Generation Interconnection Facilities Study Report

for

PJM Generation Interconnection Request Queue Position AE2-133

Penns Tap – Richfield Tie 69 kV

8.4 MW Capacity / 20.0 MW Energy

October 2021

General

This Facilities Study has been prepared in accordance with the PJM Open Access Transmission Tariff §207, as well as the Facilities Study Agreement between Dynamic Energy Solutions LLC as the Interconnection Customer (IC) and PJM Interconnection, LLC as the Transmission Provider (TP). The Interconnected Transmission Owner (TO) is PPL Electric Utilities Corporation (PPL EU).

The IC has proposed a solar generating facility located in Snyder County, Pennsylvania. The installed facilities will have a total capability of 20.0 MW with 8.4 MW of this output being recognized by PJM as capacity. The requested in service date in the AE2-133 attachment N is March 5, 2021. However, the revised in-service date to account for the Transmission Owner's 13 month construction schedule is April 1, 2023. **This study does not imply a PPL EU commitment to this in-service date.**

Point of Interconnection

AE2-133 will interconnect with the PPL EU Transmission System via a tap Sunbury – Middleburg #1 69 kV line (SUNB-MIDD 1), between the Penns Tap and Richfield Tie busses. The Point of Interconnection (POI) will be where the IC's generator lead line attaches to the PPL EU line tap termination structure.

Cost Summary

AE2-133 will be responsible for the following estimated costs:

Description	Total Cost
Attachment Facilities	$937,443
Direct Connection Network Upgrades	$0
Non-Direct Connection Network Upgrades	$213,115
Allocation for New System Upgrades	$0
Contribution to Previously Identified Upgrades	$0
Total Cost	$1,150,558

These estimates are applicable based on the assumptions listed in Section 8 of this report. The estimate also excludes any applicable state or federal taxes. If at a future date Federal CIAC (Contribution In Aid of Construction) taxes are deemed necessary by the IRS or other governing taxing authority for this project, both PJM and PPL EU shall be reimbursed by the IC for such taxes.

A. Transmission Owner Facilities Study Summary

1. Description of Project

AE2-133 is requesting to connect a new 20.0 MW solar generating facility in Snyder County, Pennsylvania. The scope of work includes all necessary Network Upgrades and Attachment Facilities required to connect the new generation to the PPL EU Transmission System. The requested in-service date is December 31, 2021. Attachment Facility and Network Upgrade construction is estimated to be 13 months**. This study does not imply a PPL EU commitment to this in-service date.**

2. Amendments to the System Impact Study data or System Impact Study Results

None.

3. Stability Analysis Results

The AE2-133 queue project did not meet the 0.95 lagging power factor requirement or the 0.95 leading power factor requirement. An additional 9.57 Mvar would be required for the plant to meet the 0.95 lagging power factor requirement. An additional 3.57 Mvar would be required for the plant to meet the 0.95 leading power factor requirement.

4. Interconnection Customer's Submitted Milestone Schedule

- Substantial site work Completed: May 01, 2022
- Delivery of major electrical equipment: August 29, 2022
- Commercial Operation: April 01, 2023

5. Scope of Customer's Work

The IC is installing a 20.0 MW solar generating facility consisting of:

- Eight (8) 2.5 MVA Sungrow inverters.
- One (1) 15/20/25 MVA 69/34.5 kV delta/grounded wye Generator Step Up (GSU) transformer *(NOTE: This transformer does not meet PPL EU's interconnection requirements. See Attachment 3)*
- One (1) fully rated, fault-interrupting circuit breaker on the high-side of the GSU transformer.

The IC will construct a generator lead line with Optical Ground Wire (OPGW) from the IC substation to the POI at the PPL EU owned termination structure. The IC will terminate the OPGW into PPL EU's fiber splice box at this structure. The IC must follow all interconnection requirements, including but not limited to protection and control requirements at the IC substation. The IC will own and operate the revenue metering in the substation between the collector bus and the incoming generator lead line.

