#T119 Sewaren 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 T119 was studied as a 600MW (capacity) injection onto PSEG's Sewaren 230kV switchyard. T119 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 are as follows:

Generator Deliverability

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

1. (**PSEG**) The Tosco-G22_MTX5 230kV line loads from 95.9% to 107.2% (DC power flow) of its emergency rating (1150MVA) for the single line contingency outage (PS10). This project contributes approximately 130.1MW to cause this thermal violation.

2. (**PSEG**) The G22_MTX5-Warinanco 230kV line loads from 97.4% to 117.3% (DC power flow) of its normal rating (653MVA) for non-contingency condition. This project contributes approximately 130.1MW to cause this thermal violation.

3. (**PSEG**) The Aldene-Springfield Road 138kV line loads from 83.8% to 102.4% (DC power flow) of its normal rating (228MVA) for non-contingency condition. This project contributes approximately 42.6MW to cause this thermal violation.

4. (**PSEG/JCP&L**) The Roseland-Whippany 230kV line loads from 97.7% to 100.5% (DC power flow) of its emergency rating (1601MVA) for the single line contingency outage (PS44B). This project contributes approximately 45.4MW 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)

5. (**PSEG**) The Sewaren-Woodbridge "V" 138kV line loads from 95.22% to 115.93% (DC power flow) of its emergency rating (308MVA) for the tower line outage (21PS). This project contributes approximately 63.8MW to cause this thermal violation.

6. (**PSEG**) The Edison 3-Brunswick 138kV line loads from 81.93% to 124.37% (DC power flow) of its emergency rating (308MVA) for the tower line outage (35PS). This project contributes approximately 130.7MW to cause this thermal violation.

Short Circuit

Analysis found 9 new breakers, to be over-dutied in the PSEG transmission area. The new over-dutied breakers are listed below:

Before T119

BUS NO	BUS	BRKR	%	Capacity	Symmetrical Fault Current	3LG Current	1LG Current
5022	SEWAREN 230 kV	1HB	86	37648.3	28772.1	28772.1	24149.3
5021	SEWAREN 138.kV	11P	97.7	41837	31415.1	33087	31415.8
5021	SEWAREN 138.kV	1PL	97.7	41837	31415.1	33087	31415.8
4996	LINDEN 230.kV	40H	96.9	75597.7	55273.5	52622.6	55273.5
4996	LINDEN 230.kV	41 H	96.9	75597.7	55273.5	52622.6	55273.5
4996	LINDEN 230.kV	42H	96.9	75597.7	55273.5	52622.6	55273.5
4996	LINDEN 230.kV	10H	96.7	63000	50806.4	52622.6	55273.5
4996	LINDEN 230.kV	20 H	95.9	63000	50189	52622.6	55273.5
4978	DEANS 230.kV	CAP	98.2	50000	49083.4	47497.6	49083.4

After T119

BUS NO	BUS	BRKR	%	Capacity	Symmetrical Fault Current	3LG Current	1LG Current
5022	SEWAREN 230.kV	1HB	110	37648.3	34771.6	34771.6	32955.3
5021	SEWAREN	11P	103.7	41837	32503.9	34031.2	32887.6

	138.kV SEWAREN						
5021	138.kV LINDEN	1PL	103.7	41837	32503.9	34031.2	32887.6
4996	230.kV LINDEN	40H	101.9	75597.7	58513.7	55917.4	58513.7
4996	230.kV LINDEN	41 H	101.9	75597.7	58513.7	55917.4	58513.7
4996	230.kV LINDEN	42H	101.9	75597.7	58513.7	55917.4	58513.7
4996	230.kV DEANS	20 H	100.9	63000	53083.7	55917.4	58513.7
4978	230.kV	CAP	100.1	50000	50042	48627	50042

In addition, the analysis also showed a significant fault contribution to 5 breakers, which were already identified as over-duty. The breakers are listed below:

Before T119

BUS NO	BUS	BRKR	%	Capacity	Symmetrical Fault Current	3LG Current	1LG Current
5110	230.kV TOSCO 5110	LINDEN	114.2	50000	48054.7	48054.7	46359
5110	TOSCO	WARINANC	114.2	50000	48054.7	48054.7	46359

	5110 230.kV TOSCO						
	5110 230.kV LINDEN						
4996	230.kV LINDEN	11H	104.6	63000	55273.5	52622.6	55273.5
4996	230.kV LINDEN	21H	104.6	63000	55273.5	52622.6	55273.5
4996	230.kV	22H	104.6	63000	55273.5	52622.6	55273.5

After T119

BUS NO	BUS	BRKR	%	Capacity	Symmetrical Fault Current	3LG Current	1LG Current
	5110 230.kV TOSCO						
5110	5110 230.kV LINDEN	LINDEN	119.5	50000	50582.8	50582.8	48399.8
5110	5110 230.kV TOSCO	WARINANCO	119.5	50000	50582.8	50582.8	48399.8
4996	230.kV LINDEN	11H	110.1	63000	58513.7	55917.4	58513.7
4996	230.kV LINDEN	21H	110.1	63000	58513.7	55917.4	58513.7
4996	230.k	22H	110.1	63000	58513.7	55917.4	58513.7

V

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 Tosco-G22_MTX5 230kV line loads from 101.77% to 115.46% (DC power flow) of its normal rating (950MVA) for non-contingency condition. This project contributes approximately 130.1MW to the thermal violation.

8. (**PSEG**) The G22_MTX5-Warinanco 230kV line loads from 102.73% to 120.03% (DC power flow) of its emergency rating (752MVA) for the single line contingency outage (PS10). This project contributes approximately 130.1MW to the thermal violation.

9. (**PPL/PENELEC**) The Lackawanna-Oxbow 230kV line loads from 175.94% to 180.57% (DC power flow) of its emergency rating (504MVA) for the single line contingency outage (APS-SB-658A). This project contributes approximately 23.3MW to the thermal violation.

10. (**PENELEC**) The North. .Meshoppen 230/115kV transformer loads from 145.99% to 150.77% (DC power flow) of its emergency rating (201MVA) for the single line contingency outage (PN47B). This project contributes approximately 9.6MW to the thermal violation.

11. (**PENELEC**) The MESH2REA-NO MESHO 115kV line loads from 145.93% to 150.71% (DC power flow) of its emergency rating (201MVA) for the single line contingency outage (PN47B). This project contributes approximately 9.6MW to the thermal violation.

12. **(AE/PECO)** The Mickleton-Delco Tap 230kV line loads from 104.75% to 108.55% (DC power flow) of its emergency rating (725MVA) for the single line contingency outage (PJM63). This project contributes approximately 27.6MW to the thermal violation.

13. **(PECO)** The Delco Tap-Trainer 2 230kV line loads from 101.08% to 104.42% (DC power flow) of its emergency rating (819MVA) for the single line contingency outage (PJM63). This project contributes approximately 27.3MW to the thermal violation.

14. (**PSEG/JCP&L**) The Roseland-Whippany 230kV line loads from 103.42% to 106.48% (DC power flow) of its normal rating (1303MVA) for non-contingency condition. This project contributes approximately 39.8MW to the thermal violation.

15. **(PPL/PENELEC)** The Lackawanna-Oxbow 230kV line loads from 177.62% to 182.74% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 25.6MW to the thermal violation.

16. **(PENELEC)** The Oxbow-North Meshoppen 230kV line loads from 177.46% to 182.58% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 25.6MW to the thermal violation.

17. **(DP&L)** The Red Lion-Keeney 230kV line loads from 101.16% to 104.97% (DC power flow) of its emergency rating (932MVA) for the single line contingency outage (PJM64). This project contributes approximately 35.5MW to the thermal violation.

18. (**BGE**) The Raphael-Northeast 2339 230kV line loads from 151.10% to 154.58% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG8). This project contributes approximately 26.4MW to the thermal violation.

19. (**BGE**) The Raphael-Northeast 2317 230kV line loads from 148.19% to 151.63% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG18). This project contributes approximately 26.1MW to the thermal violation.

20. (**BGE**) The Conastone-North Northwest 500kV line loads from 189.10% to 194.94% (DC power flow) of its normal rating (2078MVA) for non-contingency condition. This project contributes approximately 121.4MW to the thermal violation.

21. (**BGE**) The Northwest-Granite 2311 230kV line loads from 190.20% to 195.58% (DC power flow) of its emergency rating (641MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 34.5MW to the thermal violation.

22. (**PECO/BGE**) The Peach Bottom-Conastone 500kV line loads from 185.39% to 191.69% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17_2). This project contributes approximately 163.6MW to the thermal violation.

23. **(PENELEC)** The Roxbury 115/138kV transformer loads from 128.99% to 135.05% (DC power flow) of its emergency rating (140MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 8.5MW to the thermal violation.

24. **(PENELEC/AE)** The Roxbury-Greene 138kV line loads from 127.18% to 133.15% (DC power flow) of its emergency rating (142MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 8.5MW to the thermal violation.

25. (**BGE**) The Conastone-Mt. Carmel “22” 230kV line loads from 160.56% to 165.00% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 41.0MW to the thermal violation.

26. (**BGE**) The Conastone-Mt. Carmel “10” 230kV line loads from 160.56% to 165.00% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 41.0MW to the thermal violation.

27. (**BGE**) The Mt. Carmel-North Northwest “22” 230kV line loads from 158.26% to 162.70% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 41.0MW to the thermal violation.

28. (**BGE**) The Mt.Catrmel-North Northwest “10” 230kV line loads from 158.26% to 162.70% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 41.0MW to the thermal violation.

29. **(METED/PENELEC)** The Gardners-Carlisle 115kV line loads from 106.22% to 111.17% (DC power flow) of its emergency rating (109MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 5.4MW to the thermal violation.

30. (**BGE**) The Northwest-Granite 2326 230kV line loads from 134.79% to 138.52% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 34.4MW to the thermal violation.

31. (**PENELEC**) The Oxbow-North Meshoppen 230kV line loads from 193.56% to 198.62% (DC power flow) of its emergency rating (617MVA) for the tower line outage (CONAS_PB). This project contributes approximately 31.2MW to the thermal violation.

32. (**PECO**) The Three Mile Island 500/230kV transformer loads from 158.61% to 163.44% (DC power flow) of its emergency rating (1077MVA) for the tower line outage (CONAS_PB). This project contributes approximately 52.0MW to the thermal violation.

33. (**PECO**) The Nottingham-Nottingham Reactor 230kV line loads from 210.28% to 216.61% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 39.7MW to the thermal violation.

34. (**PECO/BGE**) The Peach Bottom Tap-Graceton 230kV line loads from 210.25% to 216.58% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 39.7MW to the thermal violation.

35. (**PECO**) The Nottingham Reactor-Peach Bottom Tap 230kV line loads from 210.25% to 216.58% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 39.7MW to the thermal violation.

36. (**BGE**) The Conastone-North Northwest 500kV line loads from 179.13% to 183.94% (DC power flow) of its emergency rating (2901MVA) for the tower line outage (CNSTN_NWEST). This project contributes approximately 139.8MW to the thermal violation.

37. (**BGE**) The Manor-Graceton 230kV line loads from 199.99% to 205.87% (DC power flow) of its emergency rating (531MVA) for the tower line outage (CONAS_PB). This project contributes approximately 31.2MW to the thermal violation.

38. (**PENELEC**) The North Meshoppen-East Towanda 230kV line loads from 128.17% to 132.61% (DC power flow) of its emergency rating (554MVA) for the tower line outage (CONAS_PB). This project contributes approximately 24.6MW to the thermal violation.

39. (**PECO**) The Peach Bottom-Three Mile Island 500kV line loads from 102.79% to 105.16% (DC power flow) of its emergency rating (2596MVA) for the tower line outage (CONAS_PB). This project contributes approximately 61.6MW to the thermal violation.

40. (**PPL/METED**) The Hosensack-North Boyertown 230kV line loads from 113.83% to 118.61% (DC power flow) of its emergency rating (525MVA) for the tower line outage (CONAS_PB). This project contributes approximately 25.1MW to the thermal violation.

41. **(BGE)** The North Northwest-Kempton 500kV line loads from 159.48% to 164.34% (DC power flow) of its emergency rating (2901MVA) for the tower line outage (CNSTN_NWEST_NNWEST_B). This project contributes approximately 140.8MW to the thermal violation.

42. **(PPL/BGE)** The Otter Creek-Conastone 230kV circuit loads from 174.66% to 180.15% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 34.4MW 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 Tosco – G22 Sub 230kV line overload can be alleviated by constructing a new 5.5 mile 230kV over-head circuit between Tosco and Aldene. The estimated cost of the new line is **$20M**. If during the design its determined that an overhead line is infeasible, two underground 230kV lines will be required to provide the required capacity. The cost estimate of two underground 230kV lines is about $100M. **This upgrade also mitigates Network Impact number 2, 7, and 8.**

3. The Aldene – Springfield Road 138kV underground cable will need to be reconductored since the limiting element is the rating of the conductor. The estimated cost of the reconductoring is $**10M – 12M** with an estimated time to complete of 2 years.

4. PSEG did not identify the Roseland – Whippany line as being overloaded by the T119 project, so a reinforcement was not provided. Should the project decided to proceed to an impact study phase, a retooled study will be performed to determine whether an upgrade to this line will actually be needed.

5. The Sewaren – Woodbridge H1360 138kV line overload can be alleviated by reconductoring the line to an emergency rating of 370MVA. The cost estimate of this upgrade is **$4.5M**.

6. The Edison – Brunswick V-1322 138kV line overload can be alleviated by reconductoring the line to an emergency rating of 410MVA. The cost estimate of this upgrade is **$3.2M**.

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. 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 15**.

10. N. Meshoppen 230/115 kV transformer #3: The rating for the North Meshoppen 230/115 kV #3 transformer is 146 MVA N/ 157 MVA E. This overload would require the upgrade of the transmission transformer and associated equipment (circuit breaker, substation conductor, CT circuits), which is estimated to cost approximately **$4M** and requires a lead time of at least 2 years. **This upgrade also mitigates Network Impact number 11**.

12. Mickelton – Delco Tap 230kV line: To mitigate this overload would require upgrading the 220-53 and 220-38 circuit by reconductoring. These circuits are scheduled to be reconductored in 2008. The estimated cost to perform this work is $**0 dollars**.

13. Delco Tap – Trainer 230kV line: To mitigate this overload would require the teardown and rebuild to 1243/1410 MVA rating along with the replacement of terminal equipment. The estimated cost to perform this work is **$7.1M** and will require **48 months** to complete.

16. 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 31**.

17. To mitigate the Red Lion-Keeney 230kV (DP&L) line overload would require the replacement of the 2000A wave trap. The estimated cost to perform this work is **$300,000** with a **12 month** lead time.

18. The Raphael – North East 230kV line: To mitigate the overloads would require increasing the rated conductor temp to 160°C, which attains 1153 MVA. The existing conductor is 2,167 ACSR @ 125°C. The transmission line is 3.9 miles long. Approximately 7 spans have ground clearance of less than 35 feet. Assume replacement of 5 double circuit steel poles to increase ground clearance. The estimated cost to perform the line and substation work is **$6,000,000** and will require **5 years** to complete. **This upgrade also mitigates Network Impact number 19**.

20. 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 36.

21. 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**.

22. BG&E portion of the Conastone – Peach Bottom line:

Conastone Substation - 3 - 4 years to complete – total estimate for this work is **$39,000,000**

- Rebuild 3 existing bays to 4000A (also add breaker in one of the existing bays)
- Build new 4000A bay and install 3 breakers
- Relocate Hunterstown 500kV line
- Replace 4 inch bus with 5 inch

Transmission Line Component - 7 years to build after notice to proceed - total estimate for this work is **$320,200,000**

- 2 - Double Circuit 500 kV OH lines from Conastone - Graceton - MD line ($136)
- 2 - UG 230 kV circuits from Conastone - Graceton ($122.4)*
- 3 - UG 230 kV circuit from Graceton - MD line ($30.6)
- 1 - UG 115 kV circuit from Graceton - Five Forks ($9.0)
- Acquire additional 50 ft. wide R/W Graceton - MD line ($2.2)

• Remove existing OH lines/structures ($2.0)

* assumes RTEP project b0497 Install a second Conastone - Graceton 230 kV circuit

PECO portion of the Conastone – Peach Bottom line:

Assumes 500 kV lines with ratings equal to the rating of the 4 inch diameter aluminum bus work at Peach Bottom, i.e. 3366 MVA normal and 4183 MVA emergency are able to be built.

• Relocate Peach Bottom to Graceton 220-08 line to underground to facilitate construction of additional 500kV lines in the Conastone to Peach Bottom right of way. The estimated cost to perform this work is **$29,600,000**

• The underground line will require parallel pipe type cables to achieve a rating of 800MVA. The estimated cost to perform this work is **$61,000,000** and 36 months to complete.

Note: the 220-08 line is an offsite source for the Peach Bottom Atomic Power Station and its integrity must be maintained.

• Remove existing 220-08 line towers to clear the north side of the right of way for 500kV construction. The estimated cost to perform this work is **$1,500,000** and 6 months to complete.

• Construct new double circuit 500kV line on the north side of the 300 foot wide Peach Bottom to Maryland state line right of way. The estimated cost to perform this work is **$17,000,000** and 30 months to complete after the removal of the existing 230 kV tower line.

• Remove existing 5012 line towers to clear the south side of the right of way for new higher capacity 500kV lines. The estimated cost to perform this work is **$1,500,000** and 6 months to complete.

• Construct second new double circuit 500kV line on the south side of the Peach Bottom to Maryland state line right of way. The estimated cost to perform this work is **$17,000,000** and 30 months to complete after the removal of the existing 500 kV tower line.

• Upgrade 5012 line substation equipment to achieve the new higher rating. The estimated cost to perform this work is **$3,000,000** and 18 months to complete.

• Expand the 500kV substations (North and South) at Peach Bottom to accommodate three additional 500kV lines. The estimated cost to perform this work is **$18,000,000** ($6M per new line) and 30 months to complete.

Note: The substation work may have to be coordinated with refueling outages at the Peach Bottom Atomic Power Station and that the overall project may overstress several 500 kV circuit breakers.

23. The Roxbury 138/115kV transformer overload would require the upgrade of the transmission transformer and associated equipment (circuit breaker, substation conductor, CT circuits), which is estimated to cost approximately **$2.25M** and requires a lead time of at least **2 years**. **This upgrade also mitigates Network Impact number 24**.

25. **Northwest - Mt Carmel - Conastone upgrade –**

This overload requires installation at a new North Northwest station 2-500/230kV transformers, 4-500 kV circuit breakers, 7-230 kV circuit breakers and related substation equipment and land at a cost of **$70M**. It also requires reconductoring the Conastone to Northwest #2322 circuit with 1,272kcmil ACSR 1,590kcmil ACSR at an estimated cost of **$8.21**. This work would take 3-4 years to build substation and 18-24 months for the line work.

Additional Upgrade:

- Install 2 single circuit 500 kV lines between Kemptown and North Northwest at an estimated cost of **$ 279 million** and estimated time of 10 yrs.

  Assumptions:
  New 350 ft. wide R/W parallels existing Northwest to Mt Airy Tap R/W
  Total R/W length = 28.3 miles
  3 - bundle 1,590 kcm conductor
  Kemptown located 1/4 mile west of Mt Airy Tap
  North Northwest located 4 miles north of Northwest

  Substation Terminations (all in 2012 dollars):
  North Northwest - Install a 3 breaker bay **$7.7M**
  Kemptown - Install a 3 breaker bay **$7.7M**

- Install a single circuit 500 kV line between Conastone and North Northwest 500 kV 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

  Substation Terminations (all in 2012 dollars):
  Conastone - Install a 1 breaker bay $3.2M
  NNW - Install a 2 breaker bay $6.4M

This upgrade also mitigates Network Impact number 25, 26, 27, and 28.

29. The Gardners – Carlisle 115kV line will not actually become overloaded due to a pre-contingency PJM operating procedure. A study (if necessary) will be performed in the impact study to see if this operating procedure causes any additional overloads to the system.

30. 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**.

32. To mitigate the Three Mile Island 500/230kV (METED) transformer overload would require the addition of a second 500/230kV transformer at TMI as well as transmission line upgrades between the 230kV and 500kV substations. The estimated cost to perform this work is **$15,000,000** and will take **36 months** to complete. **It should be noted that a second transformer at TMI may cause further overloading on the surrounding 230kV system. A more extensive study will be performed in the impact study to determine whether additional reinforcements are needed.**

33. 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 plusa new Susquehanna River crossing, approx **$40** million and four years to complete. **This upgrade also mitigates Network Impact numbers 34 and 35**.

37. 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.

38. North Meshoppen - East Towanda 230 kV Line - This overload would require the reconductoring 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**).

39. Peach Bottom –Three Mile Island 500kV Line – This overload requires the replacement of the appropriate circuit breakers and wave trap. The cost estimate for this upgrade is approximately **$3M**, and it will take about **30 months** to complete.

40. 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.

41. Kemptown to North Northwest 500 kV line - 2 single circuit lines at an estimated cost of **$ 279 million** and estimated time of 10 yrs.

Assumptions:
New 350 ft. wide R/W parallels existing Northwest to Mt Airy Tap R/W
Total R/W length = 28.3 miles
3 - bundle 1,590 kcm conductor
Kemptown located 1/4 mile west of Mt Airy Tap
North Northwest located 4 miles north of Northwest

Substation Terminations (all in 2012 dollars):
NNW - Install a 3 breaker bay **$7.7M**

Kemptown - Install a 3 breaker bay **$7.7M**

42. Conastone – Otter Creek 230 kV Upgrade:

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**.

43. Breaker replacemnts.

a. The breaker replacements at Linden are estimated to cost **$1 million** each because the ground grid and bus work will need to be replaced.
b. The estimated cost for the replacement of the other circuit breakers, except for those at Tosco, is estimated to cost **$0.5 million** each.
c. The circuit breakers at Tosco will require the installation of grading capacitors to increase the rating at an estimated cost of **$0.1 million** each.