#T42 Kearny 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 T42 was studied as a 138MW (capacity) injection onto PSEG's system. The project was studied at two different points-of-interconnection. Option 1 is a direct connection to the Kearny 138kV facility, while option 2 is a direct connection to the Kearny 230kV facility. T42 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:

Option #1 – 138kV

Generator Deliverability

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

1. **(JCPL)** The Williams-Freneau 230kV line loads from 99.4% to 100.2% (DC power flow) of its emergency rating (805MVA) for the single line contingency outage (JC17). This project contributes approximately 6.8MW to cause this thermal violation. ***Note that this study was run without the Q75 MTX project modeled. Had Q75 been modeled, this project would only contribute to an already existing overload on Williams-Freneau.

Multiple Facility Contingency

(Double Circuit Tower Line, Line with Failed Breaker and Bus Fault contingencies for the full energy output)

2. **(PSEG)** The Kearny 4-6-Marion 3 138kV line loads from 84.76% to 113.36% (DC power flow) of its emergency rating (482MVA) for the tower line outage (23PS). This project contributes approximately 137.9MW to cause this thermal violation.

Short Circuit

The short circuit analysis of Option 1 found no new breakers to be over-duty in the PSEG transmission area. The study also showed no significant fault current contribution to the breakers which have already been identified as over-duty. This study was performed on the 230 kV and above system.

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)

3. **(PSEG)** The Bayway 2-Federal Square 138kV line loads from 108.74% to 116.1% (DC power flow) of its emergency rating (287MVA) for the single line contingency outage (Bayway_Doremus Ave.). This project contributes approximately 21.0MW to cause this thermal violation.

4. **(PSEG)** The Kearny 4-6-Marion 3 138kV line loads from 107.76% to 146.1% (DC power flow) of its normal rating (360MVA) for non-contingency condition. This project contributes approximately 137.9MW to cause this thermal violation.

5. **(PSEG)** The Federal Square-Newark 3 138kV line loads from 100.54% to 108.4% (DC power flow) of its emergency rating (268MVA) for the single line contingency outage (Bayway_Doremus Ave). This project contributes approximately 21.0MW to cause this thermal violation.

6. **(PSEG)** The Hudson 1-6-South Waterfront P 230kV line loads from 121.75% to 124.97% (DC power flow) of its normal rating (404MVA) for non-contingency condition. This project contributes approximately 13.0MW to the thermal violation.

7. **(PSEG)** The South Waterfront P-Newport R 230kV line loads from 108.53% to 113.54% (DC power flow) of its normal rating (315MVA) for non-contingency condition. This project contributes approximately 15.8MW to the thermal violation.

8. **(PSEG)** The Bergen-Leonia T Ckt #1 230kV line loads from 114.54% to 119.49% (DC power flow) of its emergency rating (557MVA) for the single line contingency outage (PS45). This project contributes approximately 27.6MW to the thermal violation.

9. **(PSEG)** The Bergen-Leonia T Ckt #2 230kV line loads from 110.17% to 114.75% (DC power flow) of its emergency rating (557MVA) for the single line contingency outage (PS45B). This project contributes approximately 25.5MW to the thermal violation.

10. **(PSEG)** The Bergen-Leonia T Ckt #2 230kV line loads from 110.27% to 114.43% (DC power flow) of its normal rating (375MVA) for non-contingency condition. This project contributes approximately 15.6MW to the thermal violation.

11. **(PPL/PENELEC)** The Lackawanna-Oxbow 230kV line loads from 167.06% to 168.39% (DC power flow) of its emergency rating (504MVA) for the single line contingency outage (PN18). This project contributes approximately 6.7MW to the thermal violation.

12. **(PPL/PENELEC)** The Lackawanna-Oxbow 230kV line loads from 161.34% to 162.73% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 6.9MW to the thermal violation.

13. **(PENELEC)** The Oxbow-North .Meshoppen 230kV line loads from 161.17% to 162.55% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 6.9MW to the thermal violation.

14. **(BGE)** The Conastone-N. Northwest 500kV line loads from 168.23% to 169.52% (DC power flow) of its normal rating (2078MVA) for non-contingency condition. This project contributes approximately 26.7MW to the thermal violation.

15. **(BGE)** The Northwest 311-Granite 1 230kV line loads from 171.07% to 172.27% (DC power flow) of its emergency rating (641MVA) for the single line contingency outage (PJM13B_N. Northwest_B). This project contributes approximately 7.7MW to the thermal violation.

