Generation Interconnection

Feasibility Study Report

for

Queue Project AF1-339

LAURELTON-MIFFLINBURG 69 KV

12 MW Capacity / 20 MW Energy

First Revision: February 2020

Initial Issue: 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 Union County, Pennsylvania. **AF1-339** queue project will have a capability of 20 MW with 12 MW of this output being recognized by PJM as Capacity. AF1-333, AF1-337, AF1-338 and AF1-339 are behind the same Point of Interconnection and will share the same Interconnection Facilities. The proposed in-service date for this project is March 1, 2020. This study does not imply a TO commitment to this in-service date.

Queue Number	AF1-339
Project Name	LAURELTON-MIFFLINBURG 69 KV
State	Pennsylvania
County	Union
Transmission Owner	PPL
MFO	20
MWE	20
MWC	12
Fuel	Solar
Basecase Study Year	2023

2.1 Point of Interconnection (POI)

AF1-339 will interconnect with the PPL transmission system via one of the following options:

Option 1: via a tap of the Laurelton Tap - Mifflinburg Tap 69 kV line on the Sunbury – Lock Haven 69 kV line

Option 2: via a tap of the Limestone – Mifflinburg 69 kV line

2.2 Cost Summary

The **AF1-339** project will be responsible for the following costs for the physical interconnection of the project:

Description	Total Cost
Attachment Facilities	$ 0
Direct Connection Network Upgrade	$ 0
Non Direct Connection Network Upgrades	$ 0
Total Costs[1]	$ 0

In addition, the **AF1-339** project may be responsible for a contribution to the following costs for Network Upgrades to mitigate overloads identified in this report:

Description	Total Cost
System Upgrades	$ 49,000,000

[1] This report assumes that the costs for the physical interconnection will be borne by queue project AF1-333.

Cost allocations for these upgrades will be provided in the System Impact Study Report.

3 Transmission Owner Scope of Work

The Transmission Owner scope of work below is provided for reference. This report assumes that these costs will be borne by the AF1-333 queue project. However, if the AF1-333 project is withdrawn, then AF1-339 Interconnection Customer may be responsible for the costs outlined below.

The following Transmission Owner scope of work is required:

Install a single circuit 69kV tap off of the existing Sunbury-Lock Haven 69kV line with a motor operated switch to the POI. The PPL EU scope of work also includes remote end relay work at the Sunbury Substation and Lock Haven Substation.

Study Assumptions

- Availability of optimal transmission line route
- Outage feasibility not assessed until Facilities Study
- No major environmental, real estate, or permitting issues
- IC is responsible for acquisition of easements, permits, and right of way for the Attachment Facilities

3.1 Attachment Facilities

The Attachment Facilities will connect to the Sunbury-Lock Haven 69kV line approximately 2.5 miles from the Laurelton Tap and 0.16 miles from the Mifflinburg Tap. This scope of work is based on the IC POI GPS Coordinates: 40°54'8.44"N, 77° 3'50.66"W.

- Install a single circuit 69kV tap off of the existing Sunbury-Lock Haven 69kV line to AF1-339
- Replace existing 2-LDE steel pole “H-frame” structure at PPL Grid 18942N26880 with a tap structure Sunbury-Lock Haven 69kV line to AF1-339.
- Install a MOLBAB on the tap and a POI terminal pole.
- From tap structure to POI terminal poles, install ~400’ of wire utilizing 556 ACSR and OPGW.
- One adjacent structure on the Sunbury-Lock Haven line to be reframed to tension.

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
69kV Transmission Tap	$ 804,000
Total Attachment Facility Costs	**$ 804,000**

3.2 Direct Connection Cost Estimate

None

3.3 Non-Direct Connection Cost Estimate

Remote End Work – Sunbury 69kV Substation

- 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.
- Conduct a review of the IC relay settings and engineering package (submitted by IC to PPL EU)
- The following upgrades are required at the Sunbury substation:
    - Install DTT equipment.
    - Connect DTT equipment to new communication path installed between the Columbia substation and the IC customer facilities.
    - Modify the existing Lock-Haven 69kV circuit breaker 3S and 3T protection and control schemes.
    - Modify the existing protective relay settings.
    - 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
    - Update all Lock-Haven line designations on equipment, panels, and drawing to reference the new IC customer.

