Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AE1-128

Bedford North – Wills Mountain 115kV

March 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/storage generating facility located in Bedford, PA. The storage facilities will be DC connected behind the Interconnection Customers inverters, and will not have any rights associated with them. The installed facilities will have a total capability of 120 MW with 72 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is December 31, 2021. **This study does not imply a Allegheny Electric Cooperative, Inc. (AEC) commitment to this in-service date.**

Point of Interconnection

AE1-128 will interconnect with the AEC transmission system along one of the following points of interconnection:

- Bedford North – Wills Mountain (Bedford South) 115 kV Line (AEC)
- Wills Mountain (Bedford South) 115 kV Substation (AEC)

Cost Summary

The AE1-128 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 100,000
Direct Connection Network Upgrades	$ 3,940,000
Non Direct Connection Network Upgrades	$ 2,002,000
Total Costs	**$ 6,042,000**

In addition, the AE1-128 project may be responsible for a contribution to the following costs:

Description	Total Cost
System Upgrades	$ 35,000,000
Total Costs	**$ 35,000,000**

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

General Information

Interconnected Transmission Owner ("TO"): Allegheny Electric Cooperative ("AEC"). AEC is a PJM Transmission owner per Attachment L of the PJM OATT

Impacted TO(s) (if applicable): Mid-Atlantic Interstate Transmission, LLC ("MAIT")

PJM Zone: Penelec

FE Operating Company or Planning Region: Penelec

Customer Connection Request

Requested Backfeed Date: n/a

Requested Commercial Operation Date: 12/31/2021

This study does not imply a FirstEnergy commitment to these dates.

New Facilities		Existing Facilities	
Capacity:	72 MW	Capacity:	0 MW
Energy:	120 MW	Energy:	0 MW
MFO[1]:	120 MW	MFO:	0 MW
Fuel:	Solar and Battery	Prior Queue Position(s):	n/a

Point of Interconnection

Primary Point of Interconnection: Bedford North – Wills Mountain (Bedford South) 115 kV Line (AEC)

Secondary Point of Interconnection: Wills Mountain (Bedford South) 115 kV Substation (AEC)

[1] Maximum Facility Output

The following cost estimates are provided for the primary POI. Cost estimates for the Primary and secondary POI's are provided on pages 11- 12.

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
Install attachment facility line and associated hardware to accept the Interconnection Customer generator lead line terminating at the AE1-128 Interconnection substation. And Install metering.	$ 100,000
Total Attachment Facility Costs	**$ 100,000**

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	Total Cost
AEC: Build new three-breaker ring bus station for AEC-owned POI protection. Build on AEC 115 kV lines.	$ 3,490,000
AEC: Install communications for transfer trip scheme. Fiber communication is strongly recommended.	$ 350,000
AEC: Engineering/Design (spec equipment, design protection schemes, program $100,000 relays, design communications schemes, SCADA integration, etc.)	$ 100,000
Total Direct Connection Facility Costs	**$ 3,940,000**

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
Penelec: Replace relaying at Bedford North substation. The calculated tax amount of $52,200 is not included in the estimate on the right.	$ 252,000
AEC: Transmission tower & line modifications to facilitate interconnection.	$ 1,500,000
AEC: Remote end terminal work.	$ 250,000
Total Non-Direct Connection Facility Costs	**$ 2,002,000**

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.

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

The IC will be require to comply with all FE revenue metering requirements for generation interconnection customers which can be found in FE's "Requirements for Transmission Connected Facilities" document located 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

The IC must design it's Customer Facilities in accordance with all applicable standards, including the standards in FE's "Requirements for Transmission Connected Facilities" document located at: http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx. Preliminary Protection requirements will be provided as part of the Facilities Study. Detailed Protection Requirements will be provided once the project enters the construction phase.

FIRST ENERGY (PENELEC) SCOPE OF WORK

Primary POI

The IC is proposing to interconnect with the Allegheny Electric Cooperative ("AEC") owned Bedford North – Wills Mountain (Bedford South) 115 kV line. AEC has the responsibility to provide the interconnection requirements for connections to their facilities. FE will upgrade relaying at Bedford North substation on the Wills Mountain (Bedford South) terminal to accommodate a new interconnection substation on this line.

A summary of the connection facilities that will be required for the Primary POI and their estimated costs are shown in the following table. Based on this scope of work, it is expected to take a minimum of 6 months after the signing of an Interconnection Construction Service Agreement. This includes preliminary payment that compensates FE for the first three months of the engineering design work that is related to the construction of the AE1-128 interconnection substation.

Secondary POI

For a connection to the secondary POI, FE will upgrade relaying at Bedford North substation on the Wills Mountain (Bedford South) terminal to accommodate a new interconnection substation on this line. AEC and/or Bedford Rural Electric Cooperative ("Bedford REC") will be responsible for providing the interconnection requirements at this location. A full scope of work or estimated cost is not provided for the Secondary POI.

