Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position W1-111

Harwood-Berwick 69kV

July 2010

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

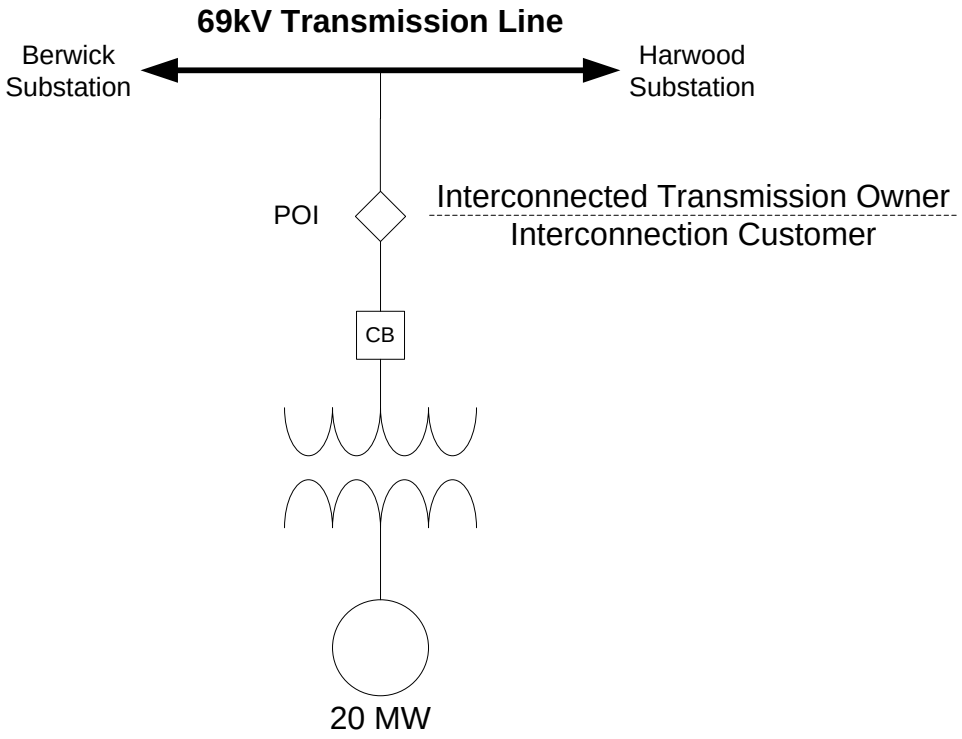
The Interconnection Customer (IC), has proposed a 20 MW (0 MW capacity) flywheel device located Hazel Township, Luzerne County, Pennsylvania. Queue W1-111 has proposed an in-service date of January 20th, 2012. **This study does not imply a PPL EU commitment to this in-service date**.

Point of Interconnection

W1-111 will interconnect with the PPL Electric Utilities transmission system on a 69kV line between the Harwood and Berwick substations.

Interconnection Customer Scope of Direct Connection Work

Queue W1-111 Interconnection Customer is responsible for design, construction and costs for all facilities associated with W1-111 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. 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. A telephone based DTT will be required for communications paths between the W1-111 Substation and PPL EU's Harwood and Berwick substations (see 'Telephone Circuit Requirements' section of this Study). However, the telephone line portion would originate from the W1-111 Substation. This is a special dedicated 4 wire analog telephone line, type PRDA.

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 Harwood 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 69 kV 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 generator is operating in parallel with the PPL system (contact is OPEN when any generator is in parallel) - this contact will close when ALL generators 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 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 Harwood and Berwick substations.

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 Humboldt 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 W1-111 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 site's step-up transformer must also be installed ahead of the isolation breaker.

Optional Capacitor Bank Requirements

If the Interconnection Customer opts to operate during certain bus outages at the Harwood 230/69 kV regional substation, it will be required to install an approximately 13 Mvar capacitor bank at the W1-111 substation 13.8 kV bus to maintain proper voltage levels during operation of the W1-111 facility. The capacitor size and control will be reanalyzed during the Impact Study to ensure it meets PPL EU flicker and harmonic guidelines.

Transmission Owner (PPL EU) Scope of Direct Connection Work

The total estimated cost of Direct Connection Facilities needed to connect Queue W1-111 to the Harwood-Berwick 69 kV line is **$1,160,000 (substation cost) + (transmission cost)** (excluding any applicable state or federal 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 W1-111 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 further breakdown of the direct connection costs are as follows:

$	800,000	New 100 ft. 69kV tap to W1-111
$	5,000	Siting/ROW for new 100 ft. 69kV tap to W1-111
$	355,000	Harwood and Berwick Substation work to accommodate W1-111
$	**1,160,000**	**Total Direct Connection**

Note: Before the Facilities Study stage, the exact location of the Interconnection Substation must be identified by the W1-111 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 siting, engineering design, material purchase, and construction of facilities identified above. The time required for siting and Right-of-Way acquisition is estimated to be 6 months assuming W1-111 is the only landowner involved and is willing to provide the necessary Right-of-Way. This work could take longer than expected if W1-111 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 12 to 15 months. All Right-of-Way will need to be acquired prior to the start of construction. The substation work may require approximately 9 to 15 months and can be completed simultaneously with the 69 kV line construction. This translates into a **12 to 18 month** project time frame for the direct connection work.