Remote End Work – Lock Haven 69 kV Substation

- The following upgrades are required at the Lock-Haven substation:

    - Install DTT equipment.
    - Connect DTT equipment to new communication path installed between the Lock-Haven substation and the IC customer facilities.
    - Modify the existing Sunbury 69kV circuit breaker 1W and 1T protection and control schemes.
    - Modify the existing protective relay settings.
    - 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.
- Update all Sunbury line designations on equipment, panels, and drawings to reference the new IC customer.

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
Remote End Work at Sunbury Substation	$ 238,000
Remote End Work at Lock Haven Substation	$ 238,000
Total Non-Direct Connection Facility Costs	**$ 476,000**

4 Schedule

The estimated time to complete the scope of work is **12-18 months** after the PJM three-party Interconnection Service Agreement (ISA) and Interconnection Construction Service Agreement (ICSA) are signed and PPL EU receives Notice to Proceed from the IC.

5 Interconnection Customer Requirements

5.1 PPL EU Interconnection Requirements

PPL EU applicable technical standards that address requirements for 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

5.2 IC Direct Transfer Trip (DTT) Requirements

PPL EU will require an independent communication path, for Direct Transfer Trip (DTT) of the IC Intertie Protective Relaying (IPR) Fault Interrupting Devices (FIDs), consisting of one communication circuit with the Sunbury 69kV Substation and one communication circuit with the Lock-Haven 69kV substation.

PPL EU does not have OPGW available on the Sunbury-Lock Haven 69 kV line available for DTT to the Sunbury and Lock Haven 69kV Substations. PPL EU assumes that the IC will procure the independent communication path through a third-party provider. Upon request, PPL EU will evaluate the feasibility of installing OPGW the Sunbury-Lock Haven 69 kV line for DTT.

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 Point of Contact (POC) relaying equipment.

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 in the vicinity of the POI 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.

7 OPTION 1: Network Impacts

The Queue Project AF1-339 was evaluated as a 20.0 MW (Capacity 12.0 MW) injection tapping the **Laurelton TP to Mifflinburg TP 69 kV** line in the PPL area. Project AF1-339 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-339 was studied with a commercial probability of 0.53. Potential network impacts 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)

None

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)

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
42331964	207968	ELIM	230.0	PPL	208109	SUNB	230.0	PPL	1	PL_P42_001406	breaker	537.0	111.04	112.18	DC	6.11
42829631	207968	ELIM	230.0	PPL	208109	SUNB	230.0	PPL	1	PL_P71_100487	tower	537.0	111.04	112.18	DC	6.11

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
42829631, 42331964	1	ELIM 230.0 kV - SUNB 230.0 kV Ckt 1	R-PL-0005 (2373) : Rebuild SUNB-ELIM 230kV Line Project Type : FAC Cost : $49,000,000 Time Estimate : 48.0 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
42829631	207968	ELIM	PPL	208109	SUNB	PPL	1	PL_P71_100487	tower	537.0	111.04	112.18	DC	6.11

Bus #	Bus	MW Impact
208945	LOHA CT	1.5401
208948	WILL CT	3.4640
212369	PATRIOT 1	50.5890
212370	PATRIOT 2	50.5890
921653	AA2-008 E	54.0092
945511	AF1-216 C1O1	36.5882
945512	AF1-216 E1O1	24.3638
945521	AF1-216 C2O1	36.5852
945522	AF1-216 E2O1	24.3618
945761	AF1-241 C	8.5278
945762	AF1-241 E	5.6852
946691	AF1-333 C O1	3.6637
946692	AF1-333 E O1	2.4425
946731	AF1-337 C	3.6637
946732	AF1-337 E	2.4425
946741	AF1-338 C	3.6637
946742	AF1-338 E	2.4425
946751	AF1-339 C O1	3.6637
946752	AF1-339 E O1	2.4425
DUCKCREEK	DUCKCREEK	0.4710
NEWTON	NEWTON	0.4395
FARMERCITY	FARMERCITY	0.0229
NY	NY	0.2350
PRAIRIE	PRAIRIE	1.0564
O-066	O-066	2.8358
COFFEEN	COFFEEN	0.2162
EDWARDS	EDWARDS	0.1431
CHEOAH	CHEOAH	0.2047
TILTON	TILTON	0.2577
G-007	G-007	0.4378
GIBSON	GIBSON	0.2233
CALDERWOOD	CALDERWOOD	0.2033
BLUEG	BLUEG	0.7100
TRIMBLE	TRIMBLE	0.2276
CATAWBA	CATAWBA	0.1431

