A	G-007A	0.4
GIBSON	GIBSON	0.04
HAMLET	HAMLET	0.1
NEWTON	NEWTON	0.28
O-066A	O-066A	0.18
PRAIRIE	PRAIRIE	0.5
RENSSELAER	RENSSELAER	0.05
SANTEETLA	SANTEETLA	0.02
SMITHLAND	SMITHLAND	0.04
TATANKA	TATANKA	0.13
TILTON	TILTON	0.13
TRIMBLE	TRIMBLE	0.11
TVA	TVA	0.28
UNIONPOWER	UNIONPOWER	0.12
VFT	VFT	1.07

Index 2

ID	FROM BUS#	FROM BUS	FROM BUS AREA	TO BUS#	TO BUS	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
149977	238547	02AT	ATSI	239036	02PERRY	ATSI	1	ATSI-P2-3-CEI-138-124	breaker	1891.0	99.99	100.35	DC	6.82

Bus #	Bus	MW Impact
200805	26COLVER13	14.57
200823	26MHP_X3-003	7.64
200828	26HNSMLK 1	2.84
200829	26HNSMLK 2	2.84
200830	26HNSMLK 3	2.84
200831	26HNSMLK 4	2.84
200832	26HNSMLK 5	2.84
200849	26LAKVU GN	0.36
200894	26K02	8.81
201201	26WRREN CT	2.96
203999	P-047 E	13.9
236828	01GRAYMONT	0.56
290086	Q-036 E	5.45
293393	V3-030E	3.47
294573	P-028 E	15.46
903643	W3-099 C OP1	5.69
903644	W3-099 E OP1	38.07
914101	Y2-055	9.8
915951	Y3-092 FTIR	553.52
916051	Z1-038	2.55
916202	Z1-069 E	11.41
916351	Z1-091	3.12
918682	AA1-082 E	8.69
918701	AA1-085 C	1.62
918702	AA1-085 E	10.79
918871	AA1-106	3.2
919201	AA1-144 O1	24.71
919491	AA2-000	75.52
920341	AA2-132	3.43
925512	AC1-025 E	0.2
930411	AB1-082	4.36
930511	AB1-092	2.77
931092	AB1-160 E	3.26
932571	AC2-077	4.0
935191	AD1-154	3.59
936421	AD2-055	5.71
936991	AD2-133 C	2.45
936992	AD2-133 E	11.21
938951	AE1-123	3.87
939171	AE1-147 C	1.68
939172	AE1-147 E	1.12
939291	AE1-160 C	4.33

Bus #	Bus	MW Impact
939292	AE1-160 E	2.49
939381	AE1-169 C O1	16.84
939382	AE1-169 E O1	11.22
AA2-500	AA2-500	246.15
BAYOU	BAYOU	3.39
BIG_CAJUN1	BIG_CAJUN1	5.16
BIG_CAJUN2	BIG_CAJUN2	10.38
BLUEG	BLUEG	18.59
CALDERWOOD	CALDERWOOD	1.59
CANNELTON	CANNELTON	1.11
CATAWBA	CATAWBA	0.82
CBM-N	CBM-N	7.45
CHEOAH	CHEOAH	1.45
CHILHOWEE	CHILHOWEE	0.52
CHOCTAW	CHOCTAW	3.39
COFFEEN	COFFEEN	2.0
COTTONWOOD	COTTONWOOD	13.52
DEARBORN	DEARBORN	5.03
DUCKCREEK	DUCKCREEK	4.5
EDWARDS	EDWARDS	2.07
ELMERSMITH	ELMERSMITH	1.9
FARMERCITY	FARMERCITY	1.3
G-007A	G-007A	9.43
GIBSON	GIBSON	0.78
HAMLET	HAMLET	2.4
NEWTON	NEWTON	5.19
NYISO	NYISO	32.61
O-066A	O-066A	4.54
PRAIRIE	PRAIRIE	9.39
SANTEETLA	SANTEETLA	0.42
SMITHLAND	SMITHLAND	0.71
TATANKA	TATANKA	2.4
TILTON	TILTON	2.45
TRIMBLE	TRIMBLE	2.07
TVA	TVA	5.53
UNIONPOWER	UNIONPOWER	2.42
VFT	VFT	25.9