#T38 Delco Tap 900 MW

Generator Interconnection

This analysis was completed to assess the reliability impact for a new generator interconnecting to the PJM System as a Capacity Resource.

Network Impacts (Option #1)

The T38 project was studied as a 900 MW Capacity injection into the Trainer – Mickleton 230 kV line. Project T38 was evaluated for compliance with reliability criteria for summer peak conditions in 2012. Potential network impacts were as follows:

NETWORK IMPACTS – OPTION #1

Generator Deliverability

(Normal System with all facilities in-service and Single, or N-1, contingencies for the Capacity portion only of the interconnection)

1. **(PENELEC/NYISO)** The LAUREL L-GOUDY115 115kV line loads from 99.0% to 103.9% (DC power flow) of its emergency rating (129MVA) for the single line contingency outage (PN20). This project contributes approximately 6.3MW to cause this thermal violation.

2. **(PECO/AEC)** The DELCOTAP-MCKLTON 230kV line loads from 2.8% to 126.9% (DC power flow) of its emergency rating (725MVA) for the single line contingency outage (PE53). This project contributes approximately 899.6MW to cause this thermal violation.

3. **(PECO/AEC)** The DELCOTAP-MCKLTON 230kV line loads from 33.0% to 110.9% (DC power flow) of its normal rating (605MVA) for non-contingency condition. This project contributes approximately 470.9MW to cause this thermal violation.

4. **(PECO)** The MACDADE3-ELMWOOD 230kV line loads from 98.8% to 107.3% (DC power flow) of its emergency rating (1339MVA) for the single line contingency outage (PE23). This project contributes approximately 112.5MW to cause this thermal violation.

5. **(PECO)** The ISLANDRD-GRAYSFR8 230kV line loads from 94.4% to 102.3% (DC power flow) of its emergency rating (1374MVA) for the single line contingency outage (PE46). This project contributes approximately 109.3MW to cause this thermal violation.

6. **(PECO)** The ELMWOOD8-GRAYSF93 230kV line loads from 94.1% to 102.5% (DC power flow) of its emergency rating (1339MVA) for the single line contingency outage (PE23). This project contributes approximately 112.5MW to cause this thermal violation.

7. **(PECO)** The PARRISH8-MASTER 230kV line loads from 91.5% to 102.1% (DC power flow) of its emergency rating (874MVA) for the single line contingency outage (PE69). This project contributes approximately 92.2MW to cause this thermal violation.

8. **(PECO)** The EDDYSTN4-PRINTZ 230kV line loads from 96.4% to 106.4% (DC power flow) of its emergency rating (1193MVA) for the single line contingency outage (PE23). This project contributes approximately 118.7MW to cause this thermal violation.

9. **(AEC/PSEG)** The MONROE-NEW FRDM 230kV line loads from 94.7% to 129.7% (DC power flow) of its emergency rating (725MVA) for the single line contingency outage (PS18). This project contributes approximately 253.9MW to cause this thermal violation.

10. **(PSEG)** The THOROFAR-DEPTFORD 230kV line loads from 90.9% to 113.8% (DC power flow) of its normal rating (653MVA) for non-contingency condition. This project contributes approximately 149.7MW to cause this thermal violation.

11. **(PECO)** The DELCOTAP-TRAINER2 230kV line loads from 61.9% to 114.3% (DC power flow) of its normal rating (819MVA) for non-contingency condition. This project contributes approximately 428.8MW to cause this thermal violation.

12. **(PSEG)** The DEPTFORD-EAGLE PT 230kV line loads from 77.4% to 100.3% (DC power flow) of its normal rating (653MVA) for non-contingency condition. This project contributes approximately 149.7MW to cause this thermal violation.

13. **(PECO)** The RIDLEY-MORTON2 230kV line loads from 96.8% to 109.8% (DC power flow) of its emergency rating (613MVA) for the single line contingency outage (PE4). This project contributes approximately 79.6MW to cause this thermal violation.

14. **(PECO)** The TRAINER-CHIREACT 230kV line loads from 55.3% to 107.6% (DC power flow) of its normal rating (819MVA) for non-contingency condition. This project contributes approximately 428.8MW to cause this thermal violation.

15. **(PECO)** The CHIREACT-CHICHST2 230kV line loads from 55.3% to 107.6% (DC power flow) of its normal rating (819MVA) for non-contingency condition. This project contributes approximately 428.8MW to cause this thermal violation.

16. **(PECO)** The CHICHST1-EDDYSTN4 230kV line loads from 92.7% to 110.9% (DC power flow) of its emergency rating (1235MVA) for the single line contingency outage (PE4). This project contributes approximately 225.3MW to cause this thermal violation.

17. **(PECO)** The CHICHST1-FOULK8 230kV line loads from 86.4% to 102.4% (DC power flow) of its emergency rating (1335MVA) for the single line contingency outage (PE36). This project contributes approximately 214.0MW to cause this thermal violation.

18. **(PECO)** The MORTON-MIDDLTW8 230kV line loads from 88.9% to 101.9% (DC power flow) of its emergency rating (613MVA) for the single line contingency outage (PE4). This project contributes approximately 79.6MW to cause this thermal violation.

19. **(DELMARVA)** The RL_230-KEEN_230 230kV line loads from 94.0% to 101.5% (DC power flow) of its emergency rating (932MVA) for the single line contingency outage (PJM64). This project contributes approximately 70.1MW to cause this thermal violation.

20. **(BGE)** The CNASTONE-CONASTON 500/230kV transformer loads from 96.96% (DC power flow) to 102.42% of its emergency rating (1500MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 81.8MW to cause this thermal violation.

21. **(BGE)** The CNASTONE-CONASTON 500/230kV transformer loads from 96.96% (DC power flow) to 102.42% of its emergency rating (1500MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 81.8MW to cause this thermal violation.

22. **(METED/PENELEC)** The GARDNERS-CARLISLE 115kV line loads from 93.2% to 100.8% (DC power flow) of its emergency rating (109MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 8.2MW to cause this thermal violation.

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Multiple Facility Contingency

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

23. **(PECO)** The DELCOTAP-TRAINER2 230kV line loads from 87.78% to 146.96% (DC power flow) of its emergency rating (819MVA) for the tower line outage (4AE_A19). This project contributes approximately 484.7MW to cause this thermal violation.

24. **(PECO)** The TRAINER-CHIREACT 230kV line loads from 81.14% to 140.33% (DC power flow) of its emergency rating (819MVA) for the tower line outage (4AE_A19). This project contributes approximately 484.7MW to cause this thermal violation.

25. **(PECO)** The CHIREACT-CHICHST2 230kV line loads from 81.12% to 140.31% (DC power flow) of its emergency rating (819MVA) for the tower line outage (4AE_A19). This project contributes approximately 484.7MW 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)

26. **(PECO)** The PRINTZ-RIDLEY 230kV line loads from 113.59% to 121.69% (DC power flow) of its emergency rating (1432MVA) for the single line contingency outage (PE23). This project contributes approximately 115.9MW to the thermal violation.

