

## **Generator 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***

Queue R26 was studied as a 940 MW (capacity) injection at a tap in the Susquehanna to Sunbury 500 kV line. The R26 project was evaluated for compliance with reliability criteria for summer peak conditions in 2011. Potential network impacts were as follows:

### **Generator Deliverability**

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

1. The Susquehanna T21 - Susquehanna 230 kV line is overloaded from 94% to 102% of its emergency rating (1431 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66\_WITH\_R24A). The R26 contributes approximately 123 MW to cause the thermal violation
2. The Stanton – Lackawanna 230 kV line is overloaded from 99% to 106% of its emergency rating (764 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66\_WITH\_R24A). The R26 contributes approximately 49 MW to cause the thermal violation
3. The R26 – Sunbury 500 kV line is overloaded from 90% to 116% of its emergency rating (3113 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66\_WITH\_R24A). The R26 contributes approximately 811 MW to cause the thermal violation.
4. The Susquehanna - R24 500 kV line is overloaded from 96% to 117% of its emergency rating (3113 MVA) for the outage of Sunbury – R26 500 kV line (Cont Id. PJM69\_WITH\_R26A). The R26 contributes approximately 650 MW to cause the thermal violation.

### **Multiple Facility Contingency**

*(Double Circuit Towerline contingencies only. Stuck breaker and bus fault contingencies will be performed for the Impact Study)*

No problems were identified

### **Short Circuit**

Will be performed for the Queue R24 Impact Study.

### **Stability Analysis**

Will be performed for the Queue R24 Impact Study.

## Contribution to Previously Identified Overloads

*(Queue R26 contributes to the following contingency overloads, i.e. Network Impacts”, identified for earlier generation or transmission interconnection projects in the PJM Queue)*

1. The Alburdis – Branchburg 500 kV line is overloaded at 110% of its emergency rating (3734 MVA) for the outage of Hosensak - Elroy 500 kV line (Cont Id: PJM22). The R26 project contributes approximately 121 MW to this overload.
2. The Hosensack – Elroy 500 kV line is overloaded to 123% of its emergency rating (3734 MVA) for the outage of Alburdis – Branchburg 500 kV line (Cont Id. PJM5). The R26 contributes approximately 172 MW to this overload.
3. The Susquehanna 500/230 kV transformer is overloaded at 126% of its emergency rating (1165 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66\_WITH\_R24A). The R26 contributes approximately 123 MW to this overload.
4. The R24 - Wescosville 500 kV line is overloaded to 141% of its emergency rating (3113 MVA) for the outage of Sunbury – R26 500 kV line (Cont Id. PJM69\_WITH\_R26A). The R26 contributes approximately 650 MW to the overload.
5. The Wescosville – Alburdis 500 kV line is overloaded to 141% of its emergency rating (3113 MVA) for the outage of Sunbury – R26 500 kV line (Cont Id. PJM69\_WITH\_R26A). The R26 contributes approximately 651 MW to the overload.
6. The Alburdis - Hosensak 500 kV line is overloaded to 108% of its emergency rating (3145 MVA) for the outage of Alburdis – Branchburg 500 kV line (Cont Id. PJM5). The R26 contributes approximately 206 MW to the overload.
7. The Three Mile Island 500/230 kV transformer is overloaded at 112% of its emergency rating (1077 MVA) for the outage of Conastone to Peachbottom 500 kV line (Cont Id. PJM17). The R26 project contributes approximately 67 MW to this overload.
8. The Sunbury – Juniata 500 kV line is overloaded to 141% of its emergency rating (3113 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66\_WITH\_R24A). The R26 contributes approximately 706 MW to the overload.
9. The Frackville - Siegfried 230 kV line is overloaded to 114% of its emergency rating (616 MVA) for the **tower outage** of Susquehanna to East Palmerton 230kV line and Harwood to Siegfried 230kV line (Cont Id. 4PPL). The R26 contributes approximately 35 MW to this overload.
10. The Conastone - Mt Carmel (2322 line) 230 kV line is overloaded at 154% of its emergency rating (803 MVA) for the **tower outage** of Brighton to Doubs and Brighton to Conastone 500 kV line (Cont Id. AP5). The R26 project contributes approximately 43 MW to this overload.

