Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position Y3-041

Peckville-Jackson 69kV

September 2013

Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the impact study is performed.

The Feasibility Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

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

General

The Interconnection Customer (IC), has proposed a wind generating facility located in Sterling, Pennsylvania. The installed facilities will have a total capability of 64.6 MW with 8.4 MW of this output being recognized by PJM as capacity. The Interconnection Customer has requested to be in-service by November 30, 2015. **This study does not imply a PPL EU commitment to this in-service date**.

Point of Interconnection

Y3-041 will interconnect with the PPL Electric Utilities (PPL EU) transmission system along the 69kV line between the Jackson and Peckville substations.

Cost Summary

The Y3-041 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 1,258,383
Direct Connection Network Upgrades	$ 0
Non Direct Connection Network Upgrades	$ 1,024,275
Total Costs	**$ 2,282,658**

In addition, the Y3-041 project may be responsible for a contribution to the following costs:

Description	Total Cost
New System Upgrades	$ 0
Previously Identified Upgrades	$ 0
Total Costs	**$ 0**

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

Attachment Facilities

A new 138/69 kV transmission line spanning approximately 1000 feet will be constructed from the customer's substation to the Peckville – Jackson 138/69 kV line. A final line route will be selected during a later PJM study after exact location of the customer's facility is provided. The tap will be designed for single circuit 138 kV operation as this cooridor may be converted to 138kV operation within the next 30 years. The tap will be initially operated at 69 kV and will use a conductor capable of carrying at least 96 MVA (summer normal rating) and 126 MVA (summer emergency rating). The tap will be built with Optical Ground Wire (OPGW) to a dead-end structure in the new Interconnection Customer owned substation. The time required for the transmission work is expected to be approximately 24 months.

The work includes installation of two 69kV MOLSAB (Motor Operated Load Sectionalizing Air Break) switches on the PPL EU Peckville-Jackson 138/69 kV line, one each on either side of the interconnection point for the isolation of the Y3-041 tap. The switches would be installed on custom designed steel poles with concrete foundations.

The estimate for the transmission tap includes costs to construct the new tap as well as the costs of associated work for line terminations, new poles & foundations, and optical ground wire for relay and control.

This transmission tap would be traversing "to-be-acquired right-of-way" and would be owned by PPL EU. PA PUC Certification will be required for a tap designed for 138 kV. A Letter of Notification will be sufficient for a tap length of less than 2 miles.

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

Description	Total Cost
Transmission work	$ 1,224,855
Siting and certification	$ 33,528
Total Attachment Facility costs	**$ 1,258,383**

Direct Connection Cost Estimate

No Direct Connection facilities are required to support this interconnection.

Non-Direct Connection Cost Estimate

A bi-directional fiber-based DTT (Direct Transfer Trip) will be required for communication paths between the Y3-041 substation and the PPL EU Peckville 230-69 kV Substation. Matching fiber-based DTT equipment is required. A communication path between the Y3-041substation and the PPL EU Jackson 138-69 kV Substation can be added in case the Interconnection Customer wants to keep generating power during abnormal sectionalizing of the Peckville – Jackson 138/ 69 kV line.

The DTT scheme provides a trip signal from the PPL EU supply substation any time the supply breaker opens.

PPL EU is scheduled to have configuration changes in the Peckville – Jackson area that would affect the Y3-041 project. These changes are scheduled to be in-service by November 2015. PPL EU reserves the right to change this in-service date based on PPL EU's annual review process. After the aforementioned date (11/2015), the Interconnection Customer will be connected to both the Lackawanna 230-69 kV and the future Pocono 230-69 kV substations in network configuration. In order to keep the wind farm in service, additional DTT equipment would be required at both the Lackawanna and Pocono 230-69 kV substations.

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

Description	Total Cost
Peckville substation DTT relaying	$ 269,054
Jackson substation DTT relaying	$ 233,260
Pocono substation DTT relaying	$ 242,475
Lackawanna substation DTT relaying	$ 279,486
Total Non-Direct Connection costs	**$ 1,024,275**

Interconnection Customer Requirements

The Interconnection Customer will be responsible for the construction of all their generating station facilities on the Interconnection Customer side of the POI (Point of Interconnection).

