Generation Interconnection Facility Study Report

For

PJM Generation Interconnection Request Queue Position AB1-182

Bear Creek

January 2019

General

Leeward Renewable Energy Development, LLC, the Interconnection Customer (IC), has proposed to interconnect a battery storage facility with a total capability of 20 MW, with 0 MW of this output being recognized by PJM as Capacity. The facility is located in Luzerne County, Pennsylvania, which is also part of the PPL Electric Utilities (PPL EU) Central Region. The IC generation interconnection proposed in-service date as provided in the Attachment N is December 2016. Subsequently, the IC provided a revised in service date of December 1, 2022. **This study does not imply a PPL EU commitment to this in-service date.**

Point of Interconnection

AB1-182 will interconnect with the PPL EU Transmission system into the Bear Creek Wind Farm Tap via the Bear Creek Tap (BECR TAP) 69kV line. The Point of Interconnection (POI) will be where the line taps terminate (with insulators) at the IC substation dead-end structure. See Attachment 1 of this Facilities Study Report for more information.

Cost Summary

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

Description	Total Cost
Attachment Facilities (PJM Network Upgrade Number, n5133)	$ 754,000
Direct Connection Network Upgrades	$ 0
Non Direct Connection Network Upgrades (PJM Network Upgrade Number, n5134)	$ 250,000
Allocation for New System Upgrades	$ 0
Contribution for Previously Identified Upgrades	$ 0
Total Costs	**$ 1,004,0000**

A. Transmission Owner Facilities Study Summary

1. Description of Project

Leeward Renewable Energy Development, LLC, the Interconnection Customer (IC), has proposed to interconnect a battery storage facility with a total capability of 20 MW, with 0 MW of this output being recognized by PJM as Capacity. The facility is located in Luzerne County, Pennsylvania, which is also part of the PPL Electric Utilities (PPL EU) Central Region. The IC generation interconnection proposed in-service date as provided in the Attachment N is December 2016. Subsequently, the IC provided a revised in service date of December 1, 2022. This study does not imply a PPL EU commitment to this in-service date.

2. Amendments to the System Impact Study Data/Results

There are no amendments to the System Impact Study/Data results as part of this Facilities Study Report.

3. Interconnection Customer (IC) Milestone Schedule

The IC generation interconnection proposed in-service date is December 1, 2022. **This study does not imply a PPL EU commitment to this in-service date.**

4. IC Scope of Work

Point of Interconnection (POI)

The IC will interconnect with the PPL EU transmission system into the Bear Creek Wind Farm Tap via the Bear Creek Tap (BECR TAP) 69kV line. The POI will be where the line taps terminate (with insulators) at the IC substation dead-end structure. See Attachment 1 of this Facilities Study Report for more information.

RTU/SCADA and Voice Communication Circuit Requirements

PPL EU will require independent communication paths for RTU/SCADA and voice circuits. The IC will be responsible to procure the following:

- One (1) dedicated phone line for SCADA to the PPL EU Transmission Control Center.
- One (1) 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 IC 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 IC.

Direct Transfer Trip (DTT) Requirements

PPL EU will require an independent communication path, for DTT of the IC Intertie Protective Relaying (IPR) Fault Interrupting Devices (FIDs), consisting of a direct fiber connection with the Jenkins (JENK) substation and another direct fiber connection with the Palooka (PALO) substation. The IC will accommodate both normal (JENK) and alternate (PALO) outlets for DTT via the JENK-PALO 1 line.

To ensure reliable communication, the IC shall also provide DTT relaying equipment identical to the PPL EU DTT relaying equipment. All DTT relaying equipment shall connect to the respective fiber based communication paths. PPL EU will provide and install the fiber paths from the Jenkins and Palooka Substations to the IC. All DTT relaying equipment should reside within the same location as the IPR and Point of Contact (POC) relaying equipment.

