Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position Y3-104

Sullivan Trail – Stanton 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.

General

The Interconnection Customer (IC), has proposed a flywheel facility located Exeter Township, Luzerne County, Pennsylvania. The installed facilities will have a total capability of 20 MW with 0 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is January 1, 2015. **This study does not imply a PPL Electric Utilities (PPL EU) commitment to this in-service date.**

Point of Interconnection

Y3-104 will interconnect with the PPL EU transmission system along the 69kV line between the Sullivan Trail and Stanton substations.

Cost Summary

The Y3-104 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 0
Direct Connection Network Upgrades	$ 1,442,399
Non Direct Connection Network Upgrades	$ 261,062
Total Costs	**$ 1,703,461**

In addition, the Y3-104 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**

Attachment Facilities

No Attachment Facilities will be constructed by the Transmission Owner.

Direct Connection Cost Estimate

The transmission direct connection work includes tapping the Stanton-Exeter 69 kV line between the Stanton 230-69 kV and Sullivan Trail 69-12 kV Substations and building a 0.15 mile connection using 556 ACSR conductor with OPGW to a dead-end structure in the new Y3-104 customer-owned substation. The tap line will be a 69 kV steel pole design. This estimate assumes that suitable line outages can be scheduled as required to terminate the new tap onto the existing transmission lines. Failure to meet a scheduled line outage may result in project delays. All right-of-way must be acquired prior to construction of the new transmission line.

The total preliminary cost estimate for the Direct Connection work is **$1,442,399**. These costs do not include CIAC Tax Gross-up.

Non-Direct Connection Cost Estimate

Y3-104 interconnection will require some modifications at the Stanton substation. The estimate includes costs to add DTT, breaker control modifications, synch check, and new line relays.

The total preliminary cost estimate for the Non-Direct Connection work is **$261,062**. These costs do not include CIAC Tax Gross-up.

Interconnection Customer Requirements

Protection equipment

The Interconnection Customer will need to install suitable protection and control equipment based on PPL EU parallel generation requirements. This includes both Intertie Protective Relaying (IPR) and Point of Contact (POC) relaying. Intertie Protective Relaying and Point of Contact relaying documents for voltages below 230 kV can be referred to on the PPL EU website. 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 Relaying Requirements

A bi-directional fiber-based DTT (Direct Transfer Trip) will be required for communication paths between the Y3-104 substation, and PPL EU's Stanton and Sullivan Trail substations or between the Stanton and Avoca substations. Matching fiber-based DTT equipment is required.

The DTT scheme is required for protection of the 69 kV line paths to isolate faults under breaker failure conditions

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 Y3-104 Interconnection Customer requires back-up electric service at a voltage less than 13 kV. The Business Accounts 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.

Isolation Breaker and Disconnect Switch Requirement

Interconnection Customer may include its own isolation breaker. This breaker can be located on either the high or low side of the Interconnection Customer's transformer. It will be operated by the IPR relay and the DTT, and if it is located on the high side, the POC relaying. This device will NOT be used to synchronize or parallel operating generation to the PPL EU system. A disconnect switch capable of de-energizing the site's step-up transformer must also be installed ahead of the isolation breaker.

Alternate Outlet for Generation Operation During PPL EU Maintenance

An alternate outlet for the generation was not requested by Queue Y3-104. The Y3-104 facility will not be able to generate into the PPL EU network during certain maintenance conditions. PPL EU on-going and long-term planned maintenance of the transmission lines terminating into the new proposed 230 kV switchyard will require PPL EU to remove the circuits from operation at least one (1) time every two (2) years, for an outage period of up to two (2) weeks. The actual duration may be shorter. During maintenance periods, the circuit may or may not be returned to service during evening hours. That decision depends on the type of work being performed. Unexpected and unplanned maintenance outages are not included in the one-in-two number and duration time.

Environmental, Real Estate, and Permitting Issues

These issues will be determined during engineering.

PPL EU anticipates that a NPDES general permit, a PADEP General Permit for limited wetlands and stream impacts, and a PennDOT entrance permit for the construction access road will be needed to perform the transmission line work.

PPL EU is assuming that sufficient right-of-way will be provided by the developer to PPL EU for the construction of the new 69 kV lines that connect the PPL EU electrical network to the Y3-104 substation. A 100 ft right-of-way width is PPL EU's standard for a 69 kV transmission line.

The estimated cost of the siting work and right-of-way is not included in the above estimate. No condemnation costs are included. Costs for threatened and endangered species studies or environmental constraints are also not included.

