Generation Interconnection

This analysis was completed to assess the reliability impact for a new generator interconnecting to the PJM system as a capacity resource.

Network Impacts -500 MW Injection into the Stanton-Susquehanna 230kV transmission line (E8)

Network Impacts

The connection of 500 MW of generation into the Stanton-Susquehanna 230kV transmission line was evaluated under summer peak condition in 2005.

Normal System

- The Susquehanna 500/230 kV transformer was normally overloaded at 113 % of the normal rating (862 MVA). E08 contributes 190 MW to the facility loading.

Multiple Facility Contingency – Tower Line Outages (MAAC Criteria IIC)

- The Susquehanna 500/230 kV transformer was overloaded at 109 % of the emergency rating (1165 MVA) due to an outage of the Kittatiny-Newton and Kittatiny-Bushkill- Shawnee 230 kV tower line. E08 contributes 235 MW to the facility loading.

- The project contributes 30 MW to a previously identified overload of the Martins Creek-Morris Park-Gilbert 230kV circuit due to the outage of the Portland-Greystone Q 230kV and Portland-Kittatinny 230kV tower line.

Generator Deliverability

- The Susquehanna 500/230 kV transformer was overloaded at 116 % of the emergency rating (1165 MVA) due to an outage of Sunbury 500/230 kV transformer. E08 contributes 230 MW to the facility loading

Short Circuit Analysis

- No problems identified.

Stability (MAAC Criteria IV)

Stability analysis was performed at light load conditions and for maximum summer net generator output of 500 MW. The range of contingencies evaluated was limited to the previously found worst case condition;

- 3 phase fault on the Juniata 500kv line terminal at Sunbury 500kv substation bus.

Stability analyses indicates that the addition of the E08 project reduces stability margins at Montour units 1 and 2, which in turn causes the following:

- A 3-phase, normally cleared fault at the Sunbury 500 kV bus causes wide-spread transient instability.

- Faults that involve either of the Sunbury 500/230 kV T24 or Susquehanna 500/230 kV T21 transformers generally result in either slowly damped rotor angle oscillations or large, slowly-damped, low-frequency rotor angle oscillations on all PJM units, with subsequently large oscillations in system flows and voltages. For the latter type of response, the frequency of rotor angle oscillatory response across the system to this fault was low, at approximately 0.5 Hz. This frequency indicates that an inter-area mode of the Eastern Interconnection, which has characteristic (resonant) frequencies in the range of 0.25 to 0.75 Hz, has been activated. System-wide oscillations in this frequency range generally indicate that a severe fault with a long reach has occurred.

The following requirements have been identified to ensure adequate transient and dynamic stability for the E08 and surrounding units:

- Instead of the above second Susquehanna 500/230kv transformer to solve the thermal overload problems, a new Elimsport – Lobo 230 kV circuit may be required (or equivalent system reinforcement) to solve both the thermal overloads and MAAC Section IV stability violations.

- Power System Stabilizers must be installed on the new project units and coordinated with those on nearby units. Tuned models suitable for dynamic simulation in PSS/e must be developed and proper response demonstrated.

- Tuned excitation and governing system models suitable for dynamic simulation in PSS/e must be developed and proper response demonstrated.

- Verification of existing Sunbury and Susquehanna substation primary and backup clearing times to ensure that the affected breakers will operate in the required timeframe must be performed.

- Verification of the adequacy of existing Sunbury and Susquehanna substation protective relay design to ensure that distance relays correctly identify system impedance characteristics must be performed.

- Recalculation of the *PJM Northern Stability Transfer Limit* must be performed.

- The above further stability evaluation will be performed as part of the IMPACT Study for Project E08. The results may indicate the need for additional facility requirements.

System Reinforcements

Second Susquehanna 500/230 kV Transformer

The new generation causes overloads on the Susquehanna 500/230 kV T21 transformer. A new Susquehanna 500/230 kV, 750 MVA transformer is required. The total cost is estimated to be $19.3 million with a lead-time of 3 years (see Figure 1).

Substation costs for the first 500/230 kV transformer addition are detailed as follows:

- $13,560,000 for work at the Susquehanna 500 kV substation.
- $2,112,000 for work at the Susquehanna 230 kV substation.

