S116 – North Temple (Ontelaunee)
Generation Interconnection

General

The Queue Position #S116 project was studied as a 1200 MW Capacity Resource at two locations in the MetEd and PPL areas. Option#1 was modeled at the North Temple 230 kV substation where as, option#2 is tapped on Juniata – Alburtis 500 kV line. Project #S116 was evaluated for compliance with reliability criteria for summer peak conditions in 2012.

Metering

The Interconnection Customer will be required to install metering and telemetry equipment to provide revenue metering and real-time telemetry data to PJM and the Transmission Owner. The PJM requirements for this equipment are listed in Appendix 2, section 8 of Attachment O to the PJM Tariff, as well as PJM Manuals 01 and 14D. The PJM and Transmission Owner requirements for Metering Equipment will be discussed in more detail in subsequent studies.

Potential network impacts were as follows:

OPTION#1 – METED
(See Figure 2)

Direct Connection Facilities

Expansion of existing North Temple substation:

	Cost ($)
Expand N. Temple Substation 5 Breaker Ring - 1 breakers, 2 switches, bus and civil work	
1.5 mile double circuit 230 kV line strung with ACSR wire	
Double Circuit Substation Termination Structure	
Move/Replace Ironwood & N. Lebanon DCT Line-End Structure	
Replace 3 Circuit Breakers	
Replace 8 Switches	
Attachment Line Fiber, Protection, Metering, SCADA etc.	
Total Connection Costs:	**8,100,000**

Generator Deliverability

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

1. The N.TEMPLE-HOSENSAK 230 kV line loads from 65.1% to 141.6% (DC power flow) of its emergency rating (624MVA) for the single line contingency outage (ME28). This project contributes approximately 477.1MW to cause this thermal violation.

Element /	Upgrade	Cost

Substation		
Line	Replace (23.13 mile Double Circuit Tower line - One Side)	See #2 below

2. The N.TEMPLE-HOSENSAK230 kV line loads from 59.5% to 128.4% (DC power flow) of its normal rating (492 MVA) for non-contingency condition. This project contributes approximately 338.9MW to cause this thermal violation.

Element / Substation	Upgrade	Cost
Line	Replace 23.13 mile Double Circuit Tower line - One Side	
N. Temple substation	Drop Loop/Bus Conductor	
Hosensack substation	Circuit Breaker (1)	
	Disconnect Switch (2)	
	Drop Loop/Bus Conductor	
	Total:	18,027,500

3. The N.TEMPLE-LYONS 230 kV line loads from 48.5% to 107.3% (DC power flow) of its emergency rating (805 MVA) for the single line contingency outage (ME23). This project contributes approximately 473.9MW to cause this thermal violation.

Element / Substation	Upgrade	Cost
Line	12.09 mile Double Circuit Tower line - One Side	
N. Temple	Drop Loop/Bus Conductor	
Hosensack	Drop Loop/Bus Conductor	
	Total:	7,334,000

Multiple Facility Contingency

(Double Circuit Tower Line for the full energy output)

4. The IRONWOOD-S.LEB 230 kV line loads from 74.21% to 107.38% (DC power flow) of its emergency rating (805MVA) for the tower line outage (3ME). This project contributes approximately 267.1MW to cause this thermal violation.

Element / Substation	Upgrade	Cost
Line	Replace 2.8 miles of 230 kV line	
Ironwood	Drop Loop/Bus Conductor	
S. Lebanon	Drop Loop/Bus Conductor	
	Total:	1,760,000

Contribution to Previously Identified Overloads

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

5. The LACKAWNA-OXBOW 230 kV line loads from 157.46% to 164.84% (DC power flow) of its emergency rating (504MVA) for the single line contingency outage (PJM JEFF-LACK 500). This project contributes approximately 37.2MW to the thermal violation.

Element / Substation	Upgrade	Cost
Line	Rebuild 16.33 miles of 230 kV line	
Oxbow	Disconnect Switch (2)	
	Drop Loop/Bus Conductor	
	Total:	24,735,000

6. The N.MESHPN-MESH2REA 230/115 kV transformer loads from 137.89% to 145.13% (DC power flow) of its emergency rating (201MVA) for the single line contingency outage (PN47B). This project contributes approximately 14.6MW to the thermal violation.