The IC will be responsible for all site preparation for the Attachment Facilities, including but not limited to, acquiring all rights-of-way, easements, vegetation clearing, access roads, civil work, and acquiring environmental and local permits. PPL EU requires a 100 ft. width easement for the 69 kV Attachment Facilities and an access road to the motor operated switch structure from a public road.

The IC will follow PJM telemetry requirements to send real time, generation data to PJM. PPL EU will obtain this data directly from PJM. PPL EU will work with PJM and the IC to ensure the generation data provided to PJM meets PPL EU's needs. The IC must also install the applicable relaying facilities at the IC substation consistent with PPL EU requirements.

6. Description of Facilities Included in the Facilities Study

PPL EU will tap the existing Sunbury – Middleburg #1 69 kV line and install a new single circuit 69 kV line with OPGW to a new dead-end structure outside the IC's substation. PPL EU will also install a SCADA controlled, Motor Operated Load Break Air Break Switch (MOLBAB) on the tap.

The SUNB-MIDD 1 line is normally operated radially from the Sunbury 69 kV substation, thus remote end relay work is required at the Sunbury 69 kV substation.

7. Total Costs of Transmission Owner Facilities included in Facilities Study

Work Description	Total Cost
Attachment Facilities (N7891) 69 kV Tap line, MOLBAB Switch, Poles, structures and foundations	$937,443
Total Attachment Facilities Cost	$937,443
Direct Network Upgrade	$0
Total Direct Network Upgrade Costs	$0
Non-Direct Network Upgrade (N7892) Modifications to the Sunbury – Middleburg #1 69 kV line to tie in the AE2-133 Attachment Facilities	$104,160
Non-Direct Network Upgrade (N7893) Relay Modifications Scope of Work	$108,955
Total Non-Direct Network Upgrade Costs	$213,115
Total Network Upgrades	$213,115
Total Project Costs	$1,150,558

The estimated costs above are based on risks and assumptions listed in Section 8.

8. Summary of Milestone Schedules for Completion of Work Included in Facilities Study:

The estimated duration for the completion of the PPL EU physical interconnection scope of work is **13 months** after the ISA and ICSA are signed, and the Construction Implementation Kick-off Meeting is held. These durations are based on the risks and assumptions listed in Section 8.

Activity	Start Month	End Month	Duration
Preliminary Engineering	1	1	1
Detailed Engineering	1	7	6
Construction Planning	7	10	3
Construction & Backfeed	10	13	3

9. Project Risks and Assumptions

The following assumption were made in preparing this Facilities Study:

- There are no major environmental, geotechnical, real estate, or permitting issues.
- There is no cost to PPL EU for easements and real estate acquisition.
- The IC will obtain all permits and approvals necessary for PPL EU owned Attachment Facilities.
- The IC will perform all site preparation for the Attachment Facilities.
- The IC will construct all access roads required for PPL EU's MOLBAB (Motor Operated Load Break Air Break) Switch to PPL EU standards and specifications.
- Suitable line/equipment outages can be scheduled as required. Failure to meet a scheduled facility outage may result in project delays.
- In the event of 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 the estimated construction period. However, no guarantees can be made.
- The ISA/ICSA must be fully executed by the IC, PJM, and PPL EU, and the construction implementation meeting kick-off meeting must be held before PPL EU design and construction activities may commence.
- Cost estimates are based on conditions when the study is performed and are subject to change based on many factors, including but not limited to, union labor rates and commodity pricing.

