

***Generation Interconnection
Feasibility
Study Report***

For

***PJM Generation Interconnection Request
Queue Position W2-097***

West Carlisle-Newville 2 69kV

October 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.

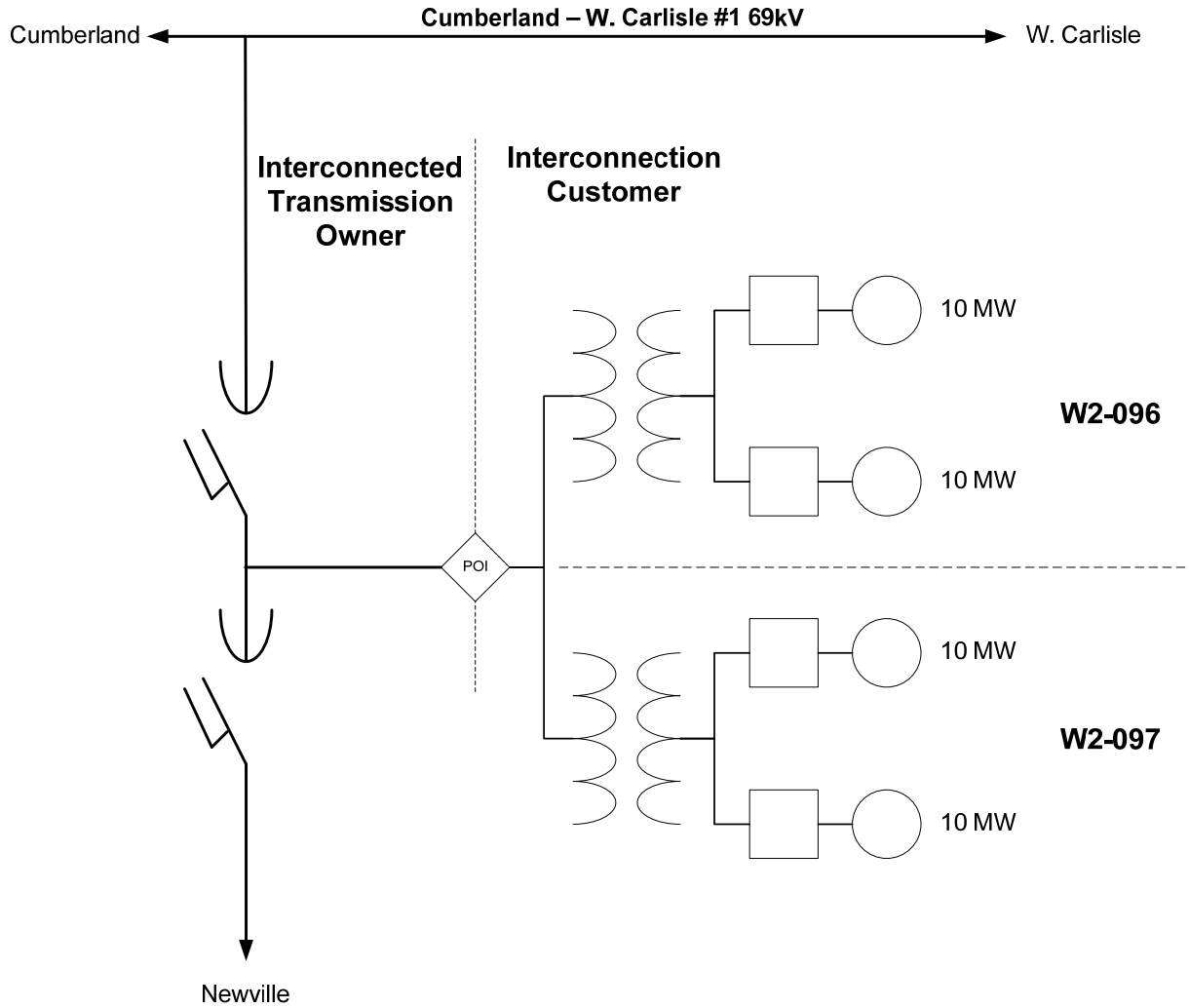
General

Queue W2-097 is an Interconnection Customer (IC) request to interconnect a 20 MW Energy (7.6 MW Capacity) Solar PV Generating Station 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 W2-097 is located in W. Pennsboro Township, Cumberland County, PA. Queue W2-097 generation interconnection desires commercial operation by June 1, 2012. **This study does not imply a PPL EU commitment to this in-service date.**

Point of Interconnection

Queue W2-097 can be connected to PPL EU's 69 kV Transmission System by tapping the Newville 69kV line off of Cumberland - W.Carlisle #1 line. The W2-097 substation is located at Lat 40.18 deg N and Long 77.33 deg W and would be connected to the Newville 69kV tap line via a short tap which was already install for the IPP project W2-096 as shown in Figure 1.

Figure 1



Transmission Owner (PPL EU) Scope of Direct Connection Work

The total estimated cost of Direct Connection Facilities needed to connect Queue W2-097 to the Newville 69 kV tap is:

\$50,000 (Substation Cost) (excluding any applicable state or federal taxes)

The cost is towards PPL EU review and commissioning since this project is connected to the same 69kV tap as the project W2-096 from the same developer. This cost estimates may vary if the location of the Queue W2-097 changes than the project W2-096.

