Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position W3-069

Cumberland-W. Shore#3-2 69kV

January 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

Queue W3-069 is an Interconnection Customer or IC request to interconnect a 20 MW Energy (7.6 MW Capacity) Solar PV Generating Station, named as Cumberland-W. Shore#3-2 with ground mounted fixed panel solar arrays. The capacity portion of 7.6 MW means that the remaining 12.4 MW will be curtailable should a system reliability constraints occur. Queue W3-069 is located in South Middleton Township, Cumberland County, PA Queue W3-069 generation interconnection desires commercial operation by July 1, 2012. **This study does not imply a PPL EU commitment to this in-service date.**

Point of Interconnection

Queue W3-069 can be connected to PPL EU's 69 kV Transmission System by tapping the Cumberland - W. Shore #3 69kV network line via an approximately 2 miles of 69kV.

Transmission Owner (PPL EU) Scope of Direct Connection Work

Option 1 – Connect to Cumberland-W. Shore #3 69kV Line

The total estimated cost of Direct Connection Facilities needed to connect Queue W3-069 to the Cumberland-W. Shore #3 69kV kV line is:

$ 50,000 excluding any applicable state or federal taxes

The cost is towards PPL EU review and commissioning this project other than that there is no other cost since this project is connected to the same 69kV tap as the project W3-068 from the same developer. This cost estimates may vary if the location of the project changes. See Attachment 1 for the connection schematic.

69 kV Transmission Tap Direct Connection Work

No cost to W3-069

Cost is covered in the scope of project W3-068 from the same developer and connected to the same transmission tap.

69 kV Transmission Siting/rights of way Work

No cost to W3-069

Cost is covered in the scope of project W3-068 from the same developer and connected to the same transmission tap, see figure 2

Substation Direct Connection Work

$ 50,000 Total Substation Direct Connection scope of work to accommodate the connection of W3-069 and includes the following work:

- PPL EU review of drawings and other IPP W3-069 equipment specifications
- PPL EU interface and support in commissioning the IPP W3-069

Option 2 – Connect to Cumberland-W. Shore #4 69kV Line

The total estimated cost of Direct Connection Facilities needed to connect Queue W3-069 to the Cumberland-W. Shore #4 69kV kV line is: (scope is same as in option 1)

$ 50,000 excluding any applicable state or federal taxes

The cost is towards PPL EU review and commissioning this project other than that there is no other cost since this project is connected to the same 69kV tap as the project W3-068 from the same developer. This cost estimates may vary if the location of the project changes. See Attachment 2 for the connection schematic.

Preliminary PPL EU Direct Connection Work Schedules

W3-069 work schedules would be the same as the W3-068 since both are connected to the same PPL EU tap

Assumptions and Notes

- Long lead-times for leased telephone lines may be encountered. Therefore, the W3-069 Interconnection Customer should investigate as soon as possible the availability of leased telephone facilities to meet its in-service schedule.

- 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 but no guarantees can be made. It is also assumed that all rights-of-way and easements are secured without impact on 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 W3-069 Interconnection Customer, PJM, and PPL EU before any PPL EU design and construction activities may commence.

Interconnection Customer's Scope of Direct Connection Work

Queue W3-069 Interconnection Customer will be responsible for the construction of all their generating station facilities on the W3-069 side of the POI (Point of Interconnection) as shown in the Figure 1 on the previous page.

Telephone Circuit Requirements

PPL EU will require communication paths between the W3-069 customer substation and PPL EU's Cumberland and W. Shore Substations for Voice, SCADA, and DTT.

For the telephone communication path, the Interconnection Customer will be responsible to procure the following to communicate with the both PPL EU substations, Cumberland and W. Shore:

a) Protective relay-grade telephone circuits for the DTT communication requirements, type PRDA.

b) A 4-wire dedicated FDDA-type phone line for SCADA.

c) A normal dialup telephone line for voice communication.

The DTT phone lines (one each for Cumberland and W. Shore) will originate at the W3-069 Substation and terminate at PPL EU Cumberland and W. Shore Substations. The SCADA phone line will go to one of our Service centers, to be determined during the Impact or Facility study. Phone lines tend to be long lead-time items and must be in place and operational for DTT equipment testing. The Interconnection Customer should secure the necessary phone lines as soon as possible.

All installation, maintenance, and monthly lease or billing charges for communications facilities for Scada, Voice, DTT, Metering, etc., 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:
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 Equipment Requirements

Telephone line based audio tone DTT (Direct Transfer Trip) equipment will be required to communicate circuit breaker tripping and status monitoring between the W3-069 and the PPL EU Cumberland and W. Shore Substations. (See 'Telephone Circuit Requirements' section of this Study for details on phone circuit requirements). These telephone lines would originate from the W3-069 Substation and are special dedicated 4 wire analog telephone lines, type PRDA. PPL EU will provide detailed specifications and design drawings for this equipment.

PPL EU will need signals to both Cumberland and W. Shore Substations from W3-069 that will indicate:

- The W3-069 isolation breaker is open (a breaker 'b' switch)

  Or

- A contact that will indicate when ANY inverter is operating in parallel or still connected with the PPL EU system (contact is in OPEN STATE when any inverter is in parallel and W3-069 system normal) - this contact will change to a close status when ALL inverters are OFF line (disconnected from the PPL EU system).

PPL EU 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 Bidirectional Metering Equipment will be required at the Queue W3-069 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 should be housed in a control cabinet or similar enclosure and must be accessible to PPL EU metering personnel.