69 kV Transmission Tap Direct Connection Work

$	800,000	New 100 ft. 69kV tap to W1-111
$	5,000	Siting/ROW for new 100 ft. 69kV tap to W1-111
$	**805,000**	**Total Direct Connection**

The transmission direct connection work includes tapping the Harwood-Berwick 69 kV line in the vicinity of grid 468-N-289 and building a 100 ft. connection using 556 ACSR conductor with ½" EHS overhead ground wire (OHGW) to a dead-end structure in the new W1-111 customer-owned substation. The tap line will be a 69 kV steel pole design. The estimated cost of the transmission line termination work is **$800,000** and is included in the above estimate.

The lead time required for the transmission line direct connection work is approximately **12 to 18 months** (6 months for the siting/right-of-way work and 12 to 15 months for the transmission engineering/construction work, where both can be done concurrently). 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 may result in project delays. All right-of-way must be acquired prior to construction of the new transmission line.

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

PPL EU is assuming that sufficient right-of-way will be provided by the developer to PPL EU for the construction of the W1-111 Tap from the existing Harwood – Berwick 69 kV line to the proposed W1-111 substation location. A 100 ft right-of-way width is PPL EU's standard. **The tap will be designed and operated at 69 kV and will therefore not require PUC certification.**

The estimated cost of the siting work is **$5,000** and is included in the above estimate. No condemnation costs are included. Costs for threatened and endangered species studies or environmental constraints are also not included.

Alternate Outlet for Generation Operation During PPL EU Maintenance

An alternate outlet for the generation was not requested. W1-111 will not be able to generate into the PPL EU network during maintenance on either the 69 kV line to W1-111 or during certain bus outages at the Harwood 230/69 kV regional substation. If W1-111 requests an alternate outlet to generate during certain bus outages at the Harwood substation then the installation of a capacitor bank will be required. Refer to the "Optional Capacitor Bank Requirements" above.

Harwood and Berwick 69 kV Substation Direct Connection Work

$	355,000	Harwood and Berwick Substation work to accommodate W1-111
$	**355,000**	**Total Direct Connection**

To accommodate W1-111, the following upgrades are required at PPL EU's Harwood 69kV Substation:

- Install two telephone line based Direct Transfer Trip (DTT) system (one to Harwood substation and one to Berwick substation)
- Install new telephone line protection equipment
- Modify the controls for the Harwood-Berwick line for the above equipment
- Modify SCADA for new alarms
- Install new cables for the above equipment

This work includes installation of phone line based DTT equipment and control design modifications for the Harwood and Berwick terminals. W1-111 will be required to provide a matching set of DTT equipment at their site. The scheme will provide a trip signal to W1-111 for any line fault or any other condition that will cause the PPL EU breaker at Harwood substation to trip. The DTT scheme provides a block-closing signal to the breakers at Harwood and Berwick from W1-111. Automatic reclosing of the PPL EU line breaker will be blocked whenever the W1-111 69 kV breaker is closed and W1-111 generation is on-line.

The estimated total cost for the work at Harwood and Berwick substations is approximately **$355,000** and is included in the above estimate.

The lead time required for the substation direct connection work is approximately **9 to 15 months**. This schedule assumes that suitable equipment outages can be scheduled as required. Failure to meet a scheduled line outage may result in project delays.

Direct Connection Issues

W1-111 Inverter and GSU modeling

Per the W1-111 supplied data, the following was used in modeling the inverters and GSUs:

W1-111 Inverter Units:

Inverters: 100 units, 110 kW each, net injected into PPL EU system 20 MW (20.9 MW Gross).

GSUs:

Inverter Step Up Transformers: Ten 0.48/13.8 kV, 2 MVA transformers with 5.77% impedance (Given) and X/R of 30 (Assumed).

Intertie Transformers:

Intertie step-up transformer base: One 13.8/69 kV, 20 MVA (12 MVA base) transformer with 8.5% impedance (Given) and X/R of 10 (Assumed).

The W1-111 Interconnection Customer must provide PPL EU and PJM with the transformer test reports and a model of the inverters 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 W1-111's equipment, the Queue W1-111 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Maximum Allowable Harmonic Voltage Distortion Table (Tariff Rule 33)		
Voltage Level	**Distortion Factor (% System Voltage)**	**Individual Harmonic (% System Voltage)**
69 kV through 138 kV	1.5	1

Concerning voltage flicker, the W1-111 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 W1-111 customer if their 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 W1-111 inverters will maintain the required voltage regulation on the Harwood-Berwick 69 kV line within its required range. The voltage schedule for the Harwood-Berwick line at the W1-111 tap is approximately **0.97 pu (66.9 kV)**. As specified in Interconnection Service Agreement, Appendix 2, Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the W1-111 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 **12 to 18 months** after the execution of an ICSA.

The schedule for the 69 kV transmission and substation work to accommodate W1-111 would depend on the project start date. The work to accommodate W1-111 will require transmission line outages. 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 W1-111 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 W1-111 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 28 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 W1-111 was studied as a(n) 20.0MW (0.0MW of which was Capacity) injection/withdrawal into PPL's system on the 69kV line between the Harwood Substation and the Salem Tap. Project W1-111 was evaluated for compliance with reliability criteria for summer peak conditions in 2014. Potential network impacts were as follows:

Generator Deliverability

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

No problems 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 problems identified.

Contribution to Previously Identified Overloads

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have % allocation of cost responsibility which will be calculated and reported for the Impact Study.)

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.

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 problems identified.

Short Circuit

No problems identified.

Stability Analysis

Not required.