W4-024 Hudson 230kV

Generation Interconnection

Network Impacts

Queue project W4-024 was studied as a(n) 550.0 MW (550.0 MW of which was Capacity) injection into PSEG's system at the Hudson 1-6 230.0 kV substation. Project W4-024 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 Hoboken R-Bergen 230 kV line (from bus 217073 to bus 217100 ckt 1) loads from 90.00% to 108.71% (DC power flow) of its emergency rating (581 MVA) for the single contingency 'PS50'. This project contributes approximately 108.72 MW to the thermal violation.

```
CONTINGENCY 'PS50'
  DISCONNECT BRANCH FROM BUS 217069 TO BUS 217084 CKT 1     /* PENHORNT KNGLND G 230 230
  DISCONNECT BRANCH FROM BUS 217084 TO BUS 216909 CKT 1     /* KNGLND G BELLVILLE 230 230
  DISCONNECT BRANCH FROM BUS 216909 TO BUS 217098 CKT 1     /* BELLVILLE 220-2 220-1
  DISCONNECT BRANCH FROM BUS 217069 TO BUS 217001 CKT 1     /* PENHORNT HDSN7-12 230 230
  MOVE 100 PERCENT LOAD FROM BUS 216979 TO BUS 216978       /* KNGLND T2 T1
END
```

2. (PSEG) The Hoboken R-Bergen 230 kV line (from bus 217073 to bus 217100 ckt 1) loads from 81.91% to 107.48% (DC power flow) of its normal rating (398 MVA) for non contingency condition. This project contributes approximately 101.79 MW to the thermal violation.

3. (PSEG) The Newport R-Hoboken R 230 kV line (from bus 217075 to bus 217073 ckt 1) loads from 97.46% to 125.34% (DC power flow) of its normal rating (365 MVA) for non contingency condition. This project contributes approximately 101.79 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

The YA 230kV circuit breaker is overdutied due to the installation of the W4-024 generation at Hudson.

BUS_NO	BUS	BREAKER	Rating Type	Duty Percent With w4-024_2015(case)	Duty Percent Without w4-024_2015(case)	Duty Percent Difference	Note
2550	WHIPPANY 230.kV	YA	S	100.40%	100.00%	0.40%	New Over-duty

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)

4. (PSEG) The Hudson 7-12-Penhorn 230 kV line (from bus 217001 to bus 217069 ckt 1) loads from 102.31% to 102.99% (DC power flow) of its emergency rating (822 MVA) for the tower contingency '27PS'. This project contributes approximately 34.66 MW to the thermal violation.

```
CONTINGENCY '27PS'    /* HUD-ESSX 230KV & NJT MEADOWS-ATHENIA 230KV DCTL
  TRIP LINE FROM BUS 216900 TO BUS 216920
  TRIP LINE FROM BUS 216920 TO BUS 217055
  TRIP LINE FROM BUS 217055 TO BUS 216943
  TRIP LINE FROM BUS 217079 TO BUS 217000
  MOVE 100 PERCENT LOAD FROM BUS 216934 TO BUS 216936      /* COOK RD T1 T2
  MOVE 100 PERCENT LOAD FROM BUS 216935 TO BUS 216937      /* COOK RD T3 T4
  MOVE 100 PERCENT LOAD FROM BUS 216978 TO BUS 216979      /* KINGSLAND T1 T2
  MOVE 100 PERCENT LOAD FROM BUS 216961 TO BUS 216960      /* NJT MEADOWS WEST EAST
END
```

5. (PECO/BG&E) The Cooper-Graceton 230 kV line (from bus 214089 to bus 220964 ckt 1) loads from 150.02% to 151.26% (DC power flow) of its emergency rating (485 MVA) for the single contingency 'PJM17'. This project contributes approximately 37.97 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1    /* CNASTONE PEACHBTM 500 500
END
```

6. (BG&E) The Bagley13-Raphael Road 230 kV line (from bus 220999 to bus 220980 ckt 1) loads from 152.39% to 153.01% (DC power flow) of its emergency rating (674 MVA) for the tower contingency 'CNSTN_NWEST'. This project contributes approximately 32.84 MW to the thermal violation.