27. **(PECO)** The EDDYSTN3-ISLANDR6 230kV line loads from 106.78% to 114.95% (DC power flow) of its emergency rating (1410MVA) for the single line contingency outage (PE46). This project contributes approximately 115.1MW to the thermal violation.

28. **(PECO)** The RIDLEY-MACDADE 230kV line loads from 100.71% to 108.57% (DC power flow) of its emergency rating (1432MVA) for the single line contingency outage (PE23). This project contributes approximately 112.5MW to the thermal violation.

29. **(AEC/PSEG)** The MCKLTON-THOROFAR 230kV line loads from 144.29% to 177.47% (DC power flow) of its normal rating (451MVA) for non-contingency condition. This project contributes approximately 149.7MW to the thermal violation.

30. **(PSEG)** The GLOUCSTR-CUTHBERT 138kV line loads from 125.71% to 141.03% (DC power flow) of its normal rating (239MVA) for non-contingency condition. This project contributes approximately 36.6MW to the thermal violation.

31. **(PSEG)** The GLOUCSTR-GLOUCSTR 230/138kV transformer loads from 121.55% to 134.17% (DC power flow) of its emergency rating (341MVA) for the single line contingency outage (PJM89A). This project contributes approximately 43.0MW to the thermal violation.

32. **(PSEG)** The GLOUCSTR-CUTHBERT 138kV line loads from 121.30% to 133.92% (DC power flow) of its emergency rating (341MVA) for the single line contingency outage (PJM89A). This project contributes approximately 43.0MW to the thermal violation.

33. **(AEC)** The MCKLTON-MONROE 230kV line loads from 133.99% to 168.44% (DC power flow) of its emergency rating (446MVA) for the single line contingency outage (AE12). This project contributes approximately 153.7MW to the thermal violation.

34. **(AEC)** The MCKLTON-MONROE 230kV line loads from 133.99% to 168.44% (DC power flow) of its emergency rating (446MVA) for the single line contingency outage (AE2_A19). This project contributes approximately 153.7MW to the thermal violation.

35. **(PSEG)** The GLOUCSTR-GLOUCSTR 230/138kV transformer loads from 113.69% to 127.50% (DC power flow) of its normal rating (265MVA) for non-contingency condition. This project contributes approximately 36.6MW to the thermal violation.

36. **(AEC)** The MCKLTON-MONROE 230kV line loads from 112.57% to 141.52% (DC power flow) of its normal rating (365MVA) for non-contingency condition. This project contributes approximately 105.7MW to the thermal violation.

37. **(AEC)** The MCKLTON-MONROE 230kV line loads from 112.57% to 141.52% (DC power flow) of its normal rating (365MVA) for non-contingency condition. This project contributes approximately 105.7MW to the thermal violation.

38. **(PSEG)** The EAGLE PT-GLOUCSTR 230kV line loads from 105.94% to 128.70% (DC power flow) of its normal rating (653MVA) for non-contingency condition. This project contributes approximately 148.6MW to the thermal violation.

39. **(PENELEC/PPL)** The LACKAWNA-OXBOW 230kV line loads from 168.79% to 174.48% (DC power flow) of its emergency rating (504MVA) for the single line contingency outage (PN18). This project contributes approximately 28.7MW to the thermal violation.

40. **(PENELEC)** The N.MESHPN-MESH2REA 230/115kV transformer loads from 135.90% to 141.44% (DC power flow) of its emergency rating (201MVA) for the single line contingency outage (PN47B). This project contributes approximately 11.1MW to the thermal violation.

41. **(PENELEC)** The MESH2REA-NO MESHO 115kV line loads from 135.84% to 141.37% (DC power flow) of its emergency rating (201MVA) for the single line contingency outage (PN47B). This project contributes approximately 11.1MW to the thermal violation.

42. **(PENELEC/PPL)** The LACKAWNA-OXBOW 230kV line loads from 163.18% to 169.08% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 29.5MW to the thermal violation.

43. **(PENELEC)** The OXBOW-N.MESHPN 230kV line loads from 163.00% to 168.90% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 29.5MW to the thermal violation.

44. **(BGE)** The RAPHAEL-NEAST339 230kV line loads from 136.77% to 142.34% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG8). This project contributes approximately 42.2MW to the thermal violation.

45. **(BGE)** The RAPHAEL-NEAST317 230kV line loads from 134.05% to 139.55% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG18). This project contributes approximately 41.7MW to the thermal violation.

46. **(BGE)** The CNASTONE-N-NWEST 500kV line loads from 165.82% to 175.35% (DC power flow) of its normal rating (2078MVA) for non-contingency condition. This project contributes approximately 198.0MW to the thermal violation.

47. **(BGE)** The NWEST311-GRANITE1 230kV line loads from 168.92% to 177.62% (DC power flow) of its emergency rating (641MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 55.7MW to the thermal violation.

48. **(PECO/BGE)** The PEACHBTM-CNASTONE 500kV line loads from 160.23% to 171.08% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17). This project contributes approximately 281.9MW to the thermal violation.

49. **(PECO/BGE)** The PEACHBTM-CNASTONE 500kV line loads from 160.23% to 171.08% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17_2). This project contributes approximately 281.9MW to the thermal violation.

50. **(PENELEC)** The ROXBURY-ROXBURY 115/138kV transformer loads from 111.39% to 119.86% (DC power flow) of its emergency rating (140MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 11.9MW to the thermal violation.

51. **(BGE)** The CONASTON-MT CAR22 230kV line loads from 143.03% to 150.16% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 65.9MW to the thermal violation.

52. **(BGE)** The CONASTON-MT CAR10 230kV line loads from 143.03% to 150.16% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 65.9MW to the thermal violation.

53. **(BGE)** The MT CAR10-N-NWEST 230kV line loads from 140.73% to 147.87% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 65.9MW to the thermal violation.

54. **(BGE)** The MT CAR22-N-NWEST 230kV line loads from 140.73% to 147.87% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 65.9MW to the thermal violation.

55. **(BGE)** The NWEST326-GRANITE6 230kV line loads from 120.07% to 126.08% (DC power flow) of its emergency rating (923MVA) for the single line contingency

outage (PJM13B_NNWEST_B). This project contributes approximately 55.5MW to the thermal violation.

56. **(BGE)** The NEAST317-N.EAST 230/115kV transformer loads from 134.81% to 139.90% (DC power flow) of its emergency rating (378MVA) for the tower line outage (NORTHEAST_RIVERSIDE). This project contributes approximately 19.2MW to the thermal violation.

57. **(AEC/PSEG)** The MCKLTON-THOROFAR 230kV line loads from 174.90% to 217.16% (DC power flow) of its emergency rating (566MVA) for the tower line outage (4AE_A19). This project contributes approximately 239.2MW to the thermal violation.

58. **(PSEG)** The EAGLE PT-GLOUCSTR 230kV line loads from 137.13% to 168.79% (DC power flow) of its emergency rating (752MVA) for the tower line outage (4AE_A19). This project contributes approximately 238.1MW to the thermal violation.

59. **(PSEG)** The THOROFAR-DEPTFORD 230kV line loads from 137.97% to 173.35% (DC power flow) of its emergency rating (676MVA) for the tower line outage (4AE_A19). This project contributes approximately 239.2MW to the thermal violation.

60. **(PSEG)** The DEPTFORD-EAGLE PT 230kV line loads from 112.29% to 144.10% (DC power flow) of its emergency rating (752MVA) for the tower line outage (4AE_A19). This project contributes approximately 239.2MW to the thermal violation.

61. **(PENELEC)** The OXBOW-N.MESHPN 230kV line loads from 167.96% to 174.31% (DC power flow) of its emergency rating (617MVA) for the tower line outage (CONAS_PB). This project contributes approximately 39.2MW to the thermal violation.

62. **(PPL/METED)** The BRUNNER-YORKANA 230kV line loads from 124.68% to 130.49% (DC power flow) of its emergency rating (617MVA) for the tower line outage (CONAS_PB). This project contributes approximately 35.8MW to the thermal violation.

63. **(METED)** The 3 MILE I-TMI 500/230kV transformer loads from 131.28% to 139.37% (DC power flow) of its emergency rating (1077MVA) for the tower line outage (CONAS_PB). This project contributes approximately 87.1MW to the thermal violation.

64. **(METED)** The TMI-JACKSON1 230kV line loads from 104.59% to 110.61% (DC power flow) of its emergency rating (599MVA) for the tower line outage (CONAS_PB). This project contributes approximately 36.1MW to the thermal violation.

65. **(PECO)** The NOTTNGHM-NOTTREAC 230kV line loads from 165.20% to 177.97% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 80.1MW to the thermal violation.

66. **(PECO)** The NOTTREAC-PCHBTMTP 230kV line loads from 165.16% to 177.94% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 80.1MW to the thermal violation.

67. **(PECO/BGE)** The PCHBTMTP-GRACETON 230kV line loads from 165.16% to 177.94% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 80.1MW to the thermal violation.

68. **(PENELEC/APS)** The ROXBURY-01GREENE 138kV line loads from 111.93% to 121.28% (DC power flow) of its emergency rating (142MVA) for the tower line outage (CONAS_PB). This project contributes approximately 13.3MW to the thermal violation.

69. **(BGE)** The CNASTONE-N-NWEST 500kV line loads from 149.73% to 157.55% (DC power flow) of its emergency rating (2901MVA) for the tower line outage (CNSTN_NWEST). This project contributes approximately 226.8MW to the thermal violation.

70. **(PPL/BGE)** The MANOR-GRACETON 230kV line loads from 168.52% to 176.37% (DC power flow) of its emergency rating (531MVA) for the tower line outage (CONAS_PB). This project contributes approximately 41.7MW to the thermal violation.

71. **(PENELEC)** The N.MESHPN-E.TWANDA 230kV line loads from 116.21% to 121.78% (DC power flow) of its emergency rating (554MVA) for the tower line outage (CONAS_PB). This project contributes approximately 30.9MW to the thermal violation.

72. **(PPL/METED)** The HOSENSAK-N.BOYTWN 230kV line loads from 101.00% to 107.16% (DC power flow) of its emergency rating (525MVA) for the tower line outage (CONAS_PB). This project contributes approximately 32.4MW to the thermal violation.

73. **(PPL/BGE)** The OTTERCRK-CONASTON 230kV line loads from 144.26% to 152.12% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 49.3MW to the thermal violation.

NETWORK UPGRADE REQUIREMENTS – OPTION #1

General Notes pertaining to cost allocation rules for overloads: (also see the PJM Tariff and Manual 14)

The first project to cause an overload has cost responsibility.

If this Queue is not the first project to cause the overload, a threshold of;

(a) 1% increase in overloaded facility loading must be caused by the this Queue generation,

and

(b) This Queue's MW contribution of 5.0 MW or greater are both required for cost allocation responsibility.

And

If this Queue is not the first project to cause the overload but both conditions (a) and (b) above are met, then a threshold of Either of the following are also required for cost allocation responsibility;

(c) A 5% generator DFAX (5 MW contribution for a generation request size of 100 MW),*

or

(d) This Queue's generation must cause an increase of 5% (230 kV) or 10% (500 kV) to the overloaded facility loading

** DFAX may not be equal to this Queue's contribution divided by generator MW size in some cases.*

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 Laurel – Goudy 115kV line overload will be alleviated by a PJM operating procedure which will open this line pre-contingency if the contingency scenario mentioned (PN20) occurs.

2. The Delco Tap – Mickleton 230kV line (PECO portion) overload can be alleviated by rebuilding the 220-38 river crossing circuit to a rating of 1243N/1410E MVA. The appropriate terminal equipment will also need to be replaced. The line rebuild will cost about **$20M**, and the terminal equipment replacement will cost about **$2.5M**. The upgrade will take about **48 months** to complete.

The Delco Tap – Mickleton 230kV line (AE portion) overload can be alleviated by a rebuild and reconductoring the line section with a bundled conductor. This upgrade will take **36 months** to complete and cost about $18.1 M. The Delaware River crossing will also need to be rebuilt and reconductored at an estimated cost of $90 M. The total AE cost of upgrades for the thermal violation on the Mickleton-Delco Tap 230 kV line section is **$108.1 M**. **These upgrades also mitigate Network Impact number 3.**

4. The MacDade – Elmwood 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

5. The Island Road – Grays Ferry 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

6. The Elmwood – Grays Ferry 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

7. The Master – Parrish 230kV line overload can be alleviated by reconductoring the line (Amtrak ROW). The line reconductoring will cost about **$4.0M** and will take about **36 months** to complete.

8. The Eddystone – Printz 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

9. The Monroe - New Freedom 230 kV line overload can be alleviated by a rebuild and reconductor of the line with a bundled conductor. This upgrade will take **36 months** to complete and cost about **$16.6 M**.

10. The Eagle Pt-Gloucester overload can be alleviated by the following upgrade:

Line upgrades
Reconductor 4 miles of the O-2241 Thorofare – Deptford 230kV line at a cost of **$3.5M**
Reconductor 1 mile of the V-2274 Deptford – Eagle Pt 230kV line at a cost of **$1.2M**
Reconductor 3 miles of the P-2242 Eagle Pt – Gloucester 230kV line at a cost of **$2.6M**
Reconductor 5 miles of the Q-1343 Gloucester – Cuthbert 230kV line at a cost of **$19.4M**

Substation upgrades
Upgrade the appropriate Thorofare IP terminal equipment at a cost of **$0.5M**
Upgrade the appropriate Deptford IP terminal equipment at a cost of **$1.2M**
Upgrade the appropriate Eagle Pt IP terminal equipment at a cost of **$1.2M**
Upgrade the appropriate Gloucester IP terminal equipment at a cost of **$1.2M**
Upgrade the Gloucester transformer at a cost of **$3.975M**
Upgrade the appropriate Cuthbert IP terminal equipment at a cost of $0.2M

This upgrade also mitigates Network Impact number 12, 30, 31, 32, 35, 38, 58, 59, and 60.

11. The Delco Tap – Trainer 230kV line overload can be alleviated by tearing down and rebuilding the existing 230kV line. This will increase the line rating to 1243N/1410E MVA. The appropriate terminal equipment will also need to be replaced. The line rebuild will cost about **$2.1M** while the terminal equipment replacement will cost about **$5.0M**. The upgrade will take about **42 months** to complete. **This upgrade also mitigates Network Impact number 23.**

13. The Ridley – Morton 230kV line overload can be alleviated by adding a second 230kV pipe type cable. The upgrade will cost about **$8.3M** and will take about **42 months** to complete.

14. The Trainer – Chichester 230kV line overload can be alleviated by tearing down and rebuilding the existing 230kV line. This will increase the line rating to 1243N/1410E MVA. The line rebuild will cost about **$4.2M** and will take about **48 months** to complete. **This upgrade also mitigates Network Impact number 24.**

15. The Trainer – Chichester line reactor overload can be alleviated by simply removing the reactor from the system. The removal will cost about **$0.1M** and will take about **6 months** to complete. **This upgrade also mitigates Network Impact number 25.**

16. The Chichester – Eddystone 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

17. The Chichester – Foulk 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

18. The Morton – Middletown 230kV line overload can be alleviated by adding a second 230kV pipe type cable. The upgrade will cost about **$18M** and will take about **42 months** to complete.

19. The Keeney – Red Lion 230kV line overload can be alleviated by the replacement of a wave trap which will increase the line rating to 916 (SN) and 1036 (SE). The upgrade will cost about **$300,000** and will take about **12 months** to complete.

20. The Conastone-North North West overloads can be alleviated 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 21, 46, and 69.

22. The Gardners – Carlisle 115kV line overload will be alleviated by a PJM operating procedure which will open this line pre-contingency if the contingency scenario mentioned (PJM13B_NNWEST_A) occurs.

Contribution to Previously Identified System Reinforcements
(This project contributes to the Network Impact causing the need for these Network Upgrades. This project will be allocated a cost to be determined during the Impact Study)

26. The Printz – Ridley 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

27. The Eddystone – Island Road 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

28. The Ridley – MacDade 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

29. The Mickleton – Thorofare 230kV line overload (AE portion) can be alleviated by a rebuild and reconductoring of the line with a bundled conductor. This upgrade will take

36 months to complete and will cost about **$4.1 M**. **This upgrade also mitigates Network Impact number 57**.

33. The Mickleton-Monroe ckt#1 230 kV line overload can be alleviated by a reconductoring of the line with an ACSS/TW conductor. This upgrade will take **30 months** to complete and will cost about **$4.5 M**. **This upgrade also mitigates Network Impact number 36**.

34. The Mickleton-Monroe ckt#2 230 kV line overload can be alleviated by a reconductoring of the line with an ACSS/TW conductor. This upgrade will take **30 months** to complete and will cost about **$4.5 M**. **This upgrade also mitigates Network Impact number 37**.

39. The Lackawanna – Oxbow 230kV line: The Penelec portion of the upgrade involves the rebuild of 16.33 miles of transmission line as well as substation work at the Oxbow facility. The estimated cost of the Penelec upgrade is **$19.771M** and it would take **4-5 years** to complete. PPL owns the Lackawanna substation. PPL is assuming that terminal upgrade work would be required at the Lackawanna substation. The estimated cost for the terminal upgrade is **$500,000**. **This upgrade also mitigates Network Impact number 42**.

40. The N. Meshoppen 230/115 kV ckt#3 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 **$4M** and requires a lead time of at least **24 months**. **This upgrade also mitigates Network Impact number 41**.

43. The Oxbow – N. Meshopen 230kV line overload require the rebuild of approximately 10.16 miles of transmission line This overload also requires the replacement of a disconnect switch and replacement of substation conductor at Oxbow substation. North Meshoppen substation requires the upgrade/replacement of two (2) CT circuits, substation conductor, and a line/wave trap. The total cost of the upgrade is estimated to be **$12.939M** and it would take **4-5 years** to complete the work. **This upgrade also mitigates Network Impact number 61**.

44. The Raphael Rd - Northeast 230 kV line overload 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 45**.

47. The Northwest 311 – Granite1 230kV overload can be alleviated by reconductoring the line with 2,167 ACSR. There will also be substation terminal cost upgrades

associated with the reinforcement. The estimated cost to perform the substation and transmission line work is **$23.6M** and will require **6 years** to complete.

48. The Peach Bottom – Conastone 500kV line (PECO portion) overload can be alleviated by building a new (third) 500kV line on new right of way. The Peach Bottom 500kV substation will also need to be expanded. The cost of building the new 500kV line will be about **$15.0M** and the cost of expanding the substation will be about **$10M**. The upgrade will take about **8 years** to complete. **This upgrade also mitigates Network Impact number 49.**

50. The Roxbury 138/115 kV 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**.

51. The Northwest - Mt Carmel - Conastone overload requires installation at N. Northwest station - 2-500/230kV xfmrs 4-500 kV bkrs, 7-230 kV Bkrs and related substation equipment and land at a cost of **$70M**. It also requires 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 number 52, 53, and 54.**

55. The Northwest 326 – Granite6 230kV overload can be alleviated by reconductoring the line with 2,167 ACSR. There will also be substation terminal cost upgrades associated with the reinforcement. The estimated cost to perform the substation and transmission line work is **$23.6M** and will require **6 years** to complete.

56. The Northeast 230/115 kV transformer overload requires that the transformer be replaced with a 500MVA unit. The estimated cost to replace the transformer is **$10.2M**.

62. The Brunner Island – Yorkana 230kV line: Meted owns 12.6 miles of the transmission line and the Yorkana substation. PPL owns .64 miles of the transmission line and the Brunner Island substation. The PPL portion of the line will be rebuilt with 1590 ACSR cable. The cost of the rebuilt and the terminal work at Brunner Island is **$2M**.

63. To mitigate the 3 MILE I-TMI 500/230kV (METED) transformer would require the installation of a second 500/230kV transformer. The estimated cost to perform this work is **$11.8M** and will take **20 months** to complete.

64. The TMI – Jackson 230kV overload requires the replacement of 18.05 miles of 230kV line, as well as substation upgrades at both TMI and Jackson. The total estimated cost of this upgrade is **$10.91M**.

65. The Nottingham – Peach Bottom line reactor overload can be alleviated by replacing the line reactor. The upgrade will cost about **$0.2M** and will take about **18 months** to complete.

66. The Nottingham – Peach Bottom 230kV line overload can be alleviated by tearing down and rebuilding the existing 230kV line. This will increase the line rating to 1243N/1410E MVA. This portion of the upgrade will cost **$40M** and take **4 years** to complete. A second 230kV line will also need to be constructed on new right of way at a cost of **$40M** and a time estimate of **10 years**. Finally, a new substation will need to be built at Peach Bottom at a cost of **$10M and** an estimated **4 years** to complete.

67. The Peach Bottom – Graceton 230kV line (PECO and BGE portions) overload can be alleviated by replacing the existing 230kV line with a double circuit 230kV underground cable capable of handling about 1226MVA during emergency conditions. The upgrade will cost about **$61M** and will take about **48 months** to complete.

68. Greene to Roxbury 138 kV line - This upgrade would be addressed with the replacement/upgrade of the Roxbury 138/115 kV transformer. 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 **$2.25M** and requires a lead time of at least **2 years**.

70. The Manor – Graceton 230kV line: PPL owns 14.5 miles of the transmission line and the Manor substation. BGE owns 1.4 miles of the transmission line and the Graceton substation. The PPL portion of the line will be rebuilt with 1590 ACSR cable. The cost of the rebuilt and the terminal work at Manor is **$36M**.

71. 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. The East Towanda substation would require the replacement of a line/wave trap, disconnect switch, and CT circuit. The North Meshoppen substation would require the upgrade or replacement of two CT circuits as well as the replacement of substation conductor. The estimated cost of this upgrade is **$16,245,000**, and it would take **4-5 years** to complete.

72. 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.

73. The Otter Creek - Conastone 230kV line: PPL owns 12 miles of the transmission line and the Otter Creek substation. BGE owns 4.7 miles of the transmission line and the Conastone substation. The PPL portion of the line will be reconductored with 795 ACSS cable. The cost of the reconductoring and the terminal work at Otter Creek is **$6M**.

Option #2

Network Impacts
and
Network Upgrade Requirements

Network Impacts (Option #2)

The T38 project was studied as a 900 MW Capacity injection into the Chichester 230 kV bus. Project T38 was evaluated for compliance with reliability criteria for summer peak conditions in 2012. Potential network impacts were as follows:

NETWORK IMPACTS – OPTION #2

Generator Deliverability

(Normal System with all facilities in-service and Single, or N-1, contingencies for the Capacity portion only of the interconnection)

1. **(PECO)** The BRADFRD2-PLANBRK1 230kV line loads from 92.5% to 102.2% (DC power flow) of its emergency rating (621MVA) for the single line contingency outage (PE31). This project contributes approximately 60.3MW to cause this thermal violation.

2. **(PENELEC/NYISO)** The LAUREL L-GOUDY115 115kV line loads from 99.0% to 103.8% (DC power flow) of its emergency rating (129MVA) for the single line contingency outage (PN20). This project contributes approximately 6.2MW to cause this thermal violation.

3. **(PECO)** The MACDADE3-ELMWOOD 230kV line loads from 98.8% to 114.3% (DC power flow) of its emergency rating (1339MVA) for the single line contingency outage (PE23). This project contributes approximately 207.2MW to cause this thermal violation.

4. **(PECO)** The PARRISH8-MASTER 230kV line loads from 86.3% to 104.8% (DC power flow) of its normal rating (736MVA) for non-contingency condition. This project contributes approximately 136.7MW to cause this thermal violation.

5. **(PECO)** The ISLANDRD-GRAYSFR8 230kV line loads from 94.4% to 108.9% (DC power flow) of its emergency rating (1374MVA) for the single line contingency outage (PE46). This project contributes approximately 198.9MW to cause this thermal violation.

6. **(PECO)** The ELMWOOD8-GRAYSF93 230kV line loads from 94.1% to 109.5% (DC power flow) of its emergency rating (1339MVA) for the single line contingency outage (PE23). This project contributes approximately 207.2MW to cause this thermal violation.

7. **(PECO)** The PARRISH8-MASTER 230kV line loads from 91.5% to 112.3% (DC power flow) of its emergency rating (874MVA) for the single line contingency outage (PE69). This project contributes approximately 181.6MW to cause this thermal violation.

8. **(PECO)** The EDDYSTN4-PRINTZ 230kV line loads from 96.4% to 114.0% (DC power flow) of its emergency rating (1193MVA) for the single line contingency outage (PE23). This project contributes approximately 208.9MW to cause this thermal violation.

9. **(PECO)** The CHICHST1-EDDYSTN4 230kV line loads from 92.7% to 124.0% (DC power flow) of its emergency rating (1235MVA) for the single line contingency outage (PE4). This project contributes approximately 386.0MW to cause this thermal violation.

10. **(PECO)** The RIDLEY-MORTON2 230kV line loads from 96.8% to 117.2% (DC power flow) of its emergency rating (613MVA) for the single line contingency outage (PE4). This project contributes approximately 125.0MW to cause this thermal violation.

11. **(PECO)** The GRAYSF71-TUNNEL2 230kV line loads from 84.7% to 107.5% (DC power flow) of its emergency rating (1395MVA) for the single line contingency outage (PE69). This project contributes approximately 318.0MW to cause this thermal violation.

12. **(AEC/PSEG)** The MONROE-NEW FRDM 230kV line loads from 94.7% to 102.7% (DC power flow) of its emergency rating (725MVA) for the single line contingency outage (PS18). This project contributes approximately 58.1MW to cause this thermal violation.

13. **(PECO)** The TUNNEL-PARRISH9 230kV line loads from 82.5% to 105.3% (DC power flow) of its emergency rating (1395MVA) for the single line contingency outage (PE69). This project contributes approximately 318.0MW to cause this thermal violation.

14. **(PECO)** The FOULK-CONCORD6 230kV line loads from 83.6% to 110.7% (DC power flow) of its emergency rating (1335MVA) for the single line contingency outage (PE36). This project contributes approximately 362.2MW to cause this thermal violation.

15. **(PECO)** The MORTON-MIDDLTW8 230kV line loads from 88.9% to 109.3% (DC power flow) of its emergency rating (613MVA) for the single line contingency outage (PE4). This project contributes approximately 125.0MW to cause this thermal violation.

16. **(BGE)** The CNASTONE-CONASTON 500/230kV transformer loads from 96.96% (DC power flow) to 102.19% of its emergency rating (1500MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 78.4MW to cause this thermal violation.

17. **(BGE)** The CNASTONE-CONASTON 500/230kV transformer loads from 96.96% (DC power flow) to 102.19% of its emergency rating (1500MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 78.4MW to cause this thermal violation.

18. **(METED/PENELEC)** The GARDNERS-CARLISLE 115kV line loads from 93.2% to 100.8% (DC power flow) of its emergency rating (109MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 8.2MW to cause this thermal violation.

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

No problems identified.

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)

19. **(PECO)** The PRINTZ-RIDLEY 230kV line loads from 113.59% to 127.99% (DC power flow) of its emergency rating (1432MVA) for the single line contingency outage (PE23). This project contributes approximately 206.1MW to the thermal violation.

20. **(PECO)** The EDDYSTN3-ISLANDR6 230kV line loads from 106.78% to 121.63% (DC power flow) of its emergency rating (1410MVA) for the single line contingency outage (PE46). This project contributes approximately 209.3MW to the thermal violation.

21. **(PECO)** The RIDLEY-MACDADE 230kV line loads from 100.71% to 115.18% (DC power flow) of its emergency rating (1432MVA) for the single line contingency outage (PE23). This project contributes approximately 207.2MW to the thermal violation.

22. **(AEC/PSEG)** The MCKLTON-THOROFAR 230kV line loads from 144.29% to 151.45% (DC power flow) of its normal rating (451MVA) for non-contingency condition. This project contributes approximately 32.3MW to the thermal violation.

23. **(AEC)** The MCKLTON-MONROE 230kV line loads from 133.99% to 142.08% (DC power flow) of its emergency rating (446MVA) for the single line contingency outage (AE2_A19). This project contributes approximately 36.1MW to the thermal violation.

24. **(AEC)** The MCKLTON-MONROE 230kV line loads from 133.99% to 142.08% (DC power flow) of its emergency rating (446MVA) for the single line contingency outage (AE12). This project contributes approximately 36.1MW to the thermal violation.

25. **(AEC)** The MCKLTON-MONROE 230kV line loads from 112.57% to 119.37% (DC power flow) of its normal rating (365MVA) for non-contingency condition. This project contributes approximately 24.8MW to the thermal violation.

26. **(AEC)** The MCKLTON-MONROE 230kV line loads from 112.57% to 119.37% (DC power flow) of its normal rating (365MVA) for non-contingency condition. This project contributes approximately 24.8MW to the thermal violation.

27. **(PSEG)** The EAGLE PT-GLOUCSTR 230kV line loads from 105.94% to 110.75% (DC power flow) of its normal rating (653MVA) for non-contingency condition. This project contributes approximately 31.4MW to the thermal violation.

28. **(PENELEC/PPL)** The LACKAWNA-OXBOW 230kV line loads from 168.79% to 174.33% (DC power flow) of its emergency rating (504MVA) for the single line contingency outage (PN18). This project contributes approximately 27.9MW to the thermal violation.

29. **(PENELEC)** The N.MESHPN-MESH2REA 230/115kV transformer loads from 135.90% to 141.29% (DC power flow) of its emergency rating (201MVA) for the single line contingency outage (PN47B). This project contributes approximately 10.8MW to the thermal violation.

30. **(PENELEC)** The MESH2REA-NO MESHO 115kV line loads from 135.84% to 141.22% (DC power flow) of its emergency rating (201MVA) for the single line contingency outage (PN47B). This project contributes approximately 10.8MW to the thermal violation.

31. **(PENELEC/PPL)** The LACKAWNA-OXBOW 230kV line loads from 163.18% to 168.92% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 28.7MW to the thermal violation.

32. **(PENELEC)** The OXBOW-N.MESHPN 230kV line loads from 163.00% to 168.74% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 28.7MW to the thermal violation.

33. **(BGE)** The RAPHAEL-NEAST339 230kV line loads from 136.77% to 143.60% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG8). This project contributes approximately 51.8MW to the thermal violation.

34. **(BGE)** The RAPHAEL-NEAST317 230kV line loads from 134.05% to 140.80% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG18). This project contributes approximately 51.1MW to the thermal violation.

35. **(BGE)** The CNASTONE-N-NWEST 500kV line loads from 165.82% to 175.25% (DC power flow) of its normal rating (2078MVA) for non-contingency condition. This project contributes approximately 195.9MW to the thermal violation.

36. **(BGE)** The NWEST311-GRANITE1 230kV line loads from 168.92% to 177.60% (DC power flow) of its emergency rating (641MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 55.6MW to the thermal violation.

37. **(PECO/BGE)** The PEACHBTM-CNASTONE 500kV line loads from 160.23% to 170.81% (DC power flow) of its emergency rating (2598MVA) for the single line

contingency outage (PJM17_2). This project contributes approximately 274.9MW to the thermal violation.

38. **(PENELEC)** The ROXBURY-ROXBURY 115/138kV transformer loads from 111.39% to 119.79% (DC power flow) of its emergency rating (140MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 11.8MW to the thermal violation.

39. **(BGE)** The CONASTON-MT CAR10 230kV line loads from 143.03% to 150.18% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 66.1MW to the thermal violation.

40. **(BGE)** The MT CAR22-N-NWEST 230kV line loads from 140.73% to 147.89% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 66.1MW to the thermal violation.

41. **(BGE)** The MT CAR10-N-NWEST 230kV line loads from 140.73% to 147.89% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 66.1MW to the thermal violation.

42. **(BGE)** The NWEST326-GRANITE6 230kV line loads from 120.07% to 126.06% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 55.3MW to the thermal violation.

43. **(BGE)** The NEAST317-N.EAST 230/115kV transformer loads from 134.81% to 140.14% (DC power flow) of its emergency rating (378MVA) for the tower line outage (NORTHEAST_RIVERSIDE). This project contributes approximately 20.1MW to the thermal violation.

44. **(AEC/PSEG)** The MCKLTON-THOROFAR 230kV line loads from 174.90% to 184.32% (DC power flow) of its emergency rating (566MVA) for the tower line outage (4AE_A19). This project contributes approximately 53.3MW to the thermal violation.

45. **(PSEG)** The EAGLE PT-GLOUCSTR 230kV line loads from 137.13% to 144.10% (DC power flow) of its emergency rating (752MVA) for the tower line outage (4AE_A19). This project contributes approximately 52.4MW to the thermal violation.

46. **(PSEG)** The THOROFAR-DEPTFORD 230kV line loads from 137.97% to 145.86% (DC power flow) of its emergency rating (676MVA) for the tower line outage (4AE_A19). This project contributes approximately 53.3MW to the thermal violation.

47. **(PSEG)** The DEPTFORD-EAGLE PT 230kV line loads from 112.29% to 119.38% (DC power flow) of its emergency rating (752MVA) for the tower line outage (4AE_A19). This project contributes approximately 53.3MW to the thermal violation.

48. **(PENELEC)** The OXBOW-N.MESHPN 230kV line loads from 167.96% to 174.14% (DC power flow) of its emergency rating (617MVA) for the tower line outage (CONAS_PB). This project contributes approximately 38.1MW to the thermal violation.

49. **(PPL/METED)** The BRUNNER-YORKANA 230kV line loads from 124.68% to 130.28% (DC power flow) of its emergency rating (617MVA) for the tower line outage (CONAS_PB). This project contributes approximately 34.6MW to the thermal violation.

50. **(METED)** The 3 MILE I-TMI 500/230kV transformer loads from 131.28% to 139.11% (DC power flow) of its emergency rating (1077MVA) for the tower line outage (CONAS_PB). This project contributes approximately 84.2MW to the thermal violation.

51. **(PECO)** The NOTTNGHM-NOTTREAC 230kV line loads from 165.20% to 182.20% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 106.6MW to the thermal violation.

52. **(PECO)** The NOTTREAC-PCHBTMTP 230kV line loads from 165.16% to 182.17% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 106.6MW to the thermal violation.

53. **(PECO/BGE)** The PCHBTMTP-GRACETON 230kV line loads from 165.16% to 182.17% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 106.6MW to the thermal violation.

54. **(METED)** The TMI-JACKSON1 230kV line loads from 104.59% to 110.45% (DC power flow) of its emergency rating (599MVA) for the tower line outage (CONAS_PB). This project contributes approximately 35.1MW to the thermal violation.

55. **(PENELEC/APS)** The ROXBURY-01GREENE 138kV line loads from 111.93% to 121.13% (DC power flow) of its emergency rating (142MVA) for the tower line outage (CONAS_PB). This project contributes approximately 13.1MW to the thermal violation.

56. **(BGE)** The CNASTONE-N-NWEST 500kV line loads from 149.73% to 157.50% (DC power flow) of its emergency rating (2901MVA) for the tower line outage (CNSTN_NWEST_NNWEST_A). This project contributes approximately 225.4MW to the thermal violation.

57. **(PPL/BGE)** The MANOR-GRACETON 230kV line loads from 168.52% to 175.88% (DC power flow) of its emergency rating (531MVA) for the tower line outage (CONAS_PB). This project contributes approximately 39.1MW to the thermal violation.

58. **(PENELEC)** The N.MESHPN-E.TWANDA 230kV line loads from 116.21% to 121.63% (DC power flow) of its emergency rating (554MVA) for the tower line outage (CONAS_PB). This project contributes approximately 30.1MW to the thermal violation.

59. **(PPL/METED)** The HOSENSAK-N.BOYTWN 230kV line loads from 101.00% to 107.10% (DC power flow) of its emergency rating (525MVA) for the tower line outage (CONAS_PB). This project contributes approximately 32.0MW to the thermal violation.

60. **(PPL/BGE)** The OTTERCRK-CONASTON 230kV line loads from 144.26% to 151.91% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 48.0MW to the thermal violation.

NETWORK UPGRADE REQUIREMENTS – OPTION #2

General Notes pertaining to cost allocation rules for overloads: (also see the PJM Tariff and Manual 14)

The first project to cause an overload has cost responsibility.

If this Queue is not the first project to cause the overload, a threshold of;

(a) 1% increase in overloaded facility loading must be caused by the this Queue generation,

and

(b) This Queue's MW contribution of 5.0 MW or greater are both required for cost allocation responsibility.

And

If this Queue is not the first project to cause the overload but both conditions (a) and (b) above are met, then a threshold of Either of the following are also required for cost allocation responsibility;

(c) A 5% generator DFAX (5 MW contribution for a generation request size of 100 MW),*

or

(d) This Queue's generation must cause an increase of 5% (230 kV) or 10% (500 kV) to the overloaded facility loading

** DFAX may not be equal to this Queue's contribution divided by generator MW size in some cases.*

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 Bradford – Planebrook 230kV line overload can be alleviated by reconductoring the line and replacing the appropriate relay equipment. The line reconductoring will cost about **$4.2M** and the relay equipment replacement will cost about **$0.5M**. The upgrades will take about **36 months** to complete.

2. The Laurel – Goudy 115kV line overload will be alleviated by a PJM operating procedure which will open this line pre-contingency if the contingency scenario mentioned (PN20) occurs.

3. The MacDade – Elmwood 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

4. The Master – Parrish 230kV line overload can be alleviated by reconductoring the line (Amtrak ROW) and replacing the appropriate terminal equipment. The line reconductoring will cost about **$4.0M** and the terminal equipment replacement will cost about **$5.0M**. The upgrades will take about **36 months** to complete. **This upgrade also mitigates Network Impact number 7.**

5. The Island Road – Grays Ferry 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

6. The Elmwood – Grays Ferry 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

8. The Eddystone – Printz 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

9. The Chichester – Eddystone 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

10. The Ridley – Morton 230kV line overload can be alleviated by adding a second 230kV pipe type cable. The upgrade will cost about **$8.3M** and will take about **42 months** to complete.

11. The Grays Ferry – Tunnel 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete. It should be noted that the Grays Ferry to Tunnel to Parish circuit will be reconductored in 2011 for an emergency rating of 882 MVA.

12. The Monroe - New Freedom 230 kV line overload can be alleviated by a rebuild and reconductor of the line with a bundled conductor. This upgrade will take **36 months** to complete and cost about **$16.6 M**.

13. The Tunnel – Parrish 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete. It should be noted that the Grays Ferry to Tunnel to Parish circuit will be reconductored in 2011 for an emergency rating of 882 MVA.

14. The Foulk – Concord 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

15. The Morton – Middletown 230kV line overload can be alleviated by adding a second 230kV pipe type cable. The upgrade will cost about **$18M** and will take about **42 months** to complete.

16. The Conastone-North North West overloads can be alleviated 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 17, 35, and 56.

18. The Gardners – Carlisle 115kV line overload will be alleviated by a PJM operating procedure which will open this line pre-contingency if the contingency scenario mentioned (PJM13B_NNWEST_A) occurs.

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)

19. The Printz – Ridley 230kV line overload can be alleviated by reconductoring the line and replacing the appropriate relay equipment. The line reconductoring will cost about **$2.7M** and the relay equipment replacement will cost about **$5.0M**. The upgrades will take about **36 months** to complete.

20. The Eddystone – Island Road 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

21. The Ridley – MacDade 230kV line overload can be alleviated by replacing the appropriate terminal equipment. The upgrade will cost about **$5.0M** and will take about **30 months** to complete.

22. The Mickleton – Thorofare 230kV line overload (AE portion) can be alleviated by a rebuild and reconductoring of the line with a bundled conductor. This upgrade will take **36 months** to complete and will cost about **$4.1 M**. **This upgrade also mitigates Network Impact number 44**.

23. The Mickleton-Monroe ckt#2 230 kV line overload can be alleviated by a reconductoring of the line with an ACSS/TW conductor. This upgrade will take **30 months** to complete and will cost about **$4.5 M**. **This upgrade also mitigates Network Impact number 25**.

24. The Mickleton-Monroe ckt#1 230 kV line overload can be alleviated by a reconductoring of the line with an ACSS/TW conductor. This upgrade will take **30 months** to complete and will cost about **$4.5 M**. **This upgrade also mitigates Network Impact number 26**.

