

#T44 Essex 230kV
Generation Interconnection

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

Network Impacts

The queue project T44 was studied as a 224MW (capacity) injection onto PSEG's system at the Essex 230kV facility. The project was studied twice, due to project T42 having two interconnection options. T44 was evaluated for compliance with reliability criteria for summer peak conditions in 2012. It should be noted that the Q75 MTX project was not modeled in our study because its associate network reinforcements were not available. Potential network impacts were as follows:

T44 with T42 Option 1:

Generator Deliverability

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

1. **(PSEG)** The Essex-Hudson 1-6 230kV line loads from 86.5% to 102.8% (DC power flow) of its normal rating (716MVA) for the non-contingency condition. This project contributes approximately 117.0MW to cause this thermal violation.
2. **(PSEG)** The Kearny-NJT Meadows 230kV line loads from 99.0% to 116.1% (DC power flow) of its emergency rating (826MVA) for the single line contingency outage (PS72). This project contributes approximately 141.0MW to cause this thermal violation.
3. **(PSEG)** The NJT Meadows-Kingsland C 230kV line loads from 97.1% to 114.2% (DC power flow) of its emergency rating (826MVA) for the single line contingency outage (PS72). This project contributes approximately 141.0MW to cause this thermal violation.
4. **(PSEG)** The Cook Road C-Athenia 230kV line loads from 91.5% to 110.3% (DC power flow) of its emergency rating (752MVA) for the single line contingency outage (PS72). This project contributes approximately 141.0MW to cause this thermal violation.
5. **(PSEG)** The Kingsland C-Cook Road C 230kV line loads from 90.4% to 107.1% (DC power flow) of its emergency rating (845MVA) for the single line contingency outage (PS72). This project contributes approximately 141.0MW to cause this thermal violation.

Multiple Facility Contingency

(Double Circuit Tower Line contingencies only for the full energy output. Stuck breaker and bus fault contingencies will be performed for the Impact Study)

6. **(PSEG)** The North Ave-Passaic Valley SC 138kV line loads from 98.54% to 112.97% (DC power flow) of its emergency rating (372MVA) for the tower line outage (27PS). This project contributes approximately 53.7MW to cause this thermal violation.

7. **(PSEG)** The Essex PAR-Stanley Terrace 230kV line loads from 81.86% to 102.82% (DC power flow) of its emergency rating (550MVA) for the tower line outage (27PS). This project contributes approximately 115.3MW to cause this thermal violation.

8. **(PSEG)** The Stanley Terrace-Aldene 230kV line loads from 79.15% to 100.11% (DC power flow) of its emergency rating (550MVA) for the tower line outage (27PS). This project contributes approximately 115.3MW to cause this thermal violation.

9. **(PSEG)** The Marion 3-Hudson 7-12 138/230kV transformer loads from 94.69% (DC power flow) to 101.53% of its emergency rating (441MVA) for the tower line outage (27PS). This project contributes approximately 30.1MW to cause this thermal violation.

10. **(PSEG)** The Hoboken R-Bergen 230kV line loads from 99.13% to 106.28% (DC power flow) of its emergency rating (524MVA) for the tower line outage (30PS). This project contributes approximately 37.5MW to cause this thermal violation.

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)

11. **(PSEG)** The Essex-Hudson 1-6 230kV line loads from 114.58% to 135.17% (DC power flow) of its emergency rating (826MVA) for the single line contingency outage (PS20). This project contributes approximately 170.1MW to the thermal violation.

12. **(PSEG)** The Hudson 1-6-S. Waterfront P 230kV line loads from 128.81% to 132.64% (DC power flow) of its normal rating (404MVA) for non-contingency condition. This project contributes approximately 15.5MW to the thermal violation.

13. **(PSEG)** The S. Waterfront P-Newport R 230kV line loads from 119.22% to 124.90% (DC power flow) of its normal rating (315MVA) for non-contingency condition. This project contributes approximately 17.9MW to the thermal violation.

14. **(PSEG)** The Bergen-Leonia T 230kV ckt #2 line loads from 125.11% to 130.73% (DC power flow) of its emergency rating (557MVA) for the single line contingency outage (PS45). This project contributes approximately 31.3MW to the thermal violation.

15. **(PSEG)** The Bergen-Leonia T 230kV ckt #1 line loads from 119.94% to 125.14% (DC power flow) of its emergency rating (557MVA) for the single line contingency outage (PS45B). This project contributes approximately 28.9MW to the thermal violation.
16. **(JCPL)** The Parlin-Williams 230kV line loads from 102.13% to 103.38% (DC power flow) of its emergency rating (805MVA) for the single line contingency outage (JC17). This project contributes approximately 10.1MW to the thermal violation.
17. **(JCPL)** The Williams-Freneau 230kV line loads from 101.50% to 102.75% (DC power flow) of its emergency rating (805MVA) for the single line contingency outage (JC17). This project contributes approximately 10.1MW to the thermal violation.
18. **(PSEG)** The Bergen-Leonia T 230kV line loads from 119.15% to 123.86% (DC power flow) of its normal rating (375MVA) for the non-contingency condition. This project contributes approximately 17.7MW to the thermal violation.
19. **(PPL/PENELEC)** The Lackawanna-Oxbow 230kV line loads from 170.37% to 172.35% (DC power flow) of its emergency rating (504MVA) for the single line contingency outage (PN18). This project contributes approximately 10.0MW to the thermal violation.
20. **(PPL/PENELEC)** The Lackawanna-Oxbow 230kV line loads from 164.79% to 166.86% (DC power flow) of its normal rating (499MVA) for the non-contingency condition. This project contributes approximately 10.3MW to the thermal violation.
21. **(PENELEC)** The Oxbow-N..Meshoppen 230kV line loads from 164.62% to 166.68% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 10.3MW to the thermal violation.
22. **(BGE)** The Raphael-Northeast 339 230kV line loads from 141.25% to 142.43% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG8). This project contributes approximately 8.9MW to the thermal violation.
23. **(BGE)** The Raphael-Northeast 317 230kV line loads from 138.48% to 139.64% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG18). This project contributes approximately 8.8MW to the thermal violation.
24. **(BGE)** The Conastone-N. Northwest 500kV line loads from 171.43% to 173.34% (DC power flow) of its normal rating (2078MVA) for the non-contingency condition. This project contributes approximately 39.7MW to the thermal violation.
25. **(BGE)** The Northwest 311-Granite 1 230kV line loads from 174.04% to 175.82% (DC power flow) of its emergency rating (641MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 11.4MW to the thermal violation.

