Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AD1-037

Martins Creek 230kV 55 MW Capacity / 101.8 MW Energy

January 2018

Introduction

This Feasibility Study has been prepared in accordance with the PJM Open Access Transmission Tariff, 36.2, as well as the Feasibility Study Agreement between the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is PPL Electric utilities (PPL EU).

Preface

The intent of the Feasibility Study is to determine a plan, with high level estimated cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the IC. The IC may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the IC 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. 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 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 IC is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by ITO, the costs may be included in the study.

General

The IC has proposed an uprate to its existing natural gas generating facility located in Northampton County of Pennsylvania, which is part of the PPL Electric Utilities (PPL EU) Lehigh Region. Under a prior queue position, X1-108, the IC proposed a project with capability of 600 MW with 553.2 MW being recognized by PJM as Capacity. AD1-037 is a 55 MWE (101.8 MWC) uprate to queue project X1-108. The total combined summer capability of queue positions AD1-037 and X1-108 will be 655 MW, with 655 MW being recognized by PJM as capacity.
The proposed in-service date for AD1-037 is May 30, 2019. **This study does not imply a PPL EU commitment to this in-service date.**

Point of Interconnection

The Interconnection Customer requested a transmission level interconnection. As a result, AD1-037 will interconnect with the PPL EU transmission network via the Martins Creek-Lower Mount Bethel (MACR-LMBE) 230kV line. The AD1-037 POI is identical to the X1-108 POI. See Attachment 1 of this Study for more information.

Cost Summary

The AD1-037 project will be responsible for the following costs:

Description	Total Estimated Costs
Attachment Facilities	$ 0
Direct Connection Network Upgrades	$ 0
Non-Direct Connection Network Upgrades	$ 25,600
Total Estimated Costs	**$ 25,600**

In addition, the AD1-037 project may be responsible for a contribution to the following costs:

Description	Total Estimated Cost
New System Upgrades	$ 16,009,000
Previously Identified Upgrades	In Above
Total Costs	**$ 16,009,000**

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

System Reinforcement

Violation #	Upgrade Description	Upgrade Cost
1, 3-6	PPL Scope: Existing Upgrade n5166: Re-conductor approximately 1700 feet of transmission three-phase (5100 feet of single-phase) 1590 ACSR with 1590 ACSS between the Springfield substation deadend structure and pole 66848S43231. Re-conductor approximately 50 feet of Springfield substation deadend structure downcomer three-phase (150 feet of single-phase) 1590 ACSR with 1590 ACSS. Estimated Cost: $500,000. Estimated ISD: 06/01/2020.	$ 500,000
1, 3-6	JCPL Scope: Existing Upgrade n5165: On the Gilbert to Springfield 230 kV tie-line re-conductor 11 miles of 1590 ACSR with 1590 ACSS. Replace 2000 A line end wave trap with a 4000 A trap and upgrade all limiting components at Gilbert substation including the relay thermal limitations. New FE ratings for Gilbert to Springfield 230 kV tie-line = 913/ 1147 MVA (SN / SE). Estimated Cost: $15,324,700. Estimated ISD: 06/01/2020.	$ 15,324,700
2	PPL: To mitigate the MACR-LMBE 230 kV line (from bus 208012 to bus 208025) overload will require reinforcements to increase the normal rating of the MACR-LMBE 230 kV line: Reconductor the existing 400 feet three-phase line utilizing 1590 kcmil ACSS 45/7 conductor. This will achieve an increase in load carrying capability to approximately 929 MVA (SN) and 1003 MVA (SE) at 160 deg C. Please note that the description of work and the cost estimates are preliminary without any field checks and extensive engineering review. The total estimated cost of the upgrade is $184,300. The estimated time to complete the reinforcement is 18 months	$ 184,300
	Total Network Upgrades	**$ 16,009,000**

Transmission Owner Scope of Work

Attachment Facilities

There are no new Attachment Facilities required for AD1-037.

Direct Connection Cost Estimate

There are no Direct Connection Upgrades required for AD1-037.

