

#S23 Graceton 550 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

The Queue S23 project was studied as a 550 MW (Capacity) injection into the Nottingham - Graceton 230 kV line. The project was evaluated for compliance with reliability criteria for summer peak conditions in 2012. Potential network impacts were as follows:

Generator Deliverability

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

Multiple Facility Contingency

(Double Circuit Tower Line contingencies only for the full energy output. Stuck breaker and bus fault contingencies will be performed for the Impact Study)

1. The Graceton – Manor 230 kV line from 89% to 106% of its emergency rating (531 MVA) for the **tower** outage of Conastone – Peach Bottom 500 kV ckt#1 and Conastone – Peach Bottom 500 kV ckt#2. This project contributes approximately **86 MW** to cause the thermal violation.

Short Circuit Analysis

Feasibility Study preliminary short circuit analysis indicates that Queue S23 contributes significant short circuit current to five Conastone 230 kV breakers previously identified as being overdutied for earlier Queue projects, and is the first project to overduty one additional Conastone 230 kV breaker and two Graceton 230 kV breakers.

Short Circuit results will be given in more detail for the S23 Impact Study.

Stability Analysis

Will be performed for the Queue S23 Impact Study.

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)

2. Contribution of **27 MW** further overloads the Northwest – Granite 230 kV line #2311 from 121% to 125% of its emergency rating (641 MVA) for the outage of Kempton – North Northwest 500 kV line (Cont Id. PJM13B_NNWestB).
3. Contribution of **78 MW** further overloads the Conastone – Peach Bottom 500 kV ckt#2 from 133% to 136% of its emergency rating (2598 MVA) