Revised
Generation Interconnection
Combined Feasibility/System Impact
Study Report

For

PJM Generation Interconnection Request
Queue Position W3-167

Nottingham II

June 2012

Preface

The intent of the Combined Feasibility/System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation, if any, is included in the System Impact Study.

The 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 associated with them will be addressed when seeking an Interconnection Agreement as outlined below. . Developer will also be responsible for providing and installing metering equipment in compliance with applicable PJM and Transmission Owner standards.

General

Queue W3-167 is an AGPCWA20MW LLC request to interconnect a 10.0 MW (3.8 MW Capacity) Energy Resource consisting of solar photovoltaic generation. Queue W3-167 has requested an in-service date of December 31, 2011. Due to the amount of work required to facilitate this interconnection, this in-service date does not appear obtainable. PPL EU proposes May 31, 2015 as a more feasible in-service date. However, this study does not imply a PPL EU commitment to this in-service date. The proposed in-service date is dependent upon numerous constraints, including the timely completion of the interconnection agreements by all involved parties.

Point of Interconnection

The developer has requested a primary and secondary interconnection to be studied in this Feasibility/Impact study. For the primary interconnection option, PPL EU studied a transmission extension from the Wakefield 69kV Tap, which is served from the Face Rock – Kinzer #13 69kV line. For the secondary interconnection option, PPL EU studied the extension of 3 phase 12kV to the proposed developer location.

- Option #1 – 69kV Interconnection

- Option #2 – 12kV Interconnection

The intent of the Feasibility/Impact study is to determine system reinforcements and associated costs and construction time estimates required to facilitate the interconnection of the generating plant to the transmission system. The reinforcements include the facilities required for direct connection of the generator to the system and any network upgrades necessary to maintain the reliability of the transmission system.

Scope of Work by Interconnection Customer:

The Queue W3-167 Interconnection Customer will be responsible for the design and construction of facilities as described below, subject to PPL EU approval.

Protection equipment

PPL EU assumes that it is the responsibility of the developer W3-167 to design and construct modifications to their proposed substation facilities. 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 W3-167 Interconnection and PPL EU's Face Rock 115/69 kV Substation. Since no fiber link between W3-167 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 W3-167 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 at least 14 miles of new fiber between Face Rock and the W3-167 substation. The 14 mile line length approximation is a straight line distance between the two locations).

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 online. 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).

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 SCADA, voice, and DTT protection. 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 the 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 Nottingham II facility.

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 W3-167 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

Option #1 – Direct Connection Requirements for the 69kV Interconnection

Queue W3-167 can be interconnected to the PPL Electric 69kV system in the Wakefield area located in Fulton Township, Lancaster County, PA. The Wakefield 69kV Tap supplies the Wakefield 69/12kV distribution substation which serves the distribution connected customers in the area. A new 69kV transmission line will need to be built from the existing Wakefield 69kV transmission tap to the developer's Point of Interconnection (POI). Figure 1 provides a functional one line arrangement of this proposed interconnection arrangement.