```
CONTINGENCY 'CNSTN_NWEST'    /* CONASTONE TO NORTHWEST CKTS #2310 & #2322
  DISCONNECT BRANCH FROM BUS 220963 TO BUS 220962 CKT 1    /* CONASTONE TO NORTHWEST
CKT#2310
  DISCONNECT BRANCH FROM BUS 220963 TO BUS 220961 CKT 1    /* CONASTONE TO NORTHWEST
CKT #2322
END
```

7. (PL/BG&E) The Otter Creek Switchyard-Conastone 230 kV line (from bus 208048 to bus 220963 ckt 1) loads from 129.70% to 130.79% (DC power flow) of its emergency rating (531 MVA) for the single contingency 'PJM17'. This project contributes approximately 35.84 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1     /* CNASTONE PEACHBTM 500 500
END
```

8. (PJM) The Peach Bottom-Conastone 500 kV line (from bus 200013 to bus 200004 ckt 1) loads from 146.30% to 147.19% (DC power flow) of its emergency rating (2815 MVA) for the single contingency 'PJM67'. This project contributes approximately 154.95 MW to the thermal violation.

```
CONTINGENCY 'PJM67'
  DISCONNECT BRANCH FROM BUS 200026 TO BUS 200004 CKT 1     /* HUNTERTN CNASTONE 500 500
END
```

9. (PJM) The Peach Bottom-Conastone 500 kV line (from bus 200013 to bus 200004 ckt 1) loads from 148.04% to 149.09% (DC power flow) of its normal rating (2490 MVA) for non contingency condition. This project contributes approximately 162.20 MW to the thermal violation.

10. (PECO) The Nottingham-Nottingham Reactor 230 kV line (from bus 213844 to bus 213846 ckt 1) loads from 118.43% to 119.39% (DC power flow) of its emergency rating (627 MVA) for the single contingency 'PJM17'. This project contributes approximately 37.97 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1     /* CNASTONE PEACHBTM 500 500
END
```

11. (PSEG) The South Waterfront-Newport R 230 kV line (from bus 217117 to bus 217075 ckt 1) loads from 119.14% to 141.33% (DC power flow) of its emergency rating (490 MVA) for the single contingency 'PS50'. This project contributes approximately 108.72 MW to the thermal violation.

```
CONTINGENCY 'PS50'
  DISCONNECT BRANCH FROM BUS 217069 TO BUS 217084 CKT 1     /* PENHORNT KNGLND G 230 230
  DISCONNECT BRANCH FROM BUS 217084 TO BUS 216909 CKT 1     /* KNGLND G BELLVILLE 230 230
  DISCONNECT BRANCH FROM BUS 216909 TO BUS 217098 CKT 1     /* BELLVILLE 220-2 220-1
  DISCONNECT BRANCH FROM BUS 217069 TO BUS 217001 CKT 1     /* PENHORNT HDSN7-12 230 230
  MOVE 100 PERCENT LOAD FROM BUS 216979 TO BUS 216978       /* KNGLND T2 T1
END
```

12. (PSEG) The South Waterfront-Newport R 230 kV line (from bus 217117 to bus 217075 ckt 1) loads from 122.82% to 155.13% (DC power flow) of its normal rating (315 MVA) for non

contingency condition. This project contributes approximately 101.79 MW to the thermal violation.

13. (PSEG) The Marion 1-Homestead E 138 kV line (from bus 217058 to bus 216903 ckt 1) loads from 135.39% to 136.26% (DC power flow) of its emergency rating (316 MVA) for the single contingency 'PS70'. This project contributes approximately 16.97 MW to the thermal violation.

