

***Generation Interconnection
Feasibility Study Report***

For

***PJM Generation Interconnection Request
Queue Position X1-019***

Sunbury-Dauphin 69kV

July 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

The Interconnection Customer (IC), has proposed a wind generation facility located around Millersburg and Elizabethville Townships in Pennsylvania. The installed facilities will have a total capability of 60.0 MW with 7.8 MW of this output being recognized by PJM as capacity. This means that the remaining 52.2 MW will be curtailable should a system reliability constraint occur. The proposed in-service date for this project is August 15, 2013. **This study does not imply a PPL Electric Utilities commitment to this in-service date.**

Point of Interconnection

X1-019 will interconnect with the PPL EU transmission system by tapping the Sunbury-Dauphin 69kV line at one of two points. Option 1 will be to connect near the Elizabethville substation to inject power into the Sunbury substation. Option 2 will be to connect near the Millersburg substation to inject power into the Dauphin substation.

Transmission Owner (PPL EU) Scope of Direct Connection Work

Option 1

Connect to Sunbury-Dauphin 69kv line near Elizabethville substation, inject power in to the Sunbury substation

The total estimated cost of Direct Connection Facilities needed to connect Queue X1-019 to the Sunbury-Dauphin 69kV kV line near Elizabethville sub 69kV tap and injecting it in to Sunbury 69kV yd1 Substation is:

\$4,575,000 (Transmission Cost) + (Siting/rights of way Cost) + (Substation Cost) (excluding any applicable state or federal taxes).

The 69 kV direct connection estimates are based on the assumptions stated below in the following Transmission Line, Transmission Line Siting, and the Substation work sections. These estimates may vary depending upon the Queue X1-019 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:

\$ 3,489,000	New ~3 Miles of single circuit 69 kV tap to project X1-019
\$ 129,000	One LSAB switch to be installed on the East side of the Interconnection point
\$ 509,000	Transmission Line Siting/rights of way for new 3 miles of 69 kV tap to X1-019
\$ 319,000	Sunbury 230/69 kV Substation work to accommodate X1-019
\$ 129,000	Generation Reduction Scheme (See alternatives to this Scheme, reconductor 3 miles of existing line or reduce no. of turbines)
\$ 4,575,000	Total Direct Connection

Estimated direct connection time frame 18-24 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

\$ 3,489,000	New 3 miles of 69 kV tap to project X1-019 (Interconnection point West side of Elizabethville 69kV tap)
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The transmission direct connection work includes tapping the Sunbury-Dauphin 69kV line's Pine-Grove section on the west side of the PPL EU pole and from there building an approximately 3 miles of 69kV tap line using 556.5 Kcmil ACSR conductors with 3/8" EHS overhead ground wire (OHGW) using Light Duty guyed direct embedded steel poles to a dead-end structure in the project X1-019 customer-owned substation. The tap line will be a 69 kV steel pole design.

Note: Depending on the location of the Customer substation on the Berry Mountain, the tap length could vary significantly and as such could have significant impact on the transmission tap cost.

Install an LSAB switch

\$ 129,000	Install an LSAB switch east of the interconnection (East of Elizabethville 69kV tap existing LSAB switch and East of the interconnection point towards the Gratz 69kV tap)
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Install an LSAB (Load Sectionalizing Air Break) switch on the PPL EU Pine Grove tap east of Elizabethville 69kV tap existing LSAB switch and east of the interconnection point **towards the Gratz 69kV tap** for the isolation of X1-019 tap. The switch would be installed on a custom designed steel pole with concrete foundations. See Attachment 1 (at the end of the document) for the connection schematic.

69 kV Transmission Line Siting/rights of way Work

\$ 509,000	Siting/rights of way for the new 3 miles of 69 kV tap to X1-019
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A 100 ft. wide right-of-way for an approximate length of 3 miles from PPL EU 69 kV line to project IPP X1-019 dead-end structure would be required for this project. **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.** Line Siting and rights of way study will be undertaken with a cost of approximately **\$ 509,000** 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 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 21-24 months. All rights-of-way will need to be acquired prior to the start of construction. The substation work may require approximately 21 to 24 months and can be completed simultaneously with the 69 kV transmission tap construction.