Note: These costs do not include any equipment replacements or upgrades due to increased fault duties, and additional costs pertaining to coordination with the Susquehanna Nuclear station may be required.

Since the Susquehanna 500 kV and 230 kV substations are physically separated by the Susquehanna river, a single-circuit 230 kV line approximately two miles in length will be required to connect T22. This line is expected to cost approximately $3.6 million dollars and take 3 years to complete. As PPL owns the property on both sides of the river, no new right of way is required for this line. However, environmental permits are required. Tasks included in the first transformer estimate are:

- Transfer and reconnect the existing 500 kV to 230 kV transmission line yard tie to a new T22 transformer at the Susquehanna Plant 500/230 kV substation.
- Transfer and reconnect the Sunbury 500 kV line to a new bay position at the Susquehanna 230 kV switchyard.

- File a certification application with the PUC and secure a permit for the new 230 kV line crossing of the Susquehanna River.

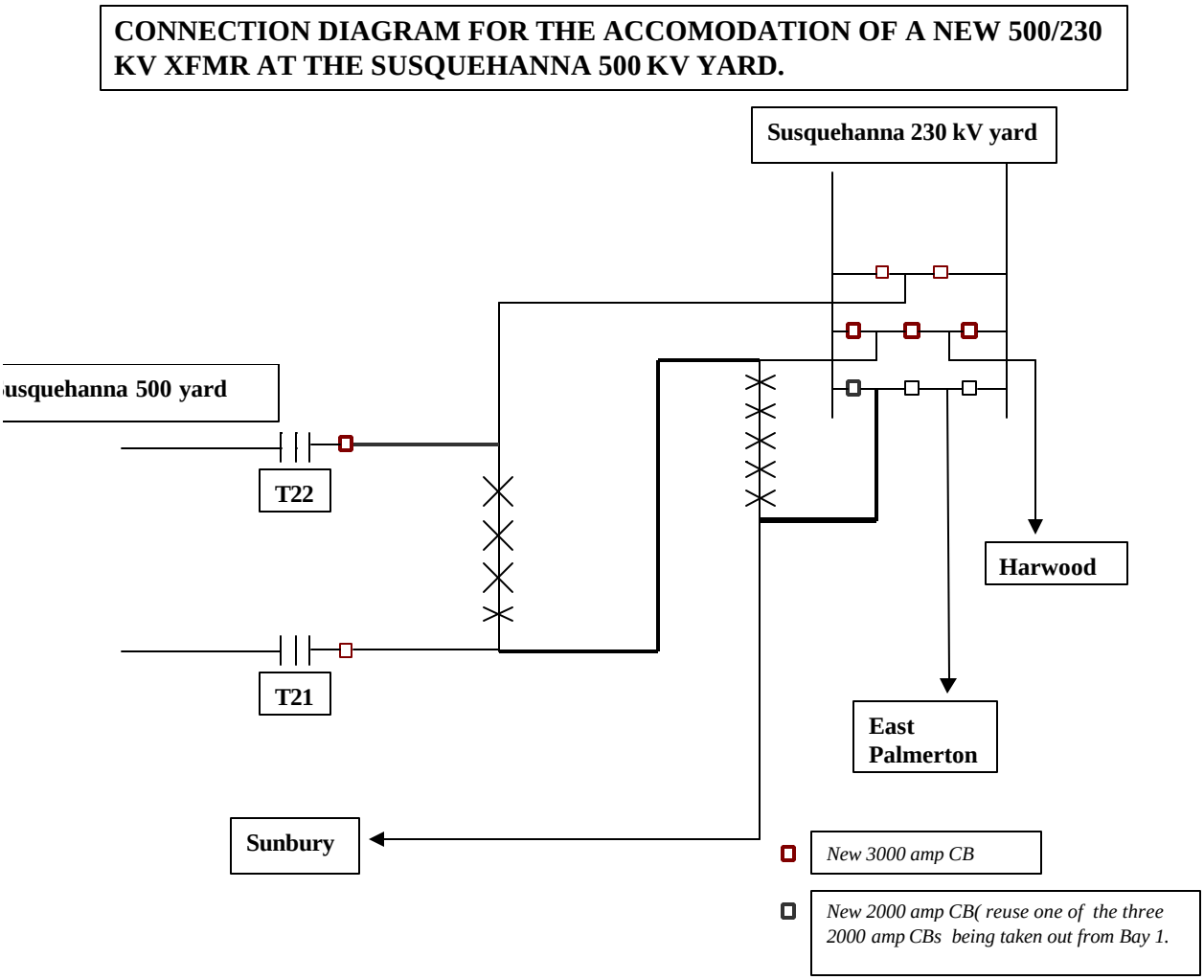

Figure 1

Martins Creek-Morris Park-Gilbert Upgrade

To alleviate the Martins Creek – Morris Park – Gilbert 230 kV overloads listed above, the Martins Creek – Morris Park – Gilbert 230 kV path will be upgraded to include a second 1590 ACSR circuit on the existing structures for most of the path (the initial 0.37 mile section of the path will require new single circuit construction in parallel with the existing line). The Delaware River crossing, which consists of a 0.3 mile section built to 2-2493 ACAR construction, will not require upgrading. See Figure #2.

Specific upgrades include:

- From Martins Creek 230 kV substation to the Delaware River crossing, install a second 0.37 mile section of single circuit 1590 ACSR parallel with the existing ssingle circuit Martins Creek – Morris Park 230 kV line. The estimated cost is $0.865 million