11. The Conastone - Mt Carmel (2310 line) 230 kV line is overloaded at 135% of its emergency rating (923 MVA) for the **tower outage** of Brighton to Doubs and Brighton to Conastone 500 kV line (Cont Id. AP5). The R26 project contributes approximately 43 MW to this overload.
12. The Mt Carmel – Nwest (2322 line) 230 kV line is overloaded at 151% of its emergency rating (803 MVA) for the **tower outage** of Brighton to Doubs and Brighton to Conastone 500 kV line (Cont Id. AP5). The R26 project contributes approximately 43 MW to this overload.
13. The Mt Carmel – Nwest (2310 line) 230 kV line is overloaded at 132% of its emergency rating (923 MVA) for the **tower outage** of Brighton to Doubs and Brighton to Conastone 500 kV line (Cont Id. AP5). The R26 project contributes approximately 43 MW to this overload.
14. The Graceton – Bagley- Rapheal 230 kV line is overloaded at 175% of its emergency rating (659 MVA) for the **tower outage** of Brighton to Doubs and Brighton to Conastone 500 kV line (Cont Id. AP5). The R26 project contributes approximately 53 MW to this overload.

### **New System Reinforcements**

*(Upgrades required to mitigate reliability criteria violations, i.e. "Network Impacts", initially caused by the addition of Queue R26 generation)*

1. Susquehanna T21 230kV – Susquehanna 230kV yard line upgrade - The estimated magnitude cost to upgrade for this 230kV line section is **\$2,100,000**.  
  
In order to provide additional capacity on the Susquehanna T21 – Susquehanna 230kV line, PPL EU is proposing to replace the 500/230kV transformer T21 230kV side 3000 amp circuit breaker with a 4000 amp circuit breaker. Presently this breaker limits the line rating below the line conductor ratings. Replacement of this breaker would restore rating of the line to its conductor thermal rating. The line is built with 2-1590 Kcmil ACSR 45/7 conductors for a conductor operating temperature rating of 125 deg C. With this upgrade the line rating would be restored to 1306/1586 MVA summer normal/emergency ratings.  
The description of work and the cost estimates are preliminary without any field checks and engineering review and therefore are subject to change.
2. Stanton – Lackawanna 230kV line upgrade - The estimated magnitude cost including the substation terminal equipment cost for this upgrade is **\$23,000,000** excluding the r/w cost.

In order to provide additional capacity on the Lackawanna-Stanton 230kV line, PPL EU's proposal is to build a new 230kV line between the two substations in a new unknown right of way (r/w). The line will be 13 miles long and will be constructed with 1590 Kcmil, ACSR conductors for a 653/793 MVA summer normal/emergency ratings. The ratings are based on the conductor ratings and may be lower when the line is actually built. A new 230kV transmission line is proposed because the existing 230kV line is already a double circuit line with Mountain - Lackawanna 230kV line. Since the proposal requires new rights of way, the project in-service date would depend on the acquisition of right of way.

3. R26 – Sunbury 500kV line upgrade - The estimated magnitude cost for this upgrade including the substation terminal equipment is **\$58,000,000**.

In order to provide additional capacity on the R26-Sunbury 500kV line, PPL EU is proposing to rebuild the existing Sunbury-Susquehanna 230kV line from a single circuit to a double circuit 500kV line between the two substations. One Circuit of this will be operated at 230kV and the other at 500kV. The line will be approximately 8 miles long and will be constructed with 1590 Kcmil ACSR triple bundle conductors for a 3000/3700 MVA summer normal/emergency ratings. The ratings are based on the conductor ratings and may be lower when the line is actually built. Cost also includes construction of a temporary 500kV line at the edge of the right of way during the double circuit 500kV construction.

4. Susquehanna – R24 500kV line upgrade - The estimated magnitude cost for this upgrade including the substation terminal equipment is **\$169,000,000**.

In order to provide additional capacity on the Susquehanna-R24 500kV line, PPL EU is proposing to rebuild the existing Susquehanna-R24 500kV line from a single circuit to a double circuit 500kV line between the two substations. The total line length is approximately 25 miles and owned by PPL EU. PPL EU will construct the new double circuit line with 1590 Kcmil ACSR triple bundle conductors for a 3000/3700 MVA summer normal/emergency ratings. The ratings are based on the conductor ratings and may be lower when the line is actually built. Additionally terminal equipment upgrades at Susquehanna and R24 substation are also included in the cost. Cost also includes construction of a temporary 500kV line at the edge of the right of way during the double circuit 500kV construction.