B. Transmission Owner Facilities Study Results

1. Transmission Lines – New

Attachment Facilities

PJM Network Upgrade Number N7891

69 kV Line Tap

PPL EU will tap the existing SUNB-MIDD 1 line near GPS Coordinates 40.792365°, -76.912028° and extend the tap towards the IC substation by completing the following:

- Intersperse a new custom steel, double circuit tap structure with a custom in between two existing structures on the SUNB-MIDD 1 line.
- Install a single circuit, direct-embed, steel, structure with a SCADA controlled MOLBAB
- Install a new single circuit, custom foundation, steel, full terminal tension structure (POI)
- Install 556 24/7 ACSR 3-phase conductors with 48-ct OPGW on the tap to the POI
- Install three (3) fiber splice boxes, one on the terminal POI structure, and two at the existing SUNB-MIDD 1 line

Note: The Sunbury-Middleburg #1 69 kV line is being rebuilt under s1036.3. This scope was created based on location and condition of assets in the field as-is. PPL EU will modify the scope based on the timing and engineering of the rebuild as applicable during implementation.

2. Transmission Line – Upgrades

Non-Direct Connection Network Upgrade

PJM Network Upgrade Number N7892

Complete SUNB-MIDD 1 line modifications to tie in the new AE2-133 Attachment Facilities. This includes connecting the conductors and OPGW from the SUNB-MIDD 1 line to the new tap structure. Reframe the two existing structures on each side of the tap.

3. New Substation/Switchyard Facilities

None.

4. Upgrades to Substation / Switchyard Facilities

Non-Direct Connection Network Upgrade

PJM Network Upgrade Number N7893

Relay Modification Work

The relay modification scope of work to interconnect the AE2-133 project will include the following:

Short Circuit Study

- Model IC in CAPE and conduct a wide area short circuit study two busses away from the IC facilities. Identify affected relays and revise settings as needed.

Review IC Engineering Package

Conduct a detailed review of the IC relay settings and engineering packaged submitted by IC to the PPL EU. Review should include but not be limited to:

- CT, PT connections
- Trip Circuit
- Relay DC supply
- Check that no customer function logic is included in the Intertie
- IPR must directly trip the breaker, and not via any PLC or other programmable device
- DTT is mapped correctly to the trip

Remote End Work – Sunbury 69 kV Substation

- Install new fiber based DTT equipment, SEL-2506 on Sunbury-Middleburg #1 69 kV line primary relay panel 8R2.
- At a minimum add a DTT blocking switch and DTT test switch into the design.
- Modify the existing 69 kV PRI and BU relay to interface with the DTT relay.

- Modify the existing 69 kV 4S and 4T circuit breaker protection and control scheme to incorporate the DTT scheme.
- Overall Maintenance switch, 52b, and relay trip should send DTT through SEL-2506.
- Modify the existing SCADA for new SEL-2506 relay and AMS alarms. This requires revising Orion LX file and point assignment sheets.
- Modify the existing Alarm Management System (AMS) to include loss of DTT communication and SEL-2506 relay failure and other alarms as needed.
- Install new cables and modify control wiring for the above.
- Perform system checks and test equipment before placing in service.
- Update the Orion LX configuration for the addition of DTT equipment and new AMS points.

5. Metering & Communications

Metering Ownership and Location

The IC will own the revenue grade Bi-directional Metering Equipment. It will be located inside the fence of the IC collector substation.

PPL EU Metering Requirements

Installation of revenue grade Bi-directional Metering Equipment will be required in the vicinity of the POI to measure kWh and kVARh. 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 bidirectional revenue metering (kWh and kVARh) and real-time data (kW, kVAR, circuit breaker status, and generator bus voltages) for the IC'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.

PJM Metering 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.

