Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AB1-182

Bear Creek

February 2016

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 battery storage facility located in 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 April 2016. **This study does not imply a PPL Electric Utilities Corporation (PPL EU) commitment to this in-service date.**

Point of Interconnection

In order to interconnect with the PPL EU transmission system, PPL EU will tap the Bear Creek Tap off of the Harwood-Jenkins #1 69 kV line.

Cost Summary

The AB1-182 project will be responsible for the following costs:

Description	Total Cost	
Attachment Facilities	$	748,000
Direct Connection Network Upgrades	$	0
Non Direct Connection Network Upgrades	$	200,000
Total Costs	**$**	**948,000**

The 69 kV connection estimate is based on the assumptions stated in the following Transmission Attachment Facilities, Non-Direct Connection Work sections. This estimate may vary depending upon the Queue AB1-182 substation location and orientation.

In addition, the AB1-182 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.

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.

Note: Before the Impact Study stage, the exact location and orientation of the Interconnection Substation must be identified by the AB1-182 IC in order to refine the cost estimate.

Attachment Facilities

Project Details:

Design & Location Details:

This work will include installation or modification of three (3) structures. The first structure involves converting an existing dead-end structure into a tap. The second structure involves the installation of a new dead-end guyed heavy angle structure. The final structure involves the installation of a new MOLBAB between the existing tap structure and the converted dead-end structure. These structures will be designed for 138kV future operation.

Steel Poles:

There will be a total of three (3) structures included in this scope of work. After the line taps off of the Bear Creek 69kV Tap a new 85ft tall MOLBAB will be installed. The existing 75ft tall dead-end structure will be converted into a tap structure. The line will continue to a new 75ft dead-end guyed heavy angle structure before going into the new battery storage facility. All structures will be direct embedded except for the MOLBAB structure which will be on a caisson foundation.

Conductor and OHGW:

Conductor

- Total Length: 1,100 ft. (for all three phases)
- 60’ average span length for 556.5 kcmil base 24/7 ACSR (conductor length at 60 deg F for all phases)

OHGW

- Total Length: 375 ft. (for single circuit section)
- 60’ average span length for 3/8” H.S. Steel (single OHGW length at 60 deg F)

Guy Wire

- Total Length: 1,200 ft. (for both the converted tap structure and dead-end structure)
- Assumed for 45 deg slope

Siting/PUC Letter of Notification required:

The current Harwood-Jenkins #1 69 kV line is designed and certified as a 138 kV line. This project will require PA PUC Letter of Notification for the new tap to the POI. The lead time required from filing preparation to PA PUC approval is approximately 8 months. The approved filing is needed before construction can start. PPL EU will determine environmental impacts and mitigation strategies of the facilities being certified (i.e. - the transmission lines). These costs to address environmental impacts are not included in this estimate.

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	$ 748,000
Total Attachment Facility Costs	**$ 748,000**

Direct Connection Cost Estimate

There are no Direct Connection Facilities required to support this interconnection.

Non-Direct Connection Cost Estimate

Below mentioned work need to be done at Jenkins substation to accommodate the proposed IPP in PPL EU's network.

- A new telephone circuit and termination box will be extended to Jenkins 230-69kV substation control cubicle's telephone panel by Telephone Company.
- Install new Positron 7501-53 transformer in telephone panel and extend wire from the new telephone termination box to it.
- Install Direct Transfer Trip (DTT) Relay Cabinet at Jenkins. The new cabinet shall have control switches, status indication lights and RFL 9745. Tie DTT scheme into Harwood-Jenkins 69kV line #1 and the 69kV Bus Tie circuit breaker control schemes.
- Modify SCADA for new alarms (program new alarms in SCADA for IPP)
- Modify Alarm Management system (program new alarms in AMS for IPP)
- Perform system checks and test equipment in Jenkins and the IPP site before placing in service.

Below mentioned work need to be done at Bear Creek Battery substation to accommodate the proposed IPP in PPL EU's network.

- The IPP will need to install a matching RFL 9745 at their substation.
- Review and acceptance of IPP's Intertie Protective Relaying (IPR) and Point of Contact (POC) design of their facility
- Perform system checks and test equipment at Jenkins and the IPP site before placing in service

Assumptions:

This scope assumes that a new control cubicle and DTT cabinet will be installed at Jenkins substation prior to the IPP interconnection project.

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
Substation work	$ 200,000
Total Non-Direct Connection Facility Costs	**$ 200,000**

Preliminary Work Schedules

The estimated PPL EU elapsed time to complete the 69 kV transmission line Attachment Facilities and Direct Connection substation work is approximately 14 months after the receipt of a fully executed ISA/CSA. 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.

