Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position W4-013

Frackville-Orwigsburg 69kV

April 2011

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

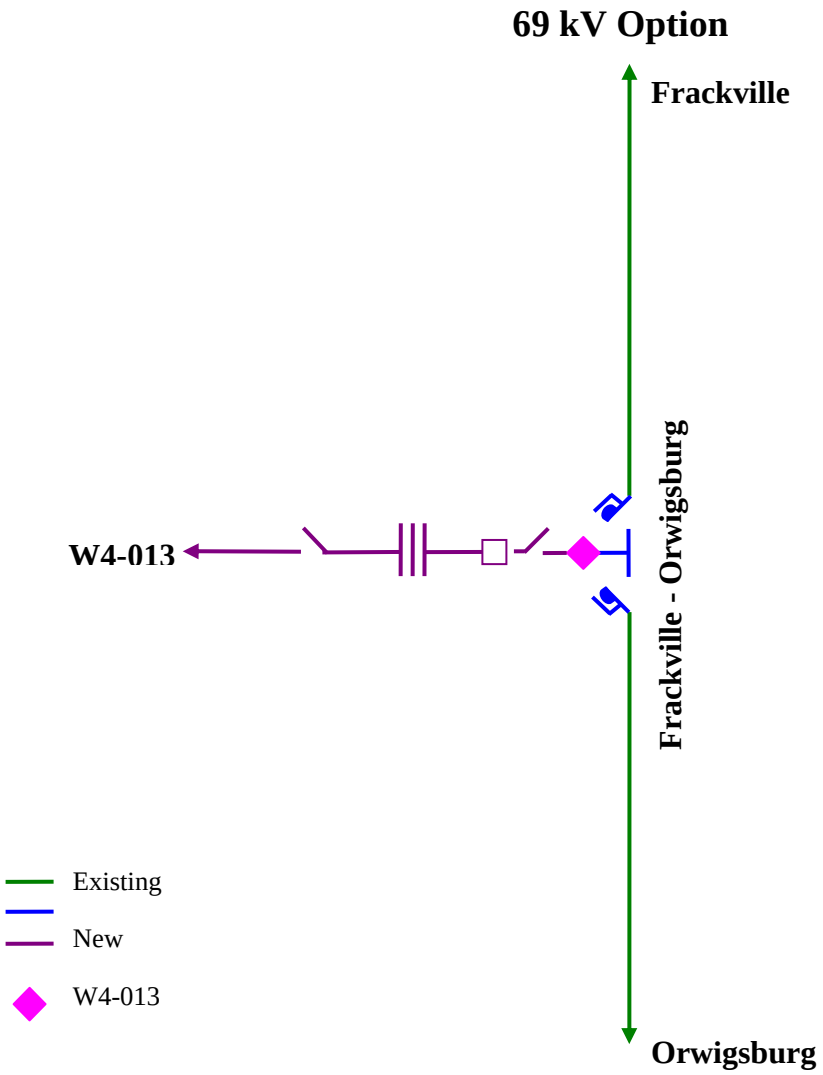
The Interconnection Customer (IC), has proposed a 50 MW (6.5 MW capacity) wind farm located in Schuylkill County, Pennsylvania. Queue W4-013 has proposed an in-service date of December 31, 2014. **This study does not imply a PPL EU commitment to this in-service date.**

Point of Interconnection

W4-013 will interconnect with the PPL Electric Utilities transmission system by connecting into the Frackville-Orwigsburg 69 kV line. A short 69 kV tap will be built between the line and the IC's substation.

Interconnection Customer Scope of Direct Connection Work

Queue W4-013 Interconnection Customer is responsible for design, construction, and costs for all facilities associated with W4-013 on the Interconnection Customer side of the POI (Point of Interconnection) shown in the figure below.



Protection Equipment

The Interconnection Customer will need to install suitable protection and control equipment based on PPL EU parallel generation requirements. The new protection must meet all applicable PPL EU, NERC, and FERC requirements. The protection equipment and schemes will be

identified during the Impact Study. Relaying requirements for voltages below 230 kV can be found on the PPL EU web site. The applicable website addresses are:

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

A bi-directional telephone line-based DTT (Direct Transfer Trip) will be required for communication paths between the W4-013 Substation and the PPL EU Frackville substation. The IPP will be required to provide matching telephone line-based DTT equipment.

The DTT scheme is required for protection of the 69 kV line paths to isolate faults under breaker failure conditions.