Protective Relaying Requirements

The IC will need to install suitable protection and control equipment at its facilities based on PPL EU parallel generation requirements. This includes DTT, IPR and POC relaying equipment. Refer to the PPL EU website addresses shown below for the IPR and POC requirements:

IPR Requirements
https://pjm.com/-/media/planning/plan-standards/private-ppl/parallel-generation-protection-requirements-69kv-138-kv.ashx?la=en

POC Requirements
http://www.pjm.com/-/media/planning/plan-standards/private-ppl/point-of-contact-requirements.ashx?la=en

Substation IPR and POC FID Requirements

The IC provided IPR FIDs, up to six (6) 13.8kV rated circuit breakers in this case, shall be equipped with dual trip coils and capable of interrupting worst-case scenario fault currents with a rated speed of 3 cycles or less. The IPR FID circuit breakers shall be operated by their respective DTT and IPR relaying equipment. As of this writing, the IC has chosen to use fuses designated as the POC FIDs. If the fuses are replaced with circuit breakers and associated POC relaying equipment, then the POC FID circuit breakers shall also be equipped with dual trip coils and capable of interrupting worst-case scenario fault currents with a rated speed of 3 cycles or less, and operated by their respective DTT, IPR and POC relaying equipment.

Generator Harmonic and Flicker Requirements

On the 69kV 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 the IC equipment, then the IC will be responsible for taking corrective measures to mitigate harmonic currents.

Concerning voltage flicker, the IC 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 POI 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 IC 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.

Generator Regulation or Reactive Support Requirements

As specified in Part VI, Attachment O Appendix 2 at 4.7.1.1 of the PJM Open Access Transmission Tariff (OATT), the IC generator shall design its Customer Facility to meet the following power factor requirement:

"For all new wind-powered and other non-synchronous generation facilities the Generation Interconnection Customer shall design its Customer Facility with the ability to maintain a composite power delivery at a power factor of at least 0.95 leading to 0.95 lagging across the full range of continuous rated power output."

Generator Voltage Schedule Requirements

The IC shall not alter the voltage along the BECR TAP 69kV transmission line. The 69kV network voltage is regulated by the PPL EU Transmission Control Center (TCC), via Bulk Electric System power transformer load tap changer adjustments, to ensure that the distribution voltages delivered to PPL EU customers remain within the prescribed secondary bandwidth as mandated by the Pennsylvania Public Utilities Commission (PA PUC). The PPL EU distribution area supply substations, tapped to the 69kV network, may have power transformers that are fixed on particular taps to achieve acceptable voltage ranges on their low sides. Therefore, IC generation that alters the 69kV voltage on the high side of the distribution area supply substation power transformers will result in voltages on their low sides that may not remain within mandated PA PUC limits.

In lieu of voltage schedules, power factor schedules ensure that PPL EU can maintain acceptable voltage ranges along the impacted 69kV transmission lines. The expectation is that the 69kV line voltage will not be altered by the injection of IC generation. Therefore, PPL EU will request an exemption from providing voltage schedules, in accordance with PJM Manual 3 section 3.3, to providing power factor schedules (i.e., MW/MVAR schedules) as an alternative to achieve the desired results on the PPL EU network. Below is an acceptable power factor schedule based on the latest IC equipment data received to date (per Attachments 2 and 3 of this Facilities Study Report).

MW (P)	MVAR (Q)	Power Factor (PF)
0	-0.93 (Absorb)	-
5	-1.94 (Absorb)	0.98 Leading

10	-2.89 (Absorb)	0.98 Leading
15	-3.78 (Absorb)	0.98 Leading
20	-4.61 (Absorb)	0.98 Leading

Power factor schedules generally require that IC generation operates slightly leading so as not to alter the expected 69kV line voltage dictated by the PPL EU TCC. After the Interconnection Service Agreement (ISA) and Interconnection Construction Service Agreement (ICSA) are signed, the acceptable power factor schedule above will be re-evaluated during the detailed design engineering phase after the IC provides PPL EU final equipment data. If the re-evaluation using final equipment data ensures continued acceptable interconnection of the IC with the PPL EU network, then PPL EU will formally request from PJM an exemption to use power factor schedules in lieu of voltage schedules. If the final equipment data change at a later date, then PPL EU shall be notified so that the impacted power factor schedules can be re-evaluated again to determine acceptability of the IC to remain interconnected with the PPL EU network.

Distribution Service Requirements

The IC must submit a request for electric service through PPL EU Industrial and Commercial Services (ICS) group if back-up electric service is required at a voltage less than 69kV. The ICS Help Desk can be reached at 1-888-220-9991. Cost for distribution electric service is NOT included in the PPL EU scope of work transmission or substation estimates.

