W2-024 Kearny 138kV

Generation Interconnection

Network Impacts

Queue project W2-024 was studied as a(n) 625.0 MW (625.0 MW of which was Capacity) injection into PSEG's system at the KRNY 1-3 138.0 kV substation. Project W2-024 was evaluated for compliance with reliability criteria for summer peak conditions in 2014.

Potential transmission network impacts are as follows:

Generator Deliverability

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

1. (PSEG) The Kearny-New Jersey Transit Meadows 230 kV line (from bus 217087 to bus 216943 ckt 1) loads from 99.03% to 101.97% (DC power flow) of its emergency rating (826 MVA) for the single contingency 'PS72'. This project contributes approximately 150.36 MW to the thermal violation.

2. (PSEG) The New Jersey Transit Meadows-Kingsland C 230 kV line (from bus 216943 to bus 217055 ckt 1) loads from 97.07% to 100.01% (DC power flow) of its emergency rating (826 MVA) for the single contingency 'PS72'. This project contributes approximately 150.36 MW to the thermal violation.

3. (PSEG) The Marion 3-Hudson 7-12 138/230 kV transformer (from bus 217137 to bus 217001 ckt 1) loads from 52.64% to 107.4% (DC power flow) of its emergency rating (441 MVA) for the single contingency 'KRNY-MARN'. This project contributes approximately 241.49 MW to the thermal violation.

4. (PSEG) The Marion 1-Homestead E 138 kV line (from bus 217058 to bus 216903 ckt 1) loads from 94.34% to 121.8% (DC power flow) of its emergency rating (316 MVA) for the single contingency 'PS70'. This project contributes approximately 86.78 MW to the thermal violation.

5. (PSEG) The Homestead E-North Bergen 138 kV line (from bus 216903 to bus 217190 ckt 1) loads from 74.82% to 103.37% (DC power flow) of its emergency rating (304 MVA) for the single contingency 'PS70'. This project contributes approximately 86.78 MW to the 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.

Short Circuit

PSE&G circuit breakers

PJM has found that nine (9) circuit breakers at Kearny 138 kV station (listed below) are over 80 kA interrupting duty. There are no circuit breakers in the industry that can interrupt fault duties over 80 kA. PJM and PSE&G will develop a mitigation plan for these circuit breakers in the Impact Study.

BUS_NO	BUS	BREAKER	RATINGTYPE	DUTY_P	DUTY_A	BKR_CAPA	ISC	X/R	3LG_AMPS	3LG_X/R	1LG_AMPS	1LG_X/R	RATED_AMPS
4992	KRNY 1-3 138.kV	14HF	T	270.3	113098.9	41837	82677.9	30.2	82677.8	30.2	81001.3	24.6	41837
4993	KRNY 4-6 138.kV	25HF	T	250.7	104904.1	41837	79658.7	31.4	82719.6	30.6	81033.7	24.6	41837
4993	KRNY 4-6 138.kV	22HF	T	234.2	97968.7	41837	71226.3	31.1	82719.6	30.6	81033.7	24.6	41837
4992	KRNY 1-3 138.kV	10HF	T	217.3	90897.7	41837	65885	31.6	82677.8	30.2	81001.3	24.6	41837
5054	ESSEX 230.kV	22H	T	176.4	81510.8	46198.1	59619.2	30.2	63834.8	30.7	60590.9	27	46198.1
5040	HUDSN1-6 230.kV	1HA	S	164	82020.4	50000	71272.8	31.8	71272.8	31.8	68158.6	28	50000
5040	HUDSN1-6 230.kV	2HA	S	164	82020.4	50000	71272.8	31.8	71272.8	31.8	68158.6	28	50000
5040	HUDSN1-6 230.kV	2HC	S	162	81017.9	50000	70417.8	31.7	71272.8	31.8	68158.6	28	50000
5037	BERGEN 230.kV	10H	T	149.2	84167.2	56399.6	65064.6	23.1	69038.4	24.1	65630.6	23.4	56399.6

In addition, the analysis found seven (**7**) new circuit breakers to be over-duty in the PSEG transmission area. Those circuit breakers are listed below.

BUS_NO	BUS	BREAKER	Rating Type	Duty Percent With w2-024	Duty Percent Without w2-024	Duty Percent Difference	Note
5004	MARION 3 138.kV	7PM	S	106.00%	98.20%	7.80%	New Over-duty
5004	MARION 3 138.kV	3PM	S	105.80%	98.20%	7.60%	New Over-duty
5004	MARION 3 138.kV	6PM	S	105.80%	98.20%	7.60%	New Over-duty
5353	ESSEX31 138.kV	2LM	S	104.40%	98.50%	5.90%	New Over-duty
5352	ESSEX34 138.kV	1LM	S	103.60%	98.20%	5.40%	New Over-duty
5050	ECRR 138.kV	903	S	103.50%	98.20%	5.30%	New Over-duty
5027	WALDWICK 230.kV	10H	T	100.10%	99.80%	0.30%	New Over-duty

The cost to replace each of the newly over-duty breakers is **$2.0 to 3.0 million** each.