SCADA Requirements

PPL EU will require the installation of PPL EU-approved SCADA equipment that will connect to its existing SCADA system. The PPL EU SCADA will use a dedicated 4-wire analog telephone 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, voice and SCADA. PPL EU anticipates that telephone circuits will be required to establish this path. The Interconnection Customer will be responsible to procure a normal dial-up telephone line for voice communication as well as the dedicated SCADA and DTT telephone lines. All installation, maintenance, and monthly lease or billing charges for communications facilities are the responsibility of the Interconnection Customer – as well as suitable high-voltage protection equipment.

Dead End Structure Requirement

IPP W4-013 will be installing a dead-end structure at the point-of-interconnection, which will connect to the new 69 kV tap. Length of the new tap is uncertain at this time, because the developer has not specified a final grid location and an orientation of the dead-end structure. The developer has provided grid number 44550-S-49816 as a possible point-of-interconnection.

Metering Equipment Installation at the Point of Interconnection

Installation of revenue grade metering equipment will be required at the Queue W4-013 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.

Metering / Telemetry for PJM

The 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. Any data from the PPL EU revenue meters can be transferred by fiber optic link to the PJM RTU located at the IPP facility.

Isolation Breaker and Disconnect Switch Requirement

The 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. A breaker will be required on the high side of the transformer because of the size of the transformer. The isolation breaker will be operated by suitable relaying depending on the final arrangement of the facilities. Refer to the previously listed documents on parallel generation and high voltage customer requirements. It is expected this device will NOT be used to synchronize or parallel operating generation to the PPL EU system.

Transmission Owner (PPL EU) Scope of Direct Connection Work

The total estimated cost of Direct Connection Facilities needed to connect Queue W4-013 to the Frackville-Orwigsburg 69 kV line is **$1,041,956 [transmission cost + substation cost]** (excluding taxes). The 69 kV connection estimate is based on the assumptions stated in the following Transmission and Substation Direct Connection Work sections. This estimate will vary depending upon the Queue W4-013 substation location and orientation. **Network impacts and associated upgrade requirements are addressed at the end of the report.**

The transmission and substation costs given above exclude any applicable state or federal taxes. If at a future date Federal CIAC taxes are deemed necessary by the IRS for this project, both PJM and PPL EU shall be reimbursed by the Interconnection Customer for such taxes.

A breakdown of the direct connection costs are:

$	800,791	Transmission work
$	241,165	Frackville Substation work
$	**1,041,956**	**Total Direct Connection**

Note: Before the Impact Study stage, the exact location and orientation of the Interconnection Substation must be identified by the W4-013 developer in order to refine the cost estimate.

After the PJM three-party Interconnection Service Agreement (ISA) and Interconnection Construction Service Agreement (ICSA) are signed and PPL EU receives written authorization by PJM to begin work, PPL EU will commence the transmission line siting, engineering design, material purchase, and construction of the Frackville substation and 69kV tap facilities identified above. The time required for siting (if required) and right-of-way acquisition for the transmission line work is estimated to be 6 months assuming W4-013 is the only landowner involved and is willing to provide the necessary right-of-way. These activities could take longer than expected if W4-013 is not the only landowner involved or if unforeseen complications arise.

The typical time needed to complete the transmission design and construction work is estimated to be approximately 24 months. All right-of-way will need to be acquired prior to the start of construction. The substation work may require approximately 6 to 9 months. Total time to complete the project is estimated to be approximately 30 months.

69 kV Transmission Tap Direct Connection Work ($800,791)

$	800,791	Transmission line work to interconnect W4-013, including r/w
$	0	Siting work related to installing the tap line
$	**800,791**	**Total Direct Connection -- Transmission**

The transmission direct connection work includes breaking the Frackville-Orwigsburg 69 kV line in the vicinity of grid 44550-S-49816 and building a 0.5 mile 69 kV tap line to the IC substation using 556 ACSR conductor with shield wire. The tap line will use a 69 kV single-circuit steel pole design. Future double circuit design or 138 kV operation is not required. PPL EU will install an LSAB switch on each side of the location where the new tap is connected. The estimated cost of the transmission line work is **$800,791**.

The lead time required for the transmission line direct connection work is approximately **24 months**. This estimate assumes that suitable line outages can be scheduled as required to terminate the new tap onto the existing transmission lines. Failure to meet a scheduled line outage window may result in project delays. All right-of-way must be acquired prior to construction of the new transmission line.

