

***Generation Interconnection
Feasibility Study Report***

For

***PJM Generation Interconnection Request
Queue Position W3-068***

Cumberland-W. Shore#3-1 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 W3-068 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#3-1 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 W3-068 is located in South Middleton Township, Cumberland County. Queue W3-068 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 W3-068 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 W3-068 to the Cumberland-W. Shore #3 69kV kV line is:

\$2,766,129 (Transmission Cost) + (Siting/rights of way Cost) + (Substation 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 may vary depending upon the Queue W3-068 substation location and orientation.

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.

A further breakdown of the direct connection costs are as follows:

\$ 1,624,692	new ~2 Miles of 69 kV tap to W3-068 and one LSAB switch
\$ 534,659	Siting/rights of way for new 2 miles of 69 kV tap to W3-068
\$ 169,452	Cumberland 230/69 kV Substation work to accommodate W3-068
\$ 221,259	W. Shore 230/69 kV Substation work to accommodate W3-068
\$ 72,001	Mount Allen 69/12 kV Substation work to accommodate W3-068
\$ 72,032	Mechanicsburg 69/12 kV Substation work to accommodate W3-068
\$ 72,032	Carlisle 69/12 kV Substation work to accommodate W3-068

\$ 2,766,129 Total Direct Connection

Estimated direct connection time frame 18-21 months after the PJM three-party Interconnection Service Agreement (ISA) and Construction Service Agreement (CSA) 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. Also this time frame is contingent upon all rights of way acquired within the stated time frame before the start of construction and detailed design.

69 kV Transmission Tap Direct Connection Work

\$ 1,624,692 New 2 miles of 69 kV tap to W3-068 and one LSAB switch

The transmission direct connection work includes tapping the Cumberland-W. Shore #3 69kV line in the vicinity of PPL EU grid pole 17100S32300 and from there building an approximately

2 miles of 69kV tap line using 556.5 Kcmil ACSR conductors with ½” EHS overhead ground wire (OHGW) using two steel poles with concrete foundations at the line and rests will be Light Duty guyed direct embedded steel poles to a dead-end structure in the new W3-068 customer-owned substation. The tap line will be a 69 kV steel pole design. In addition to the tap, one LSAB (Load Sectionalizing Air Break) switch would be installed on the PPL EU Cumberland-W. Shore #3 line on the Carlisle substation side of the tap for the isolation of W3-068 tap. The switch would be installed on a custom designed steel pole with concrete foundations. The estimated cost of the transmission tap and the LSAB switch work is **\$1,624,692** and is included in the above estimate. See Attachment 1 for the connection schematic.

69 kV Transmission Siting/rights of way Work

\$ 534,659 Siting/rights of way for the new 2 miles of 69 kV tap to W3-068

The transmission cost estimate does not include the cost to site and acquire a 100 ft. wide right-of-way for an approximate length of 2 miles from PPL EU 69 kV line to IPP W3-068 dead-end structure. **The tap will be designed and operated at 69 kV and therefore will not require PUC certification. PUC certification is required only on overhead transmission lines built with 100kV and above.** Siting and rights of way study will be undertaken with a cost of approximately **\$534,659** and is included in the total estimate. The estimate does not include costs to litigate or mitigate extraordinary environmental impacts.

The time required for siting and right-of-way requisition is estimated to be 6-9 months assuming only a few landowners are involved and are willing to provide the necessary right-of-way. If not this work could take longer than 6-9 months if there are many landowners are involved or if any unforeseen litigation takes place. The typical time needed to complete the transmission tap design and construction work is estimated to be approximately 18 months. All rights-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 tap construction. This translates into a minimum of **18-21 month** project time frame for the direct connection work and assumes that suitable line outages can be scheduled as required to terminate the new tap onto the existing Cumberland-W. Shore #3 69kV line. Failure to meet a scheduled line outage may result in project delays. Additionally, this estimate of time frame assumes that all rights-of-way are acquired with in 6-9 months or available prior to the start of construction of the new transmission tap, if rights of way acquisition is delayed than the project will take longer than 18-21 months.

