

***PJM Generator Interconnection
O39 Sunbury-Dauphin 69kV 56 MW
Impact Study***

June 2006

Docs #371939

General

Queue O39 (Sunbury-Dauphin 69kV) generator interconnection is a Gamesa Energy Wind Farm, 56 MW gross output (11.2 MW Capacity Resource *) wind generation project consisting of twenty eight 2 MW Gamesa wind turbine generators located at Mifflin township, Dauphin County, PA. Queue O39 is scheduled for commercial operation in October, 2007.

* Present PJM procedures allow wind generation to be considered initially as a Capacity Resource equal to 20% of installed MWs.

Amendments to the Feasibility Study Data or Feasibility Study Results:

The following changes from the Feasibility Study Report results are identified in this report:

1) Network Upgrade Amendment (Option 2, also see Option 1 on page 12)

The IPP developer has indicated that in lieu of conductor ratings upgrade on Sunbury – Dauphin 69kV line, the developer is proposing “tripping” of his generators automatically whenever generation output into the 69kV transmission line exceeds the line rating for both summer and winter periods. PJM and PPL EU have accepted this option.

As a result of this an automatic generation trip scheme would be installed at the point of interconnection to trip the wind farm generators whenever MW flow into Sunbury-Dauphin 69kV line in the direction of Sunbury exceeds the summer & winter normal transmission line ratings during the months of summer and winter operations. The summer operation is from April 16 to November 14 at 39 MVA Normal Rating and winter operations from November 15 to April 15 at 50 MVA Normal Rating.

Note: The feasibility study required upgrading of approximately 18 miles of conductor replacement on the Sunbury – Dauphin 69kV line from the Sunbury 69kV bus to the point of interconnection with higher rated conductors. The estimated cost of the upgrade is \$4.0 million dollars. The upgrade would have increased the line normal ratings from 39/50 MVA to 97/111 MVA for the summer/winter operations. During the Feasibility study it was indicated that under minimum load conditions, sections of Sunbury-Dauphin 69kV transmission line would load anywhere from 108 to 132% of its summer normal rating causing overloads (exceed the thermal capability of the line) on the line. Lead time for this upgrade is 27 months.

2) New Temporary Operation of Sunbury – Dauphin 69kV line Identified **Operate an existing Westwood NUG, a 30 MW generator, via Sunbury-Dauphin 69kV line temporarily due to the planned PPL EU network upgrade.**

PPL EU has plans to upgrade a section of Eldred-Pine Grove 69kV transmission line which will have some impact on the Sunbury – Dauphin 69kV line capacity. PPL EU is planning to upgrade the Pine Grove – Hegins section (5.8 miles long) of the Eldred-Pine Grove 69kV line and as a result Westwood NUG connected to this line will inject its

power output into the Sunbury-Dauphin 69kV line temporarily until the Eldred-Hegins section is upgraded. This temporary operation would take place from 8/2007 to 5/2008, a period of ~ 9 months due to prior procedure set up with Westwood NUG.

In this period if O39 generates power, it will have additional restriction on its generation output due to some of the Sunbury-Dauphin transmission line capacity used by the Westwood NUG connected to Eldred-Pine Grove 69kV line. The O39 in this period will not be allowed to exceed line rating as stipulated in amendment 1 above.

We have also reviewed the option of advancing the Eldred-Hegins section by 6 months at some cost to O39 developer but our transmission engineering department has determined that due to long lead material delivery issues this option is not feasible due to lack of time to engineer, order material, and rebuild the Eldred-Hegins 5.8 miles section.

It is also established that after the Eldred-Hegins upgrade project is complete Westwood NUG will have no temporary rights to Sunbury-Dauphin 69kV line capacity.

Note: The Westwood 69kV NUG generator (30 MW) is connected to the Eldred - Pine Grove 69kV line out of PPL EU Eldred 230/69kV substation. The Eldred – Pine Grove line has a normally open tie with the Sunbury – Dauphin 69kV line to allow such transfers. Load flow studies have indicated that the injection of this additional 30 MW of power into Sunbury Dauphin line, under minimum load conditions, it will load the line anywhere from 152 to 164% of its summer normal rating. Additionally under peak load conditions, it will load the line anywhere from 108 to 133% of its summer normal rating. Loading beyond the normal rating will exceed the thermal capability of the line causing overloads.

Direct Connection Requirements

The O39 project can be connected to the Dauphin – Sunbury 69kV line as shown in figures 1 (below) and 2 (ATTACHMENT). The connection to the generating facility will be via a short transmission tap near PPL EU transmission structure 24072S46478.