ALLEGHENY ELECTRIC COOPERATIVE (AEC) SCOPE OF WORK

1 Overview

1.1 Purpose of the Study

Allegheny Electric Cooperative, Inc. (AEC) has been approached by a developer regarding the possible interconnection and parallel operation of a photovoltaic (PV or solar) distributed energy resource (DER) installation with the AEC transmission system. AEC has asked Power System Engineering (PSE) to complete a feasibility study to determine whether adverse impacts on their existing system may result from the interconnection and operation of the DER facility.

This document represents a high-level review of the proposed interconnection, subject to additional refinement as the project moves forward to additional levels of study and ultimately to implementation. Information and recommendations in this document reflect input and discussions to-date with the following:

- Allegheny Electric Cooperative, Inc.

1.2 Background & Assumptions

Allegheny Electric Cooperative, Inc. owns and operates an electric transmission system in the state of Pennsylvania. A renewable energy developer has approached AEC regarding a possible generation interconnection to the existing 115 kV transmission facilities owned and operated by AEC. There are two potential interconnection points being considered; the system configuration in the areas (including the proposed facilities) is as follows:

- The first possible point of interconnection (POI) is immediately adjacent (within 0.1 miles) to the AEC Bedford South substation.
    - The site of the solar farm is approximately 3.2 miles from Bedford South; the proposed one-line indicates that 3.2 miles of 795 MCM ACSR will connect the facility to the AEC transmission system.

- The Wills Mountain 115 kV delivery point originates at the First Energy (FE) Bedford North substation and serves the AEC Bedford South substation, which is a 115-24.9 kV distribution substation that solely serves a large natural gas compressor facility.
    - The compressor station also takes delivery directly from the AEC 115 kV system via 115-kV-metered POI at the Bedford South substation.
- The 115 kV line serving the Bedford South substation extends approximately 11.6 miles to the FirstEnergy (FE, AEC's wholesale power provider) Bedford North substation/switching station, which is where AEC actually takes 115 kV wholesale power delivery.
- The second possible point of interconnection is at some point along the AEC-owned 115 kV transmission line, south of FE's Bedford North substation.
    - The developer-owned 115 kV line extension length for this POI would vary based on the actual interconnection location.

PSE has the following understanding regarding the distributed generation interconnection facilities being proposed by the IC based on the information supplied to PSE and subsequent conversations with AEC:

- The IC is proposing to install 121.659 MW of aggregate PV generation capacity. The field will consist of 42 inverters each rated 2,897 kW/3,339 kVA, and will feed into the AEC 115 kV system at a single POI through a 78/104/130 MVA, 34.5 kV delta-115 kV grounded-wye generator step-up (GSU) transformer.
- The IC has applied to PJM (the regional transmission organization or RTO) for 72 MW of capacity interconnection rights.
- Each inverter includes a 3.63 MVA internal dry-type 600V wye-34.5 kV delta step-up transformer.
- A three-phase, wye zig-zag grounding transformer bank will be installed on the 34.5 kV delta side of the main GSU transformer to provide a ground reference.
- The PV generation will feed into the main 34.5 kV generation bus through six feeders, each of which will include a 34.5 kV circuit breaker with SEL-351S relay control.
- Relevant information regarding the proposed generation and the area of the AEC system where the proposed interconnection is located is shown in Table 1.

Table 1: Proposed Generation and System Data

Generation Type	Photovoltaic (PV or Solar)	
Aggregate Capacity (kW)	121,659	
Rated Power Factor	0.87	
Number of Inverter/GSU Units	42	
Distance from AEC POI (mi.)	0.1	
Max Fault at AEC 115 kV without generation	4,009	LLL

1.3 FE & PJM

It is important to note that the review completed and documented in this feasibility study only considers the AEC systems. It is possible that FE may also require review of the impact of the proposed generation on their systems at this and/or later stages of study, particularly in regards to preventing an unintentional island and preventing reverse power flows onto their system. In addition, studies by PJM are already in progress, and IC will need to accommodate any recommendations or requirements that result from those studies.

2 Study Findings

The items in this section represent a review of the feasibility of the interconnection and parallel operation of the proposed DER facility. The following thoughts and recommendations are based on the best information available at the time this study was completed, subject to change based on any new information that may become available as the project progresses toward design and implementation.

2.1 AEC Substation Facilities, AEC & FE Transmission Systems

- The proposed point of interconnection is directly on the AEC 115 kV transmission system.

- The natural gas compression loads served by the AEC Bedford South substation and AEC 115 kV transmission lines can accept a significant portion of the proposed generation capacity; it is expected that the excess generation will be exported to the FirstEnergy transmission system.

- As the IC has already submitted an application to PJM for an interconnection, it is assumed that power export onto the FE transmission system will be permitted, pending the results of any in-progress or future FE and PJM interconnection studies.

- In order to maintain adequate service reliability for the natural gas compression facility, AEC will require that a new breaker station be installed to provide AEC-owned protection at the POI. If the POI is at the Bedford South substation, this will be accomplished by converting the high side of the Bedford South substation to a 5-terminal breaker station. If the POI is directly on the 115 kV lines, then a new 3-terminal breaker station will need to be constructed.

2.2 Transmission Voltage Levels

- AEC transmission planning criteria voltage limits are 0.95PU (minimum, of nominal) and 1.05PU (maximum, of nominal) per NERC standards.