Substation Direct Connection Work at Cumberland 69 kV Source Substation

\$ 169,452 Total Substation Direct Connection Work to accommodate W3-068

To accommodate W3-068, the following upgrades are required at PPL EU’s Cumberland 69 kV Substation.

- Install one telephone line based Direct Transfer Trip (DTT) Cabinet
- Install new telephone line protection equipment

- Install a Synch Check Relay on the W. Shore #3 69kV circuit breaker
- Modify the controls for the W. Shore #3 69kV Circuit breaker 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

This work includes installation of phone line based DTT equipment and control design modifications for the W. Shore #3 69kV circuit breaker at the PPL EU Cumberland Substation. W3-068 will be required to provide a matching set of DTT equipment at their site. The scheme will provide a trip signal to W3-068 for any line fault, or any other condition that will cause the PPL EU both Cumberland and W. Shore circuit breakers trip (both circuit breakers must trip due the line being in network operation between the two substations) or open or any other condition that will result in the formation of an island. This trip signal to W3-068 will be maintained for as long as the both PPL EU breakers at Cumberland and W. Shore substations remain open or the island condition exists. No automatic reclosing of the Interconnection Customer's isolation breaker will be permitted.

Once the Interconnection Customer's isolation breaker is open, a return signal via the W3-068 DTT set will be sent to PPL EU Cumberland and W. Shore breakers indicating that the W3-068 Isolation breaker is open. This return DTT signal will permit PPL EU Cumberland and W. Shore circuit breakers to close sequentially in an attempt to reenergize the line. If the line is successfully reenergized and the other customers loads connected to this line are picked up, the W3-068 generation can restart and reconnect it to the PPL EU system.

The W3-068 DTT scheme also provides a block-closing signal to the breakers at Cumberland and W. Shore substations to block auto reclosing until W3-068 breaker has tripped or any W3-068 generation is on line.

The estimated total cost for the work at Cumberland Substation is approximately **\$169,452** and is included in the above estimate.

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

Substation Direct Connection Work at W. Shore 69 kV Source Substation

\$ 221,259 Total Substation Direct Connection Work to accommodate W3-068

To accommodate W3-068, the following upgrades are required at PPL EU's W. Shore 69 kV Substation.

- Install one telephone line based Direct Transfer Trip (DTT) Cabinet

- Install new telephone line protection equipment
- Install a Synch Check Relay on the Cumberland #3 69kV circuit breaker
- Modify the controls for the Cumberland #3 69kV Circuit breaker for trip and close
- Modify SCADA for new alarms
- Install new cables and modify control wiring for the above
- Perform system checks and test equipment before placing in service
- Install new conduit and a telephone pole for the new telephone line entrance
- Install new hi-dielectric telephone cable from the new pole to the control cubicle

This work includes installation of phone line based DTT equipment and control design modifications for the Cumberland #3 69kV circuit breaker at the PPL EU W. Shore Substation. W3-068 will be required to provide a matching set of DTT equipment at their site. The scheme will provide a trip signal to W3-068 for any line fault, or any other condition that will cause the PPL EU both Cumberland and W. Shore circuit breakers trip (both circuit breakers must trip due the line being in network operation between the two substations) or open or any other condition that will result in the formation of an island. This trip signal to W3-068 will be maintained for as long as the both PPL EU breakers at Cumberland and W. Shore substations remain open or the island condition exists. No automatic reclosing of the Interconnection Customer's isolation breaker will be permitted.

Once the Interconnection Customer's isolation breaker is open, a return signal via the W3-068 DTT set will be sent to PPL EU W. Shore and Cumberland breakers indicating that the W3-068 Isolation breaker is open. This return DTT signal will permit PPL EU W. Shore and Cumberland circuit breakers to close in an attempt to reenergize the line. If the line is successfully reenergized and the other customers loads connected to this line are picked up, the W3-068 generation can restart and reconnect it to the PPL EU system.

The W3-068 DTT scheme also provides a block-closing signal to the breakers at Cumberland and W. Shore substations to block auto reclosing until W3-068 breaker has tripped or any W3-068 generation is on line.

