Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AA1-114

Harwood-East Hazelton #2 69kV

July 2016

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue AA1-114 is a EDF Renewable Development, Inc. request to interconnect a proposed 60 MW (7.72 MW capacity) wind farm to the Harwood - E. Hazleton #2 69 kV transmission line. The Queue AA1-114 generation interconnection is scheduled for commercial operation on December 29, 2017. This study does not imply a PPL Electric Utilities (PPL EU) commitment to this in-service date.

The AA1-114 project can be connected to PPL EU's 69 kV transmission system by tapping the McAdoo-Consolidated Cigar #2 Tap line off Harwood - E. Hazleton #2 69 kV line and extending approximately 200 feet of single circuit transmission line to the Interconnection Customer's (IC's) Substation. The Point of Interconnection (POI) will be where the PPL EU transmission line lands on the customer's deadend structure inside the IC's yard. Please see Attachment 1 for a one-line diagram of the POI. IC has not provided to PPL EU its substation site plan in relation to PPL EU's transmission line. Therefore, the scope and estimate of the attachment facilities lack some details and accuracy of a normal Facilities Study. Once more details are known about the exact location and positioning of the customer's deadend structure, the scope and estimate can be refined. The customer should be aware that the costs presented in this Facilities Study are liable to change depending on their IC substation location and orientation of their deadend structure.

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

Removal of PJM Network Upgrade Number n4653 from the required scope of work.

3. Interconnection Customer's Submitted Milestone Schedule

December 29, 2017 – Requested In Service Date

4. Description of Facilities Included in the Facilities Study

Attachment Facilities

- New 69kV transmission tap (PJM Network Upgrade Number n4652)

Direct Connection Network Upgrades

- None

Non-Direct Connection Network Upgrades

- Harwood substation work (PJM Network Upgrade Number n4654)

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

The 69 kV connection estimate is based on the assumptions stated in the following Transmission Attachment Facilities, Direct Connection, and Substation Non- Direct Connection Work sections.

The transmission and substation costs given 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 IC for such taxes.

Activity	NUN	Cost Estimate
Attachment Facilities		
New 69kV transmission tap	N4652	$ 984,124
Direct Connection Facilities		
None		$ 0
Non-Direct Connection Facilities		
Harwood substation work	N4654	$ 155,321
Total estimated costs		**$ 1,139,445**

Category	Cost Estimate
Direct Labor	$ 567,357
Direct Material	$ 132,531
Indirect Labor	$ 394,825
Indirect Material	$ 44,732
Total estimated cost	**$ 1,139,445**

Transmission Owner Assumptions in Developing the Cost Estimates

- For the custom-designed steel transmission poles, it is estimated that approximately two (2) custom designed steel poles will be needed for this project.
- For the new 69 kV tap from AA1-114 to the Mcadoo-Consolidated Cigar #2 Tap 69kV line, it is as assumed land rights will be provided by IC at no cost to PPL EU and the tap would be owned by PPL EU.
- This estimate has been prepared without extensive research or field review.
- This cost estimate is based on preliminary information only and costs are subject to revision after completion of the Erosion & Sediment Control design and Construction Work Outage Sequence.
- Vegetation clearing for the transmission Right-of-Way (ROW) scope of work - Not included in the cost, to be provided by IC.

- Storage laydown area adjacent to IC generation site shall be utilized by PPL EU's construction Contractor of Choice.
- The existing access road/path for construction vehicles has been assumed to be adequate for accessing the work areas without adjusting the existing terrain.
- Land restoration after construction is complete is limited to structure locations and pull pads.
- The project will have under an acre of land disturbance so a NPDES permit will not be required.
- No significant wetland impacts which require permits and there will only be one mobilization to perform wetland delineation.
- Additional surveys for species and Pennsylvania Historical and Museum Commission (PHMC) will not be required.
- Railroad crossings are not anticipated.

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

The estimated PPL EU elapsed time to complete the 69 kV Attachment Facilities and Non-Direct connection substation work is approximately 13 months after the receipt of a fully executed ISA/CSA, and other scheduling assumptions.

The schedule for the 69 kV substation work to accommodate AA1-114 would depend on the project's start date. The work to accommodate AA1-114 will require substation facility outages. PPL EU's outage windows for construction are typically available in the spring and fall of the year. Missing an outage window could result in project delays.