Future Conversion of Line to 138kV from 69kV

PPL EU presently has no plans to convert the BECR TAP 138/69 kV line to 138kV in the next 15-20 years. If the transmission system in this area is converted to 138kV in the future, the IC would be responsible for conversion of its substation to 138kV at that time.

PA PUC Certification & Environmental Issues

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

To avoid overlap of permitting boundaries and duplication of permitting efforts and costs, PPL EU recommends that the IC share pertinent detail with PPL EU during the permitting process. If the IC chooses to self-perform the ROW acquisition, then the IC shall purchase the PPL EU standard bundle of rights.

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 POI. SCADA equipment will also provide capability to trip and monitor the associated IC FID(s). PPL EU will provide detailed specifications and design drawings for this equipment should the IC proceed to an ISA/ICSA.

Revenue Metering Equipment Installation near the POI

Installation of revenue grade Bi-directional Metering Equipment will be required in the vicinity of the POI to measure kWh and kVARh. PPL EU Meter Engineering will design and supply the required metering equipment, but all the installation costs would be borne by the developer including CT/PTs. All metering equipment must meet applicable PPL EU tariff requirements and PJM Manual 1, Section 5 requirements. 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. PPL EU will require all Revenue Metering Engineering/Design to be approved by PPL Metering Engineers.

5. Total Estimated Costs of Transmission Owner Facilities included in Facilities Study

The associated costs provided in the following table are estimated costs based on the time this Facility study is issued. **This study does not imply a PPL EU commitment to these estimated costs.**

Description	Total Estimated
Attachment Facilities	$ 754,000
Direct Connection Network Upgrades	$ 0
Non Direct Connection Network Upgrades	$ 250,000
Total Estimated Costs	**$1,004,000**

Federal taxes and PA sales taxes that PPL EU would be obligated to pay are not included in the above total cost of the PPL EU portion of this project. However, the IC shall reimburse PJM and PPL EU for any future Federal taxes and PA sales taxes assessed by the IRS or governing taxing authority.

B. Transmission Owner Facilities Study Results

1. Transmission Lines – New

There are no new transmission lines as part of this Facilities Study Report.

2. Transmission Lines – Upgrades ($754,000)

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 structure at grid location 54149n39403. The second structure involves the installation of a new dead-end guyed heavy angle structure approximately 150ft away from the Bear Creek 69kV Line Tap. The final structure involves the installation of a new MOLBAB between the existing tap structure at grid location 54138n39394 and the converted dead-end structure at grid location 54149n39403.

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 at grid location 54138n39394, a new 85ft tall MOLBAB will be installed. The existing 75ft tall dead-end structure will be converted into a tap structure at grid location 54149n39403. The line will continue approximately 90ft northeast to a new dead-end guyed heavy angle structure before going into the new battery storage facility. Conductor shall be 556.5 kcmil 24/7 ACSR. Overhead shield wire shall be 0.567" 48 count OPGW.

3. New Substation/Switchyard Facilities – New

There are no new substation/switchyard facilities as part of this Facilities Study Report.

4. Substation/Switchyard Facilities – Upgrades ($250,000)

- The following upgrades are required at the JENK substation:
    - Install new fiber-based DTT equipment.
    - Modify the PALO 69kV #1 circuit breakers (PALOOKA 1 69KV CBs 3N and 3S) protection and control schemes.
    - Modify the existing SCADA to permit remote disable/enable control and status indication of the following DTT initiation signal:
        - Disable/Enable DTT Initiation of the JENK-PALO 1 Line (Normally Enabled).
    - Modify the existing SCADA for new alarms.
    - Modify the existing Alarm Management System (AMS).
    - Install new cables and modify control wiring for the above.
    - Perform system checks and test equipment before placing in service.
- The following upgrades are required at the PALO substation:
    - Install new fiber-based DTT equipment.
    - Modify the 69 kV JENK-PALO 1 line protection and control schemes for the 69kV Jenkins breakers 3N and 3T.
    - Modify the existing SCADA to permit remote disable/enable control and status indication of the following DTT initiation signal:

- Disable/Enable DTT Initiation of the new JENK-PALO 1 Line (Normally Disabled).

- Modify the existing SCADA for new alarms.

- Modify the existing AMS.

- Install new cables and modify control wiring for the above.

- Perform system checks and test equipment before placing in service.