Note: Depending on the location of the Customer substation on the Berry Mountain, the tap length could vary significantly and as such could have significant impact on the transmission tap siting cost.

Substation Direct Connection Work at Sunbury 69 kV Source Substation

\$ 319,000	Total Substation Direct Connection Work to accommodate Project X1-019
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To accommodate X1-019, the following upgrades are required at PPL EU's Sunbury 69 kV Yd#1.

- Install one telephone line based Direct Transfer Trip (DTT) Cabinet
- Install new telephone line protection equipment
- Install a Synch Check Relay on the Dauphin 69kV circuit breaker
- Modify the controls of the Dauphin 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 Dauphin 69kV circuit breaker at the PPL EU Sunbury Substation. The project X1-019 will be required to provide a matching set of DTT equipment at their site. The scheme will provide a trip signal to X1-019 for any line fault, or any other condition that will cause the PPL EU circuit breaker trip or open at the Sunbury substation or any other condition that will result in the formation of an island. This trip signal to X1-019 will be maintained for as long as the PPL EU breaker at Sunbury substation remains open or the island condition exists. Under these conditions, no automatic reclosing of the Interconnection Customer's isolation breaker at its substation will be permitted.

The X1-019 DTT scheme also provides a continuous block-closing signal to the breaker at PPL EU Sunbury Substation to block auto reclosing of Dauphin circuit breaker until X1-019 isolation breaker has tripped.

Once the project X1-019 isolation breaker at its substation is open, another signal via the X1-019 DTT set will be sent to PPL EU Dauphin breaker at Sunbury Substation indicating that the "X1-019 project" isolation circuit breaker has opened. This second DTT signal will permit PPL EU

circuit breaker to close in an attempt to reenergize the line. If the line is successfully reenergized and the other customer loads connected to this line are picked up, the X1-019 generators can restart and re-synchronize it to the PPL EU system.

The estimated total cost for the work at Sunbury Substation is approximately \$319,000 and is included in the above estimate.

The lead time required for the substation direct connection work is approximately 18 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.

Generation Reduction Scheme Due to limited line Rating

\$ 129,000	Total Generation Reduction Direct Connection Work to accommodate X1-019
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A generation trip scheme for this project would be required since the normal ratings of a portion of the line between the Pine-Grove tap and the Dalmatia-Richfield 69kV tap point (approximately 3 miles) is constructed with 4/0 CWC whose normal summer rating is 43 MVA and normal winter rating is 55 MVA.

After evaluating the interconnection point, configuration of the transmission line and the light load conditions, it is determined that at least 2 turbines would be required to be tripped automatically to stay within the line rating during the summer operations. It is determined that the winter operation will be acceptable due to higher ratings without generation reduction.

Therefore to meet the above requirements, an automatic generation reduction trip scheme would be installed at the Elizabethville substation on the Sunbury side of the Elizabethville 69kV tap to trip two pre-selected wind turbines whenever MW flow into Sunbury-Dauphin 69kV line in the direction of Sunbury exceeds the lowest summer normal transmission line rating during the months of summer operations to prevent overloading of the transmission line. The summer operation is from April 16 to November 14 of each year. The Scheme will have “load” sensing equipment installed on the Sunbury side of the existing Elizabethville 69kV tap in the direction of Sunbury substation. This equipment will monitor the “load” flow on this section of the line and will generate a trip signal whenever the load flow in the line exceeds the lowest line rating. This signal will be relayed to the plant to trip the appropriate number of turbines.

If for any reason the generation reduction scheme fails, provisions will be provided for it to default to tripping of the pre-selected generators and send an alarm.

IPP X1-019 developer will allow PPL EU to install this equipment at their generating plant with PPL EU supervision at their cost. Additionally, the IPP developer will be responsible to wire this equipment and test under PPL EU supervision for its correct operation.