6. Environmental, Real Estate and Permitting 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.

Refer to the link shown below to obtain these requirements:

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

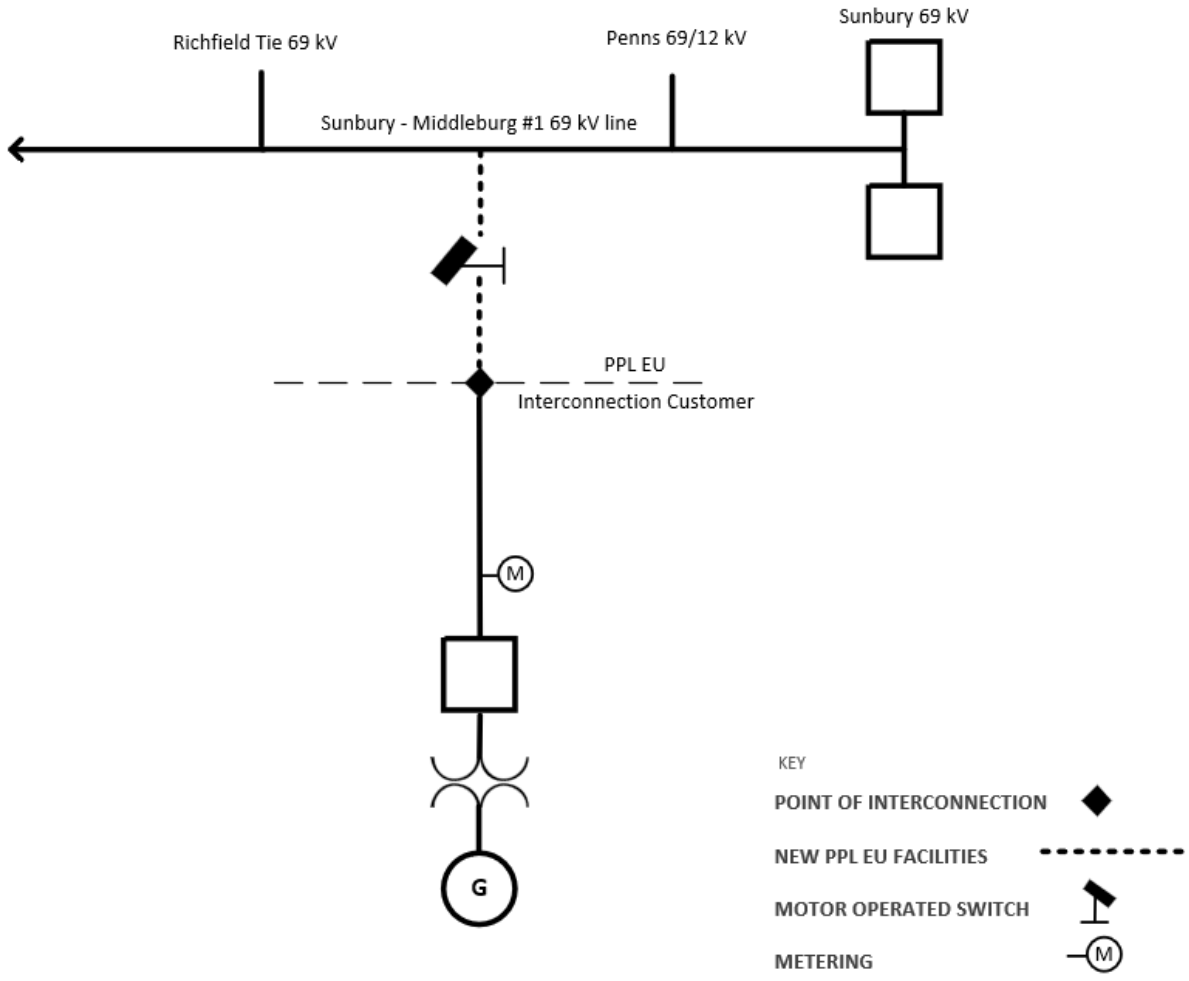
The requirements above apply to the AE2-133 Attachment Facilities.