In addition the analysis showed a significant fault contribution (i.e. above 3%) from the W2-024 project to twenty-five (25) circuit breakers that were already identified as over-duty. Those circuit breakers are listed below:

BUS_NO	BUS	BREAKER	Rating Type	Duty Percent With w2-024	Duty Percent Without w2-024	Duty Percent Difference	Note
4992	KRNY 1-3 138.kV	14HF	T	270.30%	229.80%	40.50%	Over 100%, > 3% contribution
4993	KRNY 4-6 138.kV	25HF	T	250.70%	212.30%	38.40%	Over 100%, > 3% contribution
4993	KRNY 4-6 138.kV	22HF	T	234.20%	194.30%	39.90%	Over 100%, > 3% contribution
4992	KRNY 1-3 138.kV	10HF	T	217.30%	176.90%	40.40%	Over 100%, > 3% contribution
5003	MARION 1 138.kV	2LM	T	170.80%	158.20%	12.60%	Over 100%, > 3% contribution
5050	ECRR 138.kV	901	S	168.00%	159.20%	8.80%	Over 100%, > 3% contribution
5050	ECRR 138.kV	902	S	168.00%	159.20%	8.80%	Over 100%, > 3% contribution
5004	MARION 3 138.kV	2PM3	T	167.70%	154.40%	13.30%	Over 100%, > 3% contribution
5040	HUDSN1-6 230.kV	1HA	S	164.00%	160.90%	3.10%	Over 100%, > 3% contribution
5040	HUDSN1-6 230.kV	2HA	S	164.00%	160.90%	3.10%	Over 100%, > 3% contribution
5040	HUDSN1-6 230.kV	2HC	S	162.00%	158.90%	3.10%	Over 100%, > 3% contribution
5004	MARION 3 138.kV	1HM	T	158.20%	144.40%	13.80%	Over 100%, > 3% contribution
5040	HUDSN1-6 230.kV	1HB	S	156.90%	153.80%	3.10%	Over 100%, > 3% contribution
5040	HUDSN1-6 230.kV	2HB	S	156.90%	153.80%	3.10%	Over 100%, > 3% contribution
5003	MARION 1 138.kV	2HM	T	150.00%	137.00%	13.00%	Over 100%, > 3% contribution
5353	ESSEX31 138.kV	3PM	S	121.20%	115.30%	5.90%	Over 100%, > 3% contribution
5352	ESSEX34 138.kV	1PM	S	119.30%	113.50%	5.80%	Over 100%, > 3% contribution
5003	MARION 1 138.kV	8PM	S	119.00%	110.80%	8.20%	Over 100%, > 3% contribution
5003	MARION 1 138.kV	5PM	S	118.50%	110.80%	7.70%	Over 100%, > 3% contribution
4983	ESSEX 138.kV	3LM	S	117.70%	111.30%	6.40%	Over 100%, > 3% contribution
5004	MARION 3 138.kV	4LM	T	115.50%	104.00%	11.50%	Over 100%, > 3% contribution
5003	MARION 1 138.kV	1LM	T	114.40%	109.50%	4.90%	Over 100%, > 3% contribution
5352	ESSEX34 138.kV	4LM	S	113.50%	107.80%	5.70%	Over 100%, > 3% contribution
4983	ESSEX 138.kV	1BM	S	110.80%	104.60%	6.20%	Over 100%, > 3% contribution
4983	ESSEX 138.kV	2BM	S	110.80%	104.60%	6.20%	Over 100%, > 3% contribution

The W2-024 project will be allocated a portion of the replacement costs for each of the circuit breakers listed above based upon the amount of short circuit duty the project adds to the over-dutied condition.

JCP&L circuit breaker

The BZ circuit breaker at Whippany 230kV station is driven above it's interrupting capability by the W2-024 project.

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. (PSEG) The Hudson 7-12-Penhornt 230 kV line (from bus 217001 to bus 217069 ckt 1) loads from 100.11% to 101.9% (DC power flow) of its emergency rating (822 MVA) for the tower contingency '27PS'. This project contributes approximately 91.03 MW to the thermal violation.