The estimated total cost for the work at W. Shore Substation is approximately **\$221,259** and is included in the above estimate.

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

Substation Direct Connection Work at Mt Allen 69/12 kV Substation

\$ 72,001 Total Mt. Allen Substation Direct Connection Work to accommodate W3-068

PPL EU Mt. Allen 69/12 kV substation is supplied from the two separate 69kV lines and as such would require synch check relays on the 12kV circuit breakers to prevent out of phase closing due to the installation of generation on the 69kV supply lines

The work at the PPL EU 69/12 kV substation includes:

- Modification of controls on the two 12kV circuit breakers including the installation of synch-check relays
- Installation of 12 kV potential transformer and associated wiring where required

Substation Direct Connection Work at Mechanicsburg 69/12 kV Substation

\$ 72,032 Total Mechanicsburg Substation Direct Connection Work to accommodate W3-068

PPL EU Mechanicsburg 69/12 kV substation is supplied from the two separate 69kV lines and as such would require synch check relays on the 12kV circuit breakers to prevent out of phase closing due to the installation of generation on the 69kV supply lines

The work at the PPL EU 69/12 kV substation includes:

- Modification of controls on the two 12kV circuit breakers including the installation of synch-check relays
- Installation of 12 kV potential transformer and associated wiring where required

Substation Direct Connection Work at Carlisle 69/12 kV Substation

\$ 72,032 Total Carlisle Substation Direct Connection Work to accommodate W3-068

PPL EU Carlisle 69/12 kV substation is supplied from the two separate 69kV lines and as such would require synch check relays on the 12kV circuit breakers to prevent out of phase closing due to the installation of generation on the 69kV supply lines

The work at the PPL EU 69/12 kV substation includes:

- Modification of controls on the two 12kV circuit breakers including the installation of synch-check relays
- Installation of 12 kV potential transformer and associated wiring where required

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

The total estimated cost of Direct Connection Facilities needed to connect Queue W3-068 to the Cumberland-W. Shore #4 69kV kV line is:

\$2,766,129 (Transmission Cost) + (Siting/rights of way Cost) + (Substation Cost) (excluding any applicable state or federal taxes).

The 69 kV connection estimate is based on the assumptions stated in the Transmission and Substation Direct Connection Work sections. This estimate may vary depending upon the Queue W3-068 substation location and orientation.

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.

A further breakdown of the direct connection costs are as follows:

\$ 1,624,692	new ~2 Miles of 69 kV tap to W3-068 and one LSAB switch and Hi/Lo pole design
\$ 534,659	Siting/rights of way for new 2 miles of 69 kV tap to W3-068
\$ 169,452	Cumberland 230/69 kV Substation work to accommodate W3-068
\$ 221,259	W. Shore 230/69 kV Substation work to accommodate W3-068
\$ 72,001	Mount Allen 69/12 kV Substation work to accommodate W3-068
\$ 72,032	Mechanicsburg 69/12 kV Substation work to accommodate W3-068
\$ 72,032	Carlisle 69/12 kV Substation work to accommodate W3-068
\$ 2,766,129	Total Direct Connection

Estimated direct connection time frame 18-21 months after the PJM three-party Interconnection Service Agreement (ISA) and Construction Service Agreement (CSA) 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. Also this time frame is contingent upon all rights of way are acquired within the stated time frame before the start of construction and detailed design. See Attachment 2 for the connection schematic.

69 kV Transmission Tap Direct Connection Work

\$ 1,624,692 new 2 miles of 69 kV tap to W3-068 and one LSAB switch

The 69kV tap work for the Option 2 is same as Option 1 except that it require crossing of the Cumberland – W. Shore #3 line and as such PPL EU does not prefer this option.

69 kV Transmission Siting/rights of way Work

\$ 534,659 Siting/rights of way for the new 2 miles of 69 kV tap to W3-068

The siting and right of way work for the Option 2 is same as Option 1.