7. Information Required for Interconnection Service Agreement

Description	Direct Labor	Direct Material	Indirect Labor	Indirect Material	Total Cost
Attachment Facilities	$518,490	$310,707	$65,218	$43,028	$937,443
Direct Connection Network Upgrades	$0	$0	$0	$0	$0
Non-Direct Connection Network Upgrades	$151,227	$39,073	$17,404	$5,411	$213,115
Allocation for New System Upgrades	$0	$0	$0	$0	$0
Contribution to Previously Identified Upgrades	$0	$0	$0	$0	$0
Total Cost	$669,717	$349,780	$82,622	$48,439	$1,150,558

Attachment 1

Single Line Diagram



The Point of Interconnection (POI) is where the IC generator lead line attaches to the PPL EU line tap termination structure. The fiber demarcation is where the IC fiber terminates in the PPL EU fiber splice box on the termination structure.

Attachment 2

Site Plan

The information provided above is not for construction and may be refined during the design and engineering phase of construction.

Attachment 3

Customer Interconnection Requirements

Applicable Technical Requirements and Standards

PPL EU applicable technical requirements and standards that address the interconnection of generation, transmission, and end user facilities can be found at the following link:

https://pjm.com/planning/design-engineering/to-tech-standards/private-ppl.aspx

For this request, the following documents are applicable:

- PPL Electric Utilities Transmission Facility Interconnection Requirements Revision 0, dated September 18, 2020
- Real Estate, Right of Way Acquisition & Permitting Requirements and Procedures for Independent Power Producers, Revision 0, dated July 17, 2018

IC Substation Intertie Protective Relaying (IPR) and Point of Contact (POC) Fault Interrupting Device (FID) Requirements

IPR FIDs

Based on the latest conceptual single line diagram provided by the IC, the IPR FIDs, one (1) 69 kV 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 three (3) cycles or less. The IPR FID circuit breakers shall be operated by their respective IPR and DTT relaying equipment.

POC FIDs

Based on the latest conceptual single line diagram provided by the IC, the POC FIDs, one (1) 69 kV rated circuit breaker in this case, shall be equipped with dual trip coils and capable of interrupting worst-case scenario fault currents with a rated speed of three (3) cycles or less. The POC FID circuit breakers shall be operated by their respective POC relaying equipment.

IC Direct Transfer Trip (DTT) Requirements

PPL EU requires an independent communication path, for DTT of the IC Intertie Protective Relaying (IPR) Fault Interrupting Devices (FIDs), consisting of one communication circuit with the Sunbury 69 kV substation. 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 communication path. All DTT relaying equipment should reside within the same location as the IPR and POC relaying equipment.

The DTT relaying equipment will communicate via OPGW from the Sunbury Substation along the SUNB-MIDD 1 line to the IC substation.

Note: PPL EU is rebuilding the Sunbury-Middleburg #1 69 kV line with new OPGW under Supplemental Project s1036.3. If s1036.3 is not completed prior to the interconnection of AE2-133, then the IC must procure a 3rd party circuit in lieu of OPGW from the IC substation to the Sunbury 69 kV Substation.

IC Generator Harmonic and Flicker Requirements

On the PPL EU 69 kV system, the total harmonic distortion to the fundamental voltage wave from a single customer is limited to 1.5% of nominal. In addition, no individual harmonic component can exceed 1.0% of the fundamental system voltage. If PPL EU discovers that objectionable harmonics in excess of the stated limits are being injected into the system from 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 the IC 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.

IC 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 shall design its non-synchronous Customer Facility with the ability to maintain a power factor of at least 0.95 leading to 0.95 lagging measured at the high-side of the facility substation transformers.

Power Transformer Requirements

The IC must contact PPL EU prior to ordering or specifying the main power transformer. Depending on the size, location on the PPL EU system, and other concerns, an alternate winding configuration may be specified.

The IC's power transformers at < 200 kV (nominal high voltage values) must have wye-connected, grounded primary windings, with neutral insulation suitable for impedance grounding and delta-connected secondary windings. The IC’s power transformers > 200 kV must have wye-connected, grounded primary windings, with neutral insulation suitable for impedance grounding and wye-connected secondary windings. All three-phase generation must be isolated from PPL EU customers by a power transformer.

IC Generator Voltage Schedule Requirements

Not applicable.