16. **(PECO/BGE)** The Peach Bottom-Conastone 500kV line loads from 163.50% to 164.84% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17_2). This project contributes approximately 34.8MW to the thermal violation.

17. **(PECO/BGE)** The Peach Bottom-Conastone 500kV line loads from 163.50% to 164.84% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17). This project contributes approximately 34.8MW to the thermal violation.

18. **(PSEG)** The Hudson 1-6-South Waterfront P 230kV line loads from 109.54% to 113.21% (DC power flow) of its emergency rating (622MVA) for the tower line outage (24PS). This project contributes approximately 22.8MW to the thermal violation.

19. **(PSEG)** The South Waterfront P-Newport R 230kV line loads from 103.86% to 110.39% (DC power flow) of its emergency rating (490MVA) for the tower line outage (30PS). This project contributes approximately 32.0MW to the thermal violation.

20. **(PENELEC)** The Oxbow-North .Meshoppen 230kV line loads from 166.96% to 168.27% (DC power flow) of its emergency rating (617MVA) for the tower line outage (CONAS_PB). This project contributes approximately 8.1MW to the thermal violation.

21. **(PECO)** The Nottingham-Nottingham Reactor 230kV line loads from 175.00% to 176.32% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 8.3MW to the thermal violation.

22. **(PECO/BGE)** The Peach Bottom-Graceton 230kV line loads from 174.97% to 176.29% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 8.3MW to the thermal violation.

23. **(PECO)** The Nottingham Reactor-Peach Bottom Tap 230kV line loads from 174.97% to 176.29% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 8.3MW to the thermal violation.

24. **(BGE)** The Conastone-N. Northwest 500kV line loads from 151.69% to 152.76% (DC power flow) of its emergency rating (2901MVA) for the tower line outage (CNSTN_NWEST_NNWEST_A). This project contributes approximately 30.9MW to the thermal violation.

25. **(PPL/BGE)** The Manor-Graceton 230kV line loads from 168.25% to 169.65% (DC power flow) of its emergency rating (531MVA) for the tower line outage (CONAS_PB). This project contributes approximately 7.4MW to the thermal violation.

26. **(PENELEC)** The North Meshoppen-East Towanda 230kV line loads from 115.33% to 116.48% (DC power flow) of its emergency rating (554MVA) for the tower line outage (CONAS_PB). This project contributes approximately 6.4MW to the thermal violation.

27. **(PPL/METED)** The Hosensack-North Boyertown 230kV line loads from 100.33% to 101.57% (DC power flow) of its emergency rating (525MVA) for the tower line outage (CONAS_PB). This project contributes approximately 6.5MW to the thermal violation. ***This violation was not originally identified by a previous project. However, due to subtle changes in system conditions it now appears as a contribution to a previously identified overload for the T42 queue project.

28. **(PPL/BGE)** The Otter Creek-Conastone 230kV line loads from 144.94% to 146.22% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 8.0MW 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. 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**.

2. The Kearny - Marion 138kV line overload can be alleviated by adding a new 2 mile over-head circuit between Essex and Kearny. A zero impedance connection will also be added to make the Kearny 138kV bus solid. **This upgrade also mitigates Network Impact number 4.**

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)

3. Change winding 1 angle of Linden PAR to 270MW out of Bayway. This reduces overload by 20% on Bayway-Federal Square and 30% on Federal Square to Newark. **This upgrade also mitigates Network Impact number 5**.

6. 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 18**.

7. 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 also mitigates Network Impact number 19**.

8. 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 $2.5 million**.

9. 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 $2.5 million**. **This upgrade also mitigates Network Impact number 10**.

11. 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 12**.

13. 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 20**.

14. 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 24.

15. 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**.

16. 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 17.

21. 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, 1243MVAn/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 22 and 23**.

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

<u>BGE Upgrade</u>

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.

26. 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**).

27. Hosensack – 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 Hosensack 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.

28. 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^{O}C) with new 795 kcmil 30/19

ACSS (new ratings 516/632 MVA Summer Normal/Emergency, conductor operating temperature of 160^{O} C)

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**.

Option #2 - 230kV

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 92.0% to 105.7% (DC power flow) of its emergency rating (826MVA) for the single line contingency outage (PS20). This project contributes approximately 113.3MW to cause this thermal violation.