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 ROW in the stated time frame before the start of construction and detailed design.

ISA/ICSA Executed	August 21, 2016
Receive IPP down payment to proceed	August 31, 2016
Begin Engineering	September 1, 2016
Complete Engineering	March 31, 2017
Begin Construction	May 1, 2017
Complete Construction	June 30, 2017
Back-feed to IPP	September 29, 2017
Commercial Operation	December 29, 2017

Transmission Owner Assumptions in Developing the Schedule Estimates

- For the custom-designed steel transmission poles, the lead-time is approximately 32 to 42 weeks. It is estimated that approximately two (2) custom designed steel 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 delay the schedule.

- This estimate assumes that suitable facility outages can be scheduled as required to install the new transmission facilities. 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 ROW and easements are secured by the anticipated construction start dates.

B. Transmission Owner Facilities Study Results

1. Transmission Lines – New

New 69kV Transmission Tap

PJM Network Upgrade Number n4652

IC will provide a suitable route for the 100 feet wide Right-of-Way (ROW) needed to construct the approximately 200 feet 69 kV single circuit transmission line. The line will be built to the PPL EU standard using 556 Kcmil ACSR conductors with two optical ground wires (OPGWs) to the dead end structure inside the customer's substation (POI). Line details:

- The tap will be designed to 69 kV standards by utilizing 556.5 ACSR power conductors and two OPGW fiber optic cables in the shield wire position
- The tap will connect to the existing line between the structures 48942N27450 and 48939N27459
- The total distance of the tap will be approximately 200 feet from structure 48939N27459 to the IC substation deadend structure.
- Existing wood pole 48942N27450 will be replaced with a new light duty steel pole
- Install two Custom steel poles (high pole and low pole) between the structures 48942N27450 and 48939N27459.
- Install two light duty steel poles on the tap line between the high pole and the substation DE structure.
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- Install one Motor Operated Load Break Air Break (MOLBAB) switch. Note that PPL EU has cost responsibility for the MOLBAB and it's installation.
- Install one MOLBAB structure on the tap line between the high pole and the substation DE structure .

The attachment facility taps the Mcadoo-Consolidated Cigar #2 Tap line off Harwood - E. Hazleton #2 69 kV line. See Attachment 1 for the connection schematic.

2. Transmission Line – Upgrades

None.

3. New Substation/Switchyard Facilities

None.

4. Upgrades to Substation / Switchyard Facilities

Harwood Substation Work

PJM Network Upgrade Number n4654

The protection systems at the source substation for the 69kV line will be modified to support this interconnection. To accommodate AA1-114, the following upgrades are required at PPL EU's Harwood 230-69kV Substation:

- A new telephone circuit and termination box will be extended from IPP facility to Harwood 230-69kV substation control cubicle's telephone panel by Telephone Company (IPP responsibility).
- Install new Positron 7501-53 transformer in Harwood 230-69kV substation control cubicle's telephone panel and extend wire from the new telephone termination box to it.
- Install Direct Transfer Trip (DTT) Relay Cabinet at Harwood new control panel. The new panel shall have control switches, status indication lights and RFL 9745. The IPP will need to install a matching RFL 9745 at their substation.
- Install Bus Tie DTT Selector Switch to transfer control of the DTT scheme between the East Hazleton #2 69kV Line Breaker and the Bus Tie 69kV Breaker.
- Modify SCADA for new alarms (program new alarms in SCADA for IPP).
- Modify Alarm Management system (program new alarms in AMS for IPP).
- Review and acceptance of IPP's Intertie Protective Relaying (IPR) and Point of Contact (POC) design of their facility.
  Required Relay Engineering Hours – 80 hrs.
- Perform system checks and test related equipment at Harwood and the IPP site before placing the generation facility in service.
  Required Relay Test Hours at Harwood Station – 80 hrs.
  Required Relay Test Hours at IPP location – 80 hrs.