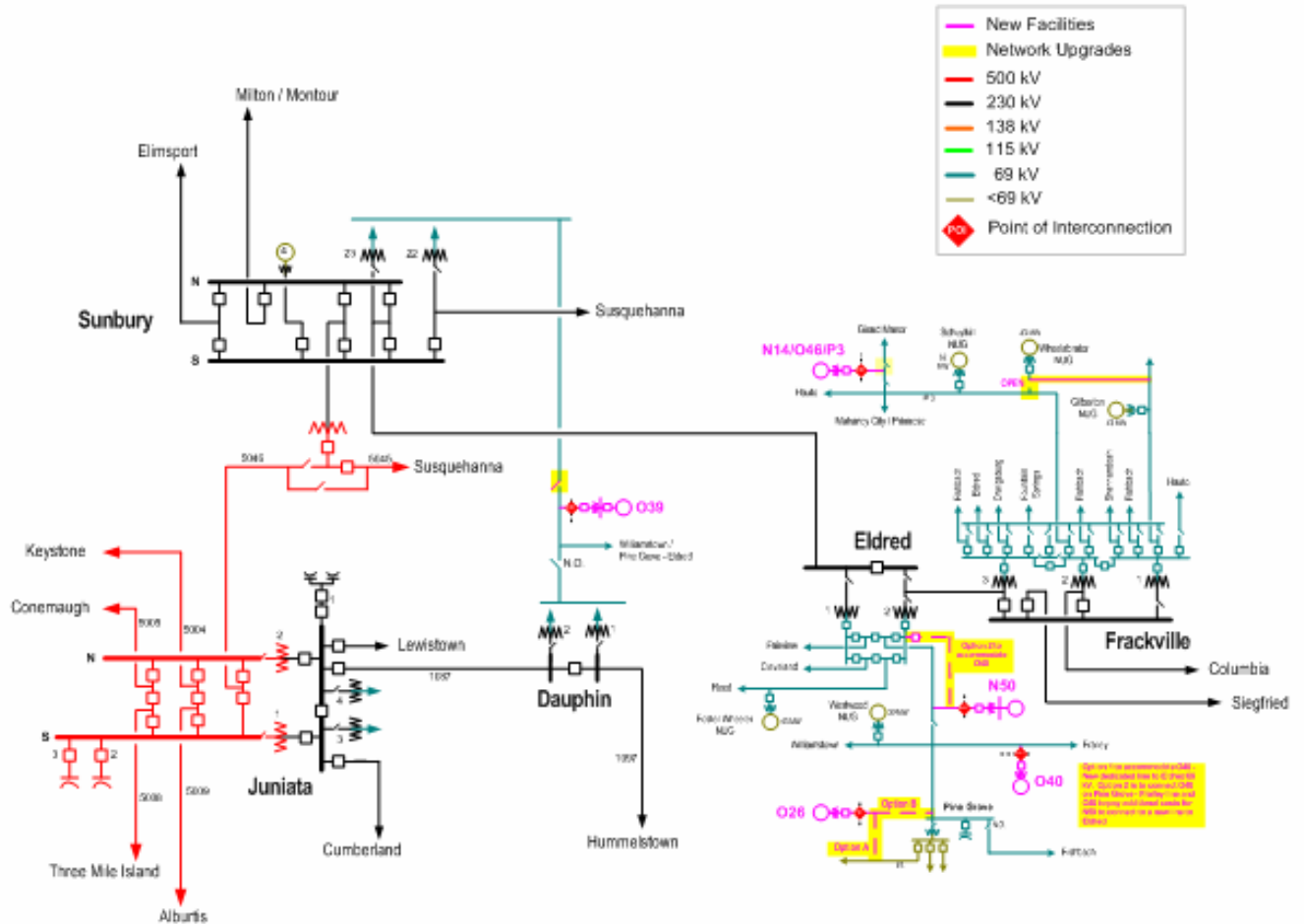


Figure 1 – Queue O39 Direct Connection

Based on the assumption that only 1000 feet of transmission tap would be required, the total direct connection cost is **\$ 651,500***** (excluding any applicable state or federal taxes)

A further breakdown of the direct connection costs is as follows:

- \$ 370,000 Transmission work for the direct connection.
- \$ 140,000 Substation work at PPL EU Sunbury substation.
- \$ 61,500 Automatic Generation Trip Scheme, to trip generators when exceed line limit
- \$ 80,000** If PPL Electric Utilities (PPL EU) is to provide the metering equipment.

** Other metering service costs may apply depending on the generation project Interconnection Customer's choice of metering options.

*** If the Interconnection Customer chooses to supply the metering, \$ 80,000 can be subtracted from the \$651,500 total.

After the Interconnection Service Agreement and Construction Service Agreement are signed, the typical time needed to complete the direct connection work is about **12 months for the transmission and substation work**. The transmission and substation work can be completed concurrently.

A breakdown of the costs is as follows:

Transmission Connection Work (69kV Tap Construction)

\$ 370,000 (69 kV Transmission tap, PUC Certification and the LSAB switch)

The above transmission direct connection cost includes Siting, Pa PUC certification, and construction of approximately 1000 feet of single circuit 69kV tap extension with 556.5 Kcmil 24/7 ACSR phase conductors and one 3/8-inch high strength, steel overhead ground wire, up to the customer's point of contact dead end structure. The tap connection to the Sunbury-Dauphin 69kV line facility will be near transmission structure 24072S46478 approximately 18 miles from PPL Sunbury substation. In addition, a 1200 amps load sectionalizing air break (LSAB) switch at approximate grid point 24072S46478 would be installed on the Sunbury side (north side) of the O39 tap to allow for the isolation of tap.

