PJM Generator Interconnection
W1-046 Face Rock 15 MW
Feasibility / Impact Study

May 2010

Docs# 592210

General

Queue W1-046 is a Community Energy request to interconnect 15.0 MW (5.7 MW Capacity) Resource (net to the system) solar photovoltaic generation located at 1067 Lancaster Pike, Drumore Twp., Lancaster County, Pennsylvania. Queue W1-046 has proposed an in-service date of June 1st, 2011. **Due to engineering and construction window constraints, PPL EU is proposing July 31st, 2011 as a more feasible in-service date. However, this study does not imply a PPL EU commitment to this in-service date.**

Direct Connection

Queue W1-046 can be connected to the Face Rock – Kinzer #13 69kV line (primary feed) as shown on the one line diagram below and described in the text that follows. The generation may also be connected to the Face Rock – Kinzer #14 line (alternate feed) during periods of abnormal sectionalizing (i.e. resectionalizing at the #13 - #14 tie switch near Face Rock sub, re-sectionalizing at Quarryville sub, or re-sectionalizing at Atglen sub). The protection scheme at Face Rock substation will be designed such that W1-046 can be connected to either the Face Rock – Kinzer #13 or #14 69kV line circuit breaker.

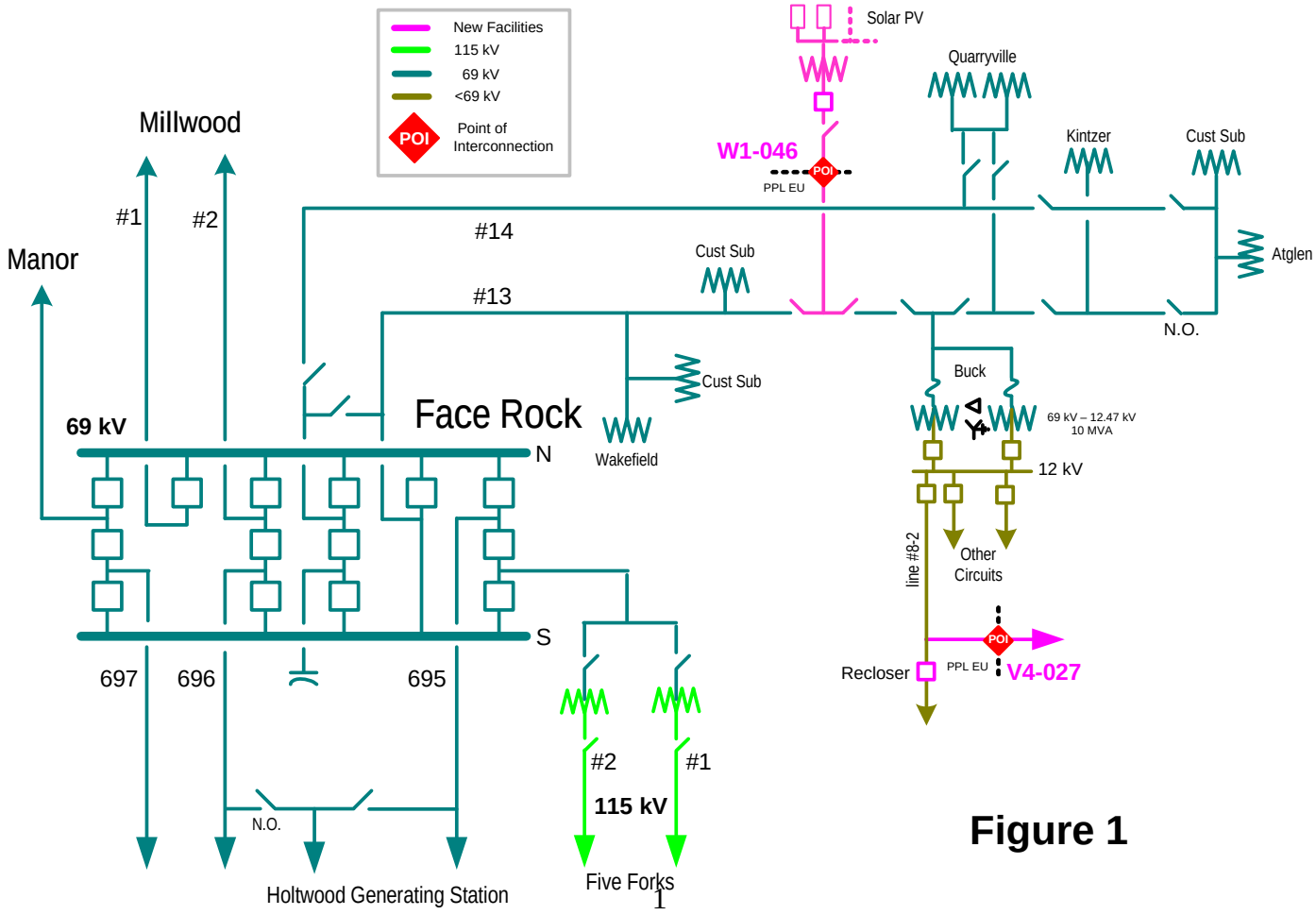

Figure 1

Interconnection Customer Scope of Direct Connection Work:

Queue W1-046 Interconnection Customer is responsible for design, construction and costs for all facilities associated with W1-046 on the Interconnection Customer side of the POI (Point of Interconnection) shown on Figure 1 single line diagram of the previous page.

Protection equipment --
The Interconnection Customer will need to install suitable protection and control equipment based on PPL EU parallel generation requirements. This includes both Intertie Protective Relaying (IPR) and Point of Contact (POC) relaying. Please refer to the PPL EU web site for the IPR and POC requirements. The website addresses are shown below:

IPR Requirements:
http://www.pplelectric.com/Business+Partners/Tools+and+Reference+Center/Customer-Owned+Generation/

POC Requirements:
http://www.pplelectric.com/NR/rdonlyres/B0937C7E-B6E9-40AD-AE8C-ED3C9558E528/0/point_of_contact.pdf

DTT Relaying Requirements--