Substation Direct Connection Work at Cumberland 69 kV Source Substation

\$ 169,452 Total Substation Direct Connection Work to accommodate W3-068

The work at Cumberland is same no matter which PPL EU line the IPP W3-068 is connected to

Substation Direct Connection Work at W. Shore 69 kV Source Substation

\$ 221,259 Total Substation Direct Connection Work to accommodate W3-068

The work at W. Shore is same no matter which PPL EU line the IPP W3-068 is connected to

Substation Direct Connection Work at Mt Allen 69/12 kV Substation

\$ 72,001 Total Mt. Allen Substation Direct Connection Work to accommodate W3-068

The work at Mt. Allen is same no matter which PPL EU line the IPP W3-068 is connected to

Substation Direct Connection Work at Mechanicsburg 69/12 kV Substation

\$ 72,032 Total Mechanicsburg Substation Direct Connection Work to accommodate W3-068

The work at Mechanicsburg is same no matter which PPL EU line the IPP W3-068 is connected to

Substation Direct Connection Work at Carlisle 69/12 kV Substation

\$ 72,032 Total Carlisle Substation Direct Connection Work to accommodate W3-068

The work at Carlisle is same no matter which PPL EU line the IPP W3-068 is connected to

Load Shed Scheme at Carlisle substation connected to Cumberland-W. Shore #4 and Carlisle 2 tie line

For a permanent loss of 69kV bus section 1 at Cumberland, the Cumberland-W. Carlisle #2 line loses its source at Cumberland but maintains a limited capacity Carlisle 2 tie line from Carlisle substation which is supplied by the Cumberland-W. Shore #4 69kV line, to prevent overloading of the Carlisle 2 tie line at Carlisle substation it is opened via a load shed scheme.

For a permanent interruption to 69kV bus section 3 at Cumberland which makes Cumberland-W. Shore #4 69kV line to be in radial operation from Cumberland, the #4 line is interrupted at Carlisle substation to reduce the loading on at the Carlisle tap 2 so it does not get overloaded.

The schemes have been reviewed and it is anticipated that their activation would cause no adverse impact on the operation of the IPP W3-068. Although the scheme does not affect the normal operations of the IPPs, but because of the weak tie with Carlisle 2 line PPL EU does not prefer this option.

Preliminary PPL EU Direct Connection Work Schedules

The estimated PPL EU elapsed time to complete the 69 kV direct connection transmission tap and the substation upgrades is approximately 18-21 months after the receipt of a fully executed ISA/CSA.

The schedule for the 69 kV transmission and substation work to accommodate W3-068 would depend on the project start date. The work to accommodate W3-068 will require transmission line outage. 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.

Assumptions and Notes

- Long lead-times for leased telephone lines may be encountered. Therefore, the W3-068 Interconnection Customer should investigate as soon as possible the availability of leased telephone facilities to meet its in-service schedule.
- For the custom-designed steel transmission poles, the current lead-time is approximately 20 to 28 weeks. It is estimated that approximately 16 or so 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 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 W3-068 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 W3-068 Interconnection Customer will be responsible for the construction of all their generating station facilities on the W3-068 side of the POI (Point of Interconnection).

Telephone Circuit Requirements

PPL EU will require communication paths between the W3-068 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 W3-068 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 W3-068 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 W3-068 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 W3-068 that will indicate:

- The W3-068 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 W3-068 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 W3-068 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 W3-068

W3-068 Inverter and GSU modeling Data (incomplete, need more information)

Per the W3-068 supplied data dated October 12, 2010, the following was used in modeling the inverters and GSUs:

W3-068 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 W3-068 Interconnection Customer must provide PPL EU and PJM with the inertia transformer test reports and a model of the inverters once they are available in order to perform a more detailed short circuit analysis.

W3-068 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 W3-068's equipment, the Queue W3-068 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Concerning voltage flicker, the W3-068 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 W3-068 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.

W3-068 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 W3-068 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 W3-068 project must provide a STATCOM or SVC device at its substation.

PPL EU preliminary load flow studies have indicated that the W3-068 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.

W3-068 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, W3-068 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 W3-068 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 W3-068 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. Please 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 W3-068 was studied as a(n) 20.0 MW (7.6 MW of which was Capacity) injection into PPL's system. Project W3-068 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