5. Metering & Communications

Communication Requirements (At the IPP)

The IC will be responsible to provide the following services:

1. Supervisory Control (SCADA) – A 4-wire dedicated FDDA-type telecom circuit, DNP over IP or direct fiber optic circuit to the PPL EU Transmission Management System (TMS) aggregation point. PPL EU will identify the location of the TMS aggregation point and communication protocols supported at that location.
2. Protective Control (DTT) – either a 4-wire dedicated PRDA-type telecommunications circuit or a direct fiber optic circuit.
3. Voice communication - A dedicated voice communications service reachable from the public telephone network.

Communication services must be in-service for acceptance and testing as well as daily operations.

Installation, maintenance, and recurring charges for communications facilities and services are the responsibility of the IC.

Metering Equipment Installation at the POI

Installation of revenue grade bi-directional metering equipment will be required at the AA1-114 POI at the IC deadend structure 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 to the PJM RTU located at the IPP facility.

SCADA Equipment Requirements

PPL EU will require installation of PPL EU approved SCADA equipment that will connect to its existing SCADA system to provide real time values of KW, KVAR, and kV metering data at the POC. SCADA equipment will also provide capability to trip and the status monitoring of the POC isolating circuit breaker. In addition to that, monitoring of other abnormal conditions at the developers plant will be provided where deemed necessary. PPL EU will provide detailed specifications and design drawings for this equipment.

PJM SCADA Equipment Requirement

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

6. Environmental, Real Estate and Permitting Issues

The IC will obtain all environmental permits for construction of the generating station and attachment facilities and share pertinent details with PPL EU prior to PPL EU beginning work on the line siting.

IC will provide a suitable route for the 100 feet wide Right-of-Way (ROW) needed to construct the approximately 200 ft.

7. Other Information

Maintenance Considerations

The AA1-114 IC will not be able to generate into the PPL EU network during maintenance on the new 69 kV generator supply line or the main Harwood-East Hazleton #2 69 kV line. PPL EU on-going annual and long-term planned maintenance of this circuit 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. The actual duration may be shorter. 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. 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.

AA1-114 Generator, GSU, and Line Modeling

The IC will be responsible for the construction of all their generating station facilities on the IC side of the POI.

AA1-114 Generator modeling (Vestas V110):

- Number of Turbines: 30
- Size: 2 MW per turbine
- MVA Base: 2.08 MVA
- 0.90 lead to 0.90 lag power factor at 69 kV bus

AA1-114 GSU modeling

- GSU (Generator Step Up Transformer):
  - Number of machines per GSU: 30
  - MVA Base: 40 MVA
  - Voltage Level: 34.5/69 kV
  - Impedance: 8.0%
- GSU (Wind Turbine Unit):
  - MVA Base: 2.1 MVA
  - Voltage Level: 34.5/0.69 kV

AA1-114 Transmission Line modeling

- Voltage Level: 69 kV
- MVA Base: 100 MVA
- Length: 0.04 mile
- Positive sequence impedance: 0.00016+j0.0006
- Zero sequence impedance: 0.00056+j0.0022

The AA1-114 IC must provide PPL EU and PJM with the transformer test reports once they are available in order to perform a more detailed short circuit analysis.

Intertie and POC Protective Relaying Equipment

The IC will need to install suitable protection and control equipment at its facilities based on PPL EU parallel generation requirements. This includes both IPR and 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

Isolation Breaker Requirement at the IC'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 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 an alternate isolation breaker.

AA1-114 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 AA1-114's equipment, the Queue AA1-114 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.

AA1-114 Generator Regulation or Reactive Support Requirements

As specified in Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the AA1-114 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 IC will be asked to hold voltage constant at the POI to the PPL EU 69 kV system. In order to minimize significant voltage deviation, PPL EU load flow studies indicate that the AA1-114 facility will need to operate at a unity power factor as measured at the 69 kV POI. This POI power factor should be maintained for all levels of generation output from the AA1-114 facility. In general, at MW output levels greater than 0 MW, PPL EU load flow studies suggest AA1-114 generation will need to hold a unity power factor to maintain approximately 67.3 kV at the high side of the interconnection transformer during peak load and approximately 66.1 kV at the high side of the interconnection transformer during light load.

Distribution Service Requirements

The IC must submit a request for electric service through PPL EU‟s Industrial and Commercial Services (ICS) group if the queue AA1-114 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 EU 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 this 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 IC would be responsible for conversion of its substation to 138kV at that time.

Attachment 1. Single Line Diagram