

#R28 Susquehanna - Alburtis 940 MW
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

The #R28 project was studied as a 940 MW (capacity) injection at a tap between Susquehanna to Wescosville / Alburtis 500 kV line in the PPL territory. Project #R28 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 Peckville - Peckville H5 230 kV line is overloaded from 97% to 103% of its emergency rating (558 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66_WITH_R24_R28A). The R28 contributes approximately 31 MW to cause this thermal violation.
2. The Susquehanna - R26 500 kV line is overloaded from 90% to 111% of its emergency rating (3015 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66_WITH_R24_R28A). The R28 contributes approximately 641 MW to cause this thermal violation.
3. The Harwood – Siegfried 230 kV line is overloaded from 97% to 105% of its emergency rating (764 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66_WITH_R24_R28A). The R28 contributes approximately 63 MW to cause this thermal violation.
4. The Juniata 500/230 kV #1 transformer is overloaded from 99% to 103% of its emergency rating (641 MVA) for the outage of Juniata 500/230 kV ckt.2 transformer (Cont Id. PJM26). The R28 contributes approximately 28 MW to cause this thermal violation.
5. The Juniata 500/230 kV #2 transformer is overloaded from 98% to 102% of its emergency rating (641 MVA) for the outage of Juniata 500/230 kV ckt.1 transformer (Cont Id. PJM62). The R28 contributes approximately 28 MW to cause this thermal violation.

Multiple Facility Contingency

(Double Circuit Towerline contingencies at full output. Stuck breaker and bus fault contingencies not tested for the Feasibility Study but will be done at the Impact Study)

No problems were identified.

Short Circuit

Will be performed for the Queue R28 Impact Study.

Stability Analysis

Will be performed for the Queue R28 Impact Study.

Contribution to Previously Identified Overloads

(Queue R28 contributes to the following contingency overloads, i.e. Network Impacts”, identified for earlier generation or transmission interconnection projects in the PJM Queue)

6. The Elroy - Branchburg 500 kV line is overloaded to 120% of its emergency rating (3040 MVA) for the outage of Alburdis – Branchburg 500 kV line (Cont Id. PJM5). The R28 contributes approximately 52 MW to this overload.
7. The Alburdis – Branchburg 500 kV line is overloaded at 112% of its emergency rating (3734 MVA) for the outage of Hosensack - Elroy 500 kV line (Cont Id: PJM22). The R28 project contributes approximately 181 MW to this overload.
8. The Hosensack – Elroy 500 kV line is overloaded to 129% of its emergency rating (3734 MVA) for the outage of Alburdis – Branchburg 500 kV line (Cont Id. PJM5). The R28 contributes approximately 253 MW to this overload.
9. The Peckville H5 – Blooming Grove H2 230 kV line is overloaded to 105% of its emergency rating (558 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66_WITH_R24_R28A). The R28 contributes approximately 30 MW to this overload.
10. The Susquehanna 500/230 kV transformer is overloaded at 151% of its emergency rating (1165 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66_WITH_R24_R28A). The R28 contributes approximately 293 MW to this overload.
11. The R24 - Wescosville 500 kV line is overloaded to 175% of its emergency rating (3113 MVA) for the outage of Sunbury – R26 500 kV line (Cont Id. PJM69_WITH_R26A). The R28 contributes approximately 755 MW to the overload.
12. The Wescosville – Alburdis 500 kV line is overloaded to 171% of its emergency rating (3015 MVA) for the outage of Sunbury – R26 500 kV line (Cont Id. PJM69_WITH_R26A). The R28 contributes approximately 733 MW to the overload.
13. The Susquehanna T21 - Susquehanna 230 kV line is overloaded to 123% of its emergency rating (1431 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66_WITH_R24A). The R28 contributes approximately 293 MW to the overload.
14. The R26 - Sunbury 500 kV line is overloaded to 138% of its emergency rating (3015 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66_WITH_R24A). The R28 contributes approximately 641 MW to the overload.
15. The Alburdis - Hosensack 500 kV line is overloaded to 120% of its emergency rating (3145 MVA) for the outage of Alburdis – Branchburg 500 kV line (Cont Id. PJM5). The R28 contributes approximately 382 MW to the overload.
16. The Stanton – Lackawanna 230 kV line is overloaded to 118% of its emergency rating (764 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66_WITH_R24_R28A). The R28 contributes approximately 92 MW to the overload.
17. The Sunbury – Juniata 500 kV line is overloaded to 161% of its emergency rating (3113 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66_WITH_R24_R28A). The R28 contributes approximately 626 MW to the overload.
18. The Conastone - Mt Carmel (2322 line) 230 kV line is overloaded at 160% 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 R28 project contributes approximately 47 MW to this overload.

19. The Conastone - Mt Carmel (2310 line) 230 kV line is overloaded at 140% 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 R28 project contributes approximately 47 MW to this overload.
20. The Mt Carmel – Nwrest (2322 line) 230 kV line is overloaded at 157% 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 R28 project contributes approximately 47 MW to this overload.
21. The Mt Carmel – Nwrest (2310 line) 230 kV line is overloaded at 138% 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 R28 project contributes approximately 47 MW to this overload.
22. The Graceton – Bagley13 – Rapheal 230 kV line is overloaded at 184% 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 R28 project contributes approximately 57 MW to this overload.
23. The Three Mile Island 500/230 kV transformer is overloaded at 119% of its emergency rating (1077 MVA) for the outage of Conastone to Peachbottom 500 kV line (Cont Id. PJM17). The R28 project contributes approximately 73 MW to this overload.