2. (PECO/BG&E) The Cooper-Graceton 230 kV line (from bus 214089 to bus 220964 ckt 1) loads from 147.16% to 148.5% (DC power flow) of its emergency rating (485 MVA) for the single contingency 'PJM17'. This project contributes approximately 42.94 MW to the thermal violation.

3. (PL/METED) The Brunner Island -Yorkana 230 kV line (from bus 207922 to bus 204515 ckt 1) loads from 126.91% to 127.71% (DC power flow) of its emergency rating (617 MVA) for the single contingency 'PJM17'. This project contributes approximately 32.22 MW to the thermal violation.

4. (PSEG/PSEG) The Marion 1-Hudson 1-6 138/230 kV transformer (from bus 217058 to bus 217000 ckt 1) loads from 121.78% to 186.31% (DC power flow) of its emergency rating (296 MVA) for the tower contingency '27PS'. This project contributes approximately 199.33 MW to the thermal violation.

5. (PL/BG&E) The Otter Creek-Conastone 230 kV line (from bus 208048 to bus 220963 ckt 1) loads from 127.59% to 128.82% (DC power flow) of its emergency rating (531 MVA) for the single contingency 'PJM17'. This project contributes approximately 40.58 MW to the thermal violation.

6. (PECO/BGE) The Peach Bottom-Conastone 500 kV line (from bus 200013 to bus 200004 ckt 1) loads from 142.66% to 143.63% (DC power flow) of its emergency rating (2815 MVA) for the single contingency 'PJM67'. This project contributes approximately 175.49 MW to the thermal violation.

7. (PECO/BGE) The Peach Bottom-Conastone 500 kV line (from bus 200013 to bus 200004 ckt 1) loads from 143.45% to 144.59% (DC power flow) of its normal rating (2490 MVA) for non contingency condition. This project contributes approximately 183.67 MW to the thermal violation.

8. (PSEG) The Essex-Hudson 1-6 230 kV line (from bus 217079 to bus 217000 ckt 1) loads from 117.00% to 120.42% (DC power flow) of its emergency rating (815 MVA) for the single contingency 'PS20'. This project contributes approximately 172.39 MW to the thermal violation.

9. (PECO) The Nottingham-Nottingham Reactor 230 kV line (from bus 213844 to bus 213846 ckt 1) loads from 116.21% to 117.25% (DC power flow) of its emergency rating (627 MVA) for the single contingency 'PJM17'. This project contributes approximately 42.94 MW to the thermal violation.

10. (PSEG) The Kearny 1-3-Marion 1 138 kV line (from bus 217060 to bus 217058 ckt 1) loads from 142.90% to 207.52% (DC power flow) of its emergency rating (456 MVA) for the tower contingency '27PS'. This project contributes approximately 307.52 MW to the thermal violation.

11. (PSEG) The Bergen - Saddle Brook 138 kV line (from bus 217158 to bus 217151 ckt 1) loads from 100.94% to 124.49% (DC power flow) of its normal rating (168 MVA) for non contingency condition. This project contributes approximately 39.56 MW to the thermal violation.

12. (PSEG) The South Waterfront-Newport R 230 kV line (from bus 217117 to bus 217075 ckt 1) loads from 117.24% to 119.81% (DC power flow) of its emergency rating (490 MVA) for the

single contingency 'PS50'. This project contributes approximately 77.93 MW to the thermal violation.

13. (PSEG) The South Waterfront-Newport R 230 kV line (from bus 217117 to bus 217075 ckt 1) loads from 120.75% to 123.61% (DC power flow) of its normal rating (315 MVA) for non contingency condition. This project contributes approximately 55.78 MW to the thermal violation.

14. (PECO) The Nottingham Reactor-Peach Bottom Tap 230 kV line (from bus 213846 to bus 213869 ckt 1) loads from 116.19% to 117.23% (DC power flow) of its emergency rating (627 MVA) for the single contingency 'PJM17'. This project contributes approximately 42.94 MW to the thermal violation.

15. (PSEG) The Newport R-Hoboken R 230 kV line (from bus 217075 to bus 217073 ckt 1) loads from 104.29% to 106.71% (DC power flow) of its emergency rating (521 MVA) for the single contingency 'PS50'. This project contributes approximately 77.93 MW to the thermal violation.

16. (BG&E) The Glen Arm 110512-Windy Edge 1 115 kV line (from bus 221090 to bus 221089 ckt 1) loads from 114.02% to 114.83% (DC power flow) of its emergency rating (156 MVA) for the tower contingency 'CNSTN_NWEST'. This project contributes approximately 7.86 MW to the thermal violation.

