Revised Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position Z1-090

Sunbury 230kV

March 2014

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 Z1-090 is a request to interconnect a 381 MW Energy (381 MW Capacity) Resource consisting of one heat recovery steam unit (new Unit 8). Units 1, 2, 3, and 4 will be retired at Sunbury. Units 5, 6, and 7 are not impacted by this project. Queue Z1-090 is located in Monroe Township, Snyder County at the existing Sunbury power plant property. Queue Z1-090 generation interconnection is scheduled for commercial operation on January 27, 2017. **This study does not imply a PPL EU commitment to this in-service date.**

The interconnection option described below was evaluated based on the assumption that Queue X2-025 and X4-019 will be placed in service prior to Queue Z1-090. If X2-025 or X4-019 are delayed or withdrawn from the queue, this Feasibility Study will be revised.

Point of Interconnection

The Z1-090 project will be connected to the existing PPL EU 230 kV substation utilizing the same connection that is currently occupied by Unit 4. A new 230 kV breaker will be installed to establish a double-breaker termination for the Z1-090 project in Bay 6 of PPL EU's 230 kV yard. PPL EU will require that the IC install a 230 kV motor-operated disconnect switch and a 230 kV circuit breaker between the PPL EU 230 kV substation and the Z1-090 GSU. The point of interconnection (POI) will be at the first dead end structure on the IC side of the fence line (IC will own the dead end structure). PPL EU will take ownership of the facilities on its side of this dead end structure which had been previously owned by the IC as a part of this POI change. Please see Attachment 1 for clarity.

Cost Summary

The Z1-090 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 0
Direct Connection Network Upgrades	$ 765,382
Non Direct Connection Network Upgrades	$ 0
Total Costs	**$ 765,382**

In addition, the Z1-090 project may be responsible for a contribution to the following costs:

Description	Total Cost
New System Upgrades	$ 0
Previously Identified Upgrades	$ 16,140,216
Total Costs	**$ 16,140,216**

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

Attachment Facilities

Queue Z1-090 is responsible for the design, construction, and costs for the motor-operated disconnect switch and 230 kV circuit breaker on the IC side of the POI.

Direct Connection Cost Estimate

The substation direct connection work includes the installation of a 230 kV circuit breaker and associated motor-operated disconnect switches in Bay 6 to complete a double-breaker bay. The lead time required for the substation direct connection work is approximately 10-12 months. This estimate assumes that suitable facility outages can be schedule as required to install the new circuit breaker. Failure to meet a scheduled facility outage may result in project delays.

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

Description	Total Cost
Installation of a new 230kV circuit breaker and associated MODs to complete double breaker termination at Sunbury 230kV substation	$ 765,382
Total Direct Connection Cost	**$ 765,382**

Non-Direct Connection Cost Estimate

There are no non-direct connection costs for this project.

Interconnection Customer Scope of Work

Queue Z1-090 Interconnection Customer will be responsible for the construction of all their generating station facilities on the Z1-090 side of the POI (Point of Interconnection).

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

DTT (Direct Transfer Trip) equipment will be used to communicate circuit breaker tripping and status monitoring between Z1-090 and the PPL EU Sunbury Substation. PPL EU will need a signal from Z1-090 that will indicate that the Z1-090 isolation breaker is open (a breaker 'b' switch).

Synchronizing Breaker Requirement at the Developer's Substation

PPL EU requires that the IC install a MOD switch and 230 kV CB on the IC's side of the POI to allow the customer-owned facilities to be fully disconnected from the PPL EU transmission system (with a clear visible open at the POI). This CB will be operated by the IPR relay and the DTT signal. , this requirement would allow the IC to fully protect their own facilities. PPL EU's standard practice document highlights the need for having PPL EU's protection equipment protecting PPL EU's facilities and the IC's protection equipment protecting all customer-owned facilities beyond the POI.

Interconnection Customer Requirements

Z1-090 Generator Harmonic and Flicker Requirements

On the PPL EU 230 kV system, the total harmonic distortion to the fundamental voltage wave from a single customer is limited to 1.0% of nominal. In addition, no individual harmonic component can exceed 0.7% 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 Z1-090's equipment, the Queue Z1-090 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Concerning voltage flicker, the Z1-090 Project 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 Z1-090 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.