Gen Reduction Scheme equipment will be procured and owned by PPL EU but all maintenance cost associated with this equipment will be the responsibility of IPP developer. IPP Developer and PPL EU would mutually decide which wind turbines to trip.

Note: The number of turbines to be tripped could change, if the load situation changes. The exact number of turbines to be tripped will be reviewed again during the later studies if the project moves further to reaffirm or change the number of turbines to be tripped.

Alternatives if the Developer desires not to install the Generator Reduction Scheme in Option 1

Two options are presented below to the developer of the Project X1-019 if the developer chooses not to install the gen reduction scheme.

Alternative 1:

In lieu of Generation Reduction Scheme-Reduce the total output by 2 Turbines

Reduce the total output by at least 6 MW i.e. install 18 turbines or less with a total out put of 54 MW or less; this reduction would bring the plant output at max generation with in transmission line ratings at its lowest ratings section. Reduction of only two turbines is necessary because the load diversity on the transmission line and power flow in two directions in relation to the interconnection point.

Alternative 2:

In lieu of Generation Reduction Scheme - Reconductor lower rated 3 mile portion of the Transmission line with higher capacity conductor

\$ 1,065,000	Total cost of reconductoring the approximately 3 mile portion of the transmission line to accommodate max generation of 60 MW.
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The lowest rated section of the Sunbury – Dauphin 69kV line from Pine-Grove 69kV tap point to Dalmatia/Richfield 69kV tap point is approximately 3.0 miles long and is constructed with 4/0 CWC The rating of this portion of the transmission line can be increased by reconductoring the line with higher capacity conductors thus eliminating the lower ratings. The cost estimate assumes that only conductors are replaced, if structures are required to be replaced due to higher capacity conductor weight and sag, the estimated cost would be much higher and is not factored in to this estimate.

Option 2

Connect to Sunbury-Dauphin 69kv line near Millersburg substation, inject power in to the Dauphin substation

The total estimated cost of Direct Connection Facilities needed to connect Queue X1-019 to the Sunbury-Dauphin 69kV line south of Millersburg sub 69kV tap and injecting in to Dauphin Substation is:

\$3,262,000 (Transmission Cost) + (Siting/rights of way Cost) + (Substation Cost) (excluding any applicable state or federal taxes).

The 69 kV direct connection estimates are based on the assumptions stated below in the following Transmission Line, Transmission Line Siting, and the Substation work sections. These estimates may vary depending upon the Queue X1-019 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:

\$ 2,340,000	New ~2 Miles of 69 kV transmission line tap to project X1-019
\$ 130,000	One LSAB switch to be installed on the south side of the Interconnection point
\$ 341,000	Transmission Line Siting/rights of way for new 2 miles of 69 kV tap to X1-019
\$ 321,000	Dauphin 230/69 kV Substation work to accommodate X1-019
\$ 130,000	Generation Reduction Scheme (See alternatives to this Scheme, reconductor 11 miles of existing line or reduce no. of turbines)
\$ 3,262,000	Total Direct Connection

Estimated direct connection time frame 21-24 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

\$ 2,340,000	New 2 miles of 69 kV tap to X1-019 (Interconnection point south of Millersburg 69kV tap)
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The transmission direct connection work includes tapping the Sunbury-Dauphin 69kV line in the vicinity of Millersburg 69kV tap and from there building an approximately 2 miles of 69kV tap line using 556.5 Kcmil ACSR conductors with 3/8" EHS overhead ground wire (OHGW) using Light Duty guyed direct embedded steel poles to a dead-end structure in the new X1-019 customer-owned substation. The tap line will be a 69 kV steel pole design.

Note: Depending on the location of the Customer substation on the Berry Mountain, the tap length could vary significantly and as such could have significant impact on the transmission tap cost.

Install an LSAB switch

\$ 130,000	Install an LSAB switch south of interconnection point
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Install an LSAB (Load Sectionalizing Air Break) switch on the Halifax side of the interconnection point for the isolation of X1-019 tap. The switch would be installed on a custom designed steel pole with concrete foundations. See Attachment 2 (at the end of the document) for the connection schematic.