26. **(PECO/BGE)** The Peach Bottom-Conastone 500kV line loads from 166.83% to 168.82% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17_2). This project contributes approximately 51.7MW to the thermal violation.

27. **(PECO/BGE)** The Peach Bottom-Conastone 500kV line loads from 166.83% to 168.82% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17). This project contributes approximately 51.7MW to the thermal violation.

28. **(BGE)** The Conastone-Mt. Carmel 22 230kV line loads from 147.24% to 148.71% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 13.6MW to the thermal violation.

29. **(BGE)** The Conastone-Mt Carmel 10 230kV line loads from 147.24% to 148.71% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 13.6MW to the thermal violation.

30. **(BGE)** The Mt. Carmel 10-N. Northwest 230kV line loads from 144.95% to 146.42% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 13.6MW to the thermal violation.

31. **(BGE)** The Mt. Carmel 22-N. Northwest 230kV line loads from 144.95% to 146.42% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 13.6MW to the thermal violation.

32. **(BGE)** The Northwest 326-Granite 6 230kV line loads from 123.61% to 124.83% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 11.3MW to the thermal violation.

33. **(PSEG)** The Linden 1-North Ave. 138kV line loads from 135.48% to 152.92% (DC power flow) of its emergency rating (308MVA) for the tower line outage (27PS). This project contributes approximately 53.7MW to the thermal violation.

34. **(PSEG)** The Essex County Resorce Recovery-Foundry 138kV line loads from 105.99% to 118.51% (DC power flow) of its emergency rating (350MVA) for the tower line outage (27PS). This project contributes approximately 43.8MW to the thermal violation.

35. **(PSEG)** The Passaic Valley SC-Bayonne 138kV line loads from 113.20% to 131.15% (DC power flow) of its emergency rating (299MVA) for the tower line outage (27PS). This project contributes approximately 53.7MW to the thermal violation.

36. **(PSEG)** The Bayonne-B-M Reactor 138kV line loads from 118.55% to 135.76% (DC power flow) of its emergency rating (311MVA) for the tower line outage (27PS). This project contributes approximately 53.5MW to the thermal violation.
37. **(PSEG)** The B-M Reactor-Marion 4 138kV line loads from 118.52% to 135.74% (DC power flow) of its emergency rating (311MVA) for the tower line outage (27PS). This project contributes approximately 53.5MW to the thermal violation.
38. **(PSEG)** The Hudson 1-6-S. Waterfront P 230kV line loads from 117.38% to 121.55% (DC power flow) of its emergency rating (622MVA) for the tower line outage (24PS). This project contributes approximately 25.9MW to the thermal violation.
39. **(PSEG)** The S. Waterfront P-Newport R 230kV line loads from 118.04% to 125.69% (DC power flow) of its emergency rating (490MVA) for the tower line outage (30PS). This project contributes approximately 37.5MW to the thermal violation.
40. **(PSEG)** The Newport R-Hoboken R 230kV line loads from 105.24% to 112.43% (DC power flow) of its emergency rating (521MVA) for the tower line outage (30PS). This project contributes approximately 37.5MW to the thermal violation.
41. **(PENELEC)** The Oxbow-N. Meshoppen 230kV line loads from 170.23% to 172.19% (DC power flow) of its emergency rating (617MVA) for the tower line outage (CONAS_PB). This project contributes approximately 12.1MW to the thermal violation.
42. **(PECO)** The Nottingham-Nottingham Reactor 230kV line loads from 178.28% to 180.24% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 12.3MW to the thermal violation.
43. **(PECO/BGE)** The Peach Bottom P-Graceton 230kV line loads from 178.25% to 180.21% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 12.3MW to the thermal violation.
44. **(PECO)** The Nottingham Reactor-Peach Bottom P 230kV line loads from 178.25% to 180.21% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 12.3MW to the thermal violation.
45. **(BGE)** The Conastone-N. Northwest 500kV line loads from 154.34% to 155.92% (DC power flow) of its emergency rating (2901MVA) for the tower line outage (CNSTN_NWEST_NNWEST_A). This project contributes approximately 45.9MW to the thermal violation.
46. **(PPL/BGE)** The Manor-Graceton 230kV line loads from 171.73% to 173.80% (DC power flow) of its emergency rating (531MVA) for the tower line outage (CONAS_PB). This project contributes approximately 11.0MW to the thermal violation.

47. **(PENELEC)** The N. Meshoppen-E. Towanda 230kV line loads from 118.20% to 119.92% (DC power flow) of its emergency rating (554MVA) for the tower line outage (CONAS_PB). This project contributes approximately 9.5MW to the thermal violation.

48. **(PPL/METED)** The Hosensack-N. Boyertown 230kV line loads from 103.41% to 105.26% (DC power flow) of its emergency rating (525MVA) for the tower line outage (CONAS_PB). This project contributes approximately 9.7MW to the thermal violation.

49. **(PPL/BGE)** The Otter Creek-Conastone 230kV line loads from 148.11% to 150.01% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 11.9MW to the thermal violation.

New System Reinforcements

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

1. The Essex – Hudson 230kV line overload can be alleviated by reconductoring the existing Essex – Hudson 230kV line with 1590 ACSS (6.25 miles) at an estimated cost of **\$10M**. This upgrade will take approximately 2-3 years to complete.

This upgrade also mitigates Network Impact number 2, 3, 4, 5, 6, 7, 8, 11, 36 & 37.

9. The Marion – Hudson 138/230kV transformer overload can be alleviated by replacing the existing transformer with a new transformer (minimum emergency rating of 315MVA). The upgrade will cost approximately **\$10M**.