Z1-090 Generator Regulation or Reactive Support Requirements

The PPL EU preliminary load flow studies have indicated that the Z1-090 generator will maintain the required voltage regulation on the Sunbury 230 kV bus within their required ranges. A voltage schedule will be developed at the Facilities Study stage.

As specified in Part IV, Subpart E at 54.7 of the PJM OATT, the Project Z1-090 generator shall design its "Facility" to maintain a composite power factor delivery at continuous rated power output at the generators terminals at a power factor of at least 0.95 leading (absorbing vars) to 0.90 lagging (supplying vars).

Z1-090 Generator and GSU Modeling

Per the Z1-090 supplied data the following was used in modeling the generator and the GSU:

Z1-090 Generator: One unit, MVA base 497.5, net injected into PPL EU system 381 MW, pf at the Sunbury 230 kV bus .9 lead and .9 lag, saturated sub-transient reactance = 15% on 497.5 MVA base.

GSU (Generator Step Up Transformer): Rating 475 MVA, 230/22 kV, Positive Sequence Impedance Z = 0.095 pu, all at 285 MVA base.

Revenue Metering and SCADA Requirements

PJM Requirements

Revenue Metering Equipment Installation at the Point of Interconnection

Installation of revenue grade Bidirectional Metering Equipment will be required at the Queue Z1-090 Point of Interconnection (POI) to measure KWh and KVARh. PPL EU will review the design of the high voltage metering equipment. PPL EU will supply the required metering equipment but the installation would be borne by the developer including CT/CCVTs. CTs and CCVTs will not be supplied by PPL EU. All metering equipment must meet applicable PPL EU tariff requirements as well as being compliant with all applicable requirements of the PJM agreements. The revenue meters should be housed in a control cabinet or similar enclosure (per PPL EU specification) and must be accessible to PPL EU metering personnel.

The developer is also required to provide revenue metering (KWH and KVARH) and real-time telemetry data (KW, KVAR, and KV) to PJM in compliance with the requirements listed in PJM Manuals M-01 and M-14. Any data from the PPL EU revenue meters can be transferred by fiber optic link to the PJM RTU located at the IPP facility.

PJM SCADA Equipment Requirements

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) to PJM via the SCADA equipment in compliance with the requirements in PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2 available at http://www.pjm.com.

PPL EU Requirements

SCADA Equipment Requirements

PPL EU will require the 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 circuit breaker. In addition to that, monitoring of other abnormal conditions at developer's plant will be provided where deemed necessary. PPL EU will provide detailed specifications and design drawings for this equipment.

Preliminary Work Schedules

PPL Scope of Work

The estimated PPL EU elapsed time to complete the 230 kV direct connection substation work is approximately 10-12 months after the receipt of a fully executed ISA/CSA.

The schedule for the 230 kV substation work to accommodate Z1-090 would depend on the project's start date. The work to accommodate Z1-090 will require substation facility outages. 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.

Transmission Owner Assumptions in Developing the Cost Estimates

- This magnitude estimate has been prepared without extensive research or field review.
- No environmental, real estate, or permitting issues were reviewed for the estimate of this project.
- Detailed analysis of the 230 kV bus capabilities (thermal and short circuit) was not performed for this study. This will be completed in the Impact Study Phase.

Network Impacts

Z1-090 is claiming the CIRs from Sunbury units 1 - 4, but the new unit (Z1-090) will be connecting to the existing Sunbury 230 kV switchyard, the same connection as the existing unit #4. Due to the POI not being the same for the new unit as Sunbury units 1 - 3, this study was performed with Sunbury units 1 - 4 removed and Z1-090 modeled at Sunbury 230 kV.

The Queue Project #Z1-090 was studied as a 381.0 MW (Capacity 381.0 MW) injection at Sunbury 230 kV substation in the PPL area. Project #Z1-090 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
PL100456	CONTINGENCY 'PL100456' /*SUNBURY 500-230 TRAN 24 OUT DISCONNECT BRANCH FROM BUS 200021 TO BUS 208109 CKT 24 END
PL100484	CONTINGENCY 'PL100484' /* D/C MONTOUR-SUSQ 230KV & MONTOUR-SUSQ T10 230KV DISCONNECT BRANCH FROM BUS 208040 TO BUS 208113 CKT 1 DISCONNECT BRANCH FROM BUS 208040 TO BUS 208120 CKT 1 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).