69 kV Transmission Tap Direct Connection Work:

No cost to W2-097, covered in the same scope as the project W2-096. See figure 2 for connection.

Substation Direct Connection Work at Cumberland 69 kV Source Substation

\$ 50,000 Total Substation Direct Connection Work to accommodate W2-097

To accommodate W2-097, the following work will be performed

- PPL EU review of drawings and other IPP W2-097 equipment specifications
- PPL EU interface in commissioning of the IPP W2-097

Preliminary PPL EU Direct Connection Work Schedules

Schedules are same as W2-097 approximately 15 to 18 months after the receipt of a fully executed ISA/CSA.

The schedule for the 69 kV transmission and substation work to accommodate W2-097 would depend on the project W2-097 start date.

Assumptions and Notes

- Long lead-times for leased telephone lines may be encountered. Therefore, the 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. 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 W2-097 Interconnection Customer, PJM, and PPL EU before any PPL EU design and construction activities may commence.

Interconnection Customer Scope of Direct Connection Work

Queue W2-097 Interconnection Customer will be responsible for the construction of all generating station facilities on the W2-097 side of the POI (Point of Interconnection) as shown on Figure 1 on the previous page.

Telephone Circuit Requirements

PPL will require a communication path between the W2-097 customer substation and PPL EU's Cumberland Substation for Voice, SCADA, and DTT.

The same phone lines used for W2-096 can be used for the W2-097 for DTT, SCADA, and the voice communication.

All installation, maintenance, and monthly lease or billing charges for communications facilities for DTT, metering, etc., would be the responsibility of the Interconnection Customer.

Intertie and POC Protective Relaying 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 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 W2-097 and PPL EU Cumberland Substation. The same telephone line used for the W2-096 can be multiplexed for W2-097.

PPL EU will need a signal from W2-097 that will indicate:

- The W2-097 isolation breaker is open (a breaker 'b' switch) or
- A contact that will indicate when ANY inverter is operating in parallel with the PPL system (contact is OPEN when any inverter is in parallel and W2-097 system normal) - this contact will close when ALL inverters are OFF line (disconnected from the PPL 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.

The W2-097 will be able to use same Scada set used for the W2-096 and the same 4-wire dedicated FDDA-type phone line used for the W2-096. 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 W2-097 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 drawing CUM2-OL-01RB, the customer has provided an high side circuit breaker at 69kV with a manual 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.

Intertie Requirements from the Developer of IPP W2-097

W2-097 Inverter and GSU modeling Data (incomplete, need more information)

Per the W2-097 supplied data (Dwg. CUM2-OL_01RB), the following was used in modeling the inverter and GSU:

W2-097 Inverter Units:

Inverters: 80, 260kW each solar inverters PV powered packaged in PowerVault Model MV-1040KW, 20.8 MW Gross, net injected into PPL EU system 20 MW

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 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.

GSU:

Inverter Step Up Transformers: Twenty (20) 0.48/12.47 kV, 1 MVA each transformers with 5.5% impedance at 1 MVA with Delta (480 Volt) and Wye (12.47kV) winding configuration.

Intertie Transformers:

Intertie Step-up transformer: One 69/12.5 kV, 12/16/20 MVA

Impedance-unknown

MVA base-unknown

The W2-097 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.

W2-097 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 W2-097's equipment, the Queue W2-097 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Concerning voltage flicker, the W2-097 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 W2-097 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.

W2-097 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 W2-097 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 W2-097 project must provide a STATCOM or SVC device at its substation.

PPL EU preliminary load flow studies have indicated that the W2-097 project would require to operate at .95 pf leading that is absorbing the vars. If this operation can't be tolerated by the inverters than an SVC would be required to maintain the required voltage regulation on the Cumberland-W.Carlisle #1 69 kV line and the Newville 69kV tap within its required range.

W2-097 will need to verify from PowerVault 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. Further, W2-097 must provide details on how these requirements will be met at the PCC (the 69 kV point of common coupling). Most inverters monitor to their output terminals, in this case 480VAC, but the voltage, frequency, and power factor must also be monitored at the 69 kV level.

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 since nearest second line is approximately 10 miles away. W2-097 will not be able to generate power during PPL EU Newville tap maintenance/outage, or maintenance/outage on the Cumberland-W. Carlisle #1 line, or some times during certain 69kV bus outages at the PPL EU Cumberland 230/69 kV Substation.

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 W2-097 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.

Load Shed Scheme at PPL EU Cumberland Substation

PPL EU has two load shed schemes at the Cumberland 69kV substation which operate under some unusual system conditions to trip the Cumberland - W. Carlisle#1 69kV line (along with some other 69kV lines) to maintain system integrity. Since Newville 69kV tap to which the Interconnection customer's generation is connected, is supplied from Cumberland-W. Carlisle #1 line, it will also be tripped and the W2-097 generation will be off line for the operation of load shed schemes.