10. The Hoboken R – Bergen 230kV overload can be alleviated by installing a 4 breaker ring bus at 49th street which taps Hoboken – Bergen. The line from 49th street to Bergen will also need to be reconductored with 1590 ACSS wire. The upgrade will cost approximately **\$21.3**. **This upgrade also mitigates Network Impact number 40.**

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)

12. The Hudson-South Waterfront 230kV line overloads can be alleviated by reconductoring the circuit to increase its normal rating to a minimum of 475MVA and the emergency rating to a minimum of 575MVA. The estimated cost is **\$6 million**.

This upgrade also mitigates Network Impact number 38.

13. The South Waterfront-Newport “R” 230kV line overloads can be alleviated by providing oil circulation to increase the rating by 10%. The estimated cost is **\$5 million**. This upgrade, in

conjunction with the 4-breaker ring bus at 49th street (upgrade for Network Impact 10) will alleviate the overload. **This upgrade also mitigates Network Impact number 39.**

14. The Bergen-Leonia “T” ckt #2 230kV line overload can be alleviated by adding oil circulation to increase the emergency rating by 15%. The estimated cost is **\$2.5M**. The overload will also warrant a cost allocation for a new 230kV line from Athenia – Bergen. The estimated cost of this upgrade is unknown at this time.

15. The Bergen-Leonia “T” ckt #1 230kV line overload can be alleviated by adding oil circulation to increase the emergency rating by 15%. The estimated cost is **\$2.5M**. The overload will also warrant a cost allocation for a new 230kV line from Athenia – Bergen. The estimated cost of this upgrade is unknown at this time. **This upgrade also mitigates Network Impact number 18.**

16. Parlin - Williams (K1025) Upgrade: This overload requires reconductoring of Parlin - Williams line from 1590 Kcmil 45/7 ACSR (2.9 mile DCT) to 1590 Kcmil 54/19 ACSS/AW - Bundled (1.7 mile DCT) for 1642/1850 MVA summer normal/emergency ratings. It also requires replacement of disconnect switch (4000 amp) (1), bundled conductor at Williams substation and at Parlin substation. Total estimated cost is **\$3,860,000**.

17. Williams - Freneau 230 kV (K1025) Upgrade: This overload requires reconductoring of Freneau to Williams line from 1590 Kcmil 45/7 ACSR (7.7 mile) to 1590 Kcmil 54/19 ACSS/AW (7.7 mile) for 869/1068 MVA summer normal/emergency ratings at an estimated cost of \$3,850,000. It requires addition of a disconnect switch (3000 amp) (1) at Freneau substation at an estimated cost of \$75,000 and a disconnect switch (3000 amp) (1) at Williams substation at an estimated cost of \$75,000. It also requires bundled conductor at Freneau substation at an estimated cost of \$20,000 and at Williams substation at an estimated cost of \$20,000. Total estimated cost is **\$4,040,000**.

19. Lackawanna-Oxbow 230kV line: Lackawanna is a PP&L owned substation and any associated terminal upgrades would have to be confirmed by PP&L. This overload would require the rebuild of approximately 16.33 miles of transmission line. (estimated to cost approximately \$19,596,000). This overload also requires the following terminal upgrades at Oxbow substation: replace substation conductor (estimated cost approximately \$125,000) and replace a disconnect switch (estimated cost approximately \$85,000). The total estimated cost is **\$19,806,000**.

This upgrade also mitigates Network Impact number 20.

21. The Oxbow-North Meshoppen 230kV line overload can be alleviated by reconductoring approximately 10.16 miles of transmission line (estimated to cost approximately \$5.08 million), a CT circuit (estimated to cost approximately \$140,000), and substation conductor (estimated to cost approximately \$125,000) at North Meshoppen substation. The total estimated cost is **\$5.345 million**.

This upgrade also mitigates Network Impact number 41.

22. Raphael Rd - Northeast 230 kV 339 line - replace 230kV breaker at Northeast The estimated cost is **\$382,000**.

23. Raphael Rd - Northeast 230 kV 317 line - replace 230kV breaker at Northeast The estimated cost is **\$382,000**.

24. The Conastone-North North West line can be upgraded by adding a single circuit 500kV line at an estimated cost of **\$109 million** and estimated time of 10 yrs.

Assumptions:

New 200 ft. wide R/W parallels existing Conastone to Northwest R/W

Total R/W length = 19.6 miles

3 - bundle 1,590 kcm conductor

North Northwest located 4 miles north of Northwest

This upgrade also mitigates Network Impact number 45.

25. The Northwest-Granite 2311 230kV line overload can be alleviated by replacing the 230kV terminal breaker at Northwest at an estimated cost of **\$383,000**.

26. Conastone – Peach Bottom 500 kV Line - To mitigate the overload of the Conastone – Peach Bottom 500 kV circuit a second circuit will need to be built.

If RIGHT OF WAY can be acquired following is the Reinforcement and Cost Estimates:

PECO portion of the Conastone – Peach Bottom line:

Substation work at Peach Bottom \$ 2,500,000

Construct 6.25 miles of 500kV line \$10,000,000

\$12,500,000

This estimate do not include the cost of new right of way.

Construction of the new line will take approximately **30 months** after the right of way is acquired.

Note: It should be noted that PJM Queue P04 project also requires widening of about two miles of this right of way for their direct connection line and would use the last remaining terminal position that exists at Peach Bottom substation. If Queue P04 proceeds with their project it may complicate right of way acquisition and double the substation costs at Peach Bottom.

BGE portion of the Conastone – Peach Bottom line:

Build new 500 kV line adjacent to existing circuit 5012 from Conastone to Pennsylvania State Line at an estimated cost of **\$48,000,000** and a construction time of approximately **84 months**.

Assumptions:

- Acquire 150 ft. wide R/W adjacent to existing R/W, mostly rural land at \$100,000 per acre
- 2 to 3 year CPCN process prior to land acquisition
- Length of line 9.6 miles

Install one 500kV breaker at Conastone **\$1,500,000**. Breaker installation can be completed concurrently with the line construction.

