

***Generation Interconnection  
Feasibility Study Report***

***For***

***PJM Generation Interconnection Request  
Queue Position Z2-008***

***East Palmerton-Wagner 69kV***

**August 2014**

## 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.

The conduct of light load analysis as required under the PJM planning process is not performed during the Generation Interconnection Feasibility Study phase of the PJM study process. Additional reinforcement requirements for this Interconnection Request may be defined during the conduct of the light load analysis which shall be performed following execution of the System Impact Study agreement.

## General

The Interconnection Customer (IC), has proposed a wind generating facility located at Carbon and Monroe Counties, Pennsylvania. The installed facilities will have a total capability of 99 MW with 12.9 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is December 31, 2017. **This study does not imply a PPL Electric Utilities Corporation (PPL EU) commitment to this in-service date.**

### Point of Interconnection

Z2-008 will interconnect with the PPL EU transmission system at one of two options. Option 1 is to connect to the East Palmerton-Acahela #1 & #2 69kV line. Option 2 is to connect to the Siegfried-Jackson #2 138kV line.

## **Cost Summary**

The Z2-008 project will be responsible for the following costs:

<b>Description</b>	<b>Total Cost</b>
Attachment Facilities	\$ 8,000,000
Direct Connection Network Upgrades	\$ 0,
Non Direct Connection Network Upgrades	\$ 300,000
<b>Total Costs</b>	<b>\$ 8,300,000</b>

The 69 kV connection estimate is based on the assumptions stated in the following Transmission Attachment Facilities and Substation Non- Direct Connection Work sections. This estimate may vary depending upon the Queue Z2-008 substation location and orientation.

**Note:** Before the Impact Study stage, the exact location of the Interconnection Substation must be identified by the Z2-008 IC in order to refine the cost estimate.

In addition, the Z2-008 project may be responsible for a contribution to the following costs:

<b>Description</b>	<b>Total Cost</b>
New System Upgrades	\$ 0
Previously Identified Upgrades	\$ 0
<b>Total Costs</b>	<b>\$ 0</b>

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

The transmission and substation costs given above exclude any applicable state or federal taxes. If at a future date Federal CIAC (cost in aid of construction) 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.

## **Overview**

The Z2-008 project can be connected to PPL EU's 69 kV transmission system by tapping both the East Palmerton-Acahela #1 & #2 69 kV lines between Carbon and Hickory Run substations (approximate grid 58607N28657) and extending approximately 1.96 mile of double circuit transmission line to the Interconnection Customer's Substation. The Point of Interconnections (POIs) will be where the PPL EU transmission lines land on the customers dead-ends inside the IC's yard.

## Attachment Facilities

### Transmission Line Work

This Project will require siting to identify a suitable route for the 100'-wide right of way needed to construct the approximately 1.96 miles of 138/69 kV double circuit transmission line using 556 Kcmil ACSR conductors with optical ground wire (2-OPGW) from the East Palmerton-Acahela #1 & #2 69 kV double circuit lines to the dead end structures inside the customer's substation (POI). The tap line will be a 138 kV double circuit steel pole design, initially operated at double circuit 69 kV.

The transmission network upgrade work includes installation of four MOLBAB (Motor Operated Load Break Air Break) switch on the PPL EU East Palmerton-Acahela #1 & #2 69 kV lines on either side of the tap points to Z2-008. The switches would be installed on a custom designed steel pole with concrete foundations. Attachment 1 for the connection schematic.

PA PUC Certification of the proposed 69 kV transmission line route will be required as it will be designed for future 138 kV operation. The certification would be through the abbreviated "Letter of Notification" (LON) process since the tap is expected to be less than 2 miles long. The lead time required to prepare, file and obtain PA PUC approval and obtain property rights will be approximately 12-15 months and assumes that no litigation or condemnation is required.

### Substation Work Mini Yard:

At the tapping points, a mini yard with motor-operated switches and 69 kV breakers will be installed. A small control house will contain the circuit breaker relays and communication devices. Refer to Attachment 1 for clarity.