17. (PSEG) The Hudson 1-6-South Waterfront 230 kV line (from bus 217000 to bus 217117 ckt 1) loads from 117.61% to 119.97% (DC power flow) of its emergency rating (750 MVA) for the single contingency 'MAR_BERF'. This project contributes approximately 109.66 MW to the thermal violation.

18. (PSEG) The Hudson 1-6-South Waterfront 230 kV line (from bus 217000 to bus 217117 ckt 1) loads from 130.14% to 132.57% (DC power flow) of its normal rating (500 MVA) for non contingency condition. This project contributes approximately 75.14 MW to the thermal violation.

19. (METED) The Three Mile Island-Three Mile Island 500/230 kV transformer (from bus 200016 to bus 204514 ckt 2) loads from 117.61% to 118.41% (DC power flow) of its emergency rating (1072 MVA) for the single contingency 'PJM17'. This project contributes approximately 55.34 MW to the thermal violation.

20. (PECO) The Peach Bottom-Cooper 230 kV line (from bus 213869 to bus 214089 ckt 1) loads from 150.23% to 151.58% (DC power flow) of its emergency rating (485 MVA) for the single contingency 'PJM17'. This project contributes approximately 42.94 MW to the thermal violation.

21. (PSEG) The Kearny 4-6-Marion 3 138 kV line (from bus 217061 to bus 217137 ckt 1) loads from 116.77% to 194.4% (DC power flow) of its emergency rating (370 MVA) for the single

contingency 'KRNY-MARN'. This project contributes approximately 287.22 MW to the thermal violation.

New System Reinforcements

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

1. The overload on the Kearny-NJT Meadows 230kV P2216-3 circuit can be alleviated by reconductoring the circuit. The estimated cost to perform this work is **$1 million** and will require 12 months to complete.

2. The overload on the NJT Meadows-Kingsland 230kV C2281-5 circuit can be alleviated by reconductoring the circuit. The estimated cost to perform this work is **$4.5 million** and will require 12 months to complete.

3. The overload on the Hudson/Marion Marion 3-Hudson 7-12 138/230 kV transformer can be alleviated by replacing the transformer with one of higher rating. The estimated cost to perform this work is **$13.5 million** and will require 36 months to complete.

4. The overload on the Marion 1 - Homestead 138kV E-1305-1 circuit can be alleviated by reconductoring the circuit. The estimated cost to perform this work is **$5 million** and will require 12 months to complete.

5. The overload on the Homestead - N. Bergen 138kV E-1305-3 circuit can be alleviated by reconductoring the circuit. The estimated cost to perform this work is **$2 million** and will require 12 months to complete.

6. The overload on the Marion 3 - Kearny 138kV U -1321 circuit can be alleviated by reconductoring the circuit. The estimated cost to perform this work is **$27 million** and will require 36-48 months to complete.

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)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

1. The overload on the Hudson 7-12-Penhornt 230 kV circuit can be mitigated by reconductoring the overhead line. The cost of this reconductoring is estimated to be **$200,000** and will require 6 months to complete.

2. The overload on the Cooper-Graceton 230kV circuit can be alleviated by reconductoring the 4 mile circuit to get a minimum summer emergency rating of 725 MVA..

PECO portion: Reconductor circuit 220-93 from Cooper Substation to the Maryland border. This cost is for the PECO portion only. The estimated cost to perform this work is **$2.8 million** and will require 24 months to complete.

BGE Portion: Rebuild from Cooper station 1.85 miles to the Pennsylvania border. New rating is 648N/802E MVA. The estimated cost to perform this work is **$7.5 million** and will require 54 months to complete.

3. The overload on the Brunner Island-Yorkana 230 kV circuit can be alleviated by the following work.

   Reconductoring approximately 0.64 miles of 1033 kcmil ACSR, (current ratings 498/617 MVA Summer Normal/Emergency based on conductor temp @ 125 deg C) with new 1590 kcmil ACSR (new ratings 653/793 MVA Summer Normal/Emergency, conductor operating temperature @ 125 deg C). The magnitude cost estimate for this upgrade including substation terminal equipment is **$1,700,000**. This estimate assumes that temporary facilities will need to be built in order to keep the line in-service.

4. The overload on the Hudson/Marion Marion 1-Hudson 1-6 138/230 kV transformer can be alleviated by replacing the transformer with one of a higher rating. The estimated cost to perform this work is **$13.5 million** and will require 36 months to complete.

5. The overload on the Conastone-Otter Creek 230kV circuit can be alleviated by rebuilding the circuit.

   PPL has recently submitted plans to PJM to rebuild their portion of the Otter Creek - Conastone 230kV line as part of a modernization project (submitted to PJM as supplemental project S0233). This project is tentatively scheduled to be complete by May 2013 (prior to the W2-024's 2014 requested in-service date). The magnitude cost estimate to rebuild PPL's portion of the Otter Creek - Conastone 230kV line is **$0**.