If RIGHT OF WAY cannot be acquired following is the Reinforcement and Cost Estimates:

The line from Graceton to Peach Bottom is about 7.5 miles long and has a normal rating of 528MVA. Assuming that we could maintain this rating with a single 230 kV pipe type cable (and we may not be able to do this), the new underground installation would cost about \$30M plus another \$1M for terminal modifications. I assume that the underground line will not have to cross any rivers or large creeks. If a cable rating of 450 MVA is insufficient, it will cost an additional \$30M.

Removal of the existing 230 kV tower line is about \$1.5M.

Construction of a double circuit 500kV line from Conastone to Peach Bottom would be about \$3.5M per mile. The line is 16.5 miles long. Total cost \$58M.

Substation additions and modifications at Peach Bottom would cost about \$10M.

Note: Future work is being done by the TOs to come up with reinforcements to further mitigate the overload.

This upgrade also mitigates Network Impact numbers 27.

28. Northwest - Mt Carmel - Conastone upgrade –

This overload requires installation at N. Northwest station - 2-500/230kV xfms 4-500 kV bkrs, 7-230 kV Bkrs and related substation equipment and land at a cost of **\$70M**. It also requires reconductoring of the 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.

This upgrade also mitigates Network Impact numbers 29, 30, and 31.

32. The Northwest-Granite 2326 230kV line overload can be alleviated by reconductoring the line with 2,167 ACSR which will increase the rating to 1105MVA. There will also be substation terminal cost upgrades associated with the reinforcement. The total cost estimate of the reinforcement is approximately **\$23.6M**, and the time estimate for completion is about **6 years**.

33. The Linden – North Ave 138kV line violation can be alleviated by adjusting the angle of the Linden PAR to 270MW out of Bayway. **This upgrade also mitigates Network Impact numbers 34 and 35.**

42. The overload on the Nottingham-Graceton-Peach Bottom 230kV circuit can be alleviated by relocating a portion of this line underground to facilitate the construction of additional 500kV lines between Peach Bottom and Conastone, **\$61 million** and three years to construct. Rebuilding the Peach Bottom to Nottingham portion of the line as a high capacity 230kV line, 1243MVA_n/1411MVA_e, 13.6 miles @ \$1.5 million per mile plus new Susquehanna river crossing, approx **\$40 million** and four years to complete.

This upgrade also mitigates Network Impact numbers 43 and 44.

46. The Manor-Graceton 230kV line overload can be alleviated by reconductoring the line as described:

BGE Upgrade

Reconductor from Graceton to PA line - **\$700,000** ~ 3 yrs.

Existing:

Circuit 2303 is 795 kcm 30/19 ACSR @ 125 C.

Assumptions:

- Reconductor with 1,590 kcm ACSR from Graceton to PA line.
- Length of this line section is 1.4 miles.
- Towers can be reinforced instead of replaced.

Based on previous estimate by R.W.M. for PJM (B48) study on circuit 22008, and Conastone to Ottercreek 2302 estimate (above)

PPL Upgrade - The estimated magnitude cost for this upgrade including substation terminal equipment cost is **\$31,000,000.**

Description of Work:

In order to provide additional capacity on the Graceton – Manor 230kV line, PPL EU is proposing to rebuild the existing single circuit 230kV line composing of 795 ACSR. This rebuild will require new custom embedded steel poles to accommodate the larger conductor size of the new conductor. The new line will be 1590 Kcmil ACSR conductors (1 per phase) designed and operated at 230 kV. The 230 kV lines will be rated for summer normal/emergency of 653/793 MVA respectively. These ratings are based on the conductor ratings and may be lower when the line is actually built.

The rebuild will be 14.4 miles long and will travel the existing right of way.

47. North Meshoppen - East Towanda 230 kV Line - This overload would require the reconductor of approximately 21.66 miles of 230 kV transmission line between North Meshoppen and East Towanda substations, which is estimated to cost approximately

\$16,245,000. This overload also requires the following terminal upgrades at East Towanda substation: replace substation conductor (estimated cost approximately \$125,000), replace line trap (estimated cost approximately \$125,000), replace/upgrade three (3) CT circuits (estimated cost approximately \$420,000), and replace/upgrade two (2) disconnect switches (estimated cost approximately \$170,000). The total estimated cost is **\$17,085,000**

48. Hosensak – North Boyertown 230kV Line – This overload would require the reconductoring of approximately 8 miles of 230kV transmission line with 1590 ACRS wire. The existing structures between Hosensak and North Boyertown are insufficient to support a large size wire, so they will also need to be upgraded. For the worst case scenario where all support structures need to be replaced, the estimated cost of the reinforcement is **\$11,760,000**. The upgrade will take approximately 3 years to complete.

49. Conastone – Otter Creek 230 kV Line -

PPL upgrade

The PPL portion of the Conastone to Otter Creek line (from Otter Creek to the point where ownership changes to BG&E) can be upgraded by reconductoring approximately 17.2 miles of 795 kcmil 30/19 ACSR conductor (Ratings 425/531 MVA Summer Normal/Emergency based on conductor temp @125^oC) with new 795 kcmil 30/19 ACSS (new ratings 516/632 MVA Summer Normal/Emergency, conductor operating temperature of 160^oC)

No terminal equipment upgrade is required at Otter Creek, it is currently built with 2000 amp rating equipment. The estimated cost of this upgrade is **\$8.5 million**. Estimated construction time is **36 months**.

This upgrade will result in minimal change to the impedance of the line.

Existing $Z = 0.0042 + j 0.0266$ pu

New $Z = 0.0048 + j 0.02676$ pu

BG&E Upgrade

The BG&E portion of the Conastone to Otter Creek line can be upgraded by Reconducting from Gorsuch Mills to the Pennsylvania State Line (change of ownership to PPL). The existing circuit 2302 conductor is 1,590 kcmil 45/7 ACSR from Conastone to Gorsuch Mills and 795 kcm 30/19 ACSR from Gorsuch Mills to the PA State Line.

Assumptions:

- Reconductor with 1,590 kcm ACSR from Gorsuch Mills to PA line to match capability of remainder of line.
- Length of this line section is 1.7 miles.
- Towers can be reinforced instead of replaced.
- Based on previous estimate by R.W.M. for PJM (B48) study on circuit 22008

The estimated cost of this upgrade is **\$700,000**. Estimated construction time is **36 months**.