- Upgrade the line termination by replacing equipment in Bay 0 with 3000 amp equipment at Martins Creek 230 substation. The estimated cost is $1.725 million

The above listed work will be done by PPL Utilities. The estimated cost is $2.6 million.

- String 1590 45/7 kcmil ACSR conductor at 125 degrees C on the vacant side of the Martins Creek-Morris Park Tap double circuit tower line from the Delaware River crossing to the Morris Park Tap (7.8 miles). The estimated cost is $1.451 million

- String 1590 45/7 kcmil ACSR conductor at 125 degrees C on the vacant side of the Morris Park Tap-Gilbert double circuit tower line from Morris Park Tap to the Route 78 crossing (3.0 miles) and from the other side of Route 78 to Gilbert substation (7.25 miles). The estimated cost is $1.945 million.

- String 2493 kcmil ACAR conductor at 100 degrees C on the vacant side of the Morris Park Tap-Gilbert double circuit tower line where it crosses Route 78 (.3 miles). The estimated cost is $0.166 million.

- Tie the ends of both circuits together to form a new single circuit. The work will include

- Connecting each new single conductor on the double circuit tower line at the Delaware River to the existing single circuit, double conductored, 500kV tower.

- Tying each of the single conductors on the double circuit tower line together at Morris Park Tap and connecting the resultant tap to the Morris Park 230kV bus.

- Tying each of the single conductors on the double circuit tower line together at Gilbert substation and Connecting the resultant circuit to the Gilbert 230kV bus.

The estimated cost is $0.316 million

The above listed work will be done by GPU Energy. The estimated cost is $3.878 million.

The total cost to upgrade the Martins Creek-Morris Park-Gilbert line is $6.478 million. It is estimated it will take 24-36 months from initiation of design engineering to complete the upgrade.

Line lengths (ft)

Martins Creek – Morris Park
38966 + 2080 + 1603 (river crossing, 2-2493 ACAR 500 kV const) + 1793 (steel pole) + 199