### Cost

The total preliminary cost estimate for the Attachment work is given in the table below. These costs do not include CIAC Tax Gross-up.

<b>Description</b>	<b>Total Cost</b>
Transmission line work	\$ 7,250,000
Substation work	\$ 750,000
<b>Total Attachment Facilities</b>	<b>\$ 8,000,000</b>

### **Direct Connection Cost Estimate**

There are no direct connection facilities required by PPL EU.

### **Non-Direct Connection Cost Estimate**

To accommodate Z2-008, the following upgrades are required at PPL EU's East Palmerton 230-69kV Substation:

- Install fiber-based Direct Transfer Trip (DTT) Cabinet at EPAL
- Install new fiber-based line protection equipment at EPAL
- Modify the controls of the East Palmerton 69kV circuit breakers for trip and close
- Modify SCADA for new alarms
- Modify AMS (Alarm Management System)
- Install new cables and modify control wiring for the above
- Perform system checks and test equipment before placing in service

The following assumptions were used to propose the above upgrades:

- New Acahela 230-69kV regional substation in service before the Z2-008 IPP is in-service
- EPAL-WAGN #1 and #2 69 kV lines’ relays upgraded to microprocessor based at East Palmerton as part of the Acahela project.
- Potential Transformers (PTs) were installed at East Palmerton for sync check of both transmission lines as part of the Acahela project.
- Synch check relay on East Palmerton 69 kV circuit breakers were also installed as part of the ACAH project.

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.

<b>Description</b>	<b>Total Cost</b>
Substation work	\$ 300,000
<b>Total Non-Direct Connection Facilities</b>	<b>\$ 300,000</b>

## Alternate Outlet

The IC has not requested an alternate outlet for their generation. When the East Palmerton-Acahela #1 and/or #2 69 kV lines need to come off line for any line maintenance or repair activities, the generator will be asked to either reduce output or come off line.

## Preliminary Schedule

The estimated PPL EU elapsed time to complete the 69 kV Attachment Facilities and Non-Direct Connection substation work is approximately 18 months after the receipt of a fully executed ISA/CSA.

The schedule for the 69 kV substation work to accommodate Z2-008 would depend on the project’s start date. The work to accommodate Z2-008 will require substation facility 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.

The transmission and substation work can be completed concurrently. PPL EU will commence siting, engineering design, material purchase and construction of the facilities identified in this study after receiving written authorization by PJM to begin work. This time frame is contingent

upon the acquisition of all rights of way in the stated time frame before the start of construction and detailed design.

## **Transmission Owner Assumptions in Developing the Cost Estimates**

- For the custom-designed steel transmission poles, the lead-time is approximately 32 to 42 weeks. It is estimated that approximately custom designed steel poles will be needed for this project.
- During construction, if extreme weather conditions or other system safety concerns arise, field construction may need to be rescheduled, which could possibly delay the schedule.
- This magnitude estimate has been prepared without extensive research or field review.
- For the new 69 kV double circuit tap from Z2-008 to the East Palmerton-Acahela #1 & #2 69 kV line, it is assumed that a new ROW and siting study would be required and the tap would be owned by PPL EU.
- No environmental, real estate, or permitting issues were reviewed for the estimate of this project.
- This schedule assumes that suitable line/equipment outages can be scheduled as required. Failure to meet a scheduled facility outage may result in project delays.
- 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 but no guarantees can be made. It is also assumed that all rights-of-way and easements are secured by the anticipated construction start dates.
- 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.
- The ISA/CSA or an Interim Interconnection Service Agreement (IISA) must be signed by the Z2-008 Interconnection Customer, PJM, and PPL EU before any PPL EU design and construction activities may commence.

## **Interconnection Customer Requirements**

### **Z2-008 Generator, GSU, and Line Modeling**

The turbines will be modeled as one unit and will inject 99 MW into PPL EU's system.