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_001406	CONTINGENCY 'PL_P42_001406' /* SAEGERS 2T BF - MONT SAEG 1 AND SAEG-CLIN DISCONNECT BRANCH FROM BUS 208040 TO BUS 212397 CKT 2 /* /* MONT-SAEG 1 230KV LINE DISCONNECT BRANCH FROM BUS 208040 TO BUS 212397 CKT 1 /* /* MONT-SAEG 1 230KV LINE END
PL_P71_100487	CONTINGENCY 'PL_P71_100487' /* MONT-SAEG #1 & 2 230KV LINES OUT DISCONNECT BRANCH FROM BUS 212397 TO BUS 208040 CKT 2 /* /* MONT-SAEG 2 DISCONNECT BRANCH FROM BUS 212397 TO BUS 208040 CKT 1 /* /* MONT-SAEG 1 END

Short Circuit

15 Short Circuit

The following Breakers are over duty:

None

16 OPTION 2: Network Impacts

The Queue Project AF1-339 was evaluated as a 20.0 MW (Capacity 12.0 MW) injection tapping the **Limestone to Mifflinburg TP 69 kV** line in the PPL area. Project AF1-339 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF1-339 was studied with a commercial probability of 0.53. Potential network impacts were as follows:

:

Summer Peak Load Flow

17 Generation Deliverability

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

None

18 Multiple Facility Contingency

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

None

19 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)

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42331964	207968	ELIM	230.0	PPL	208109	SUNB	230.0	PPL	1	PL_P42_001406	breaker	537.0	113.33	114.39	DC	5.72
42829631	207968	ELIM	230.0	PPL	208109	SUNB	230.0	PPL	1	PL_P71_100487	tower	537.0	113.33	114.39	DC	5.72

20 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

21 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.

21.1 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
42829631	207968	ELIM	PPL	208109	SUNB	PPL	1	PL_P71_100487	tower	537.0	113.33	114.39	DC	5.72

Bus #	Bus	MW Impact
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945511	AF1-216 C O2	81.2279
945512	AF1-216 E O2	54.0889
945761	AF1-241 C	8.5278
945762	AF1-241 E	5.6852
946691	AF1-333 C O2	3.4337
946692	AF1-333 E O2	2.2891
946731	AF1-337 C O2	3.4337
946732	AF1-337 E O2	2.2891
946741	AF1-338 C O2	3.4337
946742	AF1-338 E O2	2.2891
946751	AF1-339 C O2	3.4337
946752	AF1-339 E O2	2.2891
DUCKCREEK	DUCKCREEK	0.4710
NEWTON	NEWTON	0.4395
FARMERCITY	FARMERCITY	0.0229
NY	NY	0.2350
PRAIRIE	PRAIRIE	1.0564
O-066	O-066	2.8358
COFFEEN	COFFEEN	0.2162
EDWARDS	EDWARDS	0.1431
CHEOAH	CHEOAH	0.2047
TILTON	TILTON	0.2577
G-007	G-007	0.4378
GIBSON	GIBSON	0.2233
CALDERWOOD	CALDERWOOD	0.2033
BLUEG	BLUEG	0.7100
TRIMBLE	TRIMBLE	0.2276
CATAWBA	CATAWBA	0.1431

Affected Systems

22 Affected Systems

22.1 LG&E

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

22.2 MISO

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

22.3 TVA

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

22.4 Duke Energy Progress

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

22.5 NYISO

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

Contingency Name	Contingency Definition
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Short Circuit

23 Short Circuit

The following Breakers are over duty

None