Matching telephone based DTT (Direct Transfer Trip) equipment is required. PPL EU has determined that radio is not a viable communication path between W1-046 Interconnection and PPL EU's Face Rock 115/69 kV Substation. Since no fiber link between W1-046 and Face Rock 115/69 kV substation exists, PPL EU assumes that a telephone based communication scheme will be the most cost effective and therefore preferred DTT communication technology. The telephone based path is a special dedicated 4 wire analog telephone line, type PRDA which would originate from the W1-046 Substation to Face Rock 115/69 kV substation. (A fiber based DTT scheme would be feasible but this would increase the scope of work to include ~6.2 miles of a new fiber between Face Rock and the W1-046 substation).

The DTT scheme will provide a trip signal to the Interconnection Customer for any line fault, or any other condition that will cause the source Face Rock 69 kV line breaker to trip. The DTT scheme provides a block-closing signal to the breakers at PPL EU source switchyard/substation from the IPP. Automatic reclosing of the PPL EU line breaker will be blocked whenever the Interconnection Customer's 69kV breaker is closed and the generation is on-line. This signal from the Interconnection Customer will indicate:

- The isolation breaker is open (a breaker 'b' switch) OR
- A contact that will indicate when ANY inverter is operating in parallel with the PPL system (contact is OPEN when any inverter is in parallel) - this contact will close when ALL inverters are OFF line (disconnected from the PPL system).

Additional DTT requirements will exist if Queue V4-027 remains in the PJM queue.

SCADA Requirements—
PPL EU will require the installation of PPL EU approved SCADA equipment that will connect to its existing SCADA system. This connection will be a 4-wire dedicated FDDA-type phone line. PPL EU will provide detailed specifications and design drawings for this equipment.

Telephone Circuit Requirements--
PPL EU will require a communication path for DTT, SCADA, and voice. PPL EU anticipates that telephone circuits will be required to establish these paths.

The Interconnection Customer will be responsible to procure the following:

a) A 4-wire dedicated FDDA-type phone line for SCADA.
b) A normal dialup telephone line for voice communication. This may be an extension telephone.
c) A protective relay-grade telephone circuit for the DTT communication requirements, type PRDA. This phone line needs to communicate between the Interconnection Customer's control house and PPL EU's Face Rock Substation.