27. The Eagle Pt-Gloucester overload can be alleviated by the following upgrade:

Line upgrades
Reconductor 4 miles of the O-2241 Thorofare – Deptford 230kV line at a cost of **$3.5M**
Reconductor 1 mile of the V-2274 Deptford – Eagle Pt 230kV line at a cost of **$1.2M**
Reconductor 3 miles of the P-2242 Eagle Pt – Gloucester 230kV line at a cost of **$2.6M**

Substation upgrades
Upgrade the appropriate Thorofare IP terminal equipment at a cost of **$0.5M**
Upgrade the appropriate Deptford IP terminal equipment at a cost of **$1.2M**
Upgrade the appropriate Eagle Pt IP terminal equipment at a cost of **$1.2M**
Upgrade the appropriate Gloucester IP terminal equipment at a cost of **$1.2M**
Upgrade the Gloucester transformer at a cost of **$3.975M**

This upgrade also mitigates Network Impact number 45, 46, and 47.

28. The Lackawanna – Oxbow 230kV line: The Penelec portion of the upgrade involves the rebuild of 16.33 miles of transmission line as well as substation work at the Oxbow facility. The estimated cost of the Penelec upgrade is **$19.771M** and it would take **4-5 years** to complete. PPL owns the Lackawanna substation. PPL is assuming that terminal upgrade work would be required at the Lackawanna substation. The estimated cost for the terminal upgrade is **$500,000**. **This upgrade also mitigates Network Impact number 31**.

29. The N. Meshoppen 230/115 kV ckt#3 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 **$4M** and requires a lead time of at least **24 months**. **This upgrade also mitigates Network Impact number 30**.

32. 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 48**.

33. The Raphael Rd - Northeast 230 kV line overload 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 34**.

36. The Northwest 311 – Granite1 230kV overload can be alleviated by reconductoring the line with 2,167 ACSR. There will also be substation terminal cost upgrades associated with the reinforcement. The estimated cost to perform the substation and transmission line work is **$23.6M** and will require **6 years** to complete.

37. The Peach Bottom – Conastone 500kV line (PECO portion) overload can be alleviated by building a new (third) 500kV line on new right of way. The Peach Bottom 500kV substation will also need to be expanded. The cost of building the new 500kV line will be about **$15.0M** and the cost of expanding the substation will be about **$10M**. The upgrade will take about **8 years** to complete.

38. The Roxbury 138/115 kV 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**.

39. The Northwest - Mt Carmel - Conastone upgrade requires installing NNW station 2-500/230kV xfmrs 4-500 kV bkrs, 7-230 kV Bkrs and related substation equipment and land at a cost of **$70M**. It also requires to reconductor Conastone to Northwest #2322 with 1,272kcmil ACSR 1,590kcmil ACSR with an estimated cost of **$8.21M**. 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 40 and 41**.

42. The Northwest 326 – Granite6 230kV overload can be alleviated by reconductoring the line with 2,167 ACSR. There will also be substation terminal cost upgrades associated with the reinforcement. The estimated cost to perform the substation and transmission line work is **$23.6M** and will require **6 years** to complete.

43. The Northeast 230/115 kV transformer overload requires that the transformer be replaced with a 500MVA unit. The estimated cost to replace the transformer is **$10.2M**.

48. The Oxbow – N. Meshopen 230kV line overload require the rebuild of approximately 10.16 miles of transmission line This overload also requires the replacement of a disconnect switch and replacement of substation conductor at Oxbow substation. North Meshoppen substation requires the upgrade/replacement of two (2) CT circuits, substation conductor, and a line/wave trap. The total cost of the upgrade is estimated to be **$12.939M** and it would take **4-5 years** to complete the work.

49. The Brunner Island – Yorkana 230kV line: Meted owns 12.6 miles of the transmission line and the Yorkana substation. PPL owns .64 miles of the transmission line and the Brunner Island substation. The PPL portion of the line will be rebuilt with 1590 ACSR cable. The cost of the rebuilt and the terminal work at Brunner Island is **$2M**.

50. To mitigate the 3 MILE I-TMI 500/230kV (METED) transformer would require the installation of a second 500/230kV transformer. The estimated cost to perform this work is **$11.8M** and will take **20 months** to complete.

51. The Nottingham – Peach Bottom line reactor overload can be alleviated by replacing the line reactor. The upgrade will cost about **$0.2M** and will take about **18 months** to complete.

52. The Nottingham – Peach Bottom 230kV line overload can be alleviated by tearing down and rebuilding the existing 230kV line. This will increase the line rating to 1243N/1410E MVA. This portion of the upgrade will cost **$40M** and take **4 years** to complete. A second 230kV line will also need to be constructed on new right of way at a cost of **$40M** and a time estimate of **10 years**. Finally, a new substation will need to be built at Peach Bottom at a cost of **$10M and** an estimated **4 years** to complete.

53. The Peach Bottom – Graceton 230kV line (PECO and BGE portions) overload can be alleviated by replacing the existing 230kV line with a double circuit 230kV underground

cable capable of handling about 1226MVA during emergency conditions. The upgrade will cost about **$61M** and will take about **48 months** to complete.

54. The TMI – Jackson 230kV overload requires the replacement of 18.05 miles of 230kV line, as well as substation upgrades at both TMI and Jackson. The total estimated cost of this upgrade is **$10.91M**.

55. Greene to Roxbury 138 kV line - This upgrade would be addressed with the replacement/upgrade of the Roxbury 138/115 kV transformer. 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 **$2.25M** and requires a lead time of at least **2 years**.

57. The Manor – Graceton 230kV line: PPL owns 14.5 miles of the transmission line and the Manor substation. BGE owns 1.4 miles of the transmission line and the Graceton substation. The PPL portion of the line will be rebuilt with 1590 ACSR cable. The cost of the rebuilt and the terminal work at Manor is **$36M**.

58. 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. The East Towanda substation would require the replacement of a line/wave trap, disconnect switch, and CT circuit. The North Meshoppen substation would require the upgrade or replacement of two CT circuits as well as the replacement of substation conductor. The estimated cost of this upgrade is **$16,245,000**, and it would take **4-5 years** to complete..

59. 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.

60. The Otter Creek - Conastone 230kV line: PPL owns 12 miles of the transmission line and the Otter Creek substation. BGE owns 4.7 miles of the transmission line and the Conastone substation. The PPL portion of the line will be reconductored with 795 ACSS cable. The cost of the reconductoring and the terminal work at Otter Creek is **$6M**.

Options #1 & 2

Short Circuit / Stability Analysis
and
Network Upgrade Requirements

Short Circuit

The short circuit analysis identified the following 4 breakers as being newly over-duty as a result of T38:

Chichester, 230 kV – 195 S
Chichester, 230 kV – 535 S
Eddystone, 230 kV – 35 S
Eddystone, 230 kV – 45 S

The replacement/upgrade of the four 230kV breakers identified will take **24 months** to complete and the costs are as follows:

Chichester 230 kV - replace CB #195 - $250,000

Chichester 230 kV - replace CB #535 - $250,000

Eddystone 230 kV (unit 3) - upgrade CB #35 - $80,000

Eddystone 230 kV (unit 4) - upgrade CB #45 - $80,000

Stability Analysis

Will be performed for the T38 Impact Study.