Potential Overloads:

1. The Susquehanna – E. Palmerton 230 kV line is overloaded at 99% of its emergency rating (764 MVA) for the outage of Wescosville – R24 500 kV line (Cont Id. PJM66_WITH_R24_R28A). The R28 project contributes approximately 62 MW to this overload.

Network Upgrade Requirements

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. "Network Impacts", initially caused by the addition of Queue R28 generation)

1. Peckville – Peckville H5 230kV line Overload - This short line segment has a 454 MVA summer normal and 558 MVA summer emergency rating. The cost to upgrade of this section is included in the Blooming Grove-Peckville 230kV line upgrade.
2. Susquehanna - R26 500kV line - The estimated magnitude cost for this upgrade including the substation terminal equipment is \$207,000,000.

Description of Work:

In order to provide additional capacity on the Susquehanna - R26 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 36 miles long and will be constructed with 1590 Kcmil ACSR triple bundle conductors for 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.

3. Harwood – Siegfried 230kV line Overload - The estimated magnitude cost including the substation terminal Equipment cost for this upgrade is \$45,000,000 excluding the r/w cost.

Description of Work:

In order to provide additional capacity on the Siegfried-Harwood 230kV line, PPL EU is proposing to build a new, third, 230kV line between the two substations in a new, separate, unknown right-of-way. The third line will be 28 miles long and will be constructed with 1590 Kcmil ACSR conductor 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 design that currently supports the Harwood-East Palmerton and Siegfried-Harwood 230kV circuits. Because the proposal requires new rights-of-way (r/w cost not included), the project in-service date will depend on the acquisition of right-of-way.

4. Juniata 500/230kV Transformer #1 Overload - The estimated magnitude cost to replace the 500/230kV transformer#1 is \$9,000,000.

Description of Work:

In order to provide additional 500/230kV Transformer capacity at the Juniata 500/230kV substation, PPL EU is proposing to replace the existing 500/230kV transformer #1 with a higher rating transformer of at least 650/800 MVA summer normal/emergency ratings.

5. Juniata 500/230kV Transformer #2 Overload - The estimated magnitude cost to replace the 500/230kV transformer#2 is \$9,000,000.

Description of Work:

In order to provide additional 500/230kV Transformer capacity at the Juniata 500/230kV substation, PPL EU is proposing to replace the existing 500/230kV transformer #2 with a higher rating transformer of at least 650/800 MVA summer normal/emergency ratings.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by Queue R28. Queue R28 % allocation cost responsibility will be calculated for the Impact Study)

6. Elroy – Branchburg 500kV line Overload - The PECO system reinforcement for the Elroy-Branchburg 500kV line will require the replacement of Elroy substation equipment, including the circuit breakers. The cost for this work is approximately \$2.5 million and it will take about 18 months to complete.
7. Alburdis – Branchburg 500kV line Overload - The estimated magnitude cost to upgrade for 21 miles of PPL EU owned line including the terminal cost at Alburdis, is \$140,000,000.

28 miles of Transmission Line and substation upgrade cost at Branchburg to be provided by PSE&G.

Description of Work:

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. The total line length is approximately 49 miles long, 21 miles owned by PPL EU and the rest 28 miles owned by PSE&G. 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.

8. Hosensack – Elroy 500kV line Overload - The PPL EU magnitude cost estimate to expand the Hosensack 500kV switchyard is \$3,000,000.

Transmission Line and substation upgrade cost at Elroy Sub to be provided by PECO.

The entire 18 miles of this line is owned by PECO and therefore upgrade solution and cost estimate must be provided by PECO. However the line can be either double circuited or a new 500kV line can be built between the two substations in a new right of way. In either case PPL EU will have to build a new 500kV line terminal at Hosensack with two breakers in a new 500 kV bay and convert the substation operation from a ring bus to a breaker and half operation.

PECO estimate: 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.

9. Peckville - Blooming Grove 230kV line Overload - The estimated magnitude cost for this upgrade including substation terminal equipment cost is \$76,000,000.

In order to provide additional capacity on the Blooming Grove-Peckville 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 29 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.

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

Description of Work:

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.

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

Description of Work:

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.

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

Description of Work:

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.

13. Susquehanna T21 230kV – Susquehanna 230kV yard line Overload - The estimated magnitude cost to upgrade for this 230kV line section is \$2,100,000.

Description of Work:

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.

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

Description of Work:

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.

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

Description of work:

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.

16. Stanton – Lackawanna 230kV line Overload - The estimated magnitude cost including the substation terminal equipment cost for this upgrade is \$23,000,000 excluding the r/w cost.

Description of Work:

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.

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

Description of Work:

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.

18. Northwest - Mt Carmel - Conastone Overload – This overload requires to install NNW station 2-500/230kV xfmrs 4-500 kV bkrs, 7-230 kV Bkrs and related substation equipment and land at a cost of \$70M. It also requires to reconductor Conastone to Northwest #2322 with 1,272kcmil ACSR 1,590kcmil ACSR with an estimated cost of \$8.21. This work would take 3-4 years to build substation and 18-24 months for the line work. **(Note: This upgrade will suffice the overloads 19, 20 and 21 too).**
22. Graceton - Bagley - Raphael Overload – This overload requires Graceton station to add 6-230kV breakers with an estimated cost of \$10 M and Raphael Road station to add 6-230kV breakers \$10 M. It requires rebuilding Graceton to Raphael Rd to double circuit 2-conductor bundled with an estimated cost of \$30 M. This work would take an estimate of 2-3 years for the substation work and 5-6 years for the line work. **(Note: This upgrade will suffice the overload 23 too).**

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