- The proposed facility is not expected to have any significant impact on the voltage levels of the AEC 115 kV system.

- Voltage flicker due to the proposed PV facility—either from changes in insolation or from

the facility tripping offline during operation—is not expected to be a concern.

2.3 Fault Current and Protection

- The maximum fault current capability of the proposed PV system is 1.6 times the rated output current, according to the proposed facility diagrams.

- In order to examine worst-case scenarios for AEC facilities, the fault current analysis was performed with the POI at the Bedford South substation (placing the proposed PV fault current output nearer to existing AEC protective devices).

- The total maximum fault contribution from the proposed PV facility to the 115 kV system is 541 amps for three-phase faults and 1,346 amps for line to ground faults. The total increase in the available fault current through relevant AEC devices on the 115 kV system (namely the high-side protection at the Bedford South substation) is approximately 2,000 amps. It is unlikely that this increase in fault current will push any 115 kV devices outside their interrupting ratings, but it may have an effect on coordination between AEC 115 kV devices and any upline FE protective devices. Protection settings should be reviewed during a system impact and/or facilities study prior to the PV facility commencing operation.

- The proposed generation is not expected to have any significant impacts on fault currents on the 25 kV side of the Bedford South substation.

- Similar to the AEC 115 kV devices, the proposed facility may contribute up to 1,346 amps of fault current to the FE 115 kV system. FirstEnergy may wish to review the impact of this contribution to their facilities.

2.4 Interconnection Protection

- According to the one-line diagram included in Exhibit III, only one interconnection point will exist for exporting power from the proposed generation installation onto the AEC system.
- According to the facility one-line diagram, there will be two voltage transformations for the PV output before it reaches the POI. Each inverter includes and integrated 34.5 kV – 600V, 3,630 kVA dry-type transformer with a delta primary (34.5 kV side) winding and a grounded-wye secondary (600V side); a grounding transformer is included on the proposed one-line diagram to maintain an effectively grounded system and mitigate the risk of overvoltages resulting from the delta windings. The overall facility will then connect to the AEC 115 kV system through a 115 – 34.5 kV, 78 MVA transformer with a grounded-wye primary (AEC side) and a delta secondary (PV side). The grounded-wye winding on the AEC side will allow the facility to contribute to ground faults on the AEC system, but is preferred over a delta winding that could lead to dangerous overvoltages during single line to ground fault conditions.

- The protection proposed at the point of interconnection must be capable of providing the passive anti-islanding protection required to comply with IEEE Std 1547, *Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces,* and AEC's interconnection standards (included as Exhibit IV). The interconnection application and the data submitted do not include specific device settings. It is assumed that the settings programmed into the device will comply with the requirements of IEEE 1547 and will provide adequate overcurrent protection for the generation site while maintaining coordination with upline AEC overcurrent device(s). It is recommended that AEC require the IC to submit proposed settings for approval, preferably during the System Impact Study portion of the process, and certainly before the proposed generation commences operation.
- Due to the size of the potential generation output compared to the native load in the Wills Mountain area, there are concerns of unintentional islanding of the service area. Islanding can occur when the generation is able to serve a portion of the system that might be de-energized without significant variation in frequency and voltage to detect abnormal system conditions. Thus the generation may not trip off-line during these conditions. It is recommended that one or more POI devices (particularly the developer-owned SEL-351S devices at the 34.5 kV PV feeders and/or the developer-owned relay control on the Rainsburg 115 kV bus breaker, and also the AEC-owned POI breaker) be integrated into a Direct Transfer Trip (DTT) scheme so that other protection devices on the AEC system (namely protection at the new AEC breaker station, but likely including protection at the Bedford North substation as well) can send a signal to these devices to open and separate the generation whenever the devices are opened manually or automatically by their controls.
    - A fiber communication link is recommended for this purpose.
- The natural gas compressor facilities served by the 115 kV lines where the IC has requested interconnection are considered critical load by AEC. As such, any disruption in power quality or normal load flow on these lines caused by the proposed PV facilities and/or any deviation from IEEE 1547 or other applicable standards will be the IC's sole responsibility to correct. In addition, any such disruption or deviation may result in disconnection of the PV facilities from the AEC system until mitigation measures are in place and their adequacy confirmed by testing and measurement; any financial penalties incurred by such disruptions will be the IC's responsibility.

2.5 Summary of Items Required to Facilitate Interconnection

Secondary Point of Interconnection

Wills Mountain (Bedford South) 115 kV Substation (AEC)

1. AEC will construct a new breaker station to provide protection for the proposed interconnection and maintain reliability to existing native load in the area. This will be a three-terminal breaker station if the POI is on the AEC 115 kV lines, and will be a five-terminal station at the Bedford South substation if the POI is at the Bedford South substation. Cost estimates for both options are shown in the tables that follow.

2. A direct transfer trip (DTT) scheme will need to be implemented between one or more upline protective devices on the AEC 115 kV system and one or more PV protective device(s); a fiber communication link is recommended for this purpose.