Element / Substation	Upgrade	Cost
N. Meshoppen	Purchase 300 MVA 230/115 kV Bank	
	Install third Bank, Oil Containment, Protection - Civil Work	
	Line CT (1)	
	Total:	4,307,000

7. The MESH2REA-NO MESHO 115 kV line loads from 137.83% to 145.07% (DC power flow) of its emergency rating (201MVA) for the single line contingency outage (PN47B). This project contributes approximately 14.6MW to the thermal violation.

   See #6 above

8. The LACKAWNA-OXBOW 230 kV line loads from 159.62% to 167.32% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 38.4MW to the thermal violation.

   See #5 above

9. The OXBOW-N.MESHPN 230 kV line loads from 159.47% to 167.16% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 38.4MW to the thermal violation.

Element / Substation	Upgrade	Cost
Line	Rebuild 10.16 miles of 230kV line	
N. Meshoppen	Disconnect Switch (2)	
	Drop Loop/Bus Conductor (Bundled)	
Oxbow	Disconnect Switch (2)	
	Drop Loop/Bus Conductor (Bundled)	
	Total:	15,720,000

10. The OXBOW-N.MESHPN 230 kV line loads from 134.46% to 140.37% (DC power flow) of its emergency rating (617MVA) for the single line contingency outage (PJM66_WITH_R24A). This project contributes approximately 36.5MW to the thermal violation.

    See #9 above

11. The PEACHBTM-CNASTONE 500kV line loads from 153.27% to 160.98% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17). This project contributes approximately 200.2MW to the thermal violation.

    Option #1: Install second 500kV circuit from Peach Bottom to Conastone. This option is available if the necessary right of way can be acquired.

Element / Substation	Upgrade	Cost
Peach Bottom (PECO)[1]	Various upgrades to accommodate additional line	
Line (PECO)[2,3,4]	6.25 miles of 500kV line	
Line (BGE)[5,6,7]	9.6 miles of 500kV line	
Conastone	Various upgrades to accommodate additional line	
	Total:	62,000,000

Notes:

1) PJM Queue Position #P04 project also requires use of the last remaining terminal position that exists at Peach Bottom substation. If Queue Position #P04 proceeds with their project it may increase the substation costs at Peach Bottom by approximately $2,500,000.
2) Total PECO cost estimate does not include acquisition of right of way.

3) PJM Queue Position #P04 project also requires widening of about two miles of this right of way. If Queue Position #P04 proceeds with their project it may complicate right of way acquisition.
4) Construction of the new PECO line will take approximately **30 months** after the right of way is acquired.
5) Construction of the new BGE line will take approximately **84 months** after the right of way is acquired.
6) Assumes acquisition of 150 ft. wide R/W adjacent to existing R/W, mostly rural land at $100,000 per acre occurs prior to construction.
7) 2 to 3 year CPCN process prior to land acquisition.

Option #2: Install double circuit 500kV circuit from Peach Bottom to Conastone. This option is available if the necessary right of way cannot be acquired.

Element / Substation	Upgrade	Cost
Line	Install double circuit tower line (approximately 16.5 miles) from Peach Bottom to Conastone	
Peach Bottom	Substation modifications and additions	
Underground Line[1, 2]	Install new underground pipe type cable from Graceton to Peach Bottom	
	Remove existing 230 kV line	
	Total:	105,000,000

Notes:
1) Potential exists that construction of single line may not be able to carry necessary flow. If single underground cable is insufficient, then an additional line will be required which will add approximately $30,000,000 to the cost of this option.
2) Cost for construction of this line assumes that crossing of rivers or large creeks is not required. If a water crossing is required, additional costs will be incurred.

12. The PEACHBTM-CNASTONE 500kV line loads from 153.27% to 160.98% (DC power flow) of its emergency rating (2598 MVA) for the single line contingency outage (PJM17_2). This project contributes approximately 200.2MW to the thermal violation.