69 kV Transmission Line Siting/rights of way Work

\$ 341,000	Transmission Line Siting/rights of way for the new 2 miles of 69 kV tap to X1-019
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A 100 ft. wide right-of-way for an approximate length of 2 miles from PPL EU 69 kV line to IPP X1-019 dead-end structure would be required for this project. **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 **\$341,000** 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 acquisition is estimated to be 6-9 months assuming only a few landowners are involved and are willing to provide the necessary rights-of-way. If not this work could take longer than 6-9 months if there are many landowners 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 21 months. All rights-of-way will need to be acquired prior to the start of construction. The substation work may require

approximately 18 to 21 months and can be completed simultaneously with the 69 kV tap construction.

This translates into a minimum of **21-24 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 Sunbury-Dauphin 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-ways are acquired within 6-9 months or available prior to the start of construction of the new transmission tap, if right of way acquisition is delayed then the project will take longer than 21-24 months.

Note: Depending on the location of the Customer substation on the Berry Mountain, the tap length could vary significantly and as such could have significant impact on the transmission tap siting cost.

Substation Direct Connection Work at Dauphin 69 kV Source Substation

\$ 321,000	Total Substation Direct Connection Work to accommodate X1-019
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To accommodate X1-019, the following upgrades are required at PPL EU's Dauphin 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 Sunbury 69kV circuit breaker at Dauphin Sub
- Modify the controls of the Sunbury 69kV Circuit breaker at Dauphin 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

This work includes installation of phone line based DTT equipment and control design modifications for the Sunbury 69kV circuit breaker at the PPL EU Dauphin Substation. X1-019 will be required to provide a matching set of DTT equipment at their site. The scheme will provide a trip signal to X1-019 for any line fault, or any other condition that will cause the PPL EU circuit breaker trip or open at the Dauphin substation or any other condition that will result in the formation of an island. This trip signal to X1-019 will be maintained for as long as the PPL EU breaker at Dauphin Substation remains open or the island condition exists. Under these conditions, no automatic reclosing of the Interconnection Customer's isolation breaker at its substation will be permitted.

The X1-019 DTT scheme also provides a block-closing signal to the Sunbury breaker at PPL EU Dauphin substation to block its auto reclosing until X1-019 isolation breaker has tripped.

Once the Interconnection Customer's isolation breaker at its substation is open, another signal via the X1-019 DTT set will be sent to PPL EU Sunbury breaker at Dauphin Substation

indicating that the “X1-019 project” isolation circuit breaker has opened. This second DTT signal will permit PPL EU circuit breaker to close in an attempt to reenergize the line. If the line is successfully reenergized and the other customer loads connected to this line are picked up, the X1-019 generators can restart and re-synchronize it to the PPL EU system.

The estimated total cost for the work at Dauphin Substation is approximately \$321,000 and is included in the above estimate.

The lead time required for the substation direct connection work is approximately 21-24 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.

Generation Reduction Scheme Due to limited line Rating

\$	130,000	Total Generation Reduction Direct Connection Work to accommodate X1-019
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A generation reduction scheme for this project would be required since the normal ratings of the transmission line from the interconnection point to the Dauphin Substation is lower than the maximum injection of the proposed generation in to the transmission line. This portion of the line is constructed with 4/0 CWC whose normal summer rating is 43 MVA and normal winter rating is 55 MVA.

Looking in to the load locations, interconnection point, configuration of the transmission line under the light load conditions, it is determined that at least 5 turbines would be required to be tripped automatically to stay with in the line rating during the summer operations. It is determined that the winter operation will be acceptable due to higher transmission line ratings without generation reduction.

Therefore to meet the above requirements, an automatic generation reduction trip scheme would be installed at the Halifax substation to trip a selected number of wind turbine generators whenever MW flow into Dauphin exceeds the summer normal transmission line rating during the months of summer operations to prevent overloading of the transmission line. The summer operation is from April 16 to November 14 of each year. The Scheme will have “load” sensing equipment installed on the line at Halifax on the interconnection point side to monitor the “load” flow on the line to generate a trip signal whenever the load flow in the line exceeds the line rating. This signal will be relayed to the plant to trip the appropriate number of turbines, at least 5.