Short Circuit

Our analysis found no new breakers to be over-duty in the PSEG transmission area. The project did have a significant contribution to one breaker which has already been identified as over-duty. The project may receive a cost allocation for its upgrade. This allocation will be determined in the impact study phase. The study was performed on the 230 kV and above system.

Essex 230 kV - 20H

1. The Essex 230 kV line in the case without T44 (original) had a duty percentage of 118.5; in the new case this duty percentage increased to 126.6.

Station	Voltage	Breaker	Int Rating Amps	Calculated Short Circuit Current			
				Before T44		After T44	
				3- phase	Ph-Gnd	3- phase	Ph-Gnd
Essex	230kV	20H	54729.9	49486.4	46753.8	52798	51632.3

Replacement of this breaker is estimated to cost **\$500,000**.

T44 with T42 Option 2:

Generator Deliverability

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

1. **(PSEG)** The Essex-Hudson 1-6 230kV line loads from 96.6% to 113.0% (DC power flow) of its normal rating (716MVA) for the non-contingency condition. This project contributes approximately 117.0MW to cause this thermal violation.

2. **(PSEG)** The Kingsland C-Cook Road C 230kV line loads from 99.7% to 116.3% (DC power flow) of its emergency rating (845MVA) for the single line contingency outage (PS72). This project contributes approximately 141.0MW to cause this thermal violation.

Multiple Facility Contingency

(Double Circuit Tower Line contingencies only for the full energy output. Stuck breaker and bus fault contingencies will be performed for the Impact Study)

3. **(PSEG)** The Foundry-Newark 2 138kV line loads from 93.35% to 105.29% (DC power flow) of its emergency rating (367MVA) for the tower line outage (27PS). This project contributes approximately 43.8MW to cause this thermal violation.

4. **(PSEG)** The Essex PAR-Stanley Terrace 230kV line loads from 94.02% to 114.98% (DC power flow) of its emergency rating (550MVA) for the tower line outage (27PS). This project contributes approximately 115.3MW to cause this thermal violation.

5. **(PSEG)** The Stanley Terrace-Aldene 230kV line loads from 91.31% to 112.27% (DC power flow) of its emergency rating (550MVA) for the tower line outage (27PS). This project contributes approximately 115.3MW to cause this thermal violation.

6. **(PSEG)** The Hoboken R-Bergen 230kV line loads from 97.39% to 104.54% (DC power flow) of its emergency rating (524MVA) for the tower line outage (30PS). This project contributes approximately 37.5MW to cause this thermal violation.

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)

7. **(PSEG)** The Essex-Hudson 1-6 230kV line loads from 126.26% to 146.85% (DC power flow) of its emergency rating (826MVA) for the single line contingency outage (PS20). This project contributes approximately 170.1MW to the thermal violation.

8. **(PSEG)** The Kearny-NJT Meadows 230kV line loads from 108.48% to 125.54% (DC power flow) of its emergency rating (826MVA) for the single line contingency outage (PS72). This project contributes approximately 141.0MW to the thermal violation.

9. **(PSEG)** The Hudson 1-6-S. Waterfront P 230kV line loads from 127.86% to 131.69% (DC power flow) of its normal rating (404MVA) for non-contingency condition. This project contributes approximately 15.5MW to the thermal violation.

10. **(PSEG)** The NJT Meadows-Kingsland C 230kV line loads from 106.58% to 123.65% (DC power flow) of its emergency rating (826MVA) for the single line contingency outage (PS72). This project contributes approximately 141.0MW to the thermal violation.

11. **(PSEG)** The COOK Road C-Athenia 230kV line loads from 101.95% to 120.70% (DC power flow) of its emergency rating (752MVA) for the single line contingency outage (PS72). This project contributes approximately 141.0MW to the thermal violation.

12. **(PSEG)** The S. Waterfront -Newport R 230kV line loads from 117.57% to 123.25% (DC power flow) of its normal rating (315MVA) for non-contingency condition. This project contributes approximately 17.9MW to the thermal violation.
13. **(PSEG)** The Bergen-Leonia T 230kV line loads from 123.47% to 129.09% (DC power flow) of its emergency rating (557MVA) for the single line contingency outage (PS45). This project contributes approximately 31.3MW to the thermal violation.
14. **(PSEG)** The Bergen-Leonia T 230kV line loads from 118.43% to 123.62% (DC power flow) of its emergency rating (557MVA) for the single line contingency outage (PS45B). This project contributes approximately 28.9MW to the thermal violation.
15. **(JCPL)** The Parlin-Williams 230kV line loads from 102.13% to 103.38% (DC power flow) of its emergency rating (805MVA) for the single line contingency outage (JC17). This project contributes approximately 10.1MW to the thermal violation.
16. **(JCPL)** The Williams-Freneau 230kV line loads from 101.50% to 102.75% (DC power flow) of its emergency rating (805MVA) for the single line contingency outage (JC17). This project contributes approximately 10.1MW to the thermal violation.
17. **(PPL/PENELEC)** The Lackawanna-Oxbow 230kV line loads from 170.37% to 172.35% (DC power flow) of its emergency rating (504MVA) for the single line contingency outage (PN18). This project contributes approximately 10.0MW to the thermal violation.
18. **(PSEG)** The Bergen-Leonia T 230kV line loads from 117.77% to 122.49% (DC power flow) of its normal rating (375MVA) for non-contingency condition. This project contributes approximately 17.7MW to the thermal violation.
19. **(PPL/PENELEC)** The Lackawanna-Oxbow 230kV line loads from 164.79% to 166.86% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 10.3MW to the thermal violation.
20. **(PENELEC)** The Oxbow-N. Meshoppen 230kV line loads from 164.62% to 166.68% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 10.3MW to the thermal violation.
21. **(BGE)** The Raphael-Northeast 339 230kV line loads from 141.25% to 142.43% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG8). This project contributes approximately 8.9MW to the thermal violation.
22. **(BGE)** The Raphael-Northeast 317 230kV line loads from 138.48% to 139.64% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG18). This project contributes approximately 8.8MW to the thermal violation.