Line Maintenance and Alternate Outlet for Generation

During periods when line or switch maintenance is required, sections of the Frackville-Orwigsburg 69 kV line and the W4-013 69 kV tap will need to be de-energized, forcing W4-013 to come off-line. Planned maintenance is scheduled approximately once every four years, and typically lasts from a few days up to 2 weeks. During this maintenance period, the line may or may not be returned to service at the end of the workday. Unplanned maintenance is completed as soon as work can be scheduled. 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 W4-013 facility at additional cost to the IC.

Siting, Right-of-Way Acquisition, & Environmental Impact

The cost estimate is based on the assumption that sufficient right-of-way will be provided by the developer to PPL EU for the construction of the new 69 kV line (tap) into the W4-013 substation. A 100 ft right-of-way width is standard for a PPL EU 69 kV design.

Because the line design will be 69 kV, a Letter-of-Notification to the PUC for breaking into the Frackville-Orwigsburg 69 kV line and connecting to the new 69 kV tap will not be required. No condemnation costs are included. Costs for threatened and endangered species studies or environmental constraints are also not included.

Substation Direct Connection Work ($241,165)

$	241,165	Frackville Substation work
$	**241,165**	**Total Direct Connection – Substation**

To accommodate W4-013, additional protection equipment will be installed and existing settings changed at the Frackville Substation:

1. Lot of RFL 9745 equipment, and associated switches, aux relays, lights, etc., to be installed by the field in the existing cabinet. While the cabinet has room, there are very tight quarters in the control cubicle.

2. Modify the 69 kV breaker in Bay 3 to provide a 'b' aux switch for the DTT (this may require a new cable).

3. Modify Bay 3 to include a line side CCVT, foundation, conduit, and cabling to control cubicle. (No CCVT shown on LE101162 sheet 2).

4. Modify the 69 kV R&C panels to include synch check relaying, possibly replacing ACR with SEL-279 due to limited panel space (E150935 and E150936) panels C3 and R3.

5. Add TTI relay, and associated wiring to the new DTT equipment.

6. Update SCADA as necessary.

7. Update AMS if installed.

8. **NOTE: There is limited space in the existing control house to install the above equipment. During the Impact Study, PPL EU will confirm a suitable location for the equipment.**

The substation direct connection work can be performed in tandem with the 69 kV line construction.

Direct Connection Issues

W4-013 Generator and GSU modeling

Per the W4-013 supplied data, the following was used in modeling the wind turbine generators and GSUs:

W4-013 Wind Turbine:

Turbines: 25 units, 2 MW each (2.105 MVA base), net injected into PPL EU system 50 MW; saturated sub-transient reactance of 0.131 pu on MVA base (Given).

GSU:

Generator Step Up Transformer: Twenty-five units, 0.69/34.5 kV, 2.35 MVA (base) each with an impedance of 0.0102+j0.1155 pu (Given).

Intertie Transformer:

Intertie step-up transformer base: One 34.5/69 kV w/ 13.2 kV tertiary, 30/40/50 MVA (30 MVA base) transformer with an impedance of 0.00225 + j0.09 pu (Given).

The W4-013 Interconnection Customer must provide PPL EU and PJM with the transformer test reports and a model of the wind turbines once they are available in order to perform a more detailed short circuit analysis.

Generator Harmonic and Flicker Requirements

On the 69 kV system, the total harmonic distortion to the fundamental voltage wave from a single customer is limited to 1.5% of nominal. In addition, no individual harmonic component can exceed 1.0% of the fundamental system voltage.

If PPL EU discovers that objectionable harmonics in excess of the stated limits are being injected into the system from W4-013's equipment, the Queue W4-013 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Maximum Allowable Harmonic Voltage Distortion Table (REMSI* Rule 33)		
Voltage Level	**Total Harmonic Distortion (% System Voltage)**	**Individual Harmonic (% System Voltage)**
69 kV	1.5	1.0

* *"Rules for Electric Meter & Service Installations", Rules 32 and 33.*

Concerning voltage flicker, the W4-013 customer must limit the severity of their voltage variation to within a level which will not cause objectionable flicker to other customers. A voltage drop greater than 5% at the point of interconnection is generally not acceptable. The frequency and severity of the voltage variation must be considered when determining whether a customer's equipment is violating PPL EU flicker guidelines. PPL EU uses the General Electric flicker-irritation curve as a guideline to determine if the system is operating within acceptable limits. **PPL EU will require corrective actions by the W4-013 customer if its operation**

causes flicker that exceeds PPL EU guidelines. One such correction could be the installation of static var compensators (SVC) to hold a constant voltage.