If for any reason the generation reduction scheme fails, provisions will be provided for it to default to tripping of the generators and send an alarm.

IPP X1-019 developer will allow PPL EU to install this equipment at their generating plant with PPL EU supervision at their cost. Additionally, the IPP developer will be responsible to wire this equipment and test under PPL EU supervision for its correct operation.

Trip Scheme equipment will be procured and owned by PPL EU but all maintenance cost associated with this equipment will be the responsibility of IPP developer. IPP Developer and PPL EU would mutually decide which wind turbines to trip.

Note: The number of turbines to be tripped could change, if the load situation changes. The exact number of turbines to be tripped will be reviewed again during the later studies if the project moves further to reaffirm or change the number of turbines to be tripped.

Alternatives if Developer Desires not install the Generator Reduction Scheme in Option 2

Alternative 1:

In lieu of Generation Reduction Scheme-Reduce the total output by at least 4 Turbines

Reduce the total output by at least 15 MW i.e. install only 16 turbines with a total out put of 45 MW; this reduction would bring the plant output, at max generation with in the transmission line ratings at its lowest ratings section. Reduction of only four turbines is necessary because the load diversity on the transmission line and power flow in two directions in relation to the interconnection point.

Alternative 2:

In lieu of Generation Reduction Scheme-Reconductor 11 mile portion of 4/0 CWC conductor with higher capacity conductor from Interconnection point to Dauphin sub

The lowest rated section of the Sunbury – Dauphin 69kV line from the interconnection point to Dauphin substation is approximately 11 miles long and is constructed with 4/0 CWC whose ratings for Summer Normal operation is 43 MVA and for Winter Normal operation is 55 MVA. These ratings can be increased by reconductoring the line with higher capacity conductors thus eliminating the lower ratings.

\$ 3,734,000	Total cost of reconductoring the approximately 11 mile portion of the transmission line to accommodate max generation of 60 MW. The cost estimate assumes that only conductors are replaced, if structures are required to be replaced due to higher capacity conductor weight and sag, the estimated cost would be much higher and is not factored in to this estimate.
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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 **21-24 months** after the receipt of a fully executed ISA/CSA.

The schedule for the 69 kV transmission and substation work to accommodate X1-019 would depend on the project start date. The work to accommodate X1-019 will require transmission line outage. It is assumed that suitable line outages can be scheduled as required to terminate the new tap onto the existing Sunbury-Dauphin 69kV line. Failure to meet a scheduled line outage may result in project delays. 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.

Additionally, this estimate of time frame assumes that all rights-of-way are acquired within 6-9 months or available prior to the start of construction of the new transmission tap, if rights of way acquisition is delayed then the project will take longer than 21-24 months.

Assumptions and Notes

- Long lead-times for leased telephone lines may be encountered. Therefore, the X1-019 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 15-20 or so custom designed steel poles will be needed for this project. It may vary depending on the actual length of line and span requirements.
- 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 X1-019 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 X1-019 Interconnection Customer will be responsible for the construction of all their generating station facilities on the X1-019 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 X1-019 customer substation and PPL EU's Sunbury or Dauphin Substation 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:

- 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 line will originate at the project X1-019 Substation and terminate at PPL EU Substation. The SCADA phone line will go to one of our transmission control centers which 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 X1-019 Substation and the PPL EU Substation. (See 'Telephone Circuit Requirements' section of this Study for details on phone circuit requirements). These telephone lines would originate from the X1-019 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 PPL EU Substation from X1-019 project Substation that will indicate:

- The X1-019 isolation breaker is open (a breaker 'b' switch position)

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 Customer's Substation

Installation of revenue grade Bidirectional Metering Equipment will be required at the Queue X1-019 Substation 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 X1-019 Project's Substation

Per the customer's preliminary sketch, 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 X1-019