23. **(BGE)** The Conastone-N. Northwest 500kV line loads from 171.43% to 173.34% (DC power flow) of its normal rating (2078MVA) for non-contingency condition. This project contributes approximately 39.7MW to the thermal violation.
24. **(BGE)** The Northwest 311-Granite 230kV line loads from 174.04% to 175.82% (DC power flow) of its emergency rating (641MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 11.4MW to the thermal violation.
25. **(PECO/BGE)** The Peach Bottom-Conastone 500kV line loads from 166.83% to 168.82% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17). This project contributes approximately 51.7MW to the thermal violation.
26. **(PECO/BGE)** The Peach Bottom-Conastone 500kV line loads from 166.83% to 168.82% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17_2). This project contributes approximately 51.7MW to the thermal violation.
27. **(BGE)** The Conastone-Mt. Carmel 10 230kV line loads from 147.24% to 148.71% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 13.6MW to the thermal violation.
28. **(BGE)** The Conastone-Mt. Carmel 22 230kV line loads from 147.24% to 148.71% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 13.6MW to the thermal violation.
29. **(BGE)** The Mt. Carmel 10-N. Northwest 230kV line loads from 144.95% to 146.42% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 13.6MW to the thermal violation.
30. **(BGE)** The Mt. Carmel 22-N. Northwest 230kV line loads from 144.95% to 146.42% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 13.6MW to the thermal violation.
31. **(BGE)** The Northwest 326-Granite 6 230kV line loads from 123.61% to 124.83% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 11.3MW to the thermal violation.
32. **(PSEG)** The Linden 1-North Ave 138kV line loads from 147.06% to 164.49% (DC power flow) of its emergency rating (308MVA) for the tower line outage (27PS). This project contributes approximately 53.7MW to the thermal violation.

33. **(PSEG)** The ECRR-Foundry 138kV line loads from 113.10% to 125.63% (DC power flow) of its emergency rating (350MVA) for the tower line outage (27PS). This project contributes approximately 43.8MW to the thermal violation.

34. **(PSEG)** The Passaic Valley SC-Bayonne 138kV line loads from 125.12% to 143.08% (DC power flow) of its emergency rating (299MVA) for the tower line outage (27PS). This project contributes approximately 53.7MW to the thermal violation.

35. **(PSEG)** The Bayonne-B-M_REAC 138kV line loads from 129.98% to 147.19% (DC power flow) of its emergency rating (311MVA) for the tower line outage (27PS). This project contributes approximately 53.5MW to the thermal violation.

36. **(PSEG)** The B-M_REAC-Marion 4 138kV line loads from 129.95% to 147.16% (DC power flow) of its emergency rating (311MVA) for the tower line outage (27PS). This project contributes approximately 53.5MW to the thermal violation.

37. **(PSEG)** The North Ave-Passaic Valley SC 138kV line loads from 108.12% to 122.55% (DC power flow) of its emergency rating (372MVA) for the tower line outage (27PS). This project contributes approximately 53.7MW to the thermal violation.

38. **(PSEG)** The Hudson 1-6-S. Waterfront 230kV line loads from 116.18% to 120.35% (DC power flow) of its emergency rating (622MVA) for the tower line outage (24PS). This project contributes approximately 25.9MW to the thermal violation.

39. **(PSEG)** The S. Waterfront-Newport R 230kV line loads from 116.18% to 123.83% (DC power flow) of its emergency rating (490MVA) for the tower line outage (30PS). This project contributes approximately 37.5MW to the thermal violation.

40. **(PSEG)** The Newport R-Hoboken R 230kV line loads from 103.49% to 110.68% (DC power flow) of its emergency rating (521MVA) for the tower line outage (30PS). This project contributes approximately 37.5MW to the thermal violation.

41. **(PENELEC)** The Oxbow-N. Meshoppen 230kV line loads from 170.23% to 172.19% (DC power flow) of its emergency rating (617MVA) for the tower line outage (CONAS_PB). This project contributes approximately 12.1MW to the thermal violation.

42. **(PECO)** The Nottingham-Nottingham Reactor 230kV line loads from 178.28% to 180.24% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 12.3MW to the thermal violation.

43. **(PECO)** The Nottingham Reactor-Peach Bottom 230kV line loads from 178.25% to 180.21% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 12.3MW to the thermal violation.

44. **(PECO/BGE)** The Peach Bottom-Graceton 230kV line loads from 178.25% to 180.21% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 12.3MW to the thermal violation.
45. **(BGE)** The Conastone-N. Northwest 500kV line loads from 154.34% to 155.92% (DC power flow) of its emergency rating (2901MVA) for the tower line outage (CNSTN_NWEST_NNWEST_A). This project contributes approximately 45.9MW to the thermal violation.
46. **(PPL/BGE)** The Manor-Graceton 230kV line loads from 171.73% to 173.80% (DC power flow) of its emergency rating (531MVA) for the tower line outage (CONAS_PB). This project contributes approximately 11.0MW to the thermal violation.
47. **(PENELEC)** The N. Meshoppen-E. Towanda 230kV line loads from 118.20% to 119.92% (DC power flow) of its emergency rating (554MVA) for the tower line outage (CONAS_PB). This project contributes approximately 9.5MW to the thermal violation.
48. **(PPL/METED)** The Hosensack-N. Boyertown 230kV line loads from 103.41% to 105.26% (DC power flow) of its emergency rating (525MVA) for the tower line outage (CONAS_PB). This project contributes approximately 9.7MW to the thermal violation.
49. **(PPL/BGE)** The Otter Creek-Conastone 230kV line loads from 148.11% to 150.01% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 11.9MW to the thermal violation.