### **Contribution to Previously Identified System Reinforcements**

*(Overloads initially caused by prior Queue positions with additional contribution to overloading by Queue R26. Queue R26 may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)*

5. Alburdis – Branchburg 500kV line upgrade.

PPL portion of the line (21 miles) and Alburdis terminal

The estimated magnitude cost to upgrade 21 miles of PPL EU owned line including the terminal cost at Alburdis, is **\$140,000,000**.

In order to provide additional capacity on the Alburdis-Branchburg 500kV line, PPL EU is proposing to rebuild the existing Alburdis-Branchburg 500kV line from a single circuit to a double circuit 500kV line between the two substations. PPL EU will construct its portion of 21 miles with 1590 Kcmil ACSR triple bundle conductors for a 3000/3700 MVA summer normal/emergency ratings. The ratings are based on the conductor ratings and may be lower when the line is actually built. Additionally terminal equipment upgrade at Alburdis is also included in the cost. Cost also includes construction of a temporary 500kV line at the edge of the right of way during the double circuit 500kV construction.

PSE&G portion of the line (26 miles) and Branchburg terminal

The estimated cost to upgrade PSE&G's portion (26 miles) of the Alburdis – Branchburg 500kV circuit (5016), including terminal equipment, is **\$85,000,000**. It will be re-conducted.

This estimate assumes no significant property, license or permitting issues, and no temporary 500kV line construction. Because no detailed engineering analysis has been performed, it also assumes no significant structural reinforcements and a sustained outage feasibility schedule.

6. Hosensack – Elroy 500kV line upgrade.

PPL portion of line (Hosensack 500 kV terminal)

The PPL EU magnitude cost estimate to expand the Hosensack 500kV switchyard is **\$3,000,000**.

PECO portion of line (18 mi. 500kV line and Elroy terminal)

A new line must be constructed. The cost for a new 18 mile long 500kV line and the associated work at Elroy substation will be about **\$40,000,000** not including right of way costs. Acquisition of new right of way could take up to seven years. If right of way was available the project would take 42 months to complete.

7. Susquehanna 500/230kV Transformer #21 upgrade - The estimated magnitude cost to install the second 500/230kV transformer is **\$10,000,000**.

In order to provide additional 500/230kV Transformer capacity at the Susquehanna 500/230kV substation, PPL EU is proposing to install a second 500/230kV transformer similar in rating to the existing transformer #21 connected on the 500kV north bus. The transformers will be paralleled on the 230kV side.

8. R24 – Wescosville 500kV line Overload - The estimated magnitude cost for this upgrade including terminal equipment is **\$287,000,000**.

In order to provide additional capacity on the R24-Wescosville 500kV line, PPL EU is proposing to rebuild the existing R24-Wescosville 500kV line from a single circuit to a double circuit 500kV line between the two substations. The total line length is approximately 42 miles and all owned by PPL EU. PPL EU will construct the new double circuit line with 1590 Kcmil ACSR triple bundle conductors for a 3000/3700 MVA summer normal/emergency ratings. The ratings are based on the conductor ratings and may be lower when the line is actually built. Additionally terminal equipment upgrades at Wescosville and R24 substation are also included in the cost. Wescosville 500kV substation is an existing GIS substation and its expansion poses some challenges due to the space limitation. Therefore additional expansion cost is added for the Wescosville 500kV substation. Cost also includes construction of a temporary 500kV line at the edge of the right of way during the double circuit 500kV construction.

9. Wescosville – Alburdis 500kV line upgrade - The estimated magnitude cost for this upgrade including the substation terminal equipment is **\$85,000,000**.