Non-Direct Connection Cost Estimate

Non Direct Connection Network Upgrades Scope of Work ($25,600)

- Perform PPL EU protective relay analysis and revise settings where necessary.
- Review IC protective relay settings.

Estimated Schedule

The estimated time is **18** months from engineering start to construction finish, after the PJM three-party Interconnection Service Agreement (ISA) and Construction Service Agreement (CSA) are signed.

Assumptions

- There is no major environmental, real estate, or permitting issues are anticipated.
- Suitable line/equipment outages can be scheduled as required. Failure to meet a scheduled facility outage may result in project delays.
- 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.
- There are no load changes on auxiliary transformers.
- 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.

Interconnection Customer Requirements

IC Voice Communication Circuit Requirements

The IC Voice Communication requirements are identical to those specified under X1-108.

IC Protective Relaying Requirements

The IC Protective Relaying requirements are identical to those specified under X1-108.

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

The IC Substation IPR and POC FID requirements are identical to those specified under X1-108. Refer to the website addresses shown below for the PPL EU IPR and POC requirements:

IPR Requirements
http://www.pjm.com/-/media/planning/plan-standards/private-ppl/parallel-generation-requirements.ashx?la=en

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

IC Generator Harmonic and Flicker Requirements

The IC Generator Harmonic and Flicker requirements are identical to those specified under X1-108.

IC Generator Regulation or Reactive Support Requirements

The IC Generator Regulation or Reactive Support requirements are identical to those specified under X1-108.

IC Generator Voltage Schedule Requirements

The IC Generator Voltage Schedule requirements are identical to those specified under X1-108.

IC Distribution Service Requirements

The IC Distribution Service requirements are identical to those specified under X1-108.

IC PA PUC Certification & Environmental Requirements

The IC PA PUC Certification & Environmental requirements are identical to those specified under X1-108.

Revenue Metering and SCADA Requirements

PJM Requirements

The IC 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.

PPL Requirements

The IC Protective Relaying requirements are identical to those specified under X1-108.

Network Impacts

The Queue Project AD1-037 was evaluated as a 101.8 MW (Capacity 101.8 MW) injection at the Lower Mount Bethel Energy 230kV substation in the PPL area. Project AD1-037 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD1-037 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
JC-P2-3-JCN-230-4	CONTINGENCY 'JC-P2-3-JCN-230-4' /* GILBERT-GLEN GARDNER & GILBERT-TEWKSBERRY-MORRISTOWN DISCONNECT BRANCH FROM BUS 206236 TO BUS 206233 CKT 1 /* 28GILBERT 230 28G GARDNR 230 DISCONNECT BRANCH FROM BUS 206236 TO BUS 206375 CKT 1 /* 28GILBERT 230 28TEWKSBRY 230 DISCONNECT BRANCH FROM BUS 206375 TO BUS 206243 CKT 1 /* 28TEWKSBRY 230 28MO-TOWN 230 DISCONNECT BRANCH FROM BUS 206243 TO BUS 206204 CKT 5 /* 28MO-TOWN 230 28MORRISTO 35 SET BUS 206204 SHUNT TO 11 MVAR /* 28MORRISTO 35 REMOVE LOAD 1 FROM BUS 206204 /* 28MORRISTO 35 END
JC-P2-3-JCN-230-4LT	CONTINGENCY 'JC-P2-3-JCN-230-4LT' /* GILBERT-GLEN GARDNER & GILBERT-TEWKSBERRY-MORRISTOWN DISCONNECT BRANCH FROM BUS 206236 TO BUS 206233 CKT 1 /* 28GILBERT 230 28G GARDNR 230 DISCONNECT BRANCH FROM BUS 206236 TO BUS 206375 CKT 1 /* 28GILBERT 230 28TEWKSBRY 230 DISCONNECT BRANCH FROM BUS 206375 TO BUS 206243 CKT 1 /* 28TEWKSBRY 230 28MO-TOWN 230 DISCONNECT BRANCH FROM BUS 206243 TO BUS 206204 CKT 5 /* 28MO-TOWN 230 28MORRISTO 35 SET BUS 206204 SHUNT TO 11 MVAR /* 28MORRISTO 35 END