New System Reinforcements

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

1. The Essex – Hudson 230kV line overload can be alleviated by constructing a new 230kV line from Hudson to Essex (1590 ACSS). This upgrade will cost approximately **\$10M** and take 2-3 years to complete. **This upgrade also mitigates Network Impact number 2, 4, 5, 7, 8, 10, 11, 36, and 37.**
3. The Foundry – Newark line violation can be alleviated by adjusting the angle of the Linden PAR to 270MW out of Bayway. **This upgrade also mitigates Network Impact numbers 32, 33, and 34.**
6. The Hoboken R – Bergen 230kV overload can be alleviated by installing a 4 breaker ring bus at 49th street which taps Hoboken – Bergen. The line from 49th street to Bergen will also need to be reconducted with 1590 ACSS wire. The upgrade will cost approximately **\$21.3**. **This upgrade also mitigates Network Impact number 40.**

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)

9. The Hudson-South Waterfront 230kV line overloads can be alleviated by reconductoring the circuit to increase its normal rating to a minimum of 475MVA and the emergency rating to a minimum of 575MVA. The estimated cost is **\$6 million**. **This upgrade also mitigates Network Impact number 38.**

12. The South Waterfront-Newport “R” 230kV line overloads can be alleviated by providing oil circulation to increase the rating by 10%. The estimated cost is **\$5 million**. This upgrade, in conjunction with the 4-breaker ring bus at 49th street (upgrade for Network Impact 6) will alleviate the overload. **This upgrade also mitigates Network Impact number 39.**

13. The Bergen-Leonia “T” ckt #2 230kV line overload can be alleviated by adding oil circulation to increase the emergency rating by 15%. The estimated cost is **\$2.5M**. The overload will also warrant a cost allocation for a new 230kV line from Athenia – Bergen. The estimated cost of this upgrade is unknown at this time.

14. The Bergen-Leonia “T” ckt #1 230kV line overload can be alleviated by adding oil circulation to increase the emergency rating by 15%. The estimated cost is **\$2.5M**. The overload will also warrant a cost allocation for a new 230kV line from Athenia – Bergen. The estimated cost of this upgrade is unknown at this time. **The estimated cost is \$2.5 million. This upgrade also mitigates Network Impact number 18.**

15. Parlin - Williams (K1025) Upgrade: This overload requires reconductoring of Parlin - Williams line from 1590 Kcmil 45/7 ACSR (2.9 mile DCT) to 1590 Kcmil 54/19 ACSS/AW - Bundled (1.7 mile DCT) for 1642/1850 MVA summer normal/emergency ratings. It also requires replacement of disconnect switch (4000 amp) (1), bundled conductor at Williams substation and at Parlin substation. Total estimated cost is **\$3,860,000**.

16. Williams - Freneau 230 kV (K1025) Upgrade: This overload requires reconductoring of Freneau to Williams line from 1590 Kcmil 45/7 ACSR (7.7 mile) to 1590 Kcmil 54/19 ACSS/AW (7.7 mile) for 869/1068 MVA summer normal/emergency ratings at an estimated cost of **\$3,850,000**. It requires addition of a disconnect switch (3000 amp) (1) at Freneau substation at an estimated cost of **\$75,000** and a disconnect switch (3000 amp) (1) at Williams substation at an estimated cost of **\$75,000**. It also requires bundled conductor at Freneau substation at an estimated cost of **\$20,000** and at Williams substation at an estimated cost of **\$20,000**.

17. Lackawanna-Oxbow 230kV line: Lackawanna is a PP&L owned substation and any associated terminal upgrades would have to be confirmed by PP&L. This overload would require the rebuild of approximately 16.33 miles of transmission line. (estimated to cost

approximately **\$19,596,000**). This overload also requires the following terminal upgrades at Oxbow substation: replace substation conductor (estimated cost approximately **\$125,000**) and replace a disconnect switch (estimated cost approximately **\$85,000**). **This upgrade also mitigates Network Impact number 19.**

20. The Oxbow-North Meshoppen 230kV line overload can be alleviated by reconductoring approximately 10.16 miles of transmission line (estimated to cost approximately \$5.08 million), a CT circuit (estimated to cost approximately \$140,000), and substation conductor (estimated to cost approximately \$125,000) at North Meshoppen substation. The total estimated cost is **\$5.345 million. This upgrade also mitigates Network Impact number 41.**

21. Raphael Rd - Northeast 230 kV line - both 230kV lines replace 230kV breakers at NE \$382K for each bkr or \$766K. **This upgrade also mitigates Network Impact number 22.**

23. The Conastone-North North West line can be upgraded by adding a single circuit 500kV line at an estimated cost of **\$109 million** and estimated time of 10 yrs.

Assumptions:

New 200 ft. wide R/W parallels existing Conastone to Northwest R/W
Total R/W length = 19.6 miles
3 - bundle 1,590 kcm conductor

North Northwest located 4 miles north of Northwest
This upgrade also mitigates Network Impact number 45.

24. The Northwest-Granite 2311 230kV line overload can be alleviated by reconductoring the line with 2,167 ACSR which will increase the rating to 1105MVA. There will also be substation terminal cost upgrades associated with the reinforcement. The total cost estimate of the reinforcement is approximately **\$23.6M**, and the time estimate for completion is about **6 years**.

25. Conastone – Peach Bottom 500 kV Line - To mitigate the overload of the Conastone – Peach Bottom 500 kV circuit a second circuit will need to be built.

If RIGHT OF WAY can be acquired following is the Reinforcement and Cost Estimates:

<u>PECO portion of the Conastone – Peach Bottom line:</u>	
Substation work at Peach Bottom	\$ 2,500,000
Construct 6.25 miles of 500kV line	<u>\$10,000,000</u>
	\$12,500,000

This estimate do not include the cost of new right of way.
Construction of the new line will take approximately **30 months** after the right of way is acquired.

Note: It should be noted that PJM Queue P04 project also requires widening of about two miles of this right of way for their direct connection line and would use the last remaining terminal position that exists at Peach Bottom substation. If Queue P04 proceeds with their project it may complicate right of way acquisition and double the substation costs at Peach Bottom.

BGE portion of the Conastone – Peach Bottom line:

Build new 500 kV line adjacent to existing circuit 5012 from Conastone to Pennsylvania State Line at an estimated cost of **\$48,000,000** and a construction time of approximately **84 months**.

Assumptions:

- Acquire 150 ft. wide R/W adjacent to existing R/W, mostly rural land at \$100,000 per acre
- 2 to 3 year CPCN process prior to land acquisition
- Length of line 9.6 miles

Install one 500kV breaker at Conastone **\$1,500,000**. Breaker installation can be completed concurrently with the line construction.