DER Feasibility Study - Rainsburg Solar Project
Items Required to Facilitate Interconnection at Bedford South Substation
Based on Potential Impacts to AEC System

		Total Estimated Cost
AEC Substation Facilities		
1	Build new five-breaker ring bus station for AEC-owned POI protection. *Build within existing Bedford South substation.*	$7,040,000
AEC Transmission Facilities		
2	Transmission tower & line modifications to facilitate interconnection.	$1,500,000
Generator Interconnection		
	None.	
Communications		
2	Install communications for transfer trip scheme. *Fiber communication is strongly recommended.*	$350,000
3	Remote end terminal work.	$250,000
Additional Engineering, Testing and Commissioning Fees Not Included Above		
4	Engineering/Design (spec equipment, design protection schemes, program relays, design communications schemes, SCADA integration, etc.)	$100,000
6	Property Acquisitions [1]	-
Overheads and Contingencies		20%

TOTAL ESTIMATED COST **$11,088,000**
(Including noted overheads and contingencies)

NOTE: The estimates shown in this table are the most reasonable available estimates at the time of the completion of this study, and are subject to change based on economics and other conditions as the project and stages of study progress. These estimates are not to be considered firm or formal costs for any equipment, construction or services.

[1] The overall feasibility of the proposed interconnection is based to a great degree on AEC's ability to obtain property for the required breaker stations; the costs of such acquisitions are unknown at this time.

Primary Point Of Interconnection

Bedford North – Wills Mountain (Bedford South) 115 kV Line (AEC)

DER Feasibility Study - Rainsburg Solar Project
Items Required to Facilitate Interconnection on 115 kV Line Based on Potential Impacts to AEC System

		Total Estimated Cost	
AEC Substation Facilities			
1	Build new three-breaker ring bus station for AEC-owned POI protection. *Build on AEC 115 k V lines.*	$3,590,000	
AEC Transmission Facilities			
2	Transmission tower & line modifications to facilitate interconnection.	$1,500,000	
Generator Interconnection			
	None.		
Communications			
2	Install communications for transfer trip scheme. *Fiber communication is strongly recommended.*	$350,000	
3	Remote end terminal work.	$250,000	
Additional Engineering, Testing and Commissioning Fees Not Included Above			
4	Engineering/Design (spec equipment, design protection schemes, program relays, design communications schemes, SCADA integration, etc.)	$100,000	
5	Project Management/Implementation	Incl. in overheads below	
6	Property Acquisitions [1]	-	
Overheads and Contingencies		20%	20%
TOTAL ESTIMATED COST		**$6,948,000**	

(Including noted overheads and contingencies)

NOTE: The estimates shown in this table are the most reasonable available estimates at the time of the completion of this study, and are subject to change based on economics and other conditions as the project and stages of study progress. These estimates are not to be considered firm or formal costs for any equipment, construction or services.

The overall feasibility of the proposed interconnection is based to a great degree on AEC's ability to obtain property for the required breaker stations; the costs of such acquisitions are unknown at this time.

Network Impacts

The Queue Project AE1-128 was evaluated as a 120 MW (Capacity 72 MW) equivalized as an injection into the Bedford North (PSSe Bus #200501) in the PENELEC area. Project AE1-128 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-128 was studied with a commercial probability of 53%. Note: Option 2 was not studied, because both primary and secondary POI options equivalized to PSSe Bus # 200501. Potential network impacts were as follows:

Summer Peak Analysis – 2022

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Contingency Definition
PN-P2-3-PN-345-003A	CONTINGENCY 'PN-P2-3-PN-345-003A' /* WAYNE 345KV STUCK BREAKER DISCONNECT BUS 200595 /* 26WAYNE 345 END
PN-P2-3-PN-345-001AT	CONTINGENCY 'PN-P2-3-PN-345-001AT' /* HOMER CITY 345KV BKR 301 DISCONNECT BRANCH FROM BUS 200769 TO BUS 235129 CKT 1 /* 26HOMER CY 345 01ARMSTRONG 345 END
PN-P2-3-PN-500-001F	CONTINGENCY 'PN-P2-3-PN-500-001F' /* KEYSTONE 500KV BKR 6 DISCONNECT BRANCH FROM BUS 200011 TO BUS 200005 CKT 1 /* KEYSTONE 500 CONEM-GH 500 DISCONNECT BRANCH FROM BUS 200011 TO BUS 200810 TO BUS 200907 CKT 4/* KEYSTONE 500 26KEYSTONE 230 26KEYSTN#4 20.00 REDUCE BUS 200011 SHUNT BY 100 PERCENT /* KEYSTONE 500 END
PN-P2-3-PN-500-001E	CONTINGENCY 'PN-P2-3-PN-500-001E' /* KEYSTONE 500KV BKR 5 DISCONNECT BRANCH FROM BUS 200011 TO BUS 200005 CKT 1 /* KEYSTONE 500 CONEM-GH 500 DISCONNECT BUS 200031 /* CONE G2 22 END
PJM_P1_APS_B_G692	CONTINGENCY 'PJM_P1_APS_B_G692' / 200011 KEYSTONE 500 235104 01CABOT 500 1 OPEN BRANCH FROM BUS 200011 TO BUS 235104 CKT 1 END
PN-P2-3-PN-500-002C	CONTINGENCY 'PN-P2-3-PN-500-002C' /* CONEMAUGH 500KV BKR 3 DISCONNECT BRANCH FROM BUS 200005 TO BUS 200011 CKT 1 /* CONEM-GH 500 KEYSTONE 500 REDUCE BUS 200182 SHUNT BY 100 PERCENT /* CONEMCAP 500 END
PN-P2-3-PN-500-002A	CONTINGENCY 'PN-P2-3-PN-500-002A' /* CONEMAUGH 500KV BKR 1 DISCONNECT BRANCH FROM BUS 200005 TO BUS 200912 CKT 3 /* CONEM-GH 500 26CONEMAGH 230 DISCONNECT BUS 200031 /* CONE G2 22 END
Base Case	