In order to provide additional capacity on the Wescosville-Alburdis 500kV line, PPL EU is proposing to rebuild the existing Wescosville-Alburdis 500kV line from a single circuit to a double circuit 500kV line between the two substations. The total line length is approximately 11 miles and owned by PPL EU. PPL EU will construct the new double circuit line with 1590 Kcmil ACSR triple bundle conductors for a 3000/3700 MVA summer normal/emergency ratings. The ratings are based on the conductor ratings and may be lower when the line is actually built. Additionally terminal equipment upgrades at Alburdis and Wescosville substation are also included in the cost. Wescosville 500kV substation is an existing GIS substation and its expansion poses some challenges due to space limitations. Therefore additional expansion cost is added for the Wescosville substation. Cost also includes construction of a temporary 500kV line at the edge of the right of way during the double circuit 500kV construction.

10. Alburdis – Hosensack 500kV line Overload - The estimated magnitude cost including the substation terminal equipment for this upgrade is **\$39,000,000**.

In order to provide additional capacity on the Alburdis-Hosensack 500kV line, PPL EU is proposing to rebuild the existing Alburdis-Hosensack 500kV line from a single circuit to a double circuit 500kV line between the two substations. The total line length is approximately 5 miles and all owned by PPL EU. PPL EU will construct the new double circuit line with 1590 Kcmil ACSR triple bundle conductors for a 3000/3700 MVA summer normal/emergency ratings. The ratings are based on the conductor ratings and may be lower when the line is actually built. Cost also includes construction of a temporary 500kV line at the edge of the right of way during the double circuit 500kV construction.

11. TMI 500-230 kV transformer upgrade – The estimated cost to add a second 500-230 kV transformer is **\$11,800,000** and the time required is approximately 20 months.

12. Sunbury – Juniata 500kV line upgrade - The estimated magnitude cost for this upgrade including the substation terminal equipment is **\$261,000,000**.

In order to provide additional capacity on the Sunbury-Juniata 500kV line, PPL EU is proposing to rebuild the existing Sunbury-Juniata 500kV line from a single circuit to a double circuit 500kV line between the two substations. The total line length is approximately 38 miles and owned by PPL EU. PPL EU will construct the new double circuit line with 1590 Kcmil ACSR triple bundle conductors for a 3000/3700 MVA summer normal/emergency ratings. The ratings are based on the conductor ratings and may be lower when the line is actually built. Additionally terminal equipment upgrades at Sunbury and Juniata substation are also included in the cost. Sunbury 500kV substation expansion poses some challenges due to space limitations. Therefore additional expansion cost is added for the Sunbury 500kV substation. Cost also includes construction of a temporary 500kV line at the edge of the right of way during the double circuit 500kV construction.

13. Frackville - Siegfried 230kV line upgrade - The estimated magnitude cost for this upgrade including substation terminal equipment cost is **\$106,000,000**.

In order to provide additional capacity on the Siegfried-Frackville 230kV line, PPL EU is proposing to rebuild the existing single circuit 230kV line to a double-circuit 230kV line between the two substations. The new line will be 41 miles long and will travel the existing right of way. The 230kV lines will be constructed with 1590 Kcmil ACSR conductors for a 653/793 MVA, summer normal/emergency ratings. The ratings are based on the conductor ratings and may be lower when the line is actually built.

14. Northwest - Mt Carmel - Conastone upgrade – This upgrade requires the construction of a new 500kV substation slightly north of the existing Northwest 230 kV station. This station will cut into the nearby Brighton – Conastone 500 kV line and consist of two 500/230kV transformers, four 500 kV circuit breakers, seven 230 kV circuit breakers, related substation equipment and land at a cost of **\$70,000,000**. It also requires the reconductoring of the Conastone to Northwest #2322 line from the existing 1,272 kcmil ACSR to new 1,590kcmil ACSR with an estimated cost of **\$8,210,000**. This work would take 3-4 years to build the substation and 18-24 months concurrently) for the line work. **(Note: This upgrade will suffice for overloads 15, 16 and 17 as well).**

15. Graceton - Bagley - Raphael upgrade – This upgrade requires Graceton station to add 6-230kV breakers with an estimated cost of **\$10,000,000** and Raphael Road station to add 6-230kV breakers **\$10,000,000**. It also requires rebuilding Graceton to Raphael Rd to double circuit 2-conductor bundled with an estimated cost of **\$30,000,000**. This work would take an estimate of 2-3 years for the substation work concurrently with 5-6 years for the line work.