Contingency Name	Description
JC-P7-1-JCN-230-2	CONTINGENCY 'JC-P7-1-JCN-230-2' /* GILBERT-GLEN GARDNER & GILBERT-MORRISTOWN 230 KV DISCONNECT BRANCH FROM BUS 206236 TO BUS 206233 CKT 1 /* 28GILBERT 230 28G GARDNR 230 DISCONNECT BRANCH FROM BUS 206236 TO BUS 206375 CKT 1 /* 28GILBERT 230 28TEWKSBRY 230 DISCONNECT BRANCH FROM BUS 206375 TO BUS 206243 CKT 1 /* 28TEWKSBRY 230 28MO-TOWN 230 DISCONNECT BRANCH FROM BUS 206243 TO BUS 206204 CKT 5 /* 28MO-TOWN 230 28MORRISTO 35 SET BUS 206204 SHUNT TO 11 MVAR /* 28MORRISTO 35 REMOVE LOAD 1 FROM BUS 206204 /* 28MORRISTO 35 END
JC-P7-1-JCN-230-2LT	CONTINGENCY 'JC-P7-1-JCN-230-2LT' /* GILBERT-GLEN GARDNER & GILBERT-MORRISTOWN 230 KV DISCONNECT BRANCH FROM BUS 206236 TO BUS 206233 CKT 1 /* 28GILBERT 230 28G GARDNR 230 DISCONNECT BRANCH FROM BUS 206236 TO BUS 206375 CKT 1 /* 28GILBERT 230 28TEWKSBRY 230 DISCONNECT BRANCH FROM BUS 206375 TO BUS 206243 CKT 1 /* 28TEWKSBRY 230 28MO-TOWN 230 DISCONNECT BRANCH FROM BUS 206243 TO BUS 206204 CKT 5 /* 28MO-TOWN 230 28MORRISTO 35 SET BUS 206204 SHUNT TO 11 MVAR /* 28MORRISTO 35 END
PJM_P1_28A	CONTINGENCY 'PJM_P1_28A' DISCONNECT BRANCH FROM BUS 200008 TO BUS 200043 CKT 1 /* HOSENSAK STEEL 500 500 END

Summer Peak Analysis - 2021

Generator Deliverability

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

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
1	N-1	PJM_P1_28 A	JCPL - PL	28GILBERT-SFLD 230 kV line	206236	208091	1	DC	98.74	101.11	ER	783	18.79	
2	Non	Non	PL - PL	LMBE-MACR II 230 kV line	208012	208024	1	DC	90.13	105.82	NR	647	101.49	1

Multiple Facility Contingency

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

None

Short Circuit

(Summary of impacted circuit breakers)

Not required for AD1-037 since the project is an uprate to an existing unit and the electrical characteristics of the machines and GSU did not change.

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)

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
3	LFFB	JC-P2-3-JCN-230-4	JCPL - PL	28GILBERT-SFLD 230 kV line	206236	208091	1	DC	110.7	111.73	ER	783	17.98	2

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
4	DCTL	JC-P7-1-JCN-230-2	JCPL - PL	28GILBERT-SFLD 230 kV line	206236	208091	1	DC	110.7	111.73	ER	783	17.98	
5	LFFB	JC-P2-3-JCN-230-4LT	JCPL - PL	28GILBERT-SFLD 230 kV line	206236	208091	1	DC	110.56	111.59	ER	783	17.98	
6	DCTL	JC-P7-1-JCN-230-2LT	JCPL - PL	28GILBERT-SFLD 230 kV line	206236	208091	1	DC	110.56	111.59	ER	783	17.98	