Reactive Support Requirements

PPL EU load flow studies have indicated that the W4-013 wind turbine generators will maintain the required voltage regulation within its required range at the 69 kV point-of-interconnection (POI) by operating at a power factor of **0.985 leading**. This calculation was based on 50 MW injected into the POI bus while the IC facility absorbed 8.7 MVAR from the PPL EU system. As specified in Interconnection Service Agreement, Appendix 2, Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the W4-013 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."

Preliminary Schedule and Notes / Assumptions

PPL EU will begin the project only after the PJM 3-party Interconnection Service Agreement (ISA) and Interconnection Construction Service Agreement (ICSA) are fully executed and PPL EU receives a written authorization by PJM to commence activities.

The estimated PPL EU elapsed time to complete the 69 kV **direct connection** transmission and substation upgrades is approximately **30 months** after the execution of an ICSA. This work can be done concurrently.

The schedule for the 69 kV transmission and substation work to accommodate W4-013 would depend on the project start date and when transmission line outages can be arranged. PPL EU's outage windows for construction are typically available in the spring and fall of the year. Missing an outage window could result in project delays.

Notes / Assumptions:

- The ISA/ICSA or an Interim Interconnection Service Agreement (IISA) must be signed by the W4-013 Interconnection Customer, PJM, and PPL EU before any PPL EU activities may commence.

- PPL EU recommends that an Interim ISA be completed during the Facilities Study stage to address critical path items, such as long lead-time purchases and any other compressed project schedule issues.

- Long lead-times for leased telephone lines may be encountered. Therefore, the W4-013 Interconnection Customer should investigate the availability of leased telephone facilities to meet its in-service schedule.

- If custom-designed steel transmission poles are required, the current lead-time is approximately **20 to 24 weeks**.

- During construction, if extreme weather conditions or other system safety concerns arise, field construction may need to be rescheduled, which could possibly impact the schedule plan.

- Excepting any operational, governmental and/or environmental regulatory delays, the use of additional resources, such as overtime, premiums for expedited material, and/or contractor labor, may enable PPL EU to decrease this construction period. It is also assumed that all right-of-way and easements are secured without impact on anticipated construction start dates.

Network Impacts

Queue project W4-013 was studied as a(n) 50.0 MW (6.5 MW of which was Capacity) injection into PPL's system at the 50.0% tap between P 46/70 and ORWIGS T69.0 kV line. Project W4-013 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)

1. (PL) The Frackville Bus-Siegfried Bus 230 kV line (from bus 207973 to bus 208074 ckt 1) loads from 98.78% to 101.82% (DC power flow) of its emergency rating (616 MVA) for the tower contingency 'PL100484'. This project contributes approximately 18.77 MW to the thermal violation.

   CONTINGENCY 'PL100484' /* D/C MONTOUR-SUSQ 230KV & MONTOUR-SUSQ T10 230KV
   DISCONNECT BRANCH FROM BUS 208040 TO BUS 208113 CKT 1
   DISCONNECT BRANCH FROM BUS 208040 TO BUS 208120 CKT 1
   END

   PPL Response:
   PPL EU has provided a cost recently (e-mail of 1/28/2011) to upgrade this segment. Cost is approximately $109 million to rebuild the Siegfried-Frackville 230 kV line segment.

   - Rebuild Siegfried-Frackville 230 kV line, 40 miles, including line bays at each substation -- $109 million (this was updated from the $101 million cost given in previous correspondence to PJM)

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.)

Additionally, for a double circuit outage of the Susquehanna-Mountain & Mountain-Susquehanna T10 230 kV lines, the Hunlock-Berwick 69 kV line loads from 112.9% to 114.5% of its emergency rating (51 MVA) on the 9 miles section between Berwick and Koons Air Break (portions owned by PPL and UGI). Should further investigation prove this project necessary due to the addition of W4-013, the estimated cost is $7,878,710. Note that this figure is a preliminary PPL EU estimate for the entire line section, but PPL EU would actually be responsible for rebuilding approximately 7 miles, and UGI the remaining 2 miles.

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

(Report over-dutied breakers.)

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.

None required.