   BGE will rebuild their portion of the Otter Creek to Conastone 230 kV 4.7 mile line (2302) to Pennsylvania border. New rating is 648N/802E MVA. The estimated cost to perform this work is **$19 million** and will require 60 months to complete.

6,7. The overloads on the Peach Bottom-Conastone 500kV circuit can be alleviated by building a new parallel 500kV circuit.

PECO will construct a new Peach Bottom-Conastone 500 kV line with a minimum normal and emergency rating of 2,920 / 3,707 MVA, respectively. The line will be approximately 6 miles long. In addition PECO will replace the 5012 terminal equipment at Peach Bottom substation to achieve the conductor normal and emergency rating of 2,920 / 3,707 MVA, respectively. This cost is for the PECO portion only, and does not include right-of-way costs for new line**.** The estimated cost to perform this work is **$25 million** and will require 60 months to complete.

BGE will build a new 500 kV line adjacent to circuit 5012 from Conastone to PA line. The estimated cost to perform this work is **$56.7 million** and will require 7 years to complete.

8. The overload on the ESSEX-HUDSN1-6 230 kV line can be mitigated by reconductoring the overhead line. The cost of this reconductoring is estimated to be **$13 million** and will require 18 to 24 months to complete.

9. The overload on the Nottingham reactor can be alleviated by replacing the 220-08 line reactor and by-passing the circuit switcher at Nottingham substation to get a minimum summer emergency rating of 741 MVA. The estimated cost to perform this work is **$1.7 million** and will require 24 months to complete.

10. The overload on the Marion-Kearny 138kV N-1314 circuit can be alleviated by reconductoring the circuit. The estimated cost to perform this work is **$27 million** and will require 36-48 months to complete.

11. The overload on the Bergen-Saddle Brook 138kV cable circuit M-1339-1 can be alleviated by reconductoring the circuit. The estimated cost to perform this work is **$40 million** and will require 24 months to complete.

12 and 13. The overload on the South Waterfront P-Newport R 230kV line can be mitigated by reconductoring the underground line. The cost of this reconductoring is estimated to be **$15 million**, and will require 24 months to complete.

14. The overload on the Nottingham reactor-Peach Bottom Tap 230kV circuit can be alleviated by reconductoring the 220-08 circuit to get a minimum summer emergency rating of 741 MVA. The line is approximately 14 miles long. The estimated cost to perform this work is **$10 million** and will require 48 months to complete.

15. The overload on the Newport R-Hoboken R 230kV line can be mitigated by installing a 4 breaker ring bus at 49th street which taps the Hoboken – Bergen 230kV circuit. The line from 49th street to Bergen will also need to be reconductored with 1590 ACSS wire. The cost of this reinforcement is estimated to be **$21.3 million** and will require 24 months to complete.

16. The overload on the Glen Arm-Windy Edge 115kV circuit can be alleviated by upgrading the wire drop terminations at Windy Edge. The estimated cost to perform this work is **$200,000** and will require 12 months to complete.

17, 18. The overload on the Hudson1-6-South Waterfront P 230 kV line can be mitigated by adding a second 230kV underground cable between Hudson and South Waterfront. The details are explained below:

> Construct a new (second) pipe type cable circuit between Hudson and South Waterfront 230 kV stations on existing or a new right-of-way. The new circuit needs to be terminated at Hudson and South Waterfront. The termination at Hudson involves expanding the switchyard. The total cost for the project is **$50 million** and will require 24 months to complete.

Note that the installation of the cable involves crossing railroads, tunnels and various environmental challenges. The existing in production cable may allow achieving 514MVA normal rating but may not be able to support 790MVA emergency rating. The Land/Easements Acquisition, Environmental Issues and Permitting costs are not included in this estimate.

19. The overload on the TMI 500/230kV transformer can be alleviated by adding a second 500/230kV transformer at TMI as well as transmission line upgrades between the 230kV and 500kV substations. The estimated cost to perform this work is **$15 million** and will take 36 months to complete.

20. The overload on the Peach Bottom-Cooper 220-08 230kV circuit can be alleviated by reconductoring to get a minimum summer emergency rating of 741 MVA. The line is approximately 1.4 miles long. The estimated cost to perform this work is **$1.0 million** and will require 24 months to complete.

21. The overload on the Marion 3 - Kearny 138kV U -1321 circuit can be alleviated by reconductoring the circuit. The estimated cost to perform this work is **$27 million** and will require 36-48 months to complete.