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

To be determined during Impact Study

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

To be determined during Impact Study

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
1	28GILBERT-SFLD 230 kV line	PPL: Existing Upgrade n5166: Re-conductor approximately 1700 feet of transmission three-phase (5100 feet of single-phase) 1590 ACSR with 1590 ACSS between the Springfield substation deadend structure and pole 66848S43231. Re-conductor approximately 50 feet of Springfield substation deadend structure downcomer three-phase (150 feet of single-phase) 1590 ACSR with 1590 ACSS. Estimated Cost: $500,000. Estimated ISD: 06/01/2020.	n5166	$ 500,000
1	28GILBERT-SFLD 230 kV line	JCPL: Existing Upgrade n5165: On the Gilbert to Springfield 230 kV tie-line re-conductor 11 miles of 1590 ACSR with 1590 ACSS. Replace 2000 A line end wave trap with a 4000 A trap and upgrade all limiting components at Gilbert substation including the relay thermal limitations. New FE ratings for Gilbert to Springfield 230 kV tie-line = 913/ 1147 MVA (SN / SE). Estimated Cost: $15,324,700. Estimated ISD: 06/01/2020.	n5165	$ 15,324,700
2	LMBE-MACR II 230 kV line	PPL: To mitigate the MACR-LMBE 230 kV line (from bus 208012 to bus 208025) overload will require reinforcements to increase the normal rating of the MACR-LMBE 230 kV line: • Reconductor the existing 400 feet three-phase line utilizing 1590 kcmil ACSS 45/7 conductor. This will achieve an increase in load carrying capability to approximately 929 MVA (SN) and 1003 MVA (SE) at 160 deg C. Install 15 new 230kV dead-end assemblies, 6 new 230 jumper assemblies, and 1200' of 1590 ACSS 45/7 conductor. • The scope includes the installation of 15 new 230kV dead-end assemblies, 6 new 230 jumper assemblies, and 1200' of 1590 ACSS 45/7 conductor The total estimated cost of the upgrade is $184,300. The estimated time to complete the reinforcement is **18 months.**	Pending	$ 184,300
			Total New Network Upgrades	**$ 16,009,000**

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
3-6	28GILBERT-SFLD 230 kV line	PPL: Existing Upgrade n5166: Re-conductor approximately 1700 feet of transmission three-phase (5100 feet of single-phase) 1590 ACSR with 1590 ACSS between the Springfield substation deadend structure and pole 66848S43231. Re-conductor approximately 50 feet of Springfield substation deadend structure downcomer three-phase (150 feet of single-phase) 1590 ACSR with 1590 ACSS. Estimated Cost: $500,000. Estimated ISD: 06/01/2020.	n5166	$ 500,000
3-6	28GILBERT-SFLD 230 kV line	JCPL: Existing Upgrade n5165: On the Gilbert to Springfield 230 kV tie-line re-conductor 11 miles of 1590 ACSR with 1590 ACSS. Replace 2000 A line end wave trap with a 4000 A trap and upgrade all limiting components at Gilbert substation including the relay thermal limitations. New FE ratings for Gilbert to Springfield 230 kV tie-line = 913/ 1147 MVA (SN / SE). Estimated Cost: $15,324,700. Estimated ISD: 06/01/2020.	n5165	$ 15,324,700
			Total New Network Upgrades	**$ 15,824,700**

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 IC 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.

Not Applicable.

Light Load Analysis

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

Affected System Analysis & Mitigation

NYISO Impacts:

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

Appendices

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

Appendix 1

(PL - PL) The LMBE-MACR II 230 kV line (from bus 208012 to bus 208024 ckt 1) loads from 90.13% to 105.82% (**DC power flow**) of its normal rating (647 MVA) for non-contingency condition. This project contributes approximately 101.49 MW to the thermal violation.

Bus Number	*Bus Name*	*Full Contribution*
934091	*AD1-037*	*101.49*
208905	*LMBE CT1*	*35.71*
208906	*LMBE CT2*	*35.71*
208908	*LMBE ST1*	*42.9*

Appendix 2

(JCPL - PL) The 28GILBERT-SFLD 230 kV line (from bus 206236 to bus 208091 ckt 1) loads from 110.7% to 111.73% (**DC power flow**) of its emergency rating (783 MVA) for the line fault with failed breaker contingency outage of 'JC-P2-3-JCN-230-4'. This project contributes approximately 17.98 MW to the thermal violation.

