Generation Interconnection

Feasibility Study Report

for

Queue Project AF1-241

WATSON 12.47 KV

9 MW Capacity / 15 MW Energy

January, 2020

1 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. Cost allocation rules for network upgrades can be found in PJM Manual 14A, Attachment B. 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 Interconnection Customer seeking to interconnect a wind or solar generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per Schedule H to the Interconnection Service Agreement and Section 8 of Manual 14D.

PJM utilizes manufacturer models to ensure the performance of turbines is properly captured during the simulations performed for stability verification and, where applicable, for compliance with low voltage ride through requirements. Turbine manufacturers provide such models to their customers. The list of manufacturer models PJM has already validated is contained in Attachment B of Manual 14G. Manufacturer models may be updated from time to time, for various reasons such as to reflect changes to the control systems or to more accurately represent the capabilities turbines and controls which are currently available in the field. Additionally, as new turbine models are developed, turbine manufacturers provide such new models which must be used in the conduct of these studies. PJM needs adequate time to evaluate the new models in order to reduce delays to the System Impact Study process timeline for the Interconnection Customer as well as other Interconnection Customers in the study group. Therefore, PJM will require that any Interconnection Customer with a new manufacturer model must supply that model to PJM, along with a $10,000 fully refundable deposit, no later than three (3) months prior to the starting date of the System Impact Study (See Section 4.3 for starting dates) for the Interconnection Request which shall specify the use of the new model. The Interconnection Customer will be required to submit a completed dynamic model study request form (Attachment B-1 of Manual 14G) in order to document the request for the study.

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.

2 General

The Interconnection Customer (IC) has proposed a Solar generating facility located in Northumberland County, Pennsylvania. The installed facilities will have a total capability of 15 MW with 9 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is July 1, 2022. **This study does not imply a TO commitment to this in-service date.**

Queue Number	AF1-241
Project Name	WATSON 12.47 KV
State	Pennsylvania
County	Northumberland
Transmission Owner	PPL
MFO	15
MWE	15
MWC	9
Fuel	Solar
Basecase Study Year	2023

2.1 Point of Interconnection

AF1-241 will interconnect via one of the following options:

Option 1: via a direct connection into the Watson 12.47 kV Substation.

Option 2: Via a tap of the Watson 12 kV distribution circuit 33-01

2.2 Cost Summary

The AF1-241 project will be responsible for the following costs for the physical interconnection of the project:

Description	Total Cost
Distribution Scope of Work	$360,000
Non Direct Connection Network Upgrades	$4,899,000
Total Costs[1]	$5,259,000

In addition, the AF1-241 project may be responsible for a contribution to the following costs for Network Upgrades to mitigate overloads identified:

Description	Total Cost
System Upgrades	$49,000,000

[1] These costs do not include the costs for metering and service installation.

3 Transmission Owner Scope of Work

For Option 1, PPL will provide AF1-241 with a dedicated 12 kV circuit breaker at Watson substation and set of double circuit 750 Copper cables from the circuit breaker to the customer's point of interconnection outside Watson substation.

For Option 2, PPL will install a tap of approximately 500 feet of new line from the Watson 33-01 line at 41.11354, -76.86602 to the Point of Interconnection. A point of contact recloser will also be required at Point of Interconnection.

Detailed scope, cost, and schedule will be provided in a separate two party Interconnection Agreement (IA) between PPL and the Interconnection Customer. A preliminary **Option 1** estimate is provided below:

3.1 Distribution Scope of Work

The following attachment facilities will be required to support AF1-241:

- 150 feet of double circuit 750 Copper underground cable from point of contact circuit breaker to point of interconnection

The total preliminary cost estimate for the distribution work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
150 feet double circuit 750 copper underground cable	$360,000
Total Distribution Scope of Work Costs	$360,000

3.2 Non-Direct Connection Cost Estimate

The following Non-Direct connection facilities are required for AF1-241.