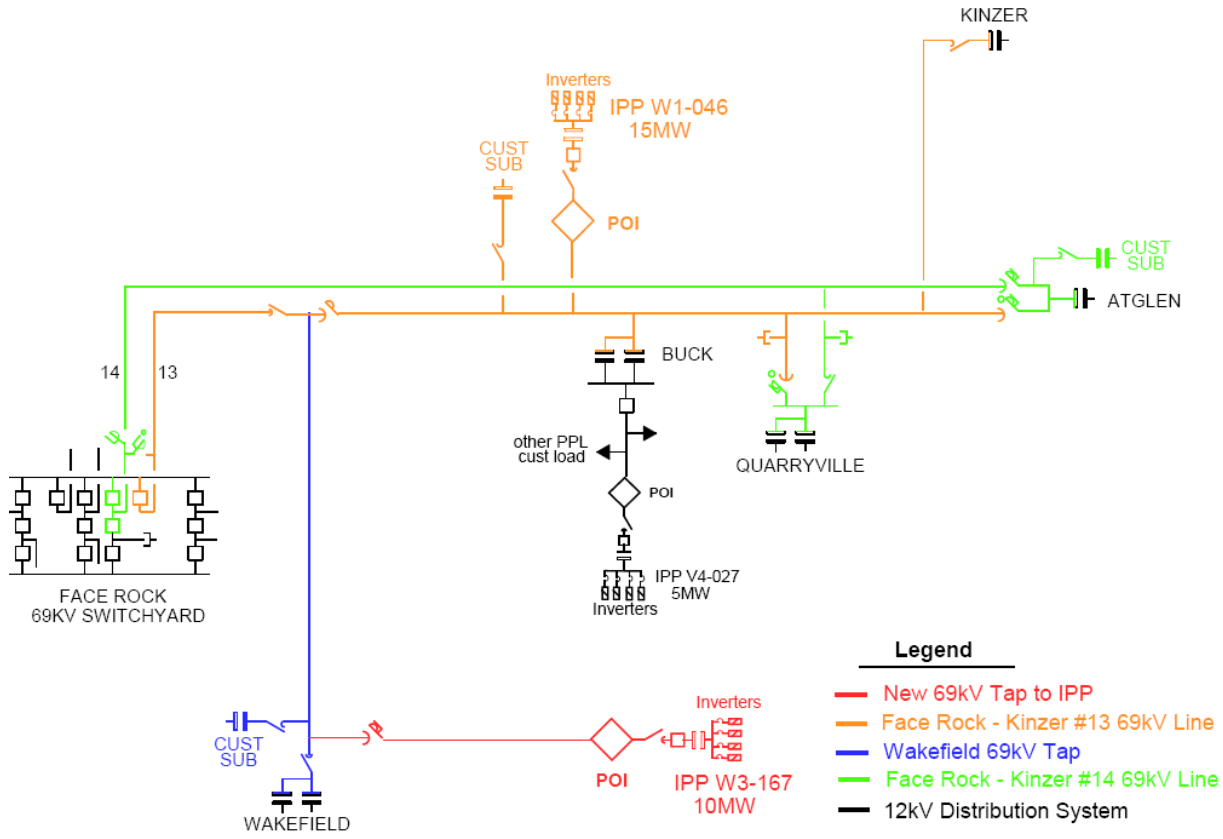

Figure 1

As shown in Figure 1, the Wakefield 69kV Tap is supplied from the Face Rock – Kinzer #13 69kV line. Both the Face Rock – Kinzer #13 and #14 69kV lines are sourced from the regional substation known as Face Rock 115/69kV Substation. The Face Rock – Kinzer #13 and #14 69kV lines are built in a double circuit configuration. Double circuit construction consists of two 69kV transmission circuits installed on the tower line, usually oriented in a side by side configuration.

The proposed generation will be normally interconnected to the Face Rock – Kinzer #13 69kV line via the Wakefield 69kV Tap. The generation may also be connected to the Face Rock – Kinzer #14 line 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 W3-167 can be connected to either the Face Rock – Kinzer #13 or #14 69kV line circuit breaker(s).

During periods of certain sections of line or switch maintenance, the Wakefield 69kV Tap and the W3-167 69kV Tap will need to be de-energized resulting in W3-167 to remain offline. This study assumes that these planned outages are acceptable to the developer. If this assumption is incorrect, a second line supply will need to be established to the W3-167 facility. At this time, there would be an extensive transmission project to bring a second line supply to the W3-167 facility.

The total direct connection cost estimate is $8,300,000 to accommodate the interconnection of W3-167 (excluding any applicable state or federal taxes).

Breakdown of estimated costs for the **69kV connection**:

$6,330,000	Transmission Work for ~6.1 miles of 69kV Line and Sectionalizing
$192,000	Face Rock 115/69 kV Substation Modifications
$1,778,000	Transmission Siting and Right-of-Way Acquisition

The costs given above are based on the assumption that Queue W3-167 will use a standard IPR (Interconnection Protective Relaying) cabinet design and that the Queue W3-167 drawings will be in good order.

Transmission Direct Connection Work ($6,330,000)

The transmission direct connection work includes tapping the Wakefield 69kV tap. A new 69kV transmission tap will need to be constructed ~6.1 miles from the Wakefield 69kV tap point to the proposed location of the developer's substation. The W3-167 Tap will be terminated onto a dead-end structure in the new W3-167 substation. The 6.1 mile approximation is the straight line distance between the two locations. The actual line length will be determined by the transmission line route through the siting process. Please note that the actual line length may be much greater than the 6.1 mile approximation and that the estimate may be adjusted upward accordingly upon further review.

A load sectionalizing air break switch (LSAB) will be required in the W3-167 Tap to isolate the tap in the event of a fault condition.

The tap will be designed per PPL EU's 69kV voltage level design standard specifications.