Phone lines tend to be long lead-time items and must be in place and operational for equipment testing. The Interconnection Customer should investigate with the local phone company the possibility of obtaining this type of service at the Quarryville facility. Please refer to the estimated telephone line in-service date in the "Schedule Requirements" section of this study. A checklist for ordering DTT and SCADA telephone circuits is available upon the Interconnection Customer's request if they decide to proceed with the interconnection.

All installation, maintenance, and monthly lease or billing charges for communications facilities are the responsibility of the Interconnection Customer.

Dead End Structure Requirement--
The Interconnection Customer must install a 69 kV dead-end structure at the point of interconnection. PPL EU will connect its 69 kV transmission line tap to this dead-end structure.

Metering Equipment Installation at the Point of Interconnection--
Installation of revenue grade Metering Equipment will be required at the Queue W1-046 Point of Interconnection (POI). PPL EU will design and supply the required metering equipment but all the installation cost would be borne by the developer. All metering equipment must meet applicable PPL EU tariff requirements as well as being compliant with all applicable requirements of the PJM agreements. The equipment should be housed in a control cabinet or similar enclosure and must be accessible to PPL EU metering personnel.

Metering / Telemetry for PJM--
Interconnection Customer is also required to provide revenue metering and real-time telemetry data to PJM in compliance with the requirements listed in PJM Manuals M-01 and M-14.

Isolation Breaker and Disconnect Switch Requirement --
Interconnection Customer will have its own isolation breaker. This breaker can be located on either the high or low side of the Interconnection Customer's transformer. It will be operated by the IPR relay and the DTT, and if it is located on the high side, the POC relaying. This device will NOT be used to synchronize or parallel operating generation to the PPL EU system. A disconnect switch capable of de-energizing the solar park's step-up transformer must also be installed ahead of the isolation breaker.

Transmission Owner (PPL EU) Scope of Direct Connection Work

Queue W1-046 solar park facility is located in the vicinity of the PPL EU owned Face Rock – Kinzer #13 and #14 69kV double circuit transmission lines and the PECO owned Peach Bottom – Limerick 500kV line. This solar park is located approximately 0.3 miles from PPL EU owned Buck 69/12kV substation. The developer has proposed a substation location directly adjacent to the Face Rock – Kinzer #13 and #14 lines to the north side to avoid a 500kV transmission crossing.

The proposed generation can be connected to the Face Rock – Kinzer #13 69kV line (primary feed) as shown on the one line diagram below and described in the text that follows. The generation may also be connected to the Face Rock – Kinzer #14 line (alternate feed) during periods of abnormal sectionalizing (i.e. resectionalizing at the #13 - #14 tie switch near Face Rock sub, resectionalizing at Quarryville sub, or resectionalizing at Atglen sub). The protection scheme at Face Rock substation will be designed such that W1-046 can be connected to either the Face Rock – Kinzer #13 or #14 69kV line circuit breaker.

During periods of certain sections of line or switch maintenance, the 69kV W1-046 tap will need to be de-energized resulting in W1-046 to remain offline. This study assumes that these planned outages are acceptable to the developer. If this assumption is incorrect, W1-046 is asked to inform PPL immediately in order to change the scope of work from a single tap, single feed arrangement to a double tap, double feed arrangement.