CONTINGENCY 'JC-P2-3-JCN-230-4' /* GILBERT-GLEN GARDNER & GILBERT-TEWKSBERRY-MORRISTOWN
DISCONNECT BRANCH FROM BUS 206236 TO BUS 206233 CKT 1 /* 28GILBERT 230 28G GARDNR 230
DISCONNECT BRANCH FROM BUS 206236 TO BUS 206375 CKT 1 /* 28GILBERT 230 28TEWKSBRY 230
DISCONNECT BRANCH FROM BUS 206375 TO BUS 206243 CKT 1 /* 28TEWKSBRY 230 28MO-TOWN 230
DISCONNECT BRANCH FROM BUS 206243 TO BUS 206204 CKT 5 /* 28MO-TOWN 230 28MORRISTO 35
SET BUS 206204 SHUNT TO 11 MVAR /* 28MORRISTO 35
REMOVE LOAD 1 FROM BUS 206204 /* 28MORRISTO 35
END

Bus Number	*Bus Name*	*Full Contribution*
206747	*28DSM_X3-029*	*1.39*
206342	*28GIL 6&7*	*7.83*
206330	*28GILCT9*	*11.9*
206679	*28M&M S721*	*0.89*
206346	*28MILF GEN*	*1.23*
206345	*28N27_Y2-018*	*0.26*
206740	*28WCRR*	*1.24*
933231	*AC2-134 C*	*0.13*
933232	*AC2-134 E*	*0.54*
933322	*AC2-144 E*	*0.02*
933582	*AC2-175 E*	*0.11*
934091	*AD1-037*	*17.98*
935071	*AD1-143 C1*	*0.53*
935081	*AD1-143 C2*	*0.02*

935091	*AD1-143 C3*	*0.53*
935101	*AD1-143 C4*	*0.02*
935072	*AD1-143 E1*	*3.15*
935082	*AD1-143 E2*	*0.44*
935092	*AD1-143 E3*	*3.15*
935102	*AD1-143 E4*	*0.44*
211064	*PSPA*	*0.92*
205900	*Q73E R57E*	*-0.34*
290131	*U2-059E*	*0.27*
904512	*V4-052 E*	*-0.27*
901612	*W1-082E*	*2.94*
902062	*W1-127E*	*0.43*
902292	*W2-016E*	*1.37*
903042	*W2-091E*	*1.7*
903631	*W3-044C OP1*	*0.86*
903632	*W3-044E OP1*	*1.4*
903961	*W3-077C*	*0.97*
903962	*W3-077E*	*1.58*
903672	*W3-106 E*	*0.81*
903682	*W3-110 E*	*0.36*
904582	*W3-139 E*	*1.7*
905442	*W4-046 E*	*0.72*
905542	*W4-064 E*	*0.16*
905602	*W4-073 E*	*2.4*
905762	*W4-097 E*	*0.47*
907012	*X1-012 E*	*0.48*
914044	*Y2-018 E*	*0.15*
919531	*AA2-017 C1*	*1.07*

919541	*AA2-017 C2*	*1.07*
919532	*AA2-017 E1*	*3.06*
919542	*AA2-017 E2*	*3.06*
919742	*AA2-060 E*	*0.47*
919752	*AA2-061 E*	*0.63*
919982	*AA2-082 E*	*4.71*
931051	*AB1-154 C*	*410.19*
931052	*AB1-154 E*	*25.62*
923781	*AB2-012*	*1.54*
924142	*AB2-058 E*	*0.99*
925461	*AC1-018 C*	*0.11*
925462	*AC1-018 E*	*0.2*
926081	*AC1-087 C*	*0.35*
926082	*AC1-087 E*	*0.57*