PJM SCADA Equipment Requirements

Interconnection Customer is also required to provide real-time (instantaneous) values of KW and KVAR data to PJM via the Scada equipment in compliance with the requirements listed in PJM Manuals M-01 and M-14D available at http://www.pjm.com

Isolation Breaker Requirement at the Developer's Substation

Per the customer's preliminary sketches, the customer is planning to provide an high side circuit breaker at 69kV with a manually operated 69kV disconnect switch on the PPL EU line side of this breaker, unless otherwise indicated it is assumed that this be will be the "Isolation Circuit Breaker" and will be operated by the IPR relay and the DTT signal. It is requested that the customer confirm this or provide alternate isolation breaker.

Intertie Requirements from the Developer of IPP W3-069

W3-069 Inverter and GSU modeling Data (incomplete, need more information)

Per the W3-069 supplied data dated October 12, 2010, the following was used in modeling the inverters and GSUs:

W3-069 Inverter Units:

Inverters:

Total number of Inverters: Not provided yet by the customer
Rating of each Inverter in kW: Not provided yet by the customer
Gross MW injected in to the PPL EU system: Not provided yet by the customer
Net MW injected in to the PPL EU system: 20

Note: All inverters to be used for connecting generation to the PPL EU system are required to be certified to UL1741 and IEEE 1547. The term certified is understood to indicate that the device has been tested to meet the above standards by a nationally recognized testing laboratory. Any inverter not meeting a nationally recognized testing laboratory certification will either not allowed to connect to PPL EU system or the customer will be required to install additional suitable external protection equipment to maintain the same level of system protection.

The inverter supplier must provide upon request copies of the certification of inverter equipment testing by a nationally recognized testing laboratory, self certification or certification by a third party that is not listed on the OSHA web site will not be accepted.

Inverter step up transformers or GSU:

No. of Transformers; 20
Each Transformer Rating and Ratio: 1.15 MVA and 34.5/0.69kV
Z = 5.75% at 1.15 MVA base, X/R ratio = 7.5

Intertie Transformers:

Intertie Step-up transformer: One 69/34.5 kV, 15/20/25 MVA
Impedance- 9% at ???? MVA base, X/R ratio = 38
MVA base- Not provided yet by the customer

In the customers one line diagram the intertie transformer is shown as Wye grounded delta. PPL EU requires that this transformer connection be Delta (69kV) and Wye grounded (34.5kV).

The W3-069 Interconnection Customer must provide PPL EU and PJM with the intertie transformer test reports and a model of the inverters once they are available in order to perform a more detailed short circuit analysis.

W3-069 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 W3-069's equipment, the Queue W3-069 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Concerning voltage flicker, the W3-069 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 W3-069 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.

W3-069 Inverter Regulation or Reactive Supply Requirements

As specified in Interconnection Service Agreement, Appendix 2, Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the W3-069 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."

This indicates that the interconnection customer must maintain a composite power factor at the point of interconnection in between .95 leading (absorbing 6.6 MVARs) or .95 lagging (supplying 6.6 MVARs). If this capability can not be met, the W3-069 project must provide a STATCOM or SVC device at its substation.

PPL EU preliminary load flow studies have indicated that the W3-069 project may require to operate at .95 pf leading that is absorbing vars from the PPL EU system. If this operation can't be tolerated by the inverters then an SVC would be required to maintain the required voltage regulation on the Cumberland-W. Shore #3 69 kV line within its required range.

W3-069 will need to verify that its inverters can adjust to the required power factor range or purchase inverters that can. In future studies, PPL EU will calculate and issue a table of MW versus MVAR for various levels of generation output for operating purposes. Further, W3-069 must provide details on how these requirements will be met at the POC (the 69 kV point of contact). Most inverters monitor to their output terminals, but the voltage, frequency, and power factor must also be monitored at the 69 kV level.

Other Direct Connection Issues Impacting the Interconnection Customer

Alternate Outlet for Generation Operation during PPL EU Maintenance

No alternate outlet for the generation will be available and W3-069 will not be able to generate power during PPL EU line maintenance/outages.

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 W3-069 solar park 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 below.

PPL EU phase rotation at 69kV

PPL EU 69kV phase rotation in this region is CBA and will require connection of POC transformer high side bushings in a certain way. Pleaser refer to the below mentioned POC document for phase rotation and transformer connection requirements.

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

Future Conversion of line to 138kV from 69kV

PPL EU presently has no plans to convert this line to 138kV Voltage in the next 20 years but after that if the area is converted to 138kV system, conversion of the Interconnection Customer's substation to 138kV would be at his cost.

Intertie 69/12kV Transformer Turns Ratio

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

70.6kV, 68.8kV, 67.0kV, 65.2kV, 63.4kV with nominal mid point voltage is 67kV, 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 67kV. The PPL 69kV system is operated at around 67.9kV at the PPL EU Cumberland and W. Shore substations.

Network Impacts

Queue project W3-069was studied as a(n) 20.0 MW (7.6 MW of which was Capacity) injection into PPL's system. Project W3-069 was evaluated for compliance with reliability criteria for summer peak conditions in 2014.

Potential transmission network impacts are as follows:

Option 1: Tap Cumberland-W. Shore #3 69 kV Line

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

Not 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.

Option 2: Tap Cumberland-W. Shore#4 69 kV Line

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

Not 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.

Attachment 1

Option 1- Primary Point of Interconnection

Attachment 2

Option 2-Secondary Point of Interconnection