Morris Park - G Gilbert
38274 + 1440 + 15669

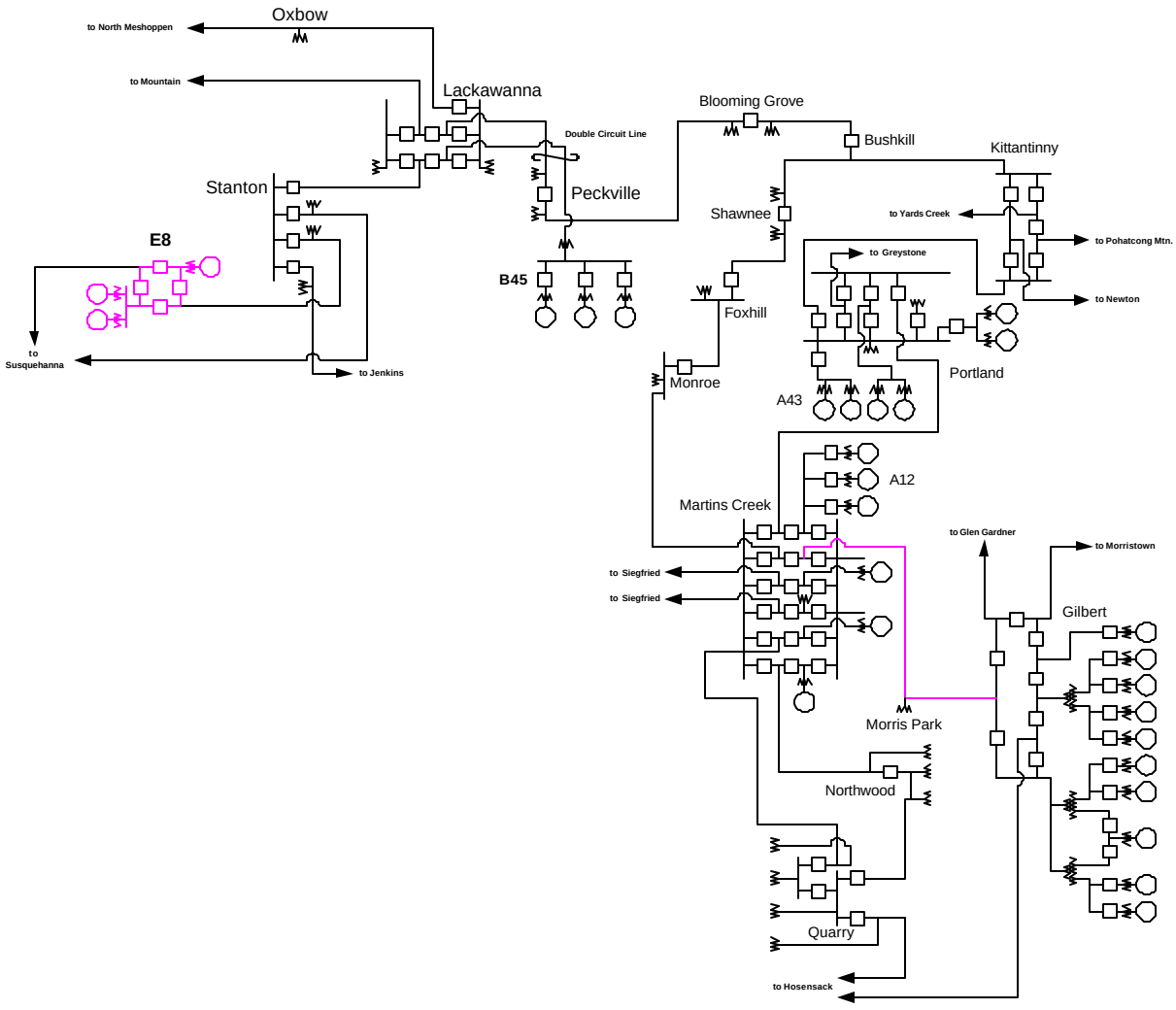

Figure #2 - Martins Creek-Morris Park-Gilbert circuit

Elimsport – Lobo 230 kV Circuit

To alleviate the stability problems described under *Network Impacts*, a new Elimsport – Lobo 230 kV circuit is required (see Figure 3). This new circuit will alleviate the transient instability and dynamic stability problems by allowing for sufficient exit of energy from the northern Pennsylvania area under the described contingency conditions. The new circuit and associated terminal equipment is expected to cost $33.1 million with a lead time of 3-4 years.

Specific upgrades include:

- Construction of a 30-mile, single circuit 1590 45/7 kcmil ACSR circuit at 125 degrees C and associated structures between the Elimsport 230 kV and Lobo 230 kV substations. The estimated cost is $27 million.

- Addition of two 230 kV breakers, bus reconfiguration, and associated protective relaying at Elimsport 230 kV to expand the substation to a 4-breaker ring bus. The estimated cost is $1 million.