PPL EU phase rotation at 69kV

PPL EU 69kV phase rotation in this region is CBA and will require connection of transformer high 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 Newville tap to 138kV from 69kV

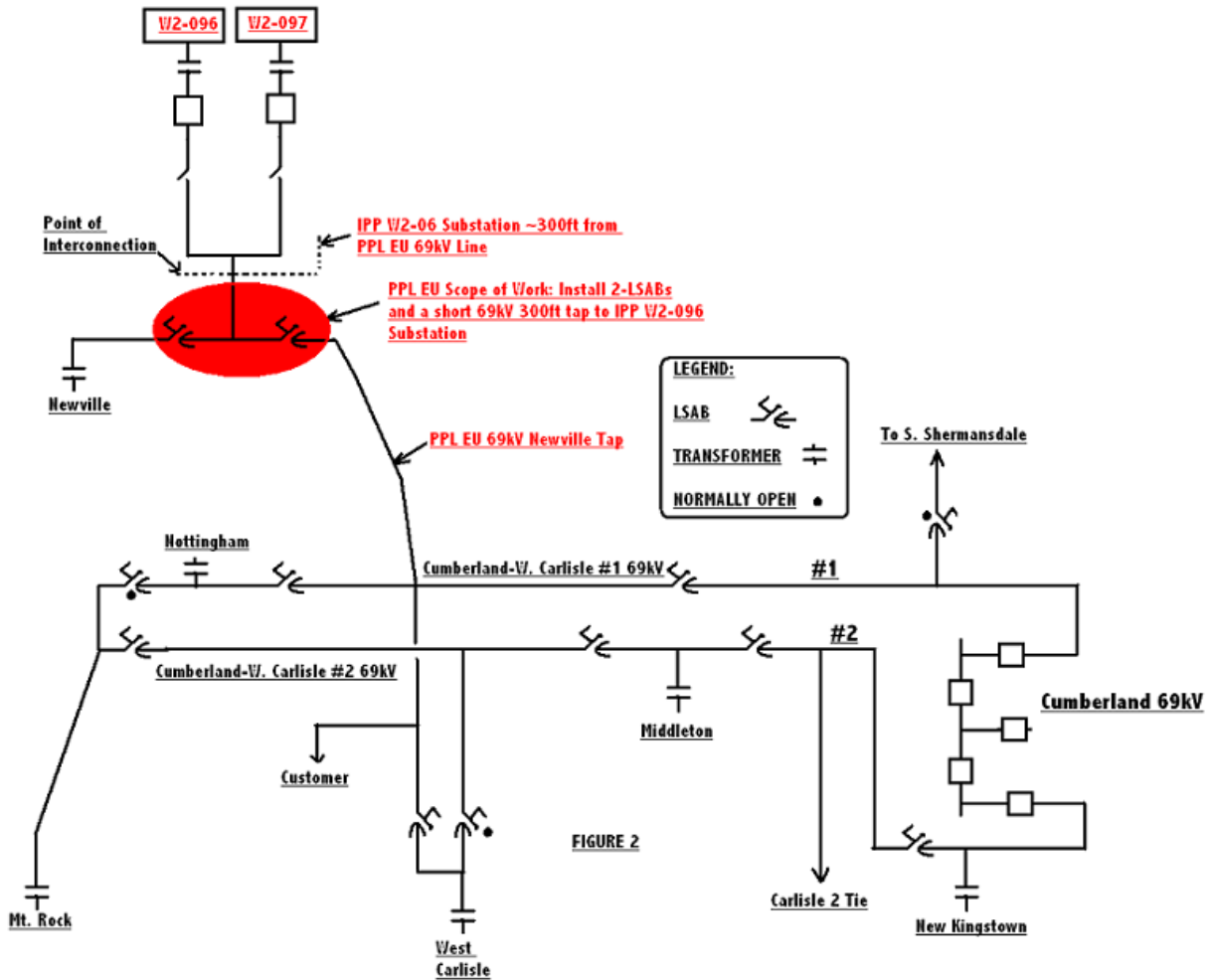
PPL EU presently has no plans to convert this tap to 138kV Voltage in the next 20 years but after that if the area is converted to 138kV system, conversion of the Interconnection Customer's substation to 138kV would be at his cost.

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) the mid point range of 67kV. The PPL 69kV system is operated at around 67.9kV at the PPL EU Cumberland substation.

PPL EU typically procures the transformers with the following low side (12kV) taps: 13.2kV fixed



PJM Analysis and Network Impacts

The Queue W2-097 project was studied as a 20 MW energy (7.6 MW Capacity) injection into the 69kV Cumberland-W.Carlisle #1 line. The project was evaluated for compliance with reliability criteria for summer peak conditions in 2014. Potential network impacts were as follows:

Generator Deliverability

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

No problems identified.

Multiple Facility Contingencies

(Double Circuit Tower Line, Stuck Breaker and Bus Fault contingencies for the full energy output)

No problems identified

Contribution to Previously Identified Overloads

(This project contributes greater than the PJM cost allocation threshold loading to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

No problems identified

Stability Analysis

Not required because of size, location and technology of proposed generation.

Short Circuit

Later

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 will have a % allocation cost responsibility)

None required.