X1-019 GSU and modeling Data (incomplete, need more information)

Per the X1-019 supplied data dated February 25, 2011; the following was used in modeling the project T/G and the GSUs:

Wind Turbines:

No. of Turbines 30, Siemens SWT3.0-101; each 3 MW; Saturated sub-transient reactance at 3 MVA base = 0.36 pu

X1-019 T/G Pad Mounted Transformers or GSU

No. of Turbine/Generators: 20; each 3 MVA; $x''_d=0.36$ pu

X1-019 T/G step up transformers or GSU:

No. of Transformers; 20

Each Transformer Rating = 3.4 MVA

Each Transformer Ratio 34.5/0.69Kv

Z1 = 0.008 + j0.06 % at 3.4 MVA base

Connection: Wye grounded 34.5kV and Wye grounded 0.69 kV

Collector Cables:

Cable size and length required from each GSU to collector bus

X1-019 Intertie Transformer:

Intertie Step-up transformer: One 69/34.5 kV, 67 MVA

Impedance- Z1 = 0.008 + j 0.131 % at 67 MVA base

Connection: Wye grounded 69kV and Delta 34.5 kV

The X1-019 Interconnection Customer must provide PPL EU and PJM with the intertie transformer test reports and all other data once they are available in order to perform a more detailed analysis.

X1-019 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 X1-019's equipment, the Queue X1-019 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Concerning voltage flicker, the X1-019 project must limit the severity of their voltage variation to within a level which will not cause objectionable flickers to other PPL EU 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 X1-019 customer if their operation causes flickers that exceed PPL EU guidelines.

X1-019 Regulation or Reactive Supply Requirements

As specified in Interconnection Service Agreement, Part VI Att. O, Appendix 2, and Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the X1-019 generators 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.”

The project X1-019 shall design its Facility to operate within a power factor range of 0.95 leading (absorbing vars) to 0.95 lagging (supplying vars) as specified in PJM requirements. In order to eliminate significant voltage deviation, the project will normally be requested to operate at approximately unity power factor, as measured at the 69 kV point of interconnection, on the high side of 69/34.5kV transformer. However, the project must have the ability to operate in either the leading or lagging mode as required from time to time. Consequently, it is strongly recommended that the wind turbines/generators be procured with power factor control capability.

In order to achieve the specified power factor, the developers may be required to install automatically controlled shunt reactors or shunt capacitors at the X1-019 facility. Either device would require a fast response, automatic, power factor controller. Such a controller would minimize the voltage change at the 69kV point of interconnection. In addition, the automatic power factor controller will allow Customer to accommodate future power factor changes that can occur as a result of upgrades or enhancements to the PPL EU transmission system.

While installation of capacitors or reactors is an option, use of mechanical switching may be too slow to respond to MW output changes due to wind gusts. The customer would be required to examine voltage flicker caused by the time lag inherent in switched capacitor or switched reactor action. The customer would be expected to mitigate flicker to levels deemed acceptable by PPL EU. These flicker levels are published on the PPL EU website.

Additional information is needed from the project developers regarding the collector system(s) with underground cables between each generator and the collector bus. This information is required to calculate the reactive contribution of generator cables to the system. In future studies, PPL EU will calculate this reactive contribution and model them as a reactive source.

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 X1-019 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 X1-019 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 tape 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 tap of 67kV. The voltage on the high side of the transformer may be between a range of 68-62kV. Expected voltage at the interconnection point would be provided in the later studies.

Network Impacts

Queue project X1-019 was studied as a(n) 60.0 MW (7.8 MW of which was Capacity) injection into PPL's system. Project X1-019 was evaluated for compliance with reliability criteria for summer peak conditions in 2015.

Option 1: SUNB YD1 69.0 kV substation

Potential transmission network impacts are as follows:

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

(Report over-dutied breakers.)

None 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: DAUP 69.0 kV substation

Potential transmission network impacts are as follows:

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

(Report over-dutied breakers.)

None 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
Single Line Diagram – Option 1

Attachment 2
Single Line Diagram – Option 2