The Interconnection Customer will be responsible for installing, on their side of point of interconnection, an air break switch located in the tap on or near their dead-end structure for the O39 project to provide a visual break for the isolation of tap from PPL EU System.

The cost estimate above is exclusive of the R/W for the tap. It is assumed that the IPP either own the land or will have easement or R/W to construct the tap up to the PPL EU transmission line. If R/W is not acquired earlier in the project it may add additional time to the project completion elapsed time. Pa PUC (Pennsylvania Public Utility Commission) letter of notification (LON) cost has been added since the existing line is built for 132kV design. PPL Legal Advisors have determined that anytime we tap a transmission line capable of operating at 100kV or above, we need to obtain Pa PUC approval.

The estimates for the tap into the O39 generation project substation has been developed using 69 kV transmission standards. If there are future changes to the system that would require a change to a 138kV conversion of the Sunbury- Dauphin 69kV line, the conversion cost of the tap would be charged to the generation owner at that time. If a 138kV design, operation at 69kV, is requested, there will be additional cost due to additional Pa PUC certification requirements and also may delay construction start and in-service dates to account for the additional certification process.

Substation Direct Connection Work (Sunbury 69kV substation)

\$ 140,000 (Total cost for DTT equipment and relay and control changes)

The substation work includes the installation of phone line based Direct Transfer Trip (DTT) equipment and phone line protection equipment, installation of control modifications, reconfiguration of controls related to the transmission work required for the interconnection of the O39 at Sunbury substation and the associated review and testing of the corresponding equipment at the O39 location.

IPP O39 Generator Trip Scheme (Option to Upgrade of the Sunbury – Dauphin 69 kV line – See Network Impacts section on pages 12 and 13)

\$ 61,500 (Total cost of equipment and installation) - A magnitude estimate only.

As identified in the “Amendment Section” an automatic generation trip scheme would be installed at the point of interconnection to trip the wind farm generators whenever MW flow into Sunbury-Dauphin 69kV line in the direction of Sunbury exceeds the summer & winter normal transmission line ratings during the months of summer and winter operations. The summer operation is from April 16 to November 14 and winter operations form November 15 to April 15 of each year.

The Scheme will have MW sensing equipment installed on the line section from the interconnection point to in the direction of Sunbury substation. This equipment will monitor the MW flow on the line and will transmit via a communication system (Free Wave radio or equivalent system), load information (MW flow) to a receiver system in the IPP O39 location where it will compare the MW flow on the line with the line rating to produce a trip output to trip the generators if the MW flow exceeds the line rating.

NOTE: If for any reason the trip scheme fails, provisions will be provided for it to default to tripping of the generators and send an alarm.

IPP 039 developer will allow this equipment to be installed at their location with PPL EU supervision. Additionally, the IPP developer will be responsible to wire this equipment and test under PPL EU supervision.

Trip Scheme equipment will be procured and owned by PPL EU but all maintenance cost associated with this equipment will be the responsibility of IPP developer.

Under the Impact Study this scheme is a rough outline only and details are not available due to lack of time. Details will be work out at time of Facilities Study, if developer opts for the Facilities Study.

Note: The feasibility study required upgrading of approximately 18 miles of conductor replacement on the Sunbury – Dauphin 69kV line from the Sunbury 69kV bus to the point of interconnection with higher rated conductors. The estimated cost of the upgrade was \$4.5 million dollars. The upgrade would have increased the line ratings from 39/50 MVA to 97/111 MVA for the summer/winter operations. During the Feasibility study it was indicated that under minimum load conditions, sections of Sunbury-Dauphin 69kV transmission line would load anywhere from 108 to 132% of its summer normal rating causing thermal overloads on the line.

+69kV Metering Equipment Installation at the point of interconnection

\$ 80,000 (If metering is supplied by PPL EU)

If Gamesa requests PPL EU will also design and install the metering equipment. The lead time for metering equipment currently varies between 5 to 30 weeks. At a PPL LP5 Rate Schedule, the Interconnection Customer would have the opportunity to apply Rule 11 for plant load. PPL EU metering equipment is specified so that it can handle Rule 11 requirements.

If PPL EU is not requested to supply the metering equipment, then all metering components supplied by Gamesa or its agent must be approved by PPL EU to determine if the equipment meets applicable PPL EU tariff metering requirements. Metering equipment must also meet applicable metering requirements of the PJM agreements. The estimated cost for Metering equipment is \$80,000.