5. Metering & Communications

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 POI. SCADA equipment will also provide capability to trip and monitor the associated IC FID(s). PPL EU will provide detailed specifications and design drawings for this equipment should the IC proceed to an ISA/ICSA. PPL EU will require all Revenue Metering Engineering/Design to be approved by PPL Metering Engineers.

Metering Equipment Installation at the POI

Installation of revenue grade Bi-directional Metering Equipment will be required in the vicinity of the POI to measure kWh and kVARh. PPL EU Meter Engineering will design and supply the required metering equipment, but all the installation costs would be borne by the developer including CT/PTs. All metering equipment must meet applicable PPL EU tariff requirements and PJM Manual 1, Section 5 requirements. 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.

6. Real Estate, ROW, Permitting, and Siting Issues

The IC will be required to follow the technical standards, requirements, and procedures for the acquisition and permitting of real estate and right-of-way (ROW). These requirements must be followed if the IC is to acquire real estate or ROW to be owned by PPL EU. For the attachment facilities scope of work, PPL EU is requesting the option to perform the siting and ROW acquisition.

Refer to the links below to obtain the PPL EU standard requirements for ROW acquisition & permitting:

https://pjm.com/-/media/planning/plan-standards/private-ppl/5474-re-row-acq-and-permit-req-proced-for-ipps.ashx?la=en
https://pjm.com/-/media/planning/plan-standards/private-ppl/ppl-electric-ipp-siting-standards-for-ipps.ashx?la=en

7. Summary of Results of Study

Cost Estimates

The associated costs provided in the following table are estimated costs based on the time this Facility study is issued. **This study does not imply a PPL EU commitment to these estimated costs.**

Description		Total Estimated
Attachment Facilities	**$**	**754,000**
Direct Material Costs	$	399,600
Indirect Material Costs	$	37,700
Direct Labor Costs	$	301,600
Indirect Labor Costs	$	15,100
Direct Connection Network Upgrades	**$**	**0**
Non Direct Connection Network Upgrades	**$**	**250,000**
Direct Material Costs	$	27,500
Indirect Material Costs	$	2,500
Direct Labor Costs	$	177,500
Indirect Labor Costs	$	42,500
TOTAL ESTIMATED COSTS	**$**	**1,004,000**

Schedule

The estimated PPL EU schedule to complete the 69 kV Attachment Facilities and Non-Direct Connection work is 19 months after the receipt of a fully executed ISA/CSA. During construction, network outages will be required. 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.

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.

Milestone	Duration
Receive Customer Down Payment/Notification to Proceed (NTP)	After PJM 3-party ISA & ICSA are signed
Engineering& Material Procurement	15 months
Construction Contract Award	2 months
Pre-Outage Construction	1 month
Outage Construction & Backfeed	1 month

Assumptions

- Estimates may vary depending upon IC substation location or orientation.

- No major environmental, real estate, or permitting issues are anticipated.
- IC will purchase the property rights needed for PPL EU's facilities and transfer the rights to PPL EU.
- New PPL EU Palooka Substation is in-service prior to AB1-182.
  Note: Target In service Date for the Palooka 230 kV-69kV substation is 05/31/2019 under supplemental project s0860.
- Lead-time to obtain custom-designed steel transmission poles is up to 26 weeks.
- With the exception of fuses designated as the POC FIDs, the IC FIDs will be those IC devices (breakers, switchers, etc.) to be tripped by their respective IPR, POC and DTT relaying equipment.
- 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.
- Suitable line/equipment outages can be scheduled as required. Failure to meet scheduled facility outages may result in project delays.
- In the event of 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.
- The ISA/CSA or an Interim Interconnection Service Agreement (IISA) must be signed by the IC, PJM, and PPL EU before any PPL EU design and construction activities may commence.

Maintenance Considerations

Although normal and alternate outlets for generation will be provided via the JENK-PALO 1 line, the IC will not be able to generate into the PPL EU network during maintenance on the new 69kV generator lead line, the BECR Wind Farm Tap or the BECR TAP 69 kV line. PPL EU on-going annual and long-term planned maintenance of these lines will require PPL EU to remove them from operation one (1) time every four (4) years, for an outage period of approximately two (2) weeks.

During maintenance periods, the circuits 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.

Attachment 1: Single Line Diagram