```
CONTINGENCY 'PS70'
  REMOVE MACHINE 1 FROM BUS 217118                    /* BERGENGT
END
```

14. (PSEG) The North Bergen-Bergen 138 kV line (from bus 217190 to bus 217156 ckt 1) loads from 108.89% to 109.79% (DC power flow) of its emergency rating (304 MVA) for the single contingency 'PS70'. This project contributes approximately 16.97 MW to the thermal violation.

```
CONTINGENCY 'PS70'
  REMOVE MACHINE 1 FROM BUS 217118                    /* BERGENGT
END
```

15. (PECO) The Nottingham Reactor-Peach Bottom 230 kV line (from bus 213846 to bus 213869 ckt 1) loads from 118.41% to 119.37% (DC power flow) of its emergency rating (627 MVA) for the single contingency 'PJM17'. This project contributes approximately 37.97 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1     /* CNASTONE PEACHBTM 500 500
END
```

16. (BG&E) The Graceton-Bagley13 230 kV line (from bus 220964 to bus 220999 ckt 1) loads from 135.40% to 135.92% (DC power flow) of its emergency rating (802 MVA) for the tower contingency 'CNSTN_NWEST'. This project contributes approximately 32.84 MW to the thermal violation.

```
CONTINGENCY 'CNSTN_NWEST'     /* CONASTONE TO NORTHWEST CKTS #2310 & #2322
  DISCONNECT BRANCH FROM BUS 220963 TO BUS 220962 CKT 1     /* CONASTONE TO NORTHWEST
CKT#2310
  DISCONNECT BRANCH FROM BUS 220963 TO BUS 220961 CKT 1     /* CONASTONE TO NORTHWEST
CKT #2322
END
```

17. (PSEG) The Newport R-Hoboken R 230 kV line (from bus 217075 to bus 217073 ckt 1) loads from 106.08% to 126.94% (DC power flow) of its emergency rating (521 MVA) for the single contingency 'PS50'. This project contributes approximately 108.72 MW to the thermal violation.

```
CONTINGENCY 'PS50'
  DISCONNECT BRANCH FROM BUS 217069 TO BUS 217084 CKT 1     /* PENHORNT KNGLND G 230 230
```

```
  DISCONNECT BRANCH FROM BUS 217084 TO BUS 216909 CKT 1     /* KNGLND G BELLVILLE 230 230
  DISCONNECT BRANCH FROM BUS 216909 TO BUS 217098 CKT 1     /* BELLVILLE 220-2 220-1
  DISCONNECT BRANCH FROM BUS 217069 TO BUS 217001 CKT 1     /* PENHORNT HDSN7-12 230 230
  MOVE 100 PERCENT LOAD FROM BUS 216979 TO BUS 216978       /* KNGLND T2 T1
END
```

18. (PSEG) The Hudson 1-6-South Waterfront 230 kV line (from bus 217000 to bus 217117 ckt 1) loads from 120.05% to 156.72% (DC power flow) of its emergency rating (750 MVA) for the single contingency 'MAR_BERF'. This project contributes approximately 275.02 MW to the thermal violation.

```
CONTINGENCY 'MAR_BERF'     /* MARION-BERGEN F 230KV
  TRIP LINE FROM BUS 217000 TO BUS 216904
  TRIP LINE FROM BUS 216904 TO BUS 217100
  MOVE 60 PERCENT LOAD FROM BUS 216982 TO BUS 216980       /* HMSTD T1 HMSTD T2
  MOVE 20 PERCENT LOAD FROM BUS 216982 TO BUS 217035       /* HMSTD T1 PENHRN T2
  MOVE 20 PERCENT LOAD FROM BUS 216982 TO BUS 216981       /* HMSTD T1 HMSTD T4
  MOVE 100 PERCENT LOAD FROM BUS 216983 TO BUS 216981      /* HMSTD T3 HMSTD T4
END
```

19. (PSEG) The Hudson 1-6-South Waterfront 230 kV line (from bus 217000 to bus 217117 ckt 1) loads from 132.91% to 174.09% (DC power flow) of its normal rating (500 MVA) for non contingency condition. This project contributes approximately 205.89 MW to the thermal violation.