Interconnection Customer's Generating Station DTT and Inter-tie Protection Requirements

The O39 project will be responsible for procurement from the telephone company of a protective relay-grade telephone circuit for the DTT facilities. The project will also be responsible for procuring the DTT receiver and inter-tie protection cabinet to be installed at the O39 interconnecting substation. All installation, maintenance and monthly lease or billing charges for communications facilities for DTT, metering, etc are the responsibility of the O39 project. Lead times for leased telephone lines are usually long. Therefore, the O39 project should investigate the availability of leased telephone facilities immediately. The point of contact relaying (inter-tie protection requirements) must be connected to 69kV CTs and PTs.

Inter-tie Protection equipment and the DTT will be procured and installed by the IPP developer but owned by PPL EU. Additionally, all maintenance cost associated with this equipment will be the responsibility of IPP developer.

Interconnection Customer's Generating Station Revenue Metering and SCADA Requirements

1) **For PJM:** The O39 Interconnection Customer will be required to install necessary equipment to provide "Revenue Metering (KWH, KVARH)" and real time data (KW, KVAR) for the Interconnection Customer's generating resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Section 58.1 through 58.5.

2) **For PPL EU:** The O39 Interconnection Customer will be required to install a PPL EU dedicated Scada to provide bi-directional "Revenue Metering (KWH, KVARH)" and real time data (KW, KVAR, circuit breaker status, and 34.5 kV voltages) for the Interconnection Customer's generating resource. Additionally, one breaker open-close control point must also be provided.

PPL EU dedicated Scada equipment will be procured and installed by the IPP developer but owned by PPL EU. Additionally, all maintenance cost associated with this equipment will be the responsibility of IPP developer.

O39 Generator MW, MVAR, and Power Factor Output Schedule & Flicker Requirements

Project O39 has stated that the plan for the facility is to use Gamesa 2.0 MW induction machines. Depending upon the design of the collector system for the generation at the O39 facility, self-excitation of the induction machines may be possible. If PPL EU determines that self-excitation is a concern, protection requirements as well as the circuit breakers used by the O39 project to isolate its system from the PPL EU transmission system may change significantly during the PJM Facility Study (start of engineering detailed design) stage.

Project O39 shall design its Facility to operate within a power factor range of 0.95 leading (absorbing vars) to 0.95 lagging (supplying vars) as measured at the Point of Interconnection. However, based on other considerations of this facility dynamic (i.e. automatic fast acting control) reactive capability within such a range may also be required.

In order to eliminate significant voltage deviation, the O39 facility will normally be requested to operate at approximately unity power factor, as measured at the 69 kV inter-tie point of interconnection, on the high side of 69/34.5kV transformer. However, the O39 project must have the ability to operate in either the leading or lagging mode as required from time to time. Consequently, it is strongly recommended that the Gamesa units be procured with power factor control capability.

This power factor requirement is based on the wind park facility using a single 59 MVA, 69/34.5 kV power transformer as described in the data submitted by the O39 project. Information supplied by the O39 Interconnection Customer regarding the collector system (two collector systems with 14 units each) with underground cables between each generator and the collector bus, it is calculated that each system of 14 generator cables will contribute approximately 0.5 MVAR of reactive supply to the system.

Load flow studies indicate that at maximum output of 56.0 MW with one MVAR of cable reactive contribution connected to the generator bus, the O39 wind park will be required to supply approximately 10 MVAR to the PPL EU system (measured at the 69 kV inter-tie connection point). The inter-tie transformer will absorb approximately 6 of the MVARs and generator transformers approximately 4 MVARs. The O39 project must ensure that it has the capability to hold and automatically maintain, with no time delay, a unity power factor (or leading power factor if the Facility Study stage determines it necessary) as measured on the 69 kV side of the interconnection transformer over the entire MW output range. In future studies, PPL EU will calculate and issue a table of MW versus MVAR for various levels of generation output.

To achieve the specified power factor, Gamesa may be required to install automatically controlled shunt reactors or shunt capacitors at the O69 IPP facility. Either device would require a fast response, automatic, power factor controller. Such a controller would minimize the voltage change at the 69kV point of interconnection. In addition, the automatic power factor

controller will allow Gamesa to accommodate future power factor changes that can occur as a result of upgrades or enhancements to the PPL EU transmission system.

While installation of capacitors or reactors is an option, use of mechanical switching may be too slow to respond to MW output changes due to wind gusts. Gamesa would need to examine voltage flicker caused by the time lag inherent in switched-capacitor or switched-reactor action. Gamesa would be expected to mitigate flicker to levels deemed acceptable by PPL EU. Those flicker levels are published on the PPL EU website.

Operating Restrictions included, but may not be limited to, the following:

1. O39 Interconnection Customer will not be permitted to generate when Sunbury-Dauphin 69kV line is not energized from Sunbury.
2. O39 Interconnection Customer has opted not to inject generation output into Dauphin substation when Sunbury-Dauphin 69kV line is not energized from Sunbury.
3. O39 Interconnection Customer will not be permitted to generate when Sunbury-Dauphin 69kV line is operated in network between PPL EU's Dauphin and Sunbury substations.
4. Power Quality – O39 generation shall not cause the PPL EU system voltage or harmonic distortion to exceed the limits established by IEEE Standard 519.
5. Gamesa would be expected to mitigate flicker to levels deemed acceptable by PPL EU. Those flicker levels are published on the PPL EU website.