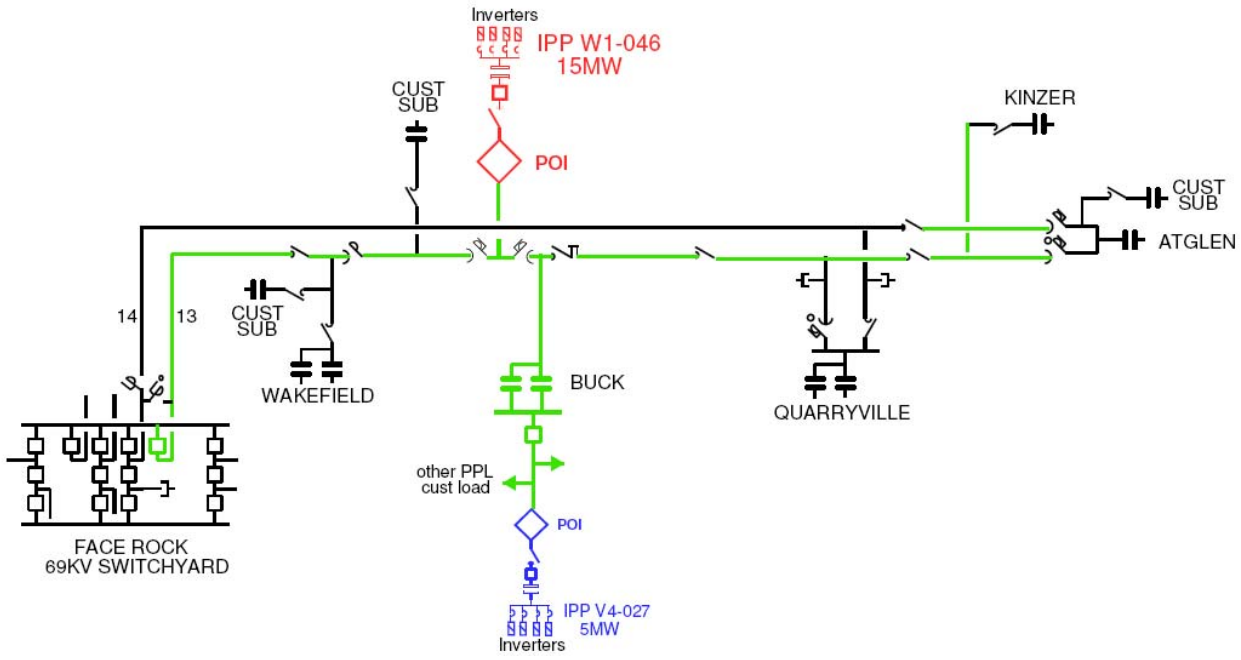

Figure 2

The total direct connection cost estimate is **$644,000** (excluding any applicable state or federal taxes).

Note: The costs given above are based on the assumption that Queue W1-046 will use a standard IPR (Interconnection Protective Relaying) cabinet design and that the Queue W1-046 drawings will be in good order.

A breakdown of the estimated costs is as follows:

$326,000	Transmission Work for ~100ft of 69kV Line and Sectionalizing
$318,000	Face Rock 115/69 kV Substation Modifications
$0	Transmission Siting and Right-of-Way Acquisition
$ not estimated	Communication Link Between W1-046 and V4-027

Transmission Direct Connection Work ($326,000)

The transmission direct connection work includes tapping the Face Rock - Kinzer #13 69 kV line in the vicinity of grid block 429-S-197. The W1-046 Tap will extend approximately 75-100 feet from the tap point using 556 ACSR conductor with 3/8" H.S. (high-strength) overhead ground wire (OHGW) to a dead-end structure in the new W1-046 substation. The estimate assumes that

a “high/low” pole structure will be required mid span of the existing transmission lines. The estimate also assumes that the customer owned deadend structure will be perpendicular to the existing transmission right-of-way.

Load sectionalizing air break switches (LSAB’s) will be required on either side of the W1-046 Tap. Due to the short distance between the W1-046 Tap point and the LSAB located at Buck 69/12kV substation in the Face Rock – Kinzer #13 69kV line, PPL EU will waive the switch requirement to the east of the W1-046 Tap. A 69kV LSAB and new switch pole will be required to the west of the W1-046 Tap.

The tap will be designed and operated at 69 kV and will therefore not require PUC certification**.**

Regional Substation Work ($318,000)

Direct Transfer Trip (DTT) protection to W1-046 is required. The work at Face Rock 115/69 kV substation yard includes:

- Installation of telephone based DTT (Direct Transfer Trip) equipment,
- Installation of line selector switch,
- Installation of synchronous reclosing relaying on the FARO – KINZ #13 69kV line CB,
- Installation of synchronous reclosing relaying on the FARO – KINZ #14 69kV line CB,
- Required telephone equipment board upgrades,
- Installation of associated wiring, cables, conduit, etc.

This work includes installation of telephone based DTT equipment and control design modifications at Face Rock 115/69 kV substation. The scheme will provide a trip signal to the W1-046 generation for any line fault, or any other condition that will cause the PPL EU line breaker at Face Rock substation to trip. Upgrades are required to the telephone entrance facilities and the telephone equipment board to meet modern telephone company standards.

The line selector switch will facilitate DTT protection for either the Face Rock – Kinzer #13 (normal) or Face Rock – Kinzer #14 (alternate) 69kV lines depending upon the system arrangement.

<u>Communication Link Between W1-046 and V4-027 (not estimated)</u>

Should V4-027 remain in the queue, the DTT scheme from Face Rock 115/69kV substation will also need to provide a trip signal to the V4-027 Interconnection Customer. This customer entered the queue prior to W1-046 therefore W1-046 will be responsible for this scope of work. PPL proposes that the above telephone based DTT be used to trip both the W1-046 and V4-027 generation for any 69kV line fault, or any other condition that will cause the PPL EU line breaker at Face Rock substation to open. Due to the close proximity of W1-046 and V4-027, a communication link (either fiber or radio) could be used to send the telephone based trip signals from/to V4-027. See Figure 2 which illustrates this proposed DTT communication arrangement.

This scope of work was not estimated. If both Queue projects move forward, the estimated cost and construction responsibilities will need to be determined.

The figure below illustrates the proposed DTT communication paths:

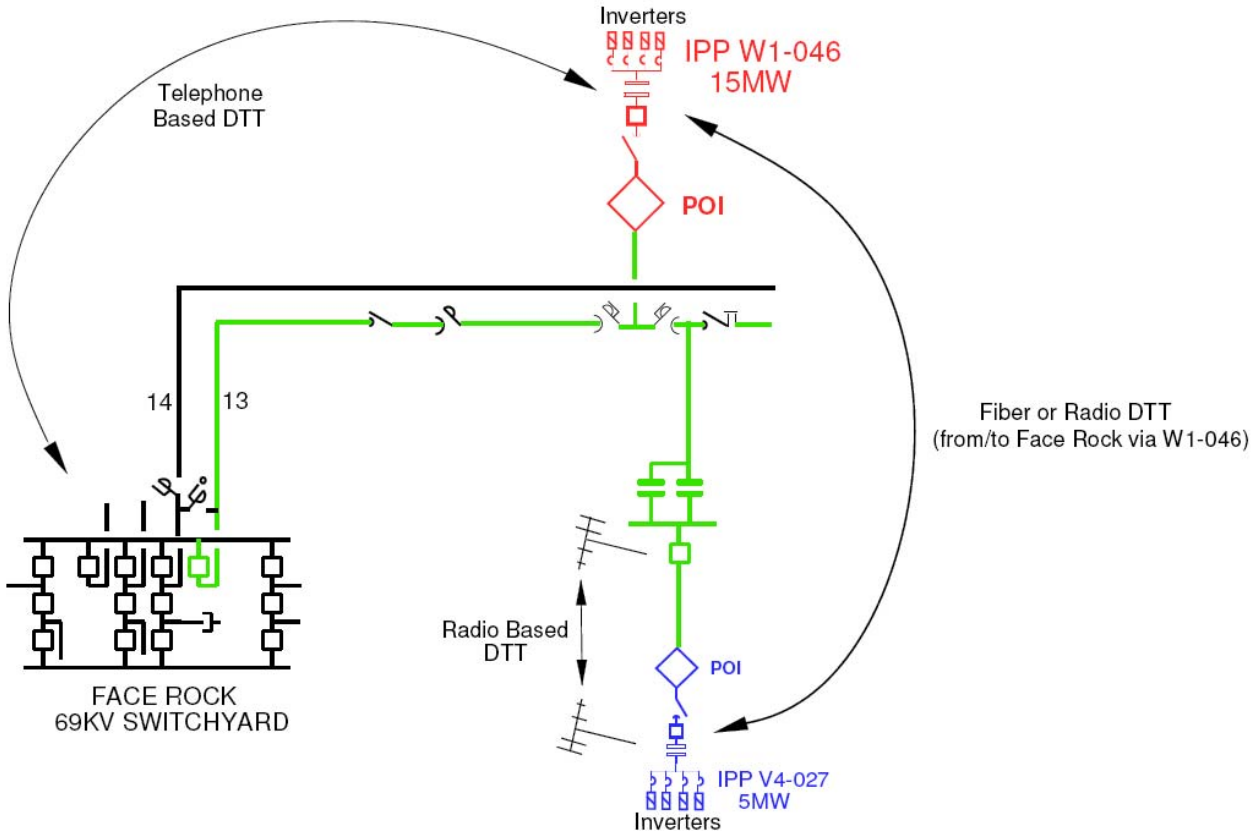

Figure 3

Siting, Right-of-Way Acquisition, & Environmental Impact ($0)