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
685627	200767	26HOMER CT	PENELEC	200795	26SHELOCTA	PENELEC	1	PN-P2-3-PN-500-002A	breaker	917.0	94.54	98.54	DC	36.43
685897	200795	26SHELOCTA	PENELEC	200810	26KEYSTONE	PENELEC	1	PN-P2-3-PN-345-001AT	breaker	917.0	95.35	98.89	DC	32.15
685894	200810	26KEYSTONE	PENELEC	999428	STAR569	PENELEC	3	PN-P2-3-PN-500-001F	breaker	612.0	97.77	99.5	DC	23.17

Note: Please see Attachment 1 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)

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
685624	200767	26HOMER CT	PENELEC	200795	26SHELOCTA	PENELEC	1	PN-P2-3-PN-345-001AT	breaker	917.0	116.69	119.89	DC	29.33
685625	200767	26HOMER CT	PENELEC	200795	26SHELOCTA	PENELEC	1	PN-P2-3-PN-500-002C	breaker	917.0	108.98	111.92	DC	26.76
685626	200767	26HOMER CT	PENELEC	200795	26SHELOCTA	PENELEC	1	PN-P2-3-PN-500-001E	breaker	917.0	101.79	104.74	DC	26.81
685826	235129	01ARMSTRONG	AP	235121	01ARMSTR	AP	2	PN-P2-3-PN-345-003A	breaker	659.0	103.04	103.55	DC	7.3

Note: Please see Attachment 1 for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper table in the Attachment.

NYISO

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

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.

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
686719	200740	26BLRSVLE	PENELEC	200763	26BLAIRSVL	PENELEC	1	PJM_P1_APS_B_G692	operation	364.0	101.82	103.02	DC	9.63
686133	200762	26GARRETT	PENELEC	235470	01GARRET	AP	1	Base Case	operation	133.0	99.22	103.24	DC	11.87
686716	200767	26HOMERCT	PENELEC	200795	26SHELOCTA	PENELEC	1	Base Case	operation	731.0	98.7	102.2	DC	25.39
686142	934440	AD1-068 TAP	AP	235120	01ALBRIG	AP	1	Base Case	operation	164.0	114.43	116.71	DC	8.28

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
685894	3	26KEYSTONE 230.0 kV - STAR569 1.0 kV Ckt 3	PENELEC Description : No Violation. Facility loading does not exceed 100%. Time Estimate : Months Cost : $0	$0
685826	4	01ARMSTRONG 345.0 kV - 01ARMSTR 138.0 kV Ckt 2	AP Description : PJM baseline upgrade b3074: Reconductor 138 kV bus at Armstrong substation. The baseline project has an projected in-service date of 06/01/2022. Time Estimate : Months Cost : $0	$0
685897	2	26SHELOCTA 230.0 kV - 26KEYSTONE 230.0 kV Ckt	PENELEC Description : No Violation. The emergency rating of this facility	$0

		1	if 923 MVA and therefore is not overloaded. Time Estimate : Months Cost : $0	
685624,685625,685626,685627	1	26HOMER CT 230.0 kV - 26SHELOCTA 230.0 kV Ckt 1	PENELEC Description : Expand the existing Homer City 230/345kV substation by installing a 500/345kV transformer and constructing a 500 kV yard configured in a breaker-and-a-half layout (initially ring bus) and terminating the Keystone Conemaugh 500kV line into the new 500kV yard. Time Estimate : 18.0 Months Cost : $35,000,000	$35,000,000
			TOTAL COST	$35,000,000

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.