Conversion to 138kV in Future:

If there are future changes to the system that would require a change to a 138kV conversion of the Sunbury- Dauphin 69kV line, the conversion cost of the IPP O39 tap would be charged to the generation owner at that time. However there are no plans to convert this line to 138kV operation in the next 10-15 year horizon.

Preliminary Schedule

The estimated time to complete the substation and the Automatic Trip Scheme work is 12 months. The tap construction lead time is also 12 months after the appropriate ISA/CSA or interim contracts have been signed by O39 Customer, PJM and PPL EU. This elapsed time may exceed where required line outages are not available or long-lead time material didn't get procured on time. Outages are required on the Sunbury – Dauphin 69kV line for the connection of the tap and the installation of LSAB.

Notes:

- The ISA/CSA or an Interim Agreement must be signed by Gamesa, PJM and PPL EU before any PPL EU activities may commence.
- PPL EU recommends that an Interim ISA/CSA be completed during the Facilities Study stage to address critical path items, such as long lead-time purchases and the compressed project schedule.
- Procurement lead-times for metering equipment may extend to 30 weeks. Meter design, procurement and installation schedules must be implemented accordingly.
- 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 for an additional cost. It is also assumed that all right-of-way and easements are secured without impact on anticipated construction start dates.

PaPUC Certification & Environmental Issues

Cost of the required PaPUC Certification is included in the cost estimates. This estimate is based on the following:

- All required land and rights-of-way are provided by Gamesa at no cost to PPL EU for tap connection.
- In its filing before the PaPUC, PPL EU will discuss environmental impacts and mitigation strategies of the facilities being certified (i.e. - the transmission lines). To avoid duplication of costs and efforts, PPL EU recommends that Gamesa obtain all environmental approvals required for construction of the wind park and share pertinent details with PPL EU prior to the PPL EU filing before the PaPUC.
- No public or other opposition to PPL EU's Certification Application before the PaPUC is encountered.

Network Impacts

The O39 project was studied as an injection of 56 MW energy (11.2 MW capacity) into the Dauphin-Sunbury 69 kV line. Project O39 was evaluated for compliance with reliability criteria for summer peak conditions in 2009. Potential network impacts were as follows:

Local System Impacts (Normal system conditions with all facilities in service)

Overload on Dauphin – Sunbury 69kV line from tap point to PPL Sunbury 69kV bus.

With minimum load on Sunbury-Dauphin 69kV line and the Lykens tap (Eldred-Pine Grove tie) load transferred to Eldred – Pine Grove 69kV line, upon the injection of O39 project max allowable output of 56 MW, the following overloads (loading exceeds thermal capability of the line) were observed for the summer operations when compared to summer normal ratings:

1. 132 % load on the section between the O39 tap point to Dalmatia tap
2. 108 % load on the section between the Dalmatia tap and the Sunbury substation.

Option 1: The Sunbury-Dauphin 69kV line would require replacement of transmission line conductors for approximately 18 miles from the point of interconnection to Sunbury substation. In order to prevent the base case overload, the conductors on the Sunbury - Dauphin 69 kV line must be changed to 556.5 Kcmil ACSR as per PPL EU standards, meaning the entire section of line from the interconnection point to PPL EU Sunbury substation must be upgraded to 556.5 Kcmil ACSR conductors. Total estimated cost to upgrade is \$4.0 million. Lead time for this Option is 27 months.

NOTE Option 2: The Interconnection Customer has proposed that they will trip their generation automatically anytime it exceeds the Sunbury-Dauphin 69kV transmission line rating. As a result of this PPL EU will install an automatic control scheme at the point of interconnection to trip the generator O39. The estimated magnitude cost for the installation of such a scheme is \$62,500.

Single Contingency (MAAC Criteria IIA)

No identified problems.

Second Contingency (MAAC Criteria IIB)

No identified problems.

Multiple Facility Contingency (MAAC Criteria IIC)

No identified problems.

Generator Deliverability (single contingency)

No identified problems.

Stability (MAAC Criteria IV)

PPL EU will also perform stability analysis during the Queue O39 Facilities Study to confirm PJM's results summarized below and in Attachment B. At present a Gamesa generator dynamics

model is not available for use with the General Electric PSLF software which is used by PPL EU. Gamesa is pursuing the development of a model which should be available by September 2006.

Stability analysis was performed by PJM at 2009 summer light load conditions and peak load conditions. The maximum generation output is considered. A unity power factor is assumed to be maintained at the interconnection point for the base case. The range of contingencies evaluated was limited to that necessary to assess expected compliance with MAAC criteria.

No stability problems were identified.