If RIGHT OF WAY cannot be acquired following is the Reinforcement and Cost Estimates:

The line from Graceton to Peach Bottom is about 7.5 miles long and has a normal rating of 528MVA. Assuming that we could maintain this rating with a single 230 kV pipe type cable (and we may not be able to do this), the new underground installation would cost about \$30M plus another \$1M for terminal modifications. I assume that the underground line will not have to cross any rivers or large creeks. If a cable rating of 450 MVA is insufficient, it will cost an additional \$30M.

Removal of the existing 230 kV tower line is about \$1.5M.

Construction of a double circuit 500kV line from Conastone to Peach Bottom would be about \$3.5M per mile. The line is 16.5 miles long. Total cost \$58M.

Substation additions and modifications at Peach Bottom would cost about \$10M.

Note: Future work is being done by the TOs to come up with reinforcements to further mitigate the overload.

This upgrade also mitigates Network Impact numbers 26.

27. Northwest - Mt Carmel - Conastone upgrade –

This overload requires to install NNW station 2-500/230kV xfms 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. **This upgrade also mitigates Network Impact numbers 28, 29, and 30.**

31. The Northwest-Granite 2326 230kV line overload can be alleviated by reconductoring the line with 2,167 ACSR which will increase the rating to 1105MVA. There will also be substation terminal cost upgrades associated with the reinforcement. The total cost estimate of the reinforcement is approximately **\$23.6M**, and the time estimate for completion is about **6 years**.

42. The overload on the Nottingham-Graceton-Peach Bottom 230kV circuit can be alleviated by relocating a portion of this line underground to facilitate the construction of additional 500kV lines between Peach Bottom and Conastone, **\$61 million** and three years to construct. Rebuilding the Peach Bottom to Bottingham portion of the line as a high capacity 230kV line, 1243MVA/1411MVAe, 13.6 miles @ \$1.5 million per mile plus new Susquehanna river crossing, approx **\$40 million** and four years to complete. **This upgrade also mitigates Network Impact numbers 43 and 44.**

46. The Manor-Graceton 230kV line overload can be alleviated by reconductoring the line as described:

BGE Upgrade

Reconductor from Graceton to PA line - \$700,000 ~ 3 yrs.

Existing:

Circuit 2303 is 795 kcm 30/19 ACSR @ 125 C.

Assumptions:

- Reconductor with 1,590 kcm ACSR from Graceton to PA line.
- Length of this line section is 1.4 miles.
- Towers can be reinforced instead of replaced.

Based on previous estimate by R.W.M. for PJM (B48) study on circuit 22008, and Conastone to Ottercreek 2302 estimate (above)

PPL Upgrade - The estimated magnitude cost for this upgrade including substation terminal equipment cost is \$31,000,000.

Description of Work:

In order to provide additional capacity on the Graceton – Manor 230kV line, PPL EU is proposing to rebuild the existing single circuit 230kV line composing of 795 ACSR. This rebuild will require new custom embedded steel poles to accommodate the larger conductor size of the new conductor. The new line will be 1590 Kcmil ACSR conductors (1 per phase) designed and operated at 230 kV. The 230 kV lines will be rated for

summer normal/emergency of 653/793 MVA respectively. These ratings are based on the conductor ratings and may be lower when the line is actually built.

The rebuild will be 14.4 miles long and will travel the existing right of way.

47. North Meshoppen - East Towanda 230 kV Line - This overload would require the reconductor of approximately 21.66 miles of 230 kV transmission line between North Meshoppen and East Towanda substations, which is estimated to cost approximately **\$16,245,000**. This overload also requires the following terminal upgrades at East Towanda substation: replace substation conductor (estimated cost approximately **\$125,000**), replace line trap (estimated cost approximately **\$125,000**), replace/upgrade three (3) CT circuits (estimated cost approximately **\$420,000**), and replace/upgrade two (2) disconnect switches (estimated cost approximately **\$170,000**).

48. Hosensak – North Boyertown 230kV Line – This overload would require the reconductoring of approximately 8 miles of 230kV transmission line with 1590 ACRS wire. The existing structures between Hosensak and North Boyertown are insufficient to support a large size wire, so they will also need to be upgraded. For the worst case scenario where all support structures need to be replaced, the estimated cost of the reinforcement is **\$11,760,000**. The upgrade will take approximately 3 years to complete.

49. Conastone – Otter Creek 230 kV Line -

PPL upgrade

The PPL portion of the Conastone to Otter Creek line (from Otter Creek to the point where ownership changes to BG&E) can be upgraded by reconductoring approximately 17.2 miles of 795 kcmil 30/19 ACSR conductor (Ratings 425/531 MVA Summer Normal/Emergency based on conductor temp @125⁰C) with new 795 kcmil 30/19 ACSS (new ratings 516/632 MVA Summer Normal/Emergency, conductor operating temperature of 160⁰C)

No terminal equipment upgrade is required at Otter Creek, it is currently built with 2000 amp rating equipment. The estimated cost of this upgrade is **\$8.5 million**. Estimated construction time is **36 months**.

This upgrade will result in minimal change to the impedance of the line.

Existing $Z = 0.0042 + j 0.0266$ pu

New $Z = 0.0048 + j 0.02676$ pu

BG&E Upgrade

The BG&E portion of the Conastone to Otter Creek line can be upgraded by Reconducting from Gorsuch Mills to the Pennsylvania State Line (change of ownership to PPL). The existing circuit 2302 conductor is 1,590 kcmil 45/7 ACSR from Conastone to Gorsuch Mills and 795 kcm 30/19 ACSR from Gorsuch Mills to the PA State Line.

Assumptions:

- Reconductor with 1,590 kcm ACSR from Gorsuch Mills to PA line to match capability of remainder of line.
- Length of this line section is 1.7 miles.
- Towers can be reinforced instead of replaced.
- Based on previous estimate by R.W.M. for PJM (B48) study on circuit 22008

The estimated cost of this upgrade is **\$700,000**. Estimated construction time is **36 months**.