Generator and GSU modeling

Per the Y3-104 supplied data, the following was used in modeling the inverter generators and GSUs:

Y3-104 Inverter Unit:

Turbines: 200 units, 100 kW each (0.1 MVA base), net injected into PPL EU system 20 MW.

GSUs:

Generator Step Up Transformers: Five 0.48/13.8 kV, 2.35 MVA (12 MVA base) transformers with a 0.0036+j0.0809 pu impedance (Given) and X/R 22.5 (Given).

Intertie Transformers:

Intertie step-up transformer base: One 13.8/69 kV, 5.75% impedance (given).

**Some information was missing and must be provided for the System Impact Study.*

The Y3-104 Interconnection Customer must provide PPL EU and PJM with the transformer test reports and a model of the inverters once they are available in order to perform a more detailed short circuit analysis.

Generator Harmonic and Flicker Requirements

On the 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 Y3-104's equipment, the Queue Y3-104 Interconnection

Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Maximum Allowable Harmonic Voltage Distortion Table (Tariff Rule 33)		
Voltage Level	**Total Harmonic Distortion (% System Voltage)**	**Individual Harmonic (% System Voltage)**
69 kV	1.5	1.0

Concerning voltage flicker, the Y3-104 customer must limit the severity of their voltage variation to within a level which will not cause objectionable flicker to other customers. A voltage drop greater than 5% at the point of interconnection is generally not acceptable. The frequency and severity of the voltage variation must be considered when determining whether a customer's equipment is violating PPL EU flicker guidelines. PPL EU uses the General Electric flicker-irritation curve as a guideline to determine if the system is operating within acceptable limits. **PPL EU will require corrective actions by the Y3-104 customer if their operation causes flicker that exceeds PPL EU guidelines.** One such correction could be the installation of static var compensators (SVC) to hold a constant voltage.

Reactive Support Requirements

PPL EU load flow studies have indicated that the Y3-104 inverter generators will maintain the required voltage regulation within its required range at the 69 kV point-of-interconnection (POI). As specified in Interconnection Service Agreement, Appendix 2, Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the Y3-104 generator shall design its facility to meet the following power factor requirement:

"For all new wind-powered and other non-synchronous generation facilities, if determined in the system impact study to be required for the safety or reliability of the Transmission System, the Generation Interconnection Customer shall design its Customer Facility with the ability to maintain a composite power delivery at continuous rated power output at a power factor of at least 0.95 leading to 0.95 lagging."

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

PPL EU SCADA Requirements

PPL EU will require the installation of PPL EU approved SCADA equipment that will connect to its existing SCADA system. PPL EU will provide detailed specifications and design drawings for this equipment.

Telephone Circuit Requirements

PPL EU will require a communication path for DTT, SCADA, and voice. PPL EU anticipates that telephone circuits will be required to establish these paths.

The Interconnection Customer will be responsible to procure the following:

a) A 4-wire dedicated FDDA-type phone line for SCADA.
b) A normal dialup telephone line for voice communication. This may be an extension telephone.

Phone lines tend to be long lead-time items and must be in place and operational for equipment testing. The Interconnection Customer should investigate with the local phone company the possibility of obtaining this type of service at their facility. A checklist for ordering DTT and SCADA telephone circuits is available upon the Interconnection Customer's request if they decide to proceed with the interconnection.

The IC may utilize the fiber from the generating substation to the proposed new switchyard to tie the customers SCADA over PPL's fiber optic system.

All installation, maintenance, and monthly lease or billing charges for communications facilities are the responsibility of the Interconnection Customer.

Metering Equipment Installation at the Point of Interconnection

Installation of revenue grade Bi-directional Metering Equipment will be required at the Queue Y3-104 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. 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.

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 current transformers (CT)/potential transformers (PT). 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 specifications) and must be accessible to PPL EU metering personnel.

Preliminary Schedule

After the PJM three-party Interconnection Service Agreement (ISA) and Interconnection Construction Service Agreement (ICSA) 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. The time required for siting and Right-of-Way acquisition is estimated to be 6 months assuming Y3-104 is the only landowner involved and is willing to provide the necessary Right-of-Way. This work could take longer than expected if Y3-104 is not the only landowner involved or if unforeseen complications arise. The typical time needed to complete the transmission design and construction work is estimated to be approximately 15 to 18 months. All Right-of-Way will need to be acquired prior to the start of construction completed simultaneously with the 69 kV line construction. This translates into a 15 to 18 month project time frame to complete the work for both options.