2. **(JCPL)** The Williams-Freneau 230kV line loads from 99.4% to 100.3% (DC power flow) of its emergency rating (805MVA) for the single line contingency outage (JC17). This project contributes approximately 6.8MW 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 Essex County Resource Recovery-Foundry St. 138kV line loads from 93.46% to 100.58% (DC power flow) of its emergency rating (350MVA) for the tower line outage (27PS). This project contributes approximately 24.9MW to cause this thermal violation.

4. **(PSEG)** The Passaic Valley SC-Bayonne 138kV line loads from 95.24% to 107.16% (DC power flow) of its emergency rating (299MVA) for the tower line outage (27PS). This project contributes approximately 35.7MW to cause this thermal violation.

Short Circuit

The short circuit analysis of Option 2 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. This study was performed on the 230kV system and above.

Essex 230 kV - 20H

1. The Essex 230 kV line in the case without T42 (original) had a duty percentage of 108.2; in the option 2 case this duty percentage increased to 112.4.

Station	Voltage	Breaker	Int Rating Amps	Calculated Short Circuit Current			
				Before T42		After T42	
				3-phase	Ph-Gnd	3-phase	Ph-Gnd
Essex	230kV	20H	49923.8	45199.4	40398.7	47000.7	43207.3

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)

5. **(PSEG)** The Hudson 1-6-South Waterfront P 230kV line loads from 121.75% to 124.02% (DC power flow) of its normal rating (404MVA) for non-contingency condition. This project contributes approximately 9.2MW to the thermal violation.

6. **(PSEG)** The South Waterfront P-Newport R 230kV line loads from 108.53% to 111.89% (DC power flow) of its normal rating (315MVA) for non-contingency condition. This project contributes approximately 10.6MW to the thermal violation.

7. **(PSEG)** The Bergen-Leonia T 230kV line loads from 114.54% to 117.85% (DC power flow) of its emergency rating (557MVA) for the single line contingency outage (PS45). This project contributes approximately 18.5MW to the thermal violation.

8. **(PSEG)** The Bergen-Leonia T 230kV line loads from 110.17% to 113.23% (DC power flow) of its emergency rating (557MVA) for the single line contingency outage (PS45B). This project contributes approximately 17.1MW to the thermal violation.

9. **(PPL/PENELEC)** The Lackawanna-Oxbow 230kV line loads from 167.06% to 168.39% (DC power flow) of its emergency rating (504MVA) for the single line contingency outage (PN18). This project contributes approximately 6.7MW to the thermal violation.

10. **(PSEG)** The Bergen-Leonia T 230kV line loads from 110.27% to 113.06% (DC power flow) of its normal rating (375MVA) for non-contingency condition. This project contributes approximately 10.4MW to the thermal violation.

11. **(PPL/PENELEC)** The Lackawanna-Oxbow 230kV line loads from 161.34% to 162.73% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 6.9MW to the thermal violation.

12. **(PENELEC)** The Oxbow-North Meshoppen 230kV line loads from 161.17% to 162.55% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 6.9MW to the thermal violation.

13. **(BGE)** The Conastone-North Northwest 500kV line loads from 168.23% to 169.52% (DC power flow) of its normal rating (2078MVA) for non-contingency condition. This project contributes approximately 26.7MW to the thermal violation.

14. **(BGE)** The Northwest 311-Granite 230kV line loads from 171.07% to 172.27% (DC power flow) of its emergency rating (641MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 7.7MW to the thermal violation.

15. **(PECO/BGE)** The Peach Bottom-Conastone 500kV line loads from 163.50% to 164.84% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17). This project contributes approximately 34.8MW to the thermal violation.

16. **(PECO/BGE)** The Peach Bottom-Conastone 500kV line loads from 163.50% to 164.84% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17_2). This project contributes approximately 34.8MW to the thermal violation.

17. **(PSEG)** The Linden-North Ave 138kV line loads from 118.05% to 129.63% (DC power flow) of its emergency rating (308MVA) for the tower line outage (27PS). This project contributes approximately 35.7MW to the thermal violation.

18. **(PSEG)** The Bayonne-B-M_REAC 138kV line loads from 101.34% to 112.77% (DC power flow) of its emergency rating (311MVA) for the tower line outage (27PS). This project contributes approximately 35.5MW to the thermal violation.

19. **(PSEG)** The B-M_REAC-Marion 4 138kV line loads from 101.31% to 112.74% (DC power flow) of its emergency rating (311MVA) for the tower line outage (27PS). This project contributes approximately 35.5MW to the thermal violation.

20. **(PSEG)** The Hudson 1-6-South Waterfront P 230kV line loads from 109.54% to 112.01% (DC power flow) of its emergency rating (622MVA) for the tower line outage (24PS). This project contributes approximately 15.3MW to the thermal violation.

21. **(PSEG)** The S outh Waterfront P-Newport R 230kV line loads from 103.86% to 108.53% (DC power flow) of its emergency rating (490MVA) for the tower line outage (30PS). This project contributes approximately 22.9MW to the thermal violation

22. **(PENELEC)** The Oxbow-North .Meshoppen 230kV line loads from 166.96% to 168.27% (DC power flow) of its emergency rating (617MVA) for the tower line outage (CONAS_PB). This project contributes approximately 8.1MW to the thermal violation.

23. **(PECO)** The Nottingham-Nottingham Reactor 230kV line loads from 175.00% to 176.32% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 8.3MW to the thermal violation.

24. **(PECO)** The Nottingham Reactor-Peach Bottom Tap 230kV line loads from 174.97% to 176.29% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 8.3MW to the thermal violation.

25. **(PECO/BGE)** The Peach Bottom Tap-Graceton 230kV line loads from 174.97% to 176.29% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 8.3MW to the thermal violation.

26. **(BGE)** The Conastone-North Northwest 500kV line loads from 151.69% to 152.76% (DC power flow) of its emergency rating (2901MVA) for the tower line outage (CNSTN_NWEST_NNWEST_A). This project contributes approximately 30.9MW to the thermal violation.

27. **(PPL/BGE)** The Manor-Graceton 230kV line loads from 168.25% to 169.65% (DC power flow) of its emergency rating (531MVA) for the tower line outage (CONAS_PB). This project contributes approximately 7.4MW to the thermal violation.

28. **(PENELEC)** The North .Meshoppen-East Towanda 230kV line loads from 115.33% to 116.48% (DC power flow) of its emergency rating (554MVA) for the tower line outage (CONAS_PB). This project contributes approximately 6.4MW to the thermal violation.

29. **(PPL/METED)** The Hosensack-North .Boyertown 230kV line loads from 100.33% to 101.57% (DC power flow) of its emergency rating (525MVA) for the tower line outage (CONAS_PB). This project contributes approximately 6.5MW to the thermal violation.

30. **(PPL/BGE)** The Otter Creek-Conastone 230kV line loads from 144.94% to 146.22% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 8.0MW 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 **$30M**. This upgrade will take approximately 1-2 years to complete.

2. 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**.

3. ECRR-Foundry 138KV line overloads can be alleviated by reducing the flow on the Aldene – Essex PAR to 0MW into Essex 230kV.

This upgrade also mitigates Network Impact number 4.

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)

5. 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 20**.

6. 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 also mitigates Network Impact number 21**.

7. The Bergen-Leonia "T" ckt #2 230kV line overload can be alleviated by adding oil circulation to increase the emergency rating by 15%. Additional engineering, which will be done in the Impact Study, is required to determine if 20% can be achieved. **The estimated cost is $2.5 million**.

8. The Bergen-Leonia "T" ckt #1 230kV line overload can be alleviated by adding oil circulation to increase the emergency rating by 15%. Additional engineering, which will be done in the Impact Study, is required to determine if 20% can be achieved. **The estimated cost is $2.5 million**.

This upgrade also mitigates Network Impact number 10.

9. 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 11**.

12. 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 22**.

13. 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 26.

14. 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**.

15. 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 16.

17. The Linden – North Ave 138kV line violation can be alleviated by installing a new circuit between Essex and Hudson 230kV stations (1590 ACSS). This upgrade will cost approximately **$10M** and take 2-3 years to complete. **This upgrade also mitigates Network Impact numbers 18 and 19**.

23. 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, 1243MVAn/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 24 and 25**.

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

<u>BGE Upgrade</u>
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)

<u>PPL Upgrade</u> - 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.

28. 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**).

29. Hosensack – 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.

30. 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^{O}C) with new 795 kcmil 30/19 ACSS (new ratings 516/632 MVA Summer Normal/Emergency, conductor operating temperature of 160^{O} C)

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**.

31. The overdutied condition of the Essex 20H breaker can be alleviated by replacing the existing circuit breaker with one rated 63 kA. The estimated cost is **$500,000**.