- At Watson substation:
  - Install a new line bay and circuit breaker with a synch check relay
  - Install (2) 69 kV circuit breakers
  - Install (2) sets of 69 kV disconnects
  - Install bus differential relaying
  - Upgrade relaying on (4) 12 kV line breakers
  - Install (2) 69 kV structures
  - Remove existing 69 kV structures
  - Install (2) sets of 69 kV PTs
  - Reconfigure 69/12 kV transformers
  - Install new (2) 12 kV structures and transformer cross yard lines
  - Extend the substation yard, including fence and ground grid
  - Upgrade battery system, station service, and SCADA

- Separate the Watson 12 kV bus into two sections
- Mobilize mobile substation

- Install a new 69 kV tap to Watson substation

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
Install new 12 kV line bay, circuit breaker, and relaying	$468,000
Install (2) 69 kV circuit breakers	$480,000
Install (2) sets of 69 kV disconnects	$24,000
Install bus differential relaying	$240,000
Upgrade relaying on (4) 12 kV line breakers	$270,000
Install (2) 69 kV structures	$360,000
Remove existing 69 kV structures	$240,000
Install (2) sets 69 kV PTs	$180,000
Reconfigure 69/12 kV transformers	$360,000
Install (2) new 12 kV structures and transformer crossyard lines	$240,000
Extend substation yard, including fence and ground grid	$462,000
Upgrade battery system, station service, and SCADA	$240,000
Split the Watson 12 kV bus into two sections	$570,000
Mobilize mobile substation	$240,000
Install new 69 kV tap to Watson substation	$525,000
Total Non-Direct Connection Facility Costs	$4,899,000

4 Schedule

The estimate time to complete the scope of work is **18 to 24 months** after an Interconnection Agreement (IA) is signed and PPL Electric receives notice to proceed from the IC.

5 Interconnection Customer Requirements

In order to ensure that the voltage rise at the point of interconnection does not exceed 2.5%, AF1-241 will be required to operate as follows:

AF1-241 would be required to operate at a power factor of 99% leading (absorbing VARs) at all times.

If customers served from Watson substation begin to experience unacceptable voltage fluctuation due to the AF1-241 Interconnection Customer's operations, the IC will be disconnected by PPL EU System Operations and will be required to cease operations and construct reinforcements necessary to mitigate the problem at their expense before being re-energized. Power factor will be monitored via SCADA to ensure this operational requirement is met and maintained. Deviation from this power factor at any time will result in being disconnected from the PPL Distribution system.

The customer's transformer windings shall be "WYE" to "WYE" with a solidly grounded high side transformer winding. Additional information can be found in PPL's Relay and Control Requirements for Parallel Operation of Distributed Generation document found at the following location:

https://www.pplelectric.com/-/media/PPLElectric/At-Your-Service/Docs/transmission-services/parallel-generation-requirements-distribution12kVandbelow.pdf?la=en

If PPL needs to operate the system in an abnormal configuration so that the customer is served by a different line, the customer may be asked to turn off their generation while abnormally configured. PPL also reserves the right to change the normal source to the customer as required by system conditions.

A point of contact recloser, to be provided by PPL and paid for by the customer, will be required at the customer's point of interconnection. Additional details on the customer point of contact requirements can be found on PPL's Point of Contact Requirements for Distribution Voltage Customer-Owned Facilities document:

https://www.pplelectric.com/-/media/PPLElectric/At-Your-Service/Docs/point-of-contact-requirements-12kV.pdf?la=en

In addition, information about requirements for a 12.47 kV service can be found at PPL's Rules for Electric Meter and Service Installations website:

https://www.pplelectric.com/at-your-service/electric-rates-and-rules/remsi.aspx

6 Revenue Metering and SCADA Requirements

6.1 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 Section 8 of Attachment O.

6.2 PPL Requirements

Installation of revenue grade Bi-directional Metering Equipment will be required near the point of interconnection to measure kWh and kVARh. PPL EU will design and supply the required metering equipment; all installation costs would be borne by the IC including CTs/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 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.

PPL also requires that the customer install SCADA at the common generator bus to provide PPL with real time operation parameters, including, but not limited to amps, voltage, MW, MVAR, power factor, etc. The SCADA system shall meet PPL SCADA standards and will primarily be for monitoring purposes but will provide PPL the ability to remotely disconnect the solar generation in emergency conditions. Additional details on the SCADA requirements for generators connecting to the PPL distribution system can be found in PPL's Relay and Control Requirements for Parallel Operation of Distributed Generation, which may be found on the PPL website or at the following link:

https://www.pplelectric.com/-/media/PPLElectric/At-Your-Service/Docs/transmission-services/parallel-generation-requirements-distribution12kVandbelow.pdf?la=en

7 Network Impacts

The Queue Project AF1-241 was evaluated as a 15.0 MW (Capacity 9.0 MW) injection at the Watson 12 kV substation in the PPL area. Project AF1-241 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-241 was studied with a commercial probability of 0.53. Potential network impacts for option 1 and option 2 were as follows:

Summer Peak Load Flow

8 Generation Deliverability

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

None

9 Multiple Facility Contingency

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

ID	FROM BUS#	FROM BUS	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
42253935	207968	ELIM	230.0	PPL	208109	SUNB	230.0	PPL	1	PL_P42_001388	breaker	537.0	99.6	100.5	DC	4.83

10 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)

None

11 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

12 System Reinforcements

ID	Index	Facility	Upgrade Description	Cost
42253935	1	ELIM 230.0 kV - SUNB 230.0 kV Ckt 1	R-PL-0005 (15) : Rebuild the SUNBURY-ELIMSPORT 230kV Line Project Type : FACILITY Cost : $49,000,000 Time Estimate : 48 Months	$49,000,000
			TOTAL COST	**$49,000,000**

13 Flow Gate Details

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

13.1 Index 1

ID	FROM BUS#	FROM BUS	FROM BUS AREA	TO BUS#	TO BUS	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
42253935	207968	ELIM	PPL	208109	SUNB	PPL	1	PL_P42_001388	breaker	537.0	99.6	100.5	DC	4.83

Bus #	Bus	MW Impact
208911	MONT G1	20.5268
208912	**MONT G2 (Deactivation : 02/18/19)**	**20.7920**
208945	LOHA CT	0.5852
208948	WILL CT	1.3833
209006	**NEPC IPP (Deactivation : 10/24/18)**	**1.2745**
211369	W1-111 BAT	0.0049
211375	BEAC	0.9804
211418	BUMO	0.6684
212369	PATRIOT 1	16.1389
212370	PATRIOT 2	16.1389
292935	U2-015E OP1	4.4732
921653	AA2-008 E	17.2300
923673	AB1-182 E	0.9285
939521	AE1-181 C	1.3235
939522	AE1-181 E	0.8824
940561	AE2-042 C O1	9.0726
940562	AE2-042 E O1	4.4976
940592	AE2-046 E	1.2745
940721	AE2-059 C	1.6284
940722	AE2-059 E	2.2488
940941	AE2-084 C	1.6284
940942	AE2-084 E	2.2488
941161	AE2-110 C	1.0437
941162	AE2-110 E	1.4413
942281	AE2-241 C	1.0437
942282	AE2-241 E	1.4413
942561	AE2-271 C O1	11.8267
942562	AE2-271 E O1	7.8715
943311	AF1-002 C	0.0879
943312	AF1-002 E	0.1214
943723	AF1-040 BAT	1.9740
945511	AF1-216 C1O1	14.3114
945512	AF1-216 E1O1	9.5298
945521	AF1-216 C2O1	14.3097
945522	AF1-216 E2O1	9.5287
945611	AF1-226 C	1.8265
945612	AF1-226 E	2.5223
945761	AF1-241 C	2.8963
945762	AF1-241 E	1.9309
946471	AF1-311 C O1	11.0512
946472	AF1-311 E O1	18.0308
DUCKCREEK	DUCKCREEK	0.6805
NEWTON	NEWTON	0.6340

Bus #	Bus	MW Impact
FARMERCITY	FARMERCITY	0.0330
G-007A	G-007A	1.4289
VFT	VFT	4.3538
PRAIRIE	PRAIRIE	1.5214
COFFEEN	COFFEEN	0.3118
EDWARDS	EDWARDS	0.2068
CHEOAH	CHEOAH	0.2918
TILTON	TILTON	0.3723
MADISON	MADISON	0.0040
GIBSON	GIBSON	0.3227
CALDERWOOD	CALDERWOOD	0.2902
BLUEG	BLUEG	1.0260
TRIMBLE	TRIMBLE	0.3289
CATAWBA	CATAWBA	0.2020

Affected Systems

14 Affected Systems

14.1 LG&E

LG&E Impacts to be determined during later study phases (as applicable).

14.2 MISO

MISO Impacts to be determined during later study phases (as applicable).

14.3 TVA

TVA Impacts to be determined during later study phases (as applicable).

14.4 Duke Energy Progress

Duke Energy Progress Impacts to be determined during later study phases (as applicable).

14.5 NYISO

NYISO Impacts to be determined during later study phases (as applicable).

Contingency Name	Contingency Definition
PL_P42_001388	CONTINGENCY 'PL_P42_001388' /* SUNB 230KV YARD 3T BF - MILT-SUNB AND SUNB-CWSA DISCONNECT BRANCH FROM BUS 208109 TO BUS 208034 CKT 1 /* /* SUNB-MILT 230KV LINE DISCONNECT BRANCH FROM BUS 208109 TO BUS 207935 CKT 1 /* /* SUNB-CWSA 230KV LINE END

Short Circuit

15 Short Circuit

The following Breakers are over duty

None.