See # 11 above

13. The CNASTONE-N-NWEST 500kV line loads from 156.37% to 166.34% (DC power flow) of its normal rating (2078 MVA) for non-contingency condition. This project contributes approximately 207.0MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
Line[1]	Install Conastone to North Northwest 500 kV line - 1 single circuit line requiring a new 200 ft. wide right of way paralleling the existing Conastone to Northwest right of way (19.6 miles)	
	Total:	109,000,000

Notes:

1) It is estimated that it will take approximately 10 years to complete this upgrade.

14. The RAPHAEL-NEAST339 230 kV line loads from 121.18% to 130.85% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG8). This project contributes approximately 73.3MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
Northeast	Replace 2 breakers	
	Total:	766,000

15. The NWEST311-GRANITE1 230 kV line loads from 161.63% to 171.84% (DC power flow) of its emergency rating (641MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 65.5MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
Northeast	Replace breaker	
	Total:	383,000

16. The RAPHAEL-NEAST317 230 kV line loads from 119.48% to 129.03% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG18). This project contributes approximately 72.3MW to the thermal violation.

See #15 above

17. The CONASTON-MT CAR22 230 kV line loads from 136.03% to 144.84% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 81.3MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
NEW North Northwest	New substation to tap the existing Kemptown – Conastone 500kV line. New substation shall also connect to the Northwest substation	
	Total:	70,000,000

18. The CONASTON-MT CAR10 230 kV line loads from 136.03% to 144.84% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 81.3MW to the thermal violation.

    See #17 above

19. The MT CAR10-N-NWEST 230 kV line loads from 133.74% to 142.55% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 81.3MW to the thermal violation.

    See #17 above

20. The MT CAR22-N-NWEST 230 kV line loads from 133.74% to 142.55% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 81.3MW to the thermal violation.

    See #17 above

21. The NEAST317-N.EAST 230/115 kV transformer loads from 119.32% to 126.84% (DC power flow) of its emergency rating (378MVA) for the tower line outage (NORTHEAST_RIVERSIDE). This project contributes approximately 28.4MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
North East	Replace Transformer	
	Total:	10,200,000

22. The BRUNNER-YORKANA 230 kV line loads from 113.44% to 125.66% (DC power flow) of its emergency rating (617MVA) for the tower line outage (Conas_PB). This project contributes approximately 75.4MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
Line	Reconductor approximately .64 miles of 230 kV line	
	A rebuild may require reinforcing the existing structures to accommodate the larger size of the new conductor	
	Total:	600,000

23. The NOTTNGHM-NOTTREAC 230 kV line loads from 159.84% to 166.21% (DC power flow) of its emergency rating (627MVA) for the tower line outage (Conas_PB). This project contributes approximately 39.9MW to the thermal violation.

Option 1 - No new Conastone to Peach Bottom 500 kV line(s)

Equipment / Substation	Upgrade	Cost ($)
Line	Replace conductor Nottingham to Graceton (20.2 miles)	
Nottingham	Replace Reactor	
	Total:	13,100,000

Option 2 - Done in conjunction with new Conastone to Peach Bottom 500 kV line(s)

Equipment / Substation	Upgrade	Cost ($)
Line	Replace conductor Nottingham to Peach Bottom (13.6 miles)	
Line[1]	Install two high pressure dielectric filled 230 kV pipe type cables in the existing right of way from Peach Bottom to Graceton (7.5 miles)	
Nottingham	Replace Reactor	
	Total:	70,400,000

Notes:

1) The underground estimate assumes that there are no large rivers or streams to cross. The estimate does not include substation upgrades at Graceton.

20. The NOTTREAC-PCHBTMTP 230 kV line loads from 159.78% to 166.15% (DC power flow) of its emergency rating (627MVA) for the tower line outage (Conas_PB). This project contributes approximately 39.9MW to the thermal violation.

See #23 above

21. The PCHBTMTP-GRACETON 230 kV line loads from 159.78% to 166.15% (DC power flow) of its emergency rating (627MVA) for the tower line outage (Conas_PB). This project contributes approximately 39.9MW to the thermal violation.

    See #23 above

22. The CNASTONE-N-NWEST 500kV line loads from 142.92% to 151.59% (DC power flow) of its emergency rating (2901MVA) for the tower line outage (CNSTN_NWEST_NNWEST_A). This project contributes approximately 251.4MW to the thermal violation.

    See as #13 above

Short Circuit

(Summary form of Cost allocation for breakers will be inserted here if any)

PJM's short circuit analysis of the S116 queue project (North Temple, 230kV) found no new breakers to be over-duty in the ME transmission area. The study also showed no significant fault current contribution to the breakers which have already been identified as over-duty. This study was performed on the 230kV and above system. Additional Short Circuit analysis will be performed during the System Impact Study.

OPTION#2 – PPL
(See Figure 3)

Direct Connection Facilities

	Cost ($)
New 3 Breaker 500 kV Ring Bus with Control Building	
New 500/230 kV - 3 single phase transformers (2)	
5 mile 230 kV double circuit line that is strung from Ontelaunee to Shoemakersville	
Wave Traps, Protection, Metering, RTU, SCADA	
Total Connection Costs:	**46,358,071**

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

None identified

Multiple Facility Contingency
(Double Circuit Tower Line for the full energy output)

1. The TMI-JACKSON1 230 kV line loads from 94.97% to 102.62% (DC power flow) of its emergency rating (599MVA) for the tower line outage (Conas_PB). This project contributes approximately 45.8MW to cause this thermal violation.

Element / Substation	Upgrade	Cost
Line	Replace 18.05 miles of 230kV line	
TMI	Drop Loop/Bus Conductor (Bundled)	
Jackson	Drop Loop/Bus Conductor (Bundled)	
	Total:	10,910,000

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)

1. The NWEST311-GRANITE1 230 kV line loads from 161.64% to 171.06% (DC power flow) of its emergency rating (641MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 60.4MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
Northeast	Replace breaker	
	Total:	383,000

2. The NOTTNGHM-NOTTREAC 230 kV line loads from 159.86% to 168.33% (DC power flow) of its emergency rating (627MVA) for the tower line outage (Conas_PB). This project contributes approximately 53.1MW to the thermal violation.

Option 1 - No new Conastone to Peach Bottom 500 kV line(s)

Equipment / Substation	Upgrade	Cost ($)
Line	Replace conductor Nottingham to Graceton (20.2 miles)	
Nottingham	Replace Reactor	
	Total:	13,100,000

Option 2 - Done in conjunction with new Conastone to Peach Bottom 500 kV line(s)

Equipment / Substation	Upgrade	Cost ($)
Line	Replace conductor Nottingham to Peach Bottom (13.6 miles)	
Line[1]	Install two high pressure dielectric filled 230 kV pipe type cables in the existing right of way from Peach Bottom to Graceton (7.5 miles)	
Nottingham	Replace Reactor	
	Total:	70,400,000

Notes:

1) The underground estimate assumes that there are no large rivers or streams to cross. The estimate does not include substation upgrades at Graceton.

3. The NOTTREAC-PCHBTMTP 230 kV line loads from 159.80% to 168.27% (DC power flow) of its emergency rating (627MVA) for the tower line outage (Conas_PB). This project contributes approximately 53.1MW to the thermal violation.

See #2 above

4. The PCHBTMTP-GRACETON 230 kV line loads from 159.80% to 168.27% (DC power flow) of its emergency rating (627MVA) for the tower line outage (Conas_PB). This project contributes approximately 53.1 MW to the thermal violation.

See #2 above

5. The LACKAWNA-OXBOW 230 kV line loads from 159.64% to 167.66% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 40.0 MW to the thermal violation.

Element / Substation	Upgrade	Cost
Line	Rebuild 16.33 miles of 230 kV line	
Oxbow	Disconnect Switch (2)	
	Drop Loop/Bus Conductor (Bundled)	
	Total:	24,735,000

6. The OXBOW-N.MESHPN 230 kV line loads from 159.49% to 167.51% (DC power flow) of its normal rating (499MVA) for non-contingency condition. This project contributes approximately 40.0 MW to the thermal violation.

Element / Substation	Upgrade	Cost
Line	Rebuild 10.16 miles of 230kV line	
N. Meshoppen	Disconnect Switch (2)	
	Drop Loop/Bus Conductor (Bundled)	
Oxbow	Disconnect Switch (2)	
	Drop Loop/Bus Conductor (Bundled)	
	Total:	15,720,000

7. The CNASTONE-N-NWEST 500kV line loads from 156.38% to 166.36% (DC power flow) of its normal rating (2078MVA) for non-contingency condition. This project contributes approximately 207.4 MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
Line	Install Conastone to North Northwest 500 kV line - 1 single circuit line requiring a new 200 ft. wide right of way paralleling the existing Conastone to Northwest right of way (19.6 miles)	
	Total:	109,000,000

8. The LACKAWNA-OXBOW 230 kV line loads from 157.47% to 165.59% (DC power flow) of its emergency rating (504MVA) for the single line contingency outage (PJM JEFF-LACK 500). This project contributes approximately 40.9MW to the thermal violation.

See #5 above

9. The PEACHBTM-CNASTONE 500kV line loads from 153.29% to 162.73% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17). This project contributes approximately 245.3MW to the thermal violation.

Option #1: Install second 500kV circuit from Peach Bottom to Conastone. This option is available if the necessary right of way can be acquired.

Element / Substation	Upgrade	Cost
Peach Bottom (PECO)[1]	Various upgrades to accommodate additional line	
Line (PECO)[2,3,4]	6.25 miles of 500kV line	
Line (BGE)[5,6,7]	9.6 miles of 500kV line	
Conastone	Various upgrades to accommodate additional line	
	Total:	62,000,000

Notes:

1. PJM Queue Position #P04 project also requires use of the last remaining terminal position that exists at Peach Bottom substation. If Queue Position #P04 proceeds with their project it may increase the substation costs at Peach Bottom by approximately $2,500,000.
2. Total PECO cost estimate does not include acquisition of right of way.
3. PJM Queue Position #P04 project also requires widening of about two miles of this right of way. If Queue Position #P04 proceeds with their project it may complicate right of way acquisition.
4. Construction of the new PECO line will take approximately **30 months** after the right of way is acquired.
5. Construction of the new BGE line will take approximately **84 months** after the right of way is acquired.
6. Assumes acquisition of 150 ft. wide R/W adjacent to existing R/W, mostly rural land at $100,000 per acre occurs prior to construction.
7. 2 to 3 year CPCN process prior to land acquisition.

Option #2: Install double circuit 500kV circuit from Peach Bottom to Conastone. This option is available if the necessary right of way cannot be acquired.

Element / Substation	Upgrade	Cost
Line	Install double circuit tower line (approximately 16.5 miles) from Peach Bottom to Conastone	
Peach Bottom	Substation modifications and additions	
Underground Line[1, 2]	Install new underground pipe type cable from Graceton to Peach Bottom	
	Remove existing 230 kV line	
	Total:	105,000,000

Notes:

1) Potential exists that construction of single line may not be able to carry necessary flow. If single underground cable is insufficient, then an additional line will be required which will add approximately $30,000,000 to the cost of this option.
2) Cost for construction of this line assumes that crossing of rivers or large creeks is not required. If a water crossing is required, additional costs will be incurred.

10. The PEACHBTM-CNASTONE 500kV line loads from 153.29% to 162.73% (DC power flow) of its emergency rating (2598MVA) for the single line contingency outage (PJM17_2). This project contributes approximately 245.3 MW to the thermal violation.

See #9 above

11. The CNASTONE-N-NWEST 500kV line loads from 142.93% to 151.22% (DC power flow) of its emergency rating (2901MVA) for the tower line outage (CNSTN_NWEST_NNWEST_A). This project contributes approximately 240.5MW to the thermal violation.

See #7 above

12. The 3 MILE I-TMI 500/230 kV transformer loads from 141.87% to 150.65% (DC power flow) of its emergency rating (1077MVA) for the tower line outage (Conas_PB). This project contributes approximately 94.6MW to the thermal violation.

Element / Substation	Upgrade	Cost
TMI	500 kV Substation Additions - Includes 500/230 kV Bank	
	230 kV Substation Additions	
	230 kV Transmission Line Between Substations	
	Total:	15,000,000

13. The N.MESHPN-MESH2REA 230/115 kV transformer loads from 137.90% to 145.44% (DC power flow) of its emergency rating (201MVA) for the single line contingency outage (PN47B). This project contributes approximately 15.1MW to the thermal violation.

Element / Substation	Upgrade	Cost
N.Meshoppen	Purchase 300 MVA 230/115 kV Bank	
	Install third Bank, Oil Containment, Protection - Civil Work	
	Line CT (1)	
	Total:	4,307,000

14. The MESH2REA-NO MESHO 115 kV line loads from 137.84% to 145.37% (DC power flow) of its emergency rating (201MVA) for the single line contingency outage (PN47B). This project contributes approximately 15.1MW to the thermal violation.

Same as #13 above

15. The CONASTON-MT CAR22 230 kV line loads from 136.04% to 143.79% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 71.5MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
NEW North Northwest	New substation to tap the existing Kemptown – Conastone 500kV line. New substation shall also connect to the Northwest substation	
	Total:	70,000,000

16. The CONASTON-MT CAR10 230 kV line loads from 136.04% to 143.79% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 71.5MW to the thermal violation.

See #15 above

17. The MT CAR22-N-NWEST 230 kV line loads from 133.75% to 141.50% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 71.5MW to the thermal violation.

See #15 above

18. The MT CAR10-N-NWEST 230 kV line loads from 133.75% to 141.50% (DC power flow) of its emergency rating (923MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 71.5MW to the thermal violation.

See #15 above

19. The OXBOW-N.MESHPN 230 kV line loads from 134.47% to 140.54% (DC power flow) of its emergency rating (617MVA) for the single line contingency outage (PJM66_WITH_R24A). This project contributes approximately 37.5MW to the thermal violation.

Element / Substation	Upgrade	Cost
Line	Rebuild 10.16 miles of 230kV line	
N.Meshoppen	Disconnect Switch (2)	
	Drop Loop/Bus Conductor (Bundled)	
Oxbow	Disconnect Switch (2)	
	Drop Loop/Bus Conductor (Bundled)	
	Total:	15,720,000

20. The RAPHAEL-NEAST339 230 kV line loads from 121.19% to 127.44% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG8). This project contributes approximately 47.4 MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
Northeast	Replace 2 breakers	
	Total:	766,000

21. The RAPHAEL-NEAST317 230 kV line loads from 119.49% to 125.66% (DC power flow) of its emergency rating (758MVA) for the single line contingency outage (BG18). This project contributes approximately 46.7MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
Northeast	Replace breaker	
	Total:	383,000

22. The NEAST317-N.EAST 230/115 kV transformer loads from 119.33% to 125.03% (DC power flow) of its emergency rating (378MVA) for the tower line outage (NORTHEAST_RIVERSIDE). This project contributes approximately 21.5 MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
North East	Replace Transformer	
	Total:	10,200,000

23. The BRUNNER-YORKANA 230 kV line loads from 113.45% to 121.39% (DC power flow) of its emergency rating (617MVA) for the tower line outage (Conas_PB). This project contributes approximately 49.0MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
Line	Reconductor approximately .64 miles of 230 kV line	
	A rebuild may require reinforcing the existing structures to accommodate the larger size of the new conductor	
	Total:	600,000

24. The ROXBURY-ROXBURY 115/138 kV transformer loads from 101.14% to 114.07% (DC power flow) of its emergency rating (140MVA) for the single line contingency outage (PJM13B_NNWEST_A). This project contributes approximately 18.1MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
Roxbury	Upgrade existing transformer and substation equipment (circuit breaker, substation conductor, CT circuits)	
	Total:	2,250,000

25. The 01CABOT-01BUTLER 138 kV line loads from 106.64% to 111.28% (DC power flow) of its emergency rating (202MVA) for the tower line outage (66). This project contributes approximately 9.4MW to the thermal violation.

Equipment / Substation	Upgrade	Cost ($)
Various	Reconfigure circuits in the area of the Cabot to Butler line	
	Total:	1,180,000

Short Circuit

(Summary form of Cost allocation for breakers will be inserted here if any)

PJM's short circuit analysis of the S116 queue project (North Temple, 230kV) found no new breakers to be over-duty in the ME transmission area. The study also showed no significant fault current contribution to the breakers which have already been identified as over-duty. This study was performed on the 230kV and above system. Additional Short Circuit analysis will be performed during the System Impact Study.