Note: While the stability analysis has been performed at expected extreme system conditions, there is a potential that evaluation at a different level of generator MW and/or MVAR output at different system load levels and operating conditions would disclose unforeseen stability problems. The regional reliability analysis routinely performed to test all system changes will include one such evaluation. Any problems uncovered in that or other operating or planning studies will need to be resolved.

Moreover, when the proposed generating station is designed and plant specific dynamics data for the wind plant and its controls are available, and if it is different than the data provided for this study, a transient stability analysis at a variety of expected operating conditions using the more accurate data shall be performed to verify impact on the dynamic performance of the system. As more accurate or unit specific dynamics data for the proposed facility, as well as Plant layout become available, it must be forwarded to PJM.

Short Circuit Analysis

No identified problems.

New System (Local Upgrades) Reinforcements (Option 1)

Upgrade Sunbury-Dauphin 69kV line (Refer to Figure 2 on page 15):

Total cost estimate to upgrade the Sunbury-Dauphin 69kV line is **\$4.0 million**. Estimated construction time **27 months**.

The Sunbury – Dauphin 69kV line would require approximately 18 miles of conductor replacement with larger size conductors (556.5 Kcmil ACSR, rated as Summer Normal = 97 MVA and Summer Emergency = 124 MVA)) from the Queue O39 tap point to PPL EU Sunbury Substation. PPL estimates that approximately 18 miles of this line would require re-conductoring at an estimated cost of \$4.0 million. Estimate assumes that adequate ROW exists for re-conductoring.

Acquisition of additional ROW, if needed, may add to cost and additional time for engineering and PA PUC approval. It is assumed that an NPDS permit will be required. Also, due to the size of the re-conductoring project, erosion and sedimentation control would also be required under the transmission line. Estimated time to complete the construction would be approximately 27 months.

It should be noted that the existing Sunbury-Dauphin 69kV line is constructed for 132kV insulation with 2/0 CWC conductors (rated as Summer Normal = 39 MVA and Winter Normal = 50 MVA) and per PA PUC regulations whenever any line 100kV or above is rebuilt, PA PUC certification is required. Since this line construction predates the PUC certification process, it is assumed that the line construction to 132kV was grandfathered under the existing PUC regulations and no certification would be required. If PUC certification required that may add additional time to the elapsed time required. Additionally, PPL EU must verify that the transmission structures are still insulated for 132kV and this may have an impact on the cost.

NOTE: The Interconnection Customer has proposed that they will trip their generation automatically anytime it exceeds the Sunbury-Dauphin 69kV transmission line rating. As a result of this PPL EU will install an automatic control scheme at the point of interconnection to trip the generator O39. The estimated magnitude cost for the installation of such a scheme is \$62,500.

Contribution to Previously Identified System Reinforcements

None

ATTACHMENT A

(Figure 2)