Regional Substation Work ($192,000)

Direct Transfer Trip (DTT) protection to W3-167 is required. Modifications at the regional Face Rock 115/69kV substation will be required. This work 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 circuit breaker,
- Installation of synchronous reclosing relaying on the FARO – KINZ #14 69kV line circuit breaker,
- 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 W3-167 generation for any line fault, or any other condition that will cause the PPL EU line breaker at Face Rock substation to trip. Upgrades may be 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 sectionalizing) or Face Rock – Kinzer #14 (abnormal sectionalizing) 69kV lines depending upon the system arrangement.

Transmission Siting and Right-of-Way Acquisition ($1,778,000)

The magnitude estimate for costs associated with the line siting and acquiring right-of-way easements to the W3-167 interconnection location is $1,522,000. No condemnation costs are included in this estimate. The costs for threatened and endangered species studies or environmental constraints are also not included.

Since the Wakefield 69kV Tap is designed for 69kV operation and PPL EU does not have 138kV conversion plans of this tap in the near future, the new Tap to the W3-167 substation will be designed per PPL EU's 69kV standards. The new transmission tap to the W3-167 interconnection facility will not need to be certified for 138kV operation through the Pennsylvania Public Utility Commission (PUC) siting process. However, this is subject to change as PPL EU continues to study this interconnection.

Option #2 – Direct Connection Requirements for the 12kV Interconnection

For the secondary interconnection option, PPL EU studied the extension of a new 3 phase, 12 kV line from the Quarryville substation as well as the extension of 3 phase from the existing Quarryville 56-3, 12kV line. This option, Option #2, is not a feasible interconnection for the proposed 10 MW of generation. This is mainly due to the magnitude of voltage rise that the proposed generation would have on the 12 kV circuit.

Other Direct Connection Issues Applicable to Option #1

Inverter Regulation or Reactive Support Requirements

PPL EU load flow studies have indicated that the W3-167 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 W3-167 tap is approximately **0.97 – 0.98 pu (67 - 68 kV)**. The voltage schedule will be similar if the W3-167 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 W3-167 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

PPL EU Study & Contracts	Start	Finish
PPL EU Study & Contracts		
Interconnection Agreement Signed		Aug 2012
PPL Siting	Sept 2012	
Right-of-Way Negotiations	March 2013	Sept 2013
PPL EU Engineering		
IPP Provides Design Drawings for PPL Review	July 2012	April 2013
PPL Substation and Transmission Engineering	April 2013	Dec 2013
Order Long Lead Time Material		Nov 2013
PPL EU Construction	May 2014	March 2015
W3-167 Phone Line In-service		Aug 2014
Commercial In-Service Date		April 2015
Complete As-Built Drawing Review		May 2015

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 AGP LLC, PJM, and PPL EU before any PPL EU activities may commence.

The ISA and CSA or an Interim Agreement must be signed by 8/31/12 to accommodate the proposed May 31, 2015 in-service date. **Note, this schedule does not imply a PPL EU commitment to this in-service date. Engineering and construction resource needs will need to be determined and evaluated prior to the development of a finalized project schedule in the ISA/CSA agreements.**

(2) The schedule is completely under the control of Queue W3-167. PPL EU will turn engineering drawings around in a reasonable timeframe, however, PPL cannot start work until the first set of drawings is received from the developer.

(3) Queue W3-167 should have their phone line (SCADA, phone and DTT circuits) in-service by 8/31/2014. Queue W3-167 Interconnection Customer will need to notify PPL by July 2012 if the phone line option cannot be provided by the telephone provider. (The July 2012 date corresponds to the start of PPL EU substation and transmission engineering).

Network Impacts

Queue project W3-167 was studied as a(n) 10.0 MW (3.8 MW of which was Capacity) injection into PPL's system at the Wakefield 69.0 kV substation. Project W3-167 was evaluated for compliance with reliability criteria for summer peak conditions in 2014.

Potential transmission network impacts are as follows:

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

No violations identified.

Multiple Facility Contingency

(Double Circuit Tower Line contingencies only with full energy output. Stuck Breaker and Bus Fault contingencies will be applied during the Impact Study)

No violations identified.

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 violations 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 required.

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 required.

Short Circuit

None required.

Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of the surrounding generation. Any potential 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 Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed. 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 analyzes all overload conditions associated with the overloaded element(s) identified. As a result of the aggregate energy resources in the area, the following violations were identified.

No violations identified.