

***Generation Interconnection
Feasibility Study Report***

For

***PJM Generation Interconnection Request
Queue Position X4-019***

Sunbury 230kV

April 2012

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. 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 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.

General

The Interconnection Customer (IC), has proposed a natural gas generating facility located in Shamokin Dam, Pennsylvania. The installed facilities will have a total capability of 227 MW with 227 MW of this output being recognized by PJM as capacity. This means that the remaining 0 MW will be curtailable should a system reliability constraint occur.

Point of Interconnection

X4-019 will interconnect with the PPL Electric Utilities system at one of two options. Option 1 is to connect at the Sunbury 500kV substation. Option 2 is to connect at the Sunbury 230kV substation.

Option 1: Overhead Connection to New Sunbury 500 kV Switchyard

The X4-019 project can be connected to an available 500 kV bay at PPL EU's proposed new Sunbury 500 kV Gas Insulated Switchyard (GIS) located adjacent to the existing Sunbury 500 kV GIS. This connection option is contingent on the completion of the new switchyard by PPL EU prior to the developer's requested in-service date, and on X2-025 selecting a 500 kV interconnection.

Figure 1. X4-019 Overhead Connection to Proposed Sunbury 500 kV Yard (One Line Diagram)

Figure 2. X4-019 Overhead Connection to Proposed Sunbury 500 kV Yard (Substation Layout)

All direct connection facilities are assumed to have been constructed and placed in service for Queue X2-025. There is no additional work required for X4-019.

Option 2: Overhead Connection to Sunbury 230 kV Bay 7

The X4-019 project can be connected to the Bay 7 position at PPL EU's Sunbury 230 kV Substation via an overhead line along the substation fence. This line would span approximately 2000 feet and be terminated at PPL EU's Bay 7 in a double breaker-double bus arrangement. The Sunbury – Montour 230 kV line is currently terminated in this bay, and will have been moved to Bay 8 for the interconnection of X2-025. This option is contingent on X2-025 selecting a 230 kV interconnection.

Figure 3. X4-019 Overhead Connection to Sunbury 230 kV Yard (One Line Diagram)

Figure 4. X4-019 Connection to Sunbury 230 kV Switchyard (Substation Layout)

All direct connection facilities are assumed to have been constructed and placed in service for Queue X2-025. There is no additional work required for X4-019.

X4-019 Generator Regulation or Reactive Support Requirements

The PPL EU preliminary load flow studies have indicated that the X4-019 generator will maintain the required voltage regulation on the Sunbury 230 kV bus or the Sunbury 500 kV bus

within their required ranges. A voltage schedule will be developed after the Facilities Study stage.

As specified in Part IV, Subpart E at 54.7 of the PJM OATT, the Project X4-019 generator shall design its “Facility” to maintain a composite power factor delivery at continuous rated power output at the generators terminals at a power factor of at least 0.95 leading (absorbing vars) to 0.90 lagging (supplying vars).

X4-019 Generator and GSU Modeling

Per the X4-019 supplied data the following was used in modeling the generator and the GSU:

X4-019 Generator: One unit, MVA base 225, net injected into PPL EU system 227 MW, pf at the Sunbury 230 kV ring bus .9 lead and .9 lag, saturated sub-transient reactance = 15.36% on 225 MVA base.

GSU (Generator Step Up Transformer): Rating 233.3 MVA, 230/16.5 kV, Positive Sequence Impedance $R = 0.00214$ pu and $X = 0.09$ pu, all at 140 MVA base.

Network Impacts

The Queue Project #X4-019 was studied as a(n) 227.0MW(Capacity227.0MW) injection in to PPL area. Project #X4-019 was evaluated for compliance with reliability criteria for summer peak conditions in 2015. Potential network impacts were as follows:

Option1: Sunbury 500kV:

Generator Deliverability

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

None.

Multiple Facility Contingency

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

None.

Short Circuit

(Summary form of Cost allocation for breakers will be inserted here if any)

None.