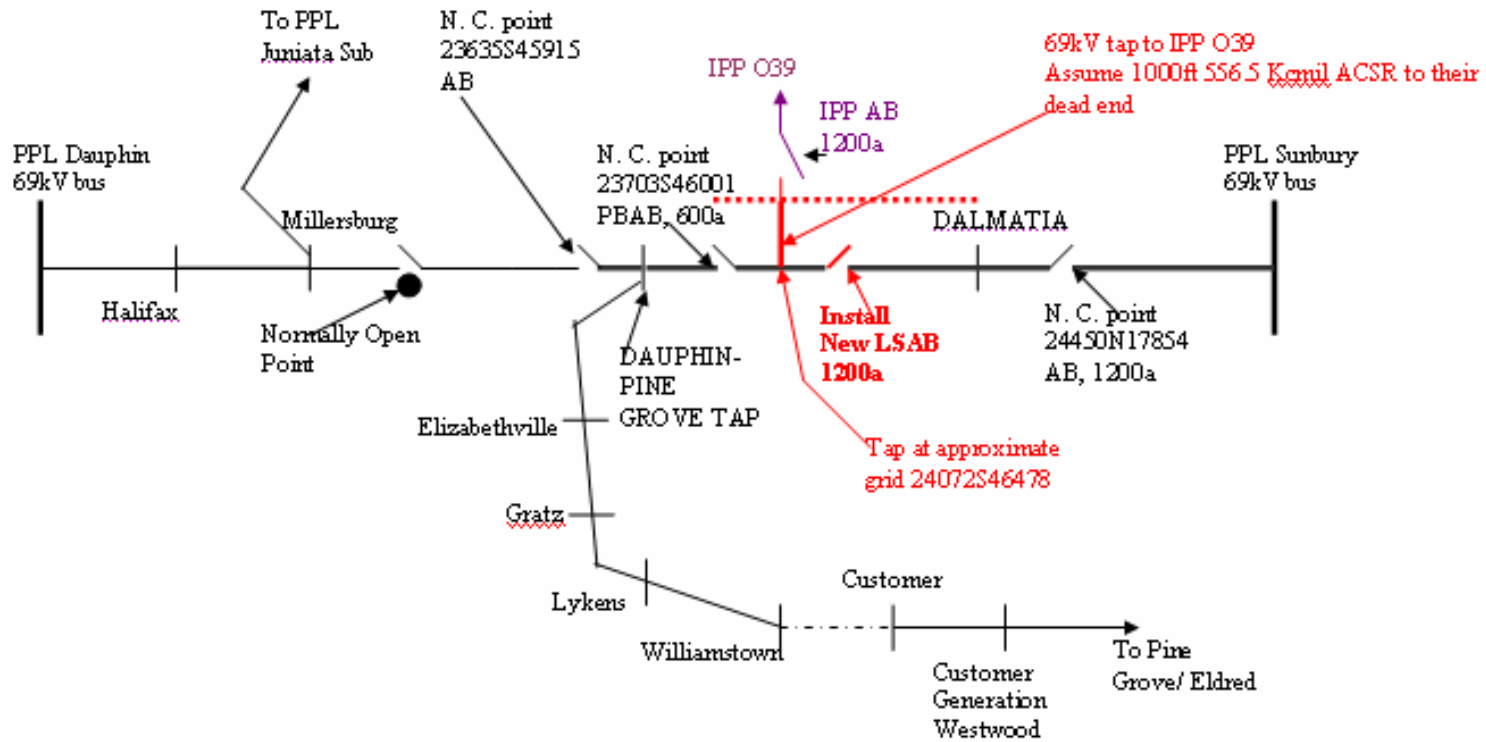


Figure 2 - Direct Connection of Queue O39 tap, New LSAB (in red), and Local upgrades

Attachment B

Queue O39

2009 Summer Peak & Light load Case Stability Faults

BREAKER CLEARING TIMES (CYCLES)

<u>Station</u>	<u>Primary (3ph/slg)</u>	<u>Stuck Breaker (total)</u>	<u>Zone 2 (total)</u>	<u>re-closing</u>
Sunbury 69 kV	4.5	60	60	
PPL 230kV	8	17	--	

All facilities in service

- 1a 3ph @ Sunbury 69 kV on Sunbury - Selinsgrove 69 kV line
- 1b slg @ Sunbury 69 kV on Sunbury - Selinsgrove 69 kV line, stuck at Sunbury
- 1c slg @ 80% of Sunbury - Selinsgrove 69 kV line, zone 2 operation

- 2a 3ph @ Sunbury 69 kV on Sunbury - Danville 69 kV line
- 2b slg @ Sunbury 69 kV on Sunbury - Danville 69 kV line, stuck at Sunbury
- 2c slg @ 80% of Sunbury - Danville 69 kV line, zone 2 operation

- 3a 3ph @ Sunbury 69/230 kV transformer 22
- 3b slg @ Sunbury 69/230 kV transformer 22, stuck at 69kV side

- 4a 3ph @ Sunbury 69/230 kV transformer 23
- 4b slg @ Sunbury 69/230 kV transformer 23, stuck at 69kV side

- 5a 3ph @ Sunbury 69/138 kV transformer 21
- 5b slg @ Sunbury 69/138 kV transformer 21, stuck at 69kV side

P: Sunbury - Selinsgrove 69 kV line

- 2a 3ph @ Sunbury 69 kV on Sunbury - Danville 69 kV line
- 3a 3ph @ Sunbury 69/230 kV transformer 22
- 4a 3ph @ Sunbury 69/230 kV transformer 23
- 5a 3ph @ Sunbury 69/138 kV transformer 21

Q: Sunbury 69/138 kV transformer

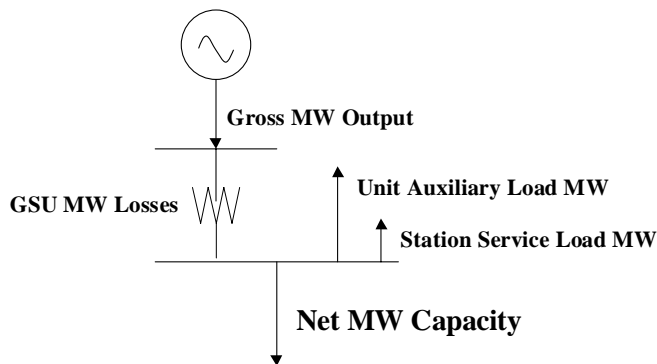
- 1a 3ph @ Sunbury 69 kV on Sunbury - Selinsgrove 69 kV line
- 2a 3ph @ Sunbury 69 kV on Sunbury - Danville 69 kV line
- 3a 3ph @ Sunbury 69/230 kV transformer 22
- 4a 3ph @ Sunbury 69/230 kV transformer 23

R: Sunbury 69/230 kV transformer 22

- 1a 3ph @ Sunbury 69 kV on Sunbury - Selinsgrove 69 kV line
- 2a 3ph @ Sunbury 69 kV on Sunbury - Danville 69 kV line
- 4a 3ph @ Sunbury 69/230 kV transformer 23
- 5a 3ph @ Sunbury 69/138 kV transformer 21