Generator and GSU Modeling

Per the Interconnection Customer supplied data, the following was used in modeling the generators and the GSUs:

- Y3-041 Generators: 76 units, 100 MVA base, net injected into PPL EU system 64.6 MW, pf at the generator terminals 0.95 lag, saturated sub-transient reactance = 8.9% on 24.65 MVA base.
- GSUs (Generator Step Up Transformers): 3 transformers with the following data:

Transformer	Rating/Base (MVA)	Voltage (kV)	R	X
1	30	24/69	0	0.06
2	20	24/69	0	0.06
3	25	24/69	0	0.06

Intertie and POC Protective Relaying Equipment

The Interconnection Customer will need to install suitable protection and control equipment at its facilities based on PPL EU parallel generation requirements. This includes both Intertie

Protective Relaying (IPR) and Point of Contact (POC) relaying. Please refer to the PPL EU web site for the IPR and POC requirements. The website addresses are shown below:

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

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

DTT Equipment Requirements

Fiber-based DTT (Direct Transfer Trip) equipment will be used to communicate circuit breaker tripping and status monitoring between the Interconnection Customer facility and the PPL EU Peckville, Jackson (possibly), Lackawanna and Pocono 230-69 kV Substations.

- Fiber optic cable exists on the Peckville-Jackson 138/69 kV lines.
- A fiber tap to the Interconnection Customer substation will be required.
- PPL EU will need signals to Peckville, Jackson (possibly), Lackawanna and Pocono 230-69 kV Substations
- The DTT scheme is required for protection of the 69 kV line paths to isolate faults under breaker failure conditions.
- Specific protective relaying requirements will be determined at the Facilities Study.

Isolation Breaker Requirement at the Interconnection Customer's Substation

Per the customer's preliminary sketches, the customer is planning to provide a high side circuit breaker at 69 kV with a manually operated 69 kV 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.

Y3-041 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 Y3-041's equipment, the Queue Y3-041 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Concerning voltage flicker, the Interconnection Customer must limit the severity of their voltage variation to within a level which will not cause objectionable flickers to other customers. A voltage drop greater than 5% at the point of interconnection is generally not acceptable. The frequency and severity of the voltage variation will be considered when determining whether a customer's equipment is violating PPL EU flicker guidelines. PPL EU uses the General Electric flicker-irritation curves as a guideline to determine if the system is operating within acceptable limits. PPL EU will require corrective actions by the Interconnection Customer if their operation causes flickers that exceed PPL EU guidelines. One such correction could be the installation of static var compensators (SVC) to hold a constant voltage.

Y3-041 Generator Regulation or Reactive Support Requirements

The PPL EU preliminary load flow studies have indicated that the Y3-041 generator will maintain the required voltage regulation on the Peckville, Jackson, Pocono and Lackawanna 69 kV buses within the required range assuming negligible underground cable capacitance.

If the Interconnection Customer proceeds to the Facility study phase, PPL EU will require the customer to provide equivalent capacitance of its underground cable system in order to calculate more accurate reactive requirements. More specific requirements will be developed at the Facility Study stage provided PPL has obtained the equivalent capacitance information from the Interconnection Customer.

As specified in Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the Y1-067 Project 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 Feasibility study to be required for the safety or reliability of the Transmission System, the Generation Interconnection Customer shall design its Customer Facility with the ability to maintain a composite power delivery at continuous rated power output at a power factor of at least 0.95 leading (absorbing vars) to 0.95 lagging (supplying vars)."

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 Y3-041 wind farm requires back-up electric service at a voltage less than 69 kV. The ICS Help Desk can be reached at 1-888-220-9991. Cost for distribution electric service is NOT included in the PPL scope of work transmission or substation estimates.

Future Conversion of line to 138 kV from 69 kV

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

Intertie 69-34.5 kV Transformer Turns Ratio

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

70.6 kV, 68.8 kV, 67.0 kV, 65.2 kV, 63.4 kV with nominal midpoint voltage is 67 kV, this provides a range of 5% above (in two 2.5% steps) and 5% below (in two 2.5% steps) to the midpoint range of 67 kV. The PPL 69 kV system is operated at around 66.7 kV at the PPL EU Peckville, Jackson, Lackawanna and Pocono 230-69 kV substations.