Not Required

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	DCTL	PL100484	PPL	SUNBURY 500/230 kV transformer	208109	200021	1	DC	104.43	111.42	ER	1165	241.98	1
2	Non	Non	PPL	W3-022 TAP-FRAC TR3 230 kV line	903300	207975	1	DC	127.48	129.85	NR	341	33.06	2
3	N-1	PL100456	PPL	W3-022 TAP-FRAC TR3 230 kV line	903300	207975	1	DC	127.72	129.94	ER	457	71.06	3

Note: Please see Attachment 2 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	SUNBURY 500/230 kV transformer	There is an existing baseline project identified to install a second 500/230kV transformer at Sunbury that will be completed by May 31, 2017. Z1-090 will have no cost responsibility for this project.	B2448	**$ 0**
2, 3	W3-022 TAP-FRAC TR3 230 kV line	PPL has proposed to reconductor the like with 1590 ACSR. This work is expected to take 5 years to complete	Pending	**$ 16,140,216**
			Total New Network Upgrades	**$ 16,140,216**

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. Single Line Diagram

Attachment 2. 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 this 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 tables are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

Table 1

(PL - PJM500) The SUNBURY 500/230 kV transformer (from bus 208109 to bus 200021 ckt 24) loads from 109.43% to 111.42% (DC power flow) of its emergency rating (1165 MVA) for the tower line contingency outage of 'PL100484'. This project contributes approximately 241.98 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
209004	KOPP IPP	4.7
208945	LOHA CT	0.3
212266	LOR1_N14_E	8.4
209027	LOR2_Q27_E	31.25
212386	R-043 E	6.25
290674	S-042 E	6.33
212449	SUNB CT	0.13
209018	SUNBIPCT	0.8
901902	W1-111 E	3.03
901932	W1-114 E	0.73
901942	W1-115 E	0.73

Bus Number	Bus Name	Full Contribution
903301	W3-022 C OP1	8.09
903302	W3-022 E OP1	54.15
208948	WILL CT	0.61
909021	X2-012 C	16.08
914031	Y2-015 C	139.83
914032	Y2-015 E	2.9
914052	Y2-037 E	0.73
914161	Y2-063 C	139.83
914162	Y2-063 E	2.9
915111	Y3-034	0.79
916411	Z1-090	241.98

Table 2

(PL - PL) The W3-022 TAP-FRAC TR3 230 kV line (from bus 903300 to bus 207975 ckt 1) loads from 127.48% to 129.85% (**DC power flow**) of its normal rating (341 MVA) for non-contingency condition. This project contributes approximately 33.06 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
212099	BRMO IPP	0.13
208981	FOWH IPP	0.79
212174	INGE	0.15
209027	LOR2_Q27_E	-20.26
290673	S-042 C	0.07
212449	SUNB CT	0.01
209018	SUNBIPCT	0.07

Bus Number	Bus Name	Full Contribution
903301	W3-022 C OP1	11.69
209021	WEST IPP	0.6
914031	Y2-015 C	202.1
914161	Y2-063 C	202.1
915111	Y3-034	0.9
916411	Z1-090	33.06

Table 3

(PL - PL) The W3-022 TAP-FRAC TR3 230 kV line (from bus 903300 to bus 207975 ckt 1) loads from 127.72% to 129.94% (**DC power flow**) of its emergency rating (457 MVA) for the single line contingency outage of 'PL100456'. This project contributes approximately 71.06 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
212099	BRMO IPP	0.15
208981	FOWH IPP	0.91
212174	INGE	0.17
209004	KOPP IPP	0.64
208945	LOHA CT	0.05
209027	LOR2_Q27_E	-15.88
290673	S-042 C	0.08
212449	SUNB CT	0.03
209018	SUNBIPCT	0.19

Bus Number	Bus Name	Full Contribution
903301	W3-022 C OP1	13.06
209021	WEST IPP	0.69
208948	WILL CT	0.09
909021	X2-012 C	1.74
914031	Y2-015 C	225.72
914161	Y2-063 C	225.72
915111	Y3-034	1.04
916411	Z1-090	71.06