ATTACHMENT C

Unit Capability Data



Net MW Capacity = (Gross MW Output - GSU MW Losses* - Unit Auxiliary Load MW - Station Service Load MW)

Queue Letter/Position/Unit ID: _____ O39

Primary Fuel Type: _____ Wind /Gamesa 2.0

Maximum Summer (92° F ambient air temp.) Net MW Output**: _____ 56/2.0 per turbine

Maximum Summer (92° F ambient air temp.) Gross MW Output: _____ 56/2.0 per turbine

Minimum Summer (92° F ambient air temp.) Gross MW Output: _____ 0

Maximum Winter (30° F ambient air temp.) Gross MW Output: _____ 56/2.0 per turbine

Minimum Winter (30° F ambient air temp.) Gross MW Output: _____ 0

Gross Reactive Power Capability at Maximum Gross MW Output – Please include
Reactive Capability Curve (Leading and Lagging): _____ N/A

Individual Unit Auxiliary Load at Maximum Summer MW Output (MW/MVAR): _0.14

Individual Unit Auxiliary Load at Minimum Summer MW Output (MW/MVAR): ____ 0

Individual Unit Auxiliary Load at Maximum Winter MW Output (MW/MVAR): ___0.28

Individual Unit Auxiliary Load at Minimum Winter MW Output (MW/MVAR): ____ 0

Station Service Load (MW/MVAR): _____0.1125

* GSU losses are expected to be minimal.

** Your project's declared MW, as first submitted in Attachment N, and later confirmed or modified by the Impact Study Agreement, should be based on either the 92° F Ambient Air Temperature rating of the unit(s) or, if less, the declared Capacity rating of your project.

Unit Generator Dynamics Data

Queue Letter/Position/Unit ID: _____ O39

MVA Base (upon which all reactances, resistance and inertia are calculated): _____ 2.1

Nominal Power Factor: _____ 1.0

Terminal Voltage (kV): _____ 0.69

Unsaturated Reactances (on MVA Base)

Direct Axis Synchronous Reactance, $X_{d(i)}$: _____ 4.63

Direct Axis Transient Reactance, $X'_{d(i)}$: _____ 0.214

Direct Axis Sub-transient Reactance, $X''_{d(i)}$: _____ 0.152

Quadrature Axis Synchronous Reactance, $X_{q(i)}$: _____ 4.63

Quadrature Axis Transient Reactance, $X'_{q(i)}$: _____ 0.214

Quadrature Axis Sub-transient Reactance, $X''_{q(i)}$: _____ 0.152

Stator Leakage Reactance, X_l : _____ 1.07

Negative Sequence Reactance, $X_{2(i)}$: _____ 0.212

Zero Sequence Reactance, X_0 : _____ 0.41

Saturated Sub-transient Reactance, $X''_{d(v)}$ (on MVA Base): _____ 0.149

Armature Resistance, R_a (on MVA Base): _____ 0.0036

Time Constants (seconds)

Direct Axis Transient Open Circuit, T'_{do} : _____ 1.4

Direct Axis Sub-transient Open Circuit, T''_{do} : _____ 0.0025

Quadrature Axis Transient Open Circuit, T'_{qo} : _____ 1.4

Quadrature Axis Sub-transient Open Circuit, T''_{qo} : _____ 0.0025

Inertia, H (kW-sec/kVA, on KVA Base): _____ 3.25

Speed Damping, D : _____ n/a

Saturation Values at Per-Unit Voltage [S(1.0), S(1.2)]: _____ n/a

Units utilize a Generator model

Unit GSU Data

Queue Letter/Position/Unit ID: _____ O39
Generator Step-up Transformer MVA Base: _____ 2.1
Generator Step-up Transformer Impedance (R+jX, or %, on transformer MVA Base): __ 7.76%
Generator Step-up Transformer Reactance-to-Resistance Ration (X/R): _____ n/a
Generator Step-up Transformer Rating (MVA): _____ 2.1
Generator Step-up Transformer Low-side Voltage (kV): _____ 0.69
Generator Step-up Transformer High-side Voltage (kV): _____ 34.5
Generator Step-up Transformer Off-nominal Turns Ratio: _____ n/a
Generator Step-up Transformer Number of Taps and Step Size: _____ n/a

Main Transformor Data

Queue Letter/Position/Unit ID: _____ O39
Generator Step-up Transformer MVA Base: _____ 34
Generator Step-up Transformer Impedance (R+jX, or %, on transformer MVA Base): ____ 9.6%
Generator Step-up Transformer Reactance-to-Resistance Ration (X/R): _____ N/A
Generator Step-up Transformer Rating (MVA): _____ 34/43/58
Generator Step-up Transformer Low-side Voltage (kV): _____ 34.5
Generator Step-up Transformer High-side Voltage (kV): _____ 69
Generator Step-up Transformer Off-nominal Turns Ratio: _____ n/a
Generator Step-up Transformer Number of Taps and Step Size: _____ 9@2.5 each