PA PUC Certification & Environmental Issues

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

PA PUC certification will be required because the tap will be designed for 138 kV. PPL EU will determine environmental impacts and mitigation strategies for the facilities being certified (i.e. the transmission lines). These costs are not included in this estimate.

To avoid duplication of costs and efforts, PPL EU recommends that the Interconnection Customer obtain all environmental approvals required for construction of the generating station and share pertinent details with PPL EU prior to PPL EU beginning work on the line siting.

Revenue Metering and SCADA Requirements

PJM Requirements

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

PPL EU Requirements

Metering Equipment Installation at the POI (Point of Interconnection)

Installation of revenue grade metering equipment will be required at the Y3-041 Point of Interconnection [at the Interconnection Customer dead-end structure]. PPL EU will design and supply the required metering equipment but all the installation cost would be borne by the developer including CT/PTs. All metering equipment must meet applicable PPL EU tariff requirements as well as being compliant with all applicable requirements of the PJM agreements. The equipment must provide bi-directional revenue metering (KWH and KVARH) and real-time data (KW, KVAR, circuit breaker status, and generator bus voltages) for the developer's generating resource.

The metering equipment should be housed in a control cabinet or similar enclosure and must be accessible to PPL EU metering personnel.

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 developers plant will be provided where deemed necessary. PPL EU will provide detailed specifications and design drawings for this equipment.

Schedule

After the Interconnection Service Agreement (ISA) and Construction Service Agreement (CSA) are signed, the estimated time needed to complete the direct connection work is about 24 months for the transmission work and substation work. The transmission and substation work can be completed concurrently. PPL EU will commence siting, engineering design, material purchase and construction of the facilities identified in this study after receiving written authorization by PJM to begin work. This time frame is contingent upon the acquisition of all rights of way in the stated time frame before the start of construction and detailed design.

Detailed Schedule

Milestone	Date
Receive Customer Down Payment/Notification to Proceed	October 1, 2013
Siting Start	January 1, 2014
Right-of-Way Acquisitions Complete	July 1, 2014
PUC Decision Received	July 1, 2014
Engineering Start	October 1, 2013
Engineering Release	August 31, 2014
Construction Start	November 30, 2014
Requested In-Service Date	November 30, 2015
Scheduled In-Service Date	November 30, 2015

Notes:

- PPL EU recommends that an Interim ISA/CSA be completed during the Facilities Study stage or earlier to address the critical path items, such as long lead-time purchases and the compressed project schedule.
- Procurement lead-times for metering equipment may extend to 30 weeks. Meter design, procurement and installation schedules must be implemented accordingly.

- 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 for an additional cost. It is also assumed that all rights-of-way, easements, and permits are secured without impact on anticipated construction start dates.

Estimate Assumptions for Interconnection

- This magnitude estimate has been prepared without extensive research or field review.
- For the new 138/69 kV Tap from Y3-041 to the Peckville – Jackson line, it is assumed that a new R/W and siting study would be required and the tap would be owned by PPL EU.
- No environmental, real estate, or permitting issues were reviewed for the estimate of this project.

Network Impacts

The Queue Project #Y3-041 was studied as a 64.6MW (Capacity 8.4MW) injection at the MADI 69 kV substation in the PPL area. Project #Y3-041 was evaluated for compliance with reliability criteria for summer peak conditions in 2017. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
PL100872	CONTINGENCY 'PL100872' /* SUSQ-LACK 500KV - STUCK CB AT LACK500 1W DISCONNECT BRANCH FROM BUS 200022 TO BUS 200074 CKT 1 DISCONNECT BRANCH FROM BUS 200074 TO BUS 208009 CKT 3 END
PL100873	CONTINGENCY 'PL100873' /* SUSQ-LACK 500KV - STUCK CB AT LACK500 1E DISCONNECT BRANCH FROM BUS 200022 TO BUS 200074 CKT 1 DISCONNECT BRANCH FROM BUS 200074 TO BUS 208009 CKT 4 END

Generator Deliverability

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

None.

Light Load Analysis

Light Load Studies to be conducted during later study phases (applicable to wind, coal, nuclear, and pumped storage projects).

Will be confirmed during the System Impact Study phase.