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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
685624	200767	26HOMER CT	PENELEC	200795	26SHELOCTA	PENELEC	1	PN-P2-3-PN-345-001AT	breaker	917.0	116.69	119.89	DC	29.33

Bus #	Bus	MW Impact
200809	26SITHE	2.31
200823	26MHP_X3-003	5.93
200833	26SEWRDB34	22.12
200834	26SW_E13_K22	0.85
200835	26DSGENWIN	2.06
200837	26HOMER C1	39.8
200838	26HOMER C2	36.24
200839	26HOMER C3	38.37
200846	26FORWARD	0.23
200864	K-013 E	6.04
200883	Q-053 E	10.46
200886	26ARWF_N39	0.63
200888	26HIGHLAND	0.49
200889	26STNY CRK	0.38
200894	26K02	6.76
200925	26R32	0.57
202225	26SCI_S29B	0.1
203034	26NA_O38_P22	0.55
203999	P-047 E	14.15
236828	01GRAYMONT	0.42
290086	Q-036 E	6.84
292340	K-022	0.03
292350	K-023	6.33
292542	L-013 1	6.33
293301	N-039 E	16.36
293393	V3-030E	4.13
293432	R-040 E	0.36
293603	O-018 E	12.83

Bus #	Bus	MW Impact
293802	O-038 E	10.23
293902	O-048 E	5.7
294515	P-022 E	4.09
294573	P-028 E	12.01
294903	P-060 E	10.04
296332	R-032 E	14.8
903643	W3-099 C OP1	1.14
903644	W3-099 E OP1	7.61
913142	Y1-033 E OP1	5.18
914101	Y2-055	3.55
916051	Z1-038	1.98
916202	Z1-069 E	11.09
916351	Z1-091	2.51
917672	Z2-108 E	3.96
918682	AA1-082 E	7.12
918701	AA1-085 C	1.16
918702	AA1-085 E	7.7
918871	AA1-106	2.76
919201	AA1-144 O1	20.15
919491	AA2-000	53.63
920341	AA2-132	2.79
925512	AC1-025 E	0.16
930411	AB1-082	3.92
930511	AB1-092	1.97
931092	AB1-160 E	3.17
932571	AC2-077	3.91
932981	AC2-122 C	3.76
932982	AC2-122 E	6.13
936421	AD2-055	4.05
936991	AD2-133 C	3.08
936992	AD2-133 E	14.07
938351	AE1-053	1.05
938881	AE1-116	1.06
938991	AE1-128 C	17.6
938992	AE1-128 E	11.73
939171	AE1-147 C	1.26
939172	AE1-147 E	0.84
939341	AE1-165 C	2.89
939342	AE1-165 E	1.93
AA2-200	AA2-200	64.17
AA2-500	AA2-500	180.77
BAYOU	BAYOU	1.38
BIG_CAJUN1	BIG_CAJUN1	2.12
BIG_CAJUN2	BIG_CAJUN2	4.26
BLUEG	BLUEG	6.79
CALDERWOOD	CALDERWOOD	0.71
CANNELTON	CANNELTON	0.41
CATAWBA	CATAWBA	0.44
CBM-N	CBM-N	4.59
CHEOAH	CHEOAH	0.65
CHILHOWEE	CHILHOWEE	0.23
CHOCTAW	CHOCTAW	1.41
COFFEEN	COFFEEN	0.71
COTTONWOOD	COTTONWOOD	5.46
DEARBORN	DEARBORN	1.04
DUCKCREEK	DUCKCREEK	1.53

Bus #	Bus	MW Impact
EDWARDS	EDWARDS	0.7
ELMERSMITH	ELMERSMITH	0.7
FARMERCITY	FARMERCITY	0.46
G-007A	G-007A	1.98
GIBSON	GIBSON	0.28
HAMLET	HAMLET	1.4
NEWTON	NEWTON	1.85
NYISO	NYISO	19.89
O-066A	O-066A	1.03
PRAIRIE	PRAIRIE	3.44
SANTEETLA	SANTEETLA	0.19
SMITHLAND	SMITHLAND	0.27
TATANKA	TATANKA	0.84
TILTON	TILTON	0.84
TRIMBLE	TRIMBLE	0.76
TVA	TVA	2.3
UNIONPOWER	UNIONPOWER	1.02
VFT	VFT	5.73

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
685897	200795	26SHELOCTA	PENELEC	200810	26KEYSTONE	PENELEC	1	PN-P2-3-PN-345-001AT	breaker	917.0	95.35	98.89	DC	32.15

Bus #	Bus	MW Impact
200636	26IUP CO-G	0.68
200805	26COLVER13	28.2
200809	26SITHE	2.14
200823	26MHP_X3-003	5.79
200833	26SEWRDB34	22.33
200834	26SW_E13_K22	0.91
200835	26DSGENWIN	2.23
200837	26HOMER C1	36.87
200838	26HOMER C2	33.72
200839	26HOMER C3	35.7
200846	26FORWARD	0.25
200864	K-013 E	6.52
200883	Q-053 E	11.91
200888	26HIGHLAND	0.54
200894	26K02	7.09
200925	26R32	0.63
202158	26CON.GEN1	0.16
203999	P-047 E	13.74
236828	01GRAYMONT	0.48
290086	Q-036 E	8.18
292350	K-023	6.87
292542	L-013 1	6.87
293301	N-039 E	16.44
293393	V3-030E	7.11