The work to accommodate AB1-182 will require an outage of the Bear Creek 69 kV tap. 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

- During construction, if extreme weather conditions or other system safety concerns arise, field construction may need to be rescheduled, which could possibly delay the schedule.
- It is assumed that outages required to construct the new tap off of the Bear Creek 69 kV Tap will be coordinated with the Bear Creek Wind Farm.
- This magnitude estimate has been prepared without extensive research or field review.
- For the new 69 kV tap line from the generation facility to the POI, it is as assumed that the IC will provide sufficient ROW and the line would be owned by PPL EU. It is also assumed that the IC is the landowner.
- No environmental, real estate, or permitting issues were reviewed for the estimate of this project.
- It is assumed that the developer will purchase the property needed for PPL EU's facilities and transfer the rights to PPL EU.
- This estimate assumes that suitable facility outages can be scheduled as required to install the new switchyard. Failure to meet a scheduled facility outage may result in project delays.
- 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 by the 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 AB1-182 Interconnection Customer, PJM, and PPL EU before any PPL EU design and construction activities may commence.

Interconnection Customer Requirements

AB1-182 Generator, GSU, and Line Modeling

The Generator interconnect consists of 5 battery storage containers. Each container producing 4MW. The total is about 20 MW.

The Battery storage was modeled and injects approximately 20 MW into PPL EU's system.

Per the AA2-182 supplied data the following was used in modeling the battery storage:

AB1-182: Battery Storage Generation

- Battery Storage Generator:
    - Number of Containers Per Transformer: 5
    - Size: 20 MW

Transformers:

- GSU (Generator Step Up Transformer):
    - Number of machines per GSU: 1
    - Voltage Levels: 34.5/69 kV

Transmission Tap Line:

- Voltage Level: 69 kV
- MVA Base: 100 MVA
- Length: approximately 200 feet

Telephone / Communication Circuit Requirements (At the IPP)

PPL EU will require a communication path for SCADA and voice circuits. It is assumed that this IPP will tie into the existing SCADA and voice circuits at Bear Creek. If not, then the IC's new substation will need its own independent RTU, SCADA circuit, and voice circuit. In this case, PPL EU anticipates that either telephone circuits or IP will be required to establish these paths. The Interconnection Customer would be responsible to procure the following:

- SCADA – either a 4-wire dedicated FDDA-type phone line or DNP over IP. It is at PPL's discretion as to which SCADA (4 wire or DNP/IP) is required to be provided.
- A normal dialup telephone line for voice communication.

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.

All installation, maintenance, and monthly lease or billing charges for communications facilities 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:
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

It is assumed that the IC will tie into the existing Direct Transfer Trip circuit at the Bear Creek Facility. If this is not the case, the IC should inform PPL at the next study phase so it can be incorporated into future study cost estimates.

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.

AB1-182 Generator Harmonic and Flicker Requirements

On the 69 kV system, the total harmonic distortion to the fundamental voltage wave is limited to 1.5% of nominal. In addition, no individual harmonic can exceed 1.0% of the fundamental. If PPL EU discovers that objectionable harmonics in excess of the stated limits are being injected into the system from AB1-182's equipment, the Queue AB1-182 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Concerning voltage flicker, the AA2-182 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 AB1-182 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.

AB1-182 Generator Regulation or Reactive Support Requirements

As specified in Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the AB1-182 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)."

The PPL EU preliminary load flow studies have indicated that the AB1-182 generator will maintain the required voltage regulation within required regulations. A MW/MVAR schedule will be provided to the developer at the Facilities Study Stage.

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 queue AB1-182 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 the Harwood-Jenkins #1 69 kV 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.

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 in the form of a Letter of Notification (LON) will be required because the new 69 kV tap is tapping a circuit designed for 138 kV.

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.

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

SCADA 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 monitoring of the POC isolating circuit breaker. PPL EU will provide detailed specifications and design drawings for this equipment should the IC proceed to an ISA/ICSA.

Metering Equipment Installation at the POI (Point of Interconnection)

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

AA2-182 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 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.

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

Other Issues Impacting the Interconnection Customer

Alternate Outlet

The Queue AB1-182 facility did not request an alternate outlet for their generation. Therefore, if the Harwood-Jenkins #1 69 kV line is out for maintenance or repair sourced from Jenkins, the IPP will not be able to transfer to the Harwood-Jenkins #1 69 kV line sourced from Harwood.

Maintenance Considerations

The Queue AB1-182 facility will not be able to generate into the PPL EU network during maintenance on the new 69 kV generator supply line or the Harwood-Jenkins #1 69 kV line. PPL EU on-going annual and long-term planned maintenance of this line will require PPL EU to remove the circuit from operation one (1) time every four (4) years, for an outage period of approximately two (2) weeks.

During maintenance periods, the circuit may or may not be returned to service during the evening hours. That decision depends on the type of work being performed. Annual inspections that uncover damaged supports, structures, or hardware, which require immediate repair are scheduled as soon as practicable. Unexpected and unplanned maintenance outages are not included in the one-in-four number and duration time. Annual inspections that uncover damaged poles, conductors, or hardware, which require immediate repair, are scheduled as soon as practicable. These types of unplanned outages may last up to 16 hours.