Multiple Facility Contingency

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

None.

Short Circuit

(Summary of impacted circuit breakers)

None.

Contribution to Previously Identified Overloads

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

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Circuit	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
1	LFFB	PL100872	PL - PJM500	LACKAW 500/230 kV transformer	208009	200074	4	DC	104.75	105.98	ER	1165	14.32	1
2	LFFB	PL100873	PL - PJM500	LACKAW 500/230 kV transformer	208009	200074	3	DC	104.75	105.98	ER	1165	14.32	2

Note: Please see Attachment 1 for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper table in the Attachment.

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

Will be confirmed during the System Impact Study phase.

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

Will be confirmed during the System Impact Study phase.

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

None.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
1	LACKAW 500/230 kV transformer	No mitigation is required for this overload. The automatic isolation of the failed breaker and automatic restoration will be installed at the future Lackawanna 500 kV switchyard. The automatic restoration scheme is expected to take approximately 20 seconds to re-energize the second transformer.	N/A	**$ 0**
2	LACKAW 500/230 kV transformer	This overload will be mitigated by #1 above.	N/A	**$ 0**
			Total New Network Upgrades	**$ 0**

Potential Congestion due to Local Energy Deliverability

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified.

None.

Attachment 1. Peckville-Jackson 138/69kV Line Connection

Attachment 2. Connection to Pocono and Lackawanna 230-69kV substations

Attachment 3. Flowgate Details

The following tables contain additional information about each flowgate presented in the body of the report. For each table, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact.

It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

Table 1

Contribution to Previously Identified Overloads, #1

(PL - PJM500) The LACKAW 500/230 kV transformer (from bus 208009 to bus 200074 ckt 4) loads from 104.75% to 105.98% (DC power flow) of its emergency rating (1165 MVA) for the line fault with failed breaker contingency outage of 'PL100872'. This project contributes approximately 14.32 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
208972	BECR K09	0.04
234312	HUN GEN6	0.4
208944	JENK CT	0.26
209003	KSTN IPP	0.06
292590	L-018 E	4.32
200851	MEHOOP3	0.51
294572	P-028 C	0.26
294573	P-028 E	23.31
200888	P-047 E	9.19
209010	PEIP 1	0.29
209009	PEIP 2	0.49
293416	V3-042C	1.62
293417	V3-042E	10.86
901902	W1-111 E	2.01
209029	WAYM IPP	0.11
907481	X1-109	125.84
910522	X3-003 E	3.88
X3-050	X3-050	12.66
910732	X3-056 E	5.65
912251	X4-048 OP1	319.13
913191	Y1-047 OP1	2.99
914061	Y2-042	4.72
Y2-044	Y2-044	20.49
914151	Y2-060	0.68
914341	Y2-089	118.08
914421	Y2-104	1.31
915181	Y3-041 C	1.86
915182	Y3-041 E	12.45

Table 2

Contribution to Previously Identified Overloads, #2

(PL - PJM500) The LACKAW 500/230 kV transformer (from bus 208009 to bus 200074 ckt 3) loads from 104.75% to 105.98% (DC power flow) of its emergency rating (1165 MVA) for the line fault with failed breaker contingency outage of 'PL100873'. This project contributes approximately 14.32 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
208972	BECR K09	0.04
234312	HUN GEN6	0.4
208944	JENK CT	0.26
209003	KSTN IPP	0.06
292590	L-018 E	4.32
200851	MEHOOP3	0.51
294572	P-028 C	0.26
294573	P-028 E	23.31
200888	P-047 E	9.19
209010	PEIP 1	0.29
209009	PEIP 2	0.49
293416	V3-042C	1.62
293417	V3-042E	10.86
901902	W1-111 E	2.01
209029	WAYM IPP	0.11
907481	X1-109	125.84
910522	X3-003 E	3.88
X3-050	X3-050	12.66
910732	X3-056 E	5.65
912251	X4-048 OP1	319.13
913191	Y1-047 OP1	2.99
914061	Y2-042	4.72
Y2-044	Y2-044	20.49
914151	Y2-060	0.68
914341	Y2-089	118.08
914421	Y2-104	1.31
915181	Y3-041 C	1.86
915182	Y3-041 E	12.45