PPL EU is assuming that sufficient right-of-way will be provided by the developer to PPL EU for the construction of the W1-046 Tap from the existing Face Rock – Kinzer #13 and #14 tap point to the proposed W1-046 substation location. A 100 ft right-of-way width is PPL EU's standard.

No condemnation costs are included. Costs for threatened and endangered species studies or environmental constraints are also not included.

Inverter Regulation or Reactive Support Requirements

PPL EU load flow studies have indicated that the W1-046 inverters will maintain the required voltage regulation on the Face Rock - Kinzer #13 69 kV tap bus within its required range. The voltage schedule for the Face Rock - Kinzer #13 line at the W1-046 tap is approximately **0.986 pu (68.0 kV).** The voltage schedule will be similar if the W1-046 generation is transferred to the

alternate Face Rock – Kinzer #14 line via the #13 and #14 69kV tie switch located outside Face Rock 115/69kV substation.
As specified in Interconnection Service Agreement, Appendix 2, Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the W1-046 generator shall design its Facility to meet the following power factor requirement:

"For all new wind-powered and other non-synchronous generation facilities, if determined in the system impact study to be required for the safety or reliability of the Transmission System, the Generation Interconnection Customer shall design its Customer Facility with the ability to maintain a composite power delivery at continuous rated power output at a power factor of at least 0.95 leading to 0.95 lagging."

The Interconnection Customer has indicated that the inverters they are using will have the capability of adjusting to the required power factor. If the IPP decides to proceed with the installation of this project, PPL EU will calculate and issue a table of MW versus VAR for various levels of generation output.

Schedule Requirements for the Generation Project

Activity	**Start**	**Finish**
PPL EU Study & Contracts:		
Feasibility/ Impact Study		5/31/2010
Interconnection Agreement Signed		6/30/2010
PPL EU Engineering:		
W1-046 Provides Design Drawings for PPL Review	09/01/2010	12/31/2010
PPL Substation and Transmission Engineering	July 2010	Nov 2010
Order Long Lead Time Material		Nov 2010
PPL EU Construction:	March 2011	July 2011
W1-046 Phone Line In-service:		Feb 2011
Commercial In-Service Date:		7/31/2011
Complete As-Built Drawing Review:		Aug 2011

Notes concerning the Schedule:

(1) The PJM three-party ISA (Interconnection Service Agreement) and CSA (Construction Service Agreement) or an Interim ISA Agreement must be signed by Community Energy, PJM, and PPL EU before any PPL EU activities may commence.

(2) The ISA and CSA or an Interim Agreement must be signed by 6/30/2010 in order to meet the proposed July 31st, 2011 in-service date.

(3) Queue W1-046 should have their SCADA and DTT protection telephone lines in-service by February 2011. This will allow time for PPL EU Relay Test to coordinate with the developer and the telephone company should issues arise. Queue W1-046 Interconnection Customer will need to notify PPL by December 2010 if the phone line option cannot be provided by the telephone provider within this timeframe.

Network Impacts

The queue W1-046 project was studied as a 15.0 MW (5.7 MW capacity) injection at the Buck 69kV bus 208251. Project W1-046 was evaluated for compliance with reliability criteria for summer peak conditions in 2014. V4-027 5.0 MW located at the Buck 12kV bus 208252 was also considered as part of this analysis. Potential network impacts were as follows:

Generator Deliverability
(Normal System and Single, or N-1, contingencies for the Capacity portion only of the interconnection)

No problems identified.

Multiple Facility Contingency
(Double Circuit Tower Line contingencies, Stuck Breaker and Bus Fault contingency analysis for the full energy output)

No problems identified.

Short Circuit

No problems identified.

Stability Analysis

Not required due to the size and location of the project.

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)

No problems identified.

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)

None.