20. (PL/BG&E) The Safe Harbor Units 3-4 Tap-Graceton 230 kV line (from bus 208071 to bus 220964 ckt 1) loads from 104.41% to 105.51% (DC power flow) of its emergency rating (485 MVA) for the single contingency 'PJM17'. This project contributes approximately 33.13 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1     /* CNASTONE PEACHBTM 500 500
END
```

21. (PSEG) The Homestead E-North Bergen 138 kV line (from bus 216903 to bus 217190 ckt 1) loads from 117.53% to 118.43% (DC power flow) of its emergency rating (304 MVA) for the single contingency 'PS70'. This project contributes approximately 16.97 MW to the thermal violation.

```
CONTINGENCY 'PS70'
  REMOVE MACHINE 1 FROM BUS 217118                  /* BERGENGT
END
```

22. (PECO) The Peach Bottom-Cooper 230 kV line (from bus 213869 to bus 214089 ckt 1) loads from 153.09% to 154.33% (DC power flow) of its emergency rating (485 MVA) for the single contingency 'PJM17'. This project contributes approximately 37.97 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
```

DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1 /* CNASTONE PEACHBTM 500 500
END

23. (PL/METED) The Brunner Island Bus-Yorkana 230 kV line (from bus 207922 to bus 204515 ckt 1) loads from 125.99% to 126.72% (DC power flow) of its emergency rating (617 MVA) for the single contingency 'PJM17'. This project contributes approximately 28.47 MW to the thermal violation.

CONTINGENCY 'PJM17'
DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1 /* CNASTONE PEACHBTM 500 500
END

New System Reinforcements

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

1,2,3,17. Hudson - S. Waterfrnt 230kV Reinforcement includes building a new underground line between Hudson 230kV and South Waterfront 230kV. Estimated Cost: **$27M**.

CB. The over-dutied condition of the Whippany YA 230kV circuit breaker can be alleviated by replacing the breaker at a total cost of **$560,100.**

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)

4. The overload on the Hudson 7-12- Penhorn 230kV circuit can be mitigated by the BRH-4 project. The BRH-4 Reinforcement is Branchburg-Roseland-Hudson Optiono 4 project. It's estimated in service date is 2015 but the project will need to be expedited in order to mitigate the overloads caused by this project. Estimated cost **$907M**.

5. The overload on the Cooper-Graceton 230kV circuit can be alleviated by rebuilding the 1.85 miles of circuit from Graceton to the PA border. The new rating will be 648N/802E. Estimated time to construct is 54 months. The estimated cost **$7.5 million**.

6,16. The overload on the Graceton-Raphael Road & Graceton-Bagley circuits can be mitigated by upgrading Graceton station to add 6-230kV breakers with an estimated cost of $**10,000,000** and Raphael Road station to add 6-230kV breakers with an estimated cost of **$10,000,000**. It also requires rebuilding Graceton to Raphael Rd to a double circuit 2-conductor bundled line with an estimated cost of **$30,000,000**. This work would take an estimate of 2-3 years for the substation work concurrently with 5-6 years for the line work.

7. The overload on the Otter Creek-Conastone 230kV circuit can be alleviated by the following work.

PPL Portion: PPL has recently submitted plans to PJM to rebuild 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 IPP'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 Portion: Rebuild Otter Creek to Conastone 230 kV 4.7 mile line (2302) to PA Border. The new rating is 648N/802E MVA. The estimated cost to perform this work is **$19M** and will require 60 months to complete.

8,9.

The overload on the Peach Bottom-Conastone 500kV circuit can be alleviated by the following work.