Network Impacts

The Queue Project AB1-182 was evaluated as a 20.0 MW (Capacity 0.0 MW) injection at the Bear Creek 69kV substation in the PPL area. Project AB1-182 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB1-182 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
UGI - MOUNTAIN - SUSQHNA TOWER_SPS_A	CONTINGENCY 'UGI - MOUNTAIN - SUSQHNA TOWER_SPS_A' /* WITH SPS 8227 TRIP SCHEME OPEN BRANCH FROM BUS 208113 TO BUS 234250 CKT 1 / 208113 SUSQ 230 234250 MOUN-TAP 230 1 OPEN BRANCH FROM BUS 208120 TO BUS 918210 CKT 1 / 208120 SU10 230 918210 AA1-036 TAP 230 1 OPEN BRANCH FROM BUS 234251 TO BUS 234252 CKT 1 / 234251 MOUNT-H1 230 234252 MOUNTAIN 230 1 OPEN BRANCH FROM BUS 234251 TO BUS 234254 CKT 1 / 234251 MOUNT-H1 230 234254 MNTN TR1 69.0 1 OPEN BRANCH FROM BUS 234257 TO BUS 234254 CKT 1 / 234257 MOUNT 2 69.0 234254 MNTN TR1 69.0 1 OPEN BRANCH FROM BUS 234256 TO BUS 234254 CKT 1 / 234256 MOUNT 1 69.0 234254 MNTN TR1 69.0 1 DISCONNECT BUS 207999 /* BUS 208000 REPLACED WITH BUS 207999 MAR 3, 2010 DISCONNECT BRANCH FROM BUS 208094 TO BUS 207999 CKT 2 /*STAN-JENK DISCONNECT BRANCH FROM BUS 208095 TO BUS 208094 CKT 1 /*JENK-STAN TR1 DISCONNECT BRANCH FROM BUS 207999 TO BUS 208001 CKT 1 END

Contingency Name	Description
UGI - MOUNTAIN - SUSQHNA TOWER_SPS_B	CONTINGENCY 'UGI - MOUNTAIN - SUSQHNA TOWER_SPS_B' /* WITH SPS 8227 TRIP SCHEME OPEN BRANCH FROM BUS 208113 TO BUS 234250 CKT 1 / 208113 SUSQ 230 234250 MOUN-TAP 230 1 OPEN BRANCH FROM BUS 918210 TO BUS 234251 CKT 1 / 918210 AA1-036 TAP 230 234251 MOUNT-H1 230 1 OPEN BRANCH FROM BUS 234251 TO BUS 234252 CKT 1 / 234251 MOUNT-H1 230 234252 MOUNTAIN 230 1 OPEN BRANCH FROM BUS 234251 TO BUS 234254 CKT 1 / 234251 MOUNT-H1 230 234254 MNTN TR1 69.0 1 OPEN BRANCH FROM BUS 234257 TO BUS 234254 CKT 1 / 234257 MOUNT 2 69.0 234254 MNTN TR1 69.0 1 OPEN BRANCH FROM BUS 234256 TO BUS 234254 CKT 1 / 234256 MOUNT 1 69.0 234254 MNTN TR1 69.0 1 DISCONNECT BUS 207999 /* BUS 208000 REPLACED WITH BUS 207999 MAR 3, 2010 DISCONNECT BRANCH FROM BUS 208094 TO BUS 207999 CKT 2 /*STAN-JENK DISCONNECT BRANCH FROM BUS 208095 TO BUS 208094 CKT 1 /*JENK-STAN TR1 DISCONNECT BRANCH FROM BUS 207999 TO BUS 208001 CKT 1 END

Generator Deliverability

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

None.

Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

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	UGI - MOUNTAIN - SUSQHNA TOWER_SPS_A	PL - PL	JENK TR2 230/69 kV transformer	208001	211654	2	DC	105.87	114.56	ER	230	20	1
2	DCTL	UGI - MOUNTAIN - SUSQHNA TOWER_SPS_B	PL - PL	JENK TR2 230/69 kV transformer	208001	211654	2	DC	105.87	114.56	ER	230	20	

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.

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.

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, 2	JENK TR2 230/69 kV transformer	b2269 Jenkins SPS will be retired by May 2018, thus this contingency shall be deleted for 2019 case	B2269	**$ 0**
			Total New Network Upgrades	**$ 0**

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.

Appendix 1

(PL - PL) The JENK TR2 230/69 kV transformer (from bus 208001 to bus 211654 ckt 2) loads from 105.87% to 114.56% (DC power flow) of its emergency rating (230 MVA) for the tower line contingency outage of 'UGI - MOUNTAIN - SUSQHNA TOWER_SPS_A'. This project contributes approximately 20.0 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
931942	AB1-182 E	20.