Bus #	Bus	MW Impact
293432	R-040 E	0.39
293603	O-018 E	14.17
293802	O-038 E	10.28
293902	O-048 E	6.19
294515	P-022 E	4.11
294573	P-028 E	11.72
294903	P-060 E	10.93
296332	R-032 E	16.35
903643	W3-099 C OP1	1.26
903644	W3-099 E OP1	8.45
913142	Y1-033 E OP1	5.66
914101	Y2-055	3.83
916051	Z1-038	1.93
916202	Z1-069 E	10.87
916351	Z1-091	2.45
917672	Z2-108 E	4.3
918682	AA1-082 E	7.04
918701	AA1-085 C	1.33
918702	AA1-085 E	8.89
918871	AA1-106	2.77
919201	AA1-144 O1	20.02
919491	AA2-000	59.84
920341	AA2-132	2.73
925512	AC1-025 E	0.18
930411	AB1-082	3.89
930511	AB1-092	2.2
931092	AB1-160 E	3.11
932571	AC2-077	3.83
932981	AC2-122 C	4.08
932982	AC2-122 E	6.66
935191	AD1-154	3.39
936421	AD2-055	4.52
936991	AD2-133 C	3.68
936992	AD2-133 E	16.83
938351	AE1-053	1.14
938881	AE1-116	1.14
938951	AE1-123	1.86
938991	AE1-128 C	19.29
938992	AE1-128 E	12.86
939171	AE1-147 C	1.44
939172	AE1-147 E	0.96
939291	AE1-160 C	1.12
939292	AE1-160 E	0.64
939341	AE1-165 C	3.25
939342	AE1-165 E	2.17
939381	AE1-169 C O1	4.53
939382	AE1-169 E O1	3.02
AA2-200	AA2-200	57.03
AA2-500	AA2-500	175.17
BAYOU	BAYOU	1.13
BIG_CAJUN1	BIG_CAJUN1	1.75
BIG_CAJUN2	BIG_CAJUN2	3.52
BLUEG	BLUEG	5.48
CALDERWOOD	CALDERWOOD	0.59
CANNELTON	CANNELTON	0.33
CATAWBA	CATAWBA	0.38

Bus #	Bus	MW Impact
CBM-N	CBM-N	4.32
CHEOAH	CHEOAH	0.54
CHILHOWEE	CHILHOWEE	0.19
CHOCTAW	CHOCTAW	1.17
COFFEEN	COFFEEN	0.57
COTTONWOOD	COTTONWOOD	4.5
DEARBORN	DEARBORN	0.74
DUCKCREEK	DUCKCREEK	1.23
EDWARDS	EDWARDS	0.56
ELMERSMITH	ELMERSMITH	0.57
FARMERCITY	FARMERCITY	0.37
G-007A	G-007A	1.11
GIBSON	GIBSON	0.22
HAMLET	HAMLET	1.23
NEWTON	NEWTON	1.49
NYISO	NYISO	18.74
O-066A	O-066A	0.62
PRAIRIE	PRAIRIE	2.78
SANTEETLA	SANTEETLA	0.16
SMITHLAND	SMITHLAND	0.22
TATANKA	TATANKA	0.67
TILTON	TILTON	0.68
TRIMBLE	TRIMBLE	0.61
TVA	TVA	1.9
UNIONPOWER	UNIONPOWER	0.84
VFT	VFT	3.38

Index 3

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
685894	200810	26KEYSTONE	PENELEC	999428	STAR569	PENELEC	3	PN-P2-3-PN-500-001F	breaker	612.0	97.77	99.5	DC	23.17

Bus #	Bus	MW Impact
200636	26IUP CO-G	0.49
200805	26COLVER13	21.44
200809	26SITHE	1.46
200823	26MHP_X3-003	4.5
200833	26SEWRDB34	16.72
200834	26SW_E13_K22	0.65
200835	26DSGENWIN	1.57
200837	26HOMER C1	25.14
200838	26HOMER C2	20.98
200839	26HOMER C3	22.21
200846	26FORWARD	0.18
200864	K-013 E	4.66
200883	Q-053 E	8.77
200888	26HIGHLAND	0.39
200894	26K02	5.48
200925	26R32	0.46

Bus #	Bus	MW Impact
202158	26CON.GEN1	0.12
203999	P-047 E	9.63
236828	01GRAYMONT	0.39
290086	Q-036 E	6.2
292350	K-023	4.83
292542	L-013 1	4.83
293301	N-039 E	12.09
293393	V3-030E	5.33
293432	R-040 E	0.27
293603	O-018 E	10.29
293802	O-038 E	7.56
293902	O-048 E	4.35
294515	P-022 E	3.02
294573	P-028 E	9.11
294903	P-060 E	7.81
296332	R-032 E	11.88
903643	W3-099 C OP1	1.12
903644	W3-099 E OP1	7.46
913142	Y1-033 E OP1	3.89
914101	Y2-055	3.07
916051	Z1-038	1.5
916202	Z1-069 E	7.57
916351	Z1-091	1.82
917672	Z2-108 E	3.02
918682	AA1-082 E	5.28
918701	AA1-085 C	1.09
918702	AA1-085 E	7.29
918871	AA1-106	2.05
919201	AA1-144 O1	15.05
919491	AA2-000	47.78
920341	AA2-132	1.99
925512	AC1-025 E	0.15
930411	AB1-082	2.73
930511	AB1-092	1.75
931092	AB1-160 E	2.16
932571	AC2-077	2.67
932981	AC2-122 C	2.87
932982	AC2-122 E	4.68
935191	AD1-154	2.93
936421	AD2-055	3.61
936991	AD2-133 C	2.79
936992	AD2-133 E	12.75
938351	AE1-053	0.8
938881	AE1-116	0.81
938951	AE1-123	1.97
938991	AE1-128 C	13.9
938992	AE1-128 E	9.27
939171	AE1-147 C	1.19
939172	AE1-147 E	0.79
939291	AE1-160 C	1.22
939292	AE1-160 E	0.7
939341	AE1-165 C	2.38
939342	AE1-165 E	1.59
939381	AE1-169 C O1	4.97
939382	AE1-169 E O1	3.31
AA2-500	AA2-500	132.94