- Addition of four 230 kV breakers, bus reconfiguration, and associated protective relaying at Lobo 230 kV to expand the substation to a 4-breaker ring bus. The estimated cost is $5.08 million.

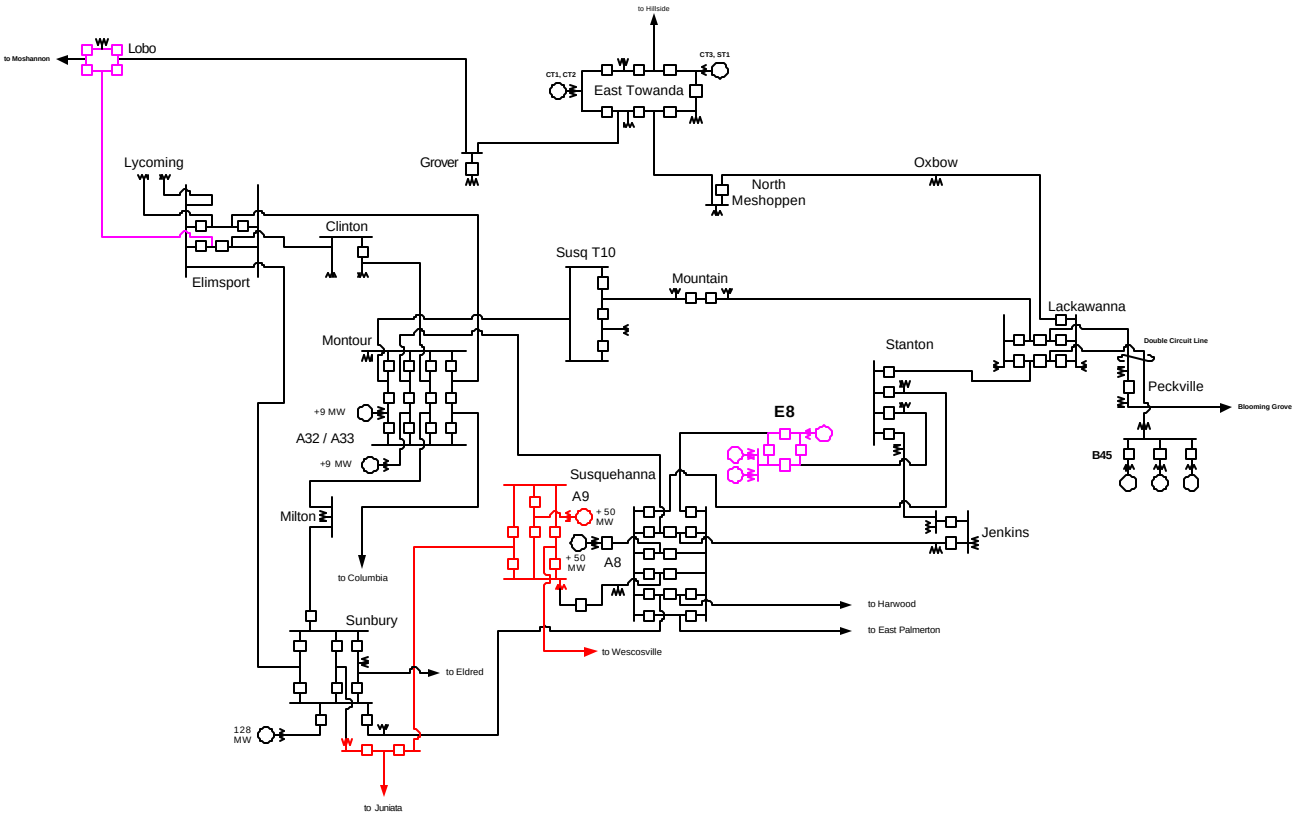

Figure 3: Elimsport – Lobo 230 kV Circuit

The analysis results and system reinforcements listed above were completed prior to the withdrawal of project E38 Erie West, A42 Atlantic, A43 Portland, B49 Erie South-Warren. The withdrawal of the projects listed could have a significant impact on the network reinforcements required for interconnection of this project to the transmission system.

IPP-E18