Notes / Assumptions:

- The ISA/ICSA or an Interim Interconnection Service Agreement (IISA) must be signed by the Y3-104 Interconnection Customer, PJM and PPL EU before any PPL EU design and construction activities may commence.
- If custom-designed steel transmission poles are required, the current lead-time is approximately 40 weeks. It is estimated that custom designed poles will be needed for this project.
- During construction, if extreme weather conditions or other system safety concerns arise, field construction may need to be rescheduled, which could possibly impact the schedule plan.
- Excepting any operational, governmental and/or environmental regulatory delays, the use of additional resources, such as overtime, premiums for expedited material, and/or contractor labor, may enable PPL EU to decrease this construction period. It is also assumed that all right-of-way and easements are secured without impact on anticipated construction start dates.

Network Impacts

The Queue Project #Y3-104 was studied as a 20.0MW (Capacity 0.0MW) injection as a tap of the SUTR – STAN 69 kV substation in the PPL area. Project #Y3-104 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
PL100857	CONTINGENCY 'PL100857' /* STAN-LACK 230KV - STUCK CB AT STAN DISCONNECT BUS 208094 DISCONNECT BUS 208098 END
PL100863	CONTINGENCY 'PL100863' /* JENK-STAN #1 230KV - STUCK CB AT STAN DISCONNECT BUS 208094 DISCONNECT BUS 208097 END
PL100865	CONTINGENCY 'PL100865' /* JENK-STAN #2 230KV - STUCK CB AT STAN DISCONNECT BUS 208094 DISCONNECT BUS 208095 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).

None

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.)

	Contingency		Affected		Bus			Power	Loading %		Rating		MW	
#	Type	Name	Area	Facility Description	From	To	Circuit	Flow	Initial	Final	Type	MVA	Contribution	Ref
1	LFFB	PL100865	PL - PL	STAN TR2 230/69 kV transformer	208096	211856	2	DC	99.09	103.61	ER	113	5.11	1
2	LFFB	PL100863	PL - PL	STAN TR2 230/69 kV transformer	208096	211856	2	DC	99.54	104.1	ER	113	5.15	2

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.

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
3	LFFB	PL100857	PL - PL	STAN TR2 230/69 kV transformer	208096	211856	2	DC	100.31	105.14	ER	113	5.46	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 in the System Impact Study

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 in the System Impact Study

New System Reinforcements

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

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
1	STAN TR2 230/69 kV transformer	PJM Baseline upgrade b1760 installed motor operated disconnect switches on either side of the 230 kV circuit breakers at Stanton. This allows for the faulted breaker to be isolated within a short period of time without human intervention and for the Stanton 230 kV bus to be returned to service. After the Stanton 230 kV bus is returned to service, the load is split evenly across the remaining 3 transformers and the overload is mitigated.	B1760	**$ 0**
2	STAN TR2 230/69 kV transformer	This overload is mitigated by the upgrade listed in #1 above.	N/A	**$ 0**
			Total New Network Upgrades	**$ 0**

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
3	STAN TR2 230/69 kV transformer	This overload is mitigated by the upgrade listed in #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. Single Line Diagram

Attachment 2. Flowgate Details

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, 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

Multiple Facility Contingency, #1

(PL - PL) The STAN TR2 230/69 kV transformer (from bus 208096 to bus 211856 ckt 2) loads from 99.09% to 103.61% (DC power flow) of its emergency rating (113 MVA) for the line fault with failed breaker contingency outage of 'PL100865'. This project contributes approximately 5.11 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
907481	X1-109	-6.15
909021	X2-012 C	8.83
915642	Y3-104 E	5.11

Table 2

Multiple Facility Contingency, #2

(PL - PL) The STAN TR2 230/69 kV transformer (from bus 208096 to bus 211856 ckt 2) loads from 99.54% to 104.1% (DC power flow) of its emergency rating (113 MVA) for the line fault with failed breaker contingency outage of 'PL100863'. This project contributes approximately 5.15 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
907481	X1-109	-6.2
909021	X2-012 C	8.89
915642	Y3-104 E	5.15

Table 3

Contribution to Previously Identified Overloads, #3

(PL - PL) The STAN TR2 230/69 kV transformer (from bus 208096 to bus 211856 ckt 2) loads from 100.31% to 105.14% (DC power flow) of its emergency rating (113 MVA) for the line fault with failed breaker contingency outage of 'PL100857'. This project contributes approximately 5.46 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
909021	X2-012 C	6.06
915642	Y3-104 E	5.46