Bus #	Bus	MW Impact
BAYOU	BAYOU	1.67
BIG_CAJUN1	BIG_CAJUN1	2.56
BIG_CAJUN2	BIG_CAJUN2	5.16
BLUEG	BLUEG	8.5
CALDERWOOD	CALDERWOOD	0.85
CANNELTON	CANNELTON	0.51
CATAWBA	CATAWBA	0.5
CBM-N	CBM-N	3.79
CHEOAH	CHEOAH	0.78
CHILHOWEE	CHILHOWEE	0.28
CHOCTAW	CHOCTAW	1.71
COFFEEN	COFFEEN	0.88
COTTONWOOD	COTTONWOOD	6.64
DEARBORN	DEARBORN	1.29
DUCKCREEK	DUCKCREEK	1.92
EDWARDS	EDWARDS	0.87
ELMERSMITH	ELMERSMITH	0.88
FARMERCITY	FARMERCITY	0.58
G-007A	G-007A	4.12
GIBSON	GIBSON	0.35
HAMLET	HAMLET	1.58
NEWTON	NEWTON	2.3
NYISO	NYISO	16.47
O-066A	O-066A	1.99
PRAIRIE	PRAIRIE	4.25
SANTEETLA	SANTEETLA	0.23
SMITHLAND	SMITHLAND	0.34
TATANKA	TATANKA	1.04
TILTON	TILTON	1.06
TRIMBLE	TRIMBLE	0.94
TVA	TVA	2.79
UNIONPOWER	UNIONPOWER	1.22
VFT	VFT	11.35

Index 4

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
685826	235129	01ARMSTRONG	AP	235121	01ARMSTR	AP	2	PN-P2-3-PN-345-003A	breaker	659.0	103.04	103.55	DC	7.3

Bus #	Bus	MW Impact
200828	26HNSMLK 1	3.28
200829	26HNSMLK 2	3.28
200830	26HNSMLK 3	3.28
200831	26HNSMLK 4	3.28
200832	26HNSMLK 5	3.28
200834	26SW_E13_K22	0.21
200839	26HOMER C3	16.99
200864	K-013 E	1.54
203999	P-047 E	4.74

Bus #	Bus	MW Impact
293301	N-039 E	4.17
293603	O-018 E	3.21
293802	O-038 E	2.6
294515	P-022 E	1.04
294903	P-060 E	2.53
296332	R-032 E	3.7
916202	Z1-069 E	3.43
930411	AB1-082	1.09
931092	AB1-160 E	0.98
932571	AC2-077	1.22
938881	AE1-116	0.27
938991	AE1-128 C	4.38
938992	AE1-128 E	2.92
939341	AE1-165 C	0.72
939342	AE1-165 E	0.48
AA2-200	AA2-200	35.1
AA2-500	AA2-500	61.23
BAYOU	BAYOU	0.87
BIG_CAJUN1	BIG_CAJUN1	1.33
BIG_CAJUN2	BIG_CAJUN2	2.69
BLUEG	BLUEG	4.58
CALDERWOOD	CALDERWOOD	0.43
CANNELTON	CANNELTON	0.27
CATAWBA	CATAWBA	0.24
CBM-N	CBM-N	1.74
CHEOAH	CHEOAH	0.39
CHILHOWEE	CHILHOWEE	0.14
CHOCTAW	CHOCTAW	0.88
COFFEEN	COFFEEN	0.48
COTTONWOOD	COTTONWOOD	3.47
DEARBORN	DEARBORN	0.91
DUCKCREEK	DUCKCREEK	1.06
EDWARDS	EDWARDS	0.49
ELMERSMITH	ELMERSMITH	0.47
FARMERCITY	FARMERCITY	0.31
G-007A	G-007A	1.99
GIBSON	GIBSON	0.19
HAMLET	HAMLET	0.74
NEWTON	NEWTON	1.26
NYISO	NYISO	7.51
O-066A	O-066A	0.96
PRAIRIE	PRAIRIE	2.3
SANTEETLA	SANTEETLA	0.12
SMITHLAND	SMITHLAND	0.18
TATANKA	TATANKA	0.57
TILTON	TILTON	0.58
TRIMBLE	TRIMBLE	0.51
TVA	TVA	1.44
UNIONPOWER	UNIONPOWER	0.63
VFT	VFT	5.49