BGE:

- At Conastone construct a new two breaker 4000A bay (breakers D, F) with two 63 kA breakers. Includes line termination structures, allowance for a second line and the relocation of the 500kV cap bank. 36 months to complete **- $14M**
- Construct a new 500kV line from Conastone – Peach Botton rated for a minimum of 2939/3733 SN/SE. Build 9.6 miles 500KV line from Conastone to the Pennsylvania line. Purchase 150' R/W. Total for project **$46.8 million** 5-7 years

PECO:

- Replace existing Peach Bottom-Conastone 500kV Line (5012) terminal equipment at Peach Bottom Substation to match the conductor summer normal and emergency rating of 2920 / 3707 MVA (PECO portion only)- **$5 million**, 3 years

- Build new second Peach Bottom-Conastone 500kV Line on separate towers from existing 5012 Line with a minimum summer emergency rating of 3510 MVA (PECO portion only)- $20 million, 5 years [Right-of-way costs are not included]

Total cost: **85.8M**
Total time: up to 7years

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

11. The overload on the S. Waterfront-Newport 230kV circuits (L-2264 & Q-2269) can be mitigated by providing oil circulation to increase the emergency rating on Q-2269 by 10% [Old rating: 315N/490E, New rating: 315N/565E, increase of 15%]. Estimated cost: **$5M**.

13,14,21. These overloads on the Marion-Homestead circuit will be mitigated by the F&E Ckt Conv. *F & E circuit conversion includes converting the E-1305 and F-1306 line from Marion138kV to Homestead138kV to Bergen 138kV. Estimated cost **$7.3M**.

15. The overload on the Nottingham Reactor-Peach Bottom Tap 230kV line can be alleviated by reconductoring circuit 220-08 from Nottingham Reactor to the Peach Bottom Tap 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 **$10M** and will require 48 months to complete.

18,19. The overload on the Hudson-S Waterfront (P2268) 230kV circuit can be alleviated by re-conductoring the circuit to increase its normal rating to a minimum of 475MVA (and emergency rating to a minimum of 575MVA). Estimated cost: **$6M** [Old rating: 404N/575E, New rating: 475N/575E]

20. The overload on the Safe Harbor Units 3-4 Tap-Graceton 230kV overload can be alleviated by the following work.

PPL: A PPL project to re-conductor Manor-Graceton 230 kV with 1590 ACSR is underway. This project will equip the line to handle 653/793 MVA (Summer Normal/Emergency). Estimated cost: $22.7M. Estimated in-service date: November 2013

BGE: Line rated 559/674. There are substation limitations at Graceton that will be removed with project b0497

22. The overload on the Peach Bottom-Cooper 230kV circuit can be alleviated by reconductoring Line 220-08 from Peach Bottom Tap to Cooper Substation 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 **$1.0M**, and will require 24 months to complete.

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

PPL Portion: PPL EU will rebuild and upgrade approximately 0.6 miles of the PPL EU owned Brunner Island – Yorkana 230kV line and the substation line terminal equipment. The existing 1033 kcmil ACSR conductor will be replaced with new 1590 kcmil ACSR conductor or

equivalent with and operating temperature of 140deg C to achieve the summer normal and emergency ratings of 712 MVA and 865 MVA respectively. The Yorkana 230kV bay conductors at Brunner Island 230kV switchyard will also be upgraded to conform the higher line ratings.PPL EU will require 24 months to construct this upgrade after the ISA/CSA are signed. The total transmission and substation upgrade cost is **$1.3 million**.

METED Portion: To reconductor Met-Ed's 12.5 mile section of the Brunner -Yorkana (1055) 230 kV line with 1590 ACSS conductor. Based on the Feasibility Study review performed, the total cost of this Network Upgrade is **$9,270,900** excluding tax. It is estimated that it will take three years from the full execution of a Construction Service Agreement to complete the work needed to implement this project. Note that a revised estimate will be required if this project proceeds to an Impact Study.