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.

Steady-State Voltage Requirements

(Results of the steady-state voltage studies should be inserted here)

To be determined during the System Impact Study phase.

Stability and Reactive Power Requirement

(Results of the dynamic studies should be inserted here)

To be determined during the System Impact Study phase.

New System Reinforcements

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

None.

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)

(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

None.

Delivery of Energy Portion of Interconnection Request

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.

Only the most severely overloaded conditions are listed. 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 will study all overload conditions associated with the overloaded element(s) identified.

None.

Option2: Sunbury 230kV:

Generator Deliverability

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

None.

Multiple Facility Contingency

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

1. The SUNBURY 500/230 kV transformer (from bus 208109 to bus 200021 ckt 24) loads from 91.56% to 103.99% (**DC power flow**) of its rating (1165 MVA) for the tower line contingency ('PL100484'). This project contributes approximately 144.7 MW to the thermal violation.

```
CONTINGENCY 'PL100484'  
  /* D/C MONTOUR-SUSQ 230KV & MONTOUR-SUSQ T10 230KV  
  DISCONNECT BRANCH FROM BUS 208040 TO BUS 208113 CKT 1  
  DISCONNECT BRANCH FROM BUS 208040 TO BUS 208120 CKT 1  
  END
```

Short Circuit

(Summary form of Cost allocation for breakers will be inserted here if any)

PJM identified two new circuit breakers which are overdutied as a result of this project:

Bus No.	Bus	Breaker	Rating Type	Duty Percent with X4-019	Duty Percent without X4-019	Duty Percent Difference
208109	SUNB 230.kV	XF BNK #24 N	S	102.30%	94.70%	7.60%
208109	SUNB 230.kV	XF BNK #24 S	S	100.60%	93.00%	7.60%

In addition, PJM has identified two breakers where this project contributes to the overloaded condition:

Bus No.	Bus	Breaker	Rating Type	Duty Percent with X4-019	Duty Percent without X4-019	Duty Percent Difference
208109	SUNB 230.kV	ELIMSPORT NO	S	122.70%	114.00%	8.70%
208109	SUNB 230.kV	ELDRED NORTH	S	118.50%	109.80%	8.70%

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)

- The SUSQ-JENK TR2 230 kV line (from bus 208113 to bus 208001 ckt 1) loads from 103.42% to 103.8% (**DC power flow**) of its rating (617 MVA) for the tower line contingency ('UGI - MOUNTAIN - SUSQHNA TOWER'). This project contributes approximately 14.65 MW to the thermal violation.

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CONTINGENCY 'UGI - MOUNTAIN - SUSQHNA TOWER'
  OPEN BRANCH FROM BUS 208113 TO BUS 234250 CKT 1
    / 208113 SUSQ 230 234250 MOUN-TAP 230 1
  OPEN BRANCH FROM BUS 208120 TO BUS 234251 CKT 1
    / 208120 SU10 230 234251 MOUNT-H1 230 1
  OPEN BRANCH FROM BUS 234251 TO BUS 234252 CKT 1
    / 234251 MOUNT-H1 230 234252 MOUNTAIN 230 1
  OPEN BRANCH FROM BUS 234251 TO BUS 234254 CKT 1
    / 234251 MOUNT-H1 230 234254 MNTN TR1 69.0 1
  OPEN BRANCH FROM BUS 234257 TO BUS 234254 CKT 1
    / 234257 MOUNT 2 69.0 234254 MNTN TR1 69.0 1
  OPEN BRANCH FROM BUS 234256 TO BUS 234254 CKT 1
    / 234256 MOUNT 1 69.0 234254 MNTN TR1 69.0 1
END

```

Steady-State Voltage Requirements

(Results of the steady-state voltage studies should be inserted here)

To be determined during the System Impact Study phase.

Stability and Reactive Power Requirement

(Results of the dynamic studies should be inserted here)

To be determined during the System Impact Study phase.

New System Reinforcements

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

None.

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)

(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

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None.