Per the Z2-008 supplied data the following was used in modeling the generator and the GSU:

### **Z2-008 Generator (Vestas V117):**

- Number of Turbines: 30
- Size: 3.3 MW per turbine
- MVA Base: 3.8 MVA
- Terminal Voltage: 0.65 kV
- 0.95 lead to 0.95 lag power factor

### **Transformers:**

- GSU (Generator Step Up Transformer):
  - Number of machines per GSU: 30
  - MVA Base: 60 MVA
  - Voltage Level: 69/34.5/13.8 MVA
  - Impedance: 9.0%
- GSU (Wind Turbine Unit):
  - MVA Base: 3.75 kV
  - Voltage Level: 34.5/0.65 kV
  - Impedance: 8.7%

### **Transmission Line:**

- Voltage Level: 69 kV
- Length: 1.0 mile

### **Telephone Circuit Requirements (At the IPP)**

PPL EU will require a communication path for SCADA and voice circuits. PPL EU anticipates that telephone circuits will be required to establish these paths. The Interconnection Customer will be responsible to procure the following:

1. A 4-wire dedicated FDDA-type phone line for SCADA
2. A normal dialup telephone line for voice communication

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 their facility.

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

### **Intertie and POC Protective Relaying Equipment**

The Interconnection Customer will need to install suitable protection and control equipment at its facilities 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:**

<https://www.pplelectric.com/at-your-service/electric-rates-and-rules/customer-owned-generation.aspx>

**POC Requirements:**

<https://www.pplelectric.com/at-your-service/electric-rates-and-rules/point-of-contact-requirements-for-high-voltage-facilities.aspx>

**DTT Equipment Requirements**

Fiber-based DTT (Direct Transfer Trip) equipment will be used to communicate circuit breaker tripping and status monitoring between the Interconnection Customer facility and the PPL EU East Palmerton and Acahela 230-69 kV Substations.

- A fiber tap to the Interconnection Customer substation will be required
- The DTT scheme is required for protection of the 69 kV line paths to isolate faults under breaker failure conditions
- Specific protective relaying requirements will be determined at the Facilities Study

**Isolation Breaker Requirement at the Interconnection Customer’s Substation**

Per the customer’s preliminary sketches, the customer is planning to provide high side circuit breakers at 69 kV with manually operated 69 kV disconnect switches on the PPL EU line side of the breakers. Unless otherwise indicated, it is assumed that these be will be the “Isolation Circuit Breakers” and will be operated by the IPR relay and the DTT signal. It is requested that the customer confirm this or provide alternate isolation breakers.

**Z2-008 Generator Harmonic and Flicker Requirements**

On the PPL EU 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 Z2-008’s equipment, the Queue Z2-008 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Concerning voltage flicker, the Interconnection Customer must limit the severity of their voltage variation to within a level which will not cause objectionable flickers 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 will be considered when determining whether a

customer's equipment is violating PPL EU flicker guidelines. PPL EU uses the General Electric flicker-irritation curves as a guideline to determine if the system is operating within acceptable limits. PPL EU will require corrective actions by the Interconnection Customer if their operation causes flickers that exceed PPL EU guidelines. One such correction could be the installation of static var compensators (SVC) to hold a constant voltage.

## **Z2-008 Generator Regulation or Reactive Support Requirements**

As specified in Part IV, Subpart E at 54.7 of the PJM OATT, the Project Z2-008 generator shall design its "Facility" to maintain a composite power factor delivery at continuous rated power output at the generators terminals at a power factor of at least 0.95 leading (absorbing vars) to 0.95 lagging (supplying vars).

*"For all new wind-powered and other non-synchronous generation facilities, if determined in the system Feasibility 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 PPL EU preliminary load flow studies have indicated that the Z2-008 generator will maintain the required voltage regulation within the required ranges. A voltage schedule will be developed at the time of the Facilities Study.

## **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.

### **PPL EU Requirements**

#### **SCADA Equipment Requirements**

PPL EU will require installation of PPL EU approved SCADA equipment that will connect to its existing SCADA system to provide real time values of KW, KVAR, and kV metering data at the POC. SCADA equipment will also provide capability to trip and the status monitoring of the POC isolating circuit breaker. In addition to that, monitoring of other abnormal conditions at developer's plant will be provided where deemed necessary. This connection will be a 4-wire dedicated FDDA-type phone line. PPL EU will provide detailed specifications and design drawings for this equipment.

#### **Revenue Metering Equipment Installation at the Point of Interconnection**

Installation of revenue grade Bi-directional Metering Equipment will be required at the Queue Z2-008 Point of Interconnection (POI) to measure KWh and KVARh. PPL EU will design and

supply the required metering equipment but all the installation cost would be borne by the developer including CT/PTs. 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 must provide bi-directional revenue metering (KWH and KVARH) and real-time data (KW, KVAR, circuit breaker status, and generator bus voltages) for the developer's generating resource. The equipment should be housed in a control cabinet or similar enclosure and must be accessible to PPL EU metering personnel.

## **Other Issues Impacting the Interconnection Customer**

### **Distribution Service Requirements**

The Interconnection Customer must submit a request for electric service through PPL EU's Industrial and Commercial Services (ICS) group if the queue Z2-008 requires back-up electric service at a voltage less than 69 kV. The ICS Help Desk can be reached at 1-888-220-9991. Cost for distribution electric service is NOT included in the PPL scope of work transmission or substation estimates.

### **Future Conversion of line to 138 kV from 69 kV**

PPL EU presently has no plans to convert this line to 138 kV in the next 15-20 years. If the transmission system in this area is converted to 138 kV in the future, the Interconnection Customer would be responsible for conversion of its substation to 138 kV at that time.

### **PA PUC Certification & Environmental Issues**

All required land and right of way will be made available to PPL EU at no cost from the Interconnection Customer developer. It is assumed here that the transmission tap would be owned by PPL EU.

PA PUC certification will be required as the tap will be designed for future 138 kV but will initially operate at 69 kV.

### **Intertie 69-34.5 kV Transformer Turns Ratio**

PPL EU typically procures the transformers with the following high side (69 kV) taps:

70.6 kV, 68.8 kV, 67.0 kV, 65.2 kV, 63.4 kV with nominal mid-point voltage is 67 kV, this provides a range of 5% above (in two 2.5% steps) and 5% below (in two 2.5% steps) to the mid-point range of 67 kV.

# Network Impacts

## Option 1

The Queue Project Z2-008 was studied as a 99.0 MW (Capacity 12.9 MW) injection as a tap of the East Palmerton – Wagner #1 and #2 69 kV lines in the PPL area. Project Z2-008 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project Z2-008 was studied with a commercial probability of 53%. A Summer 2018 case was used for this analysis.

Potential network impacts were as follows:

### Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
PJM69	CONTINGENCY 'PJM69' DISCONNECT BRANCH FROM BUS 200021 TO BUS 200009 CKT 1 /* SUNBURY JUNIATA 500 500 DISCONNECT BRANCH FROM BUS 200021 TO BUS 200022 CKT 2 /* SUNBURY SUSQHANA 500 500 / CKT 1 -> 2 DISCONNECT BRANCH FROM BUS 200021 TO BUS 208109 CKT 24 /* SUNBURY SUNBURY 500 230 END

**Generator Deliverability**

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

None.

**Multiple Facility Contingency**

*(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)*

None.

**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)*

None.

**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.*

#	Contingency		Affected Area	Facility Description	Bus		Circuit	Power Flow	Loading %		Rating		MW Contribution
	Type	Name			From	To			Initial	Final	Type	MVA	
1	N-1	PJM69	PPL	SUSQHANA 500/230kV transformer	208116	200022	21	DC	112.88	113.54	ER	1165	53.42

**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.

## **Option 2**

The Queue Project Z2-008 was studied as a 99.0 MW (Capacity 12.9 MW) injection as a tap of the Siegfried – Jackson #2 138 kV line in the PPL area. Project Z2-008 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project Z2-008 was studied with a commercial probability of 53%. A Summer 2018 case was used for this analysis.

Potential network impacts were as follows:

### **Generator Deliverability**

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

None.

### **Multiple Facility Contingency**

*(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)*

None.

### **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)*

None.

### **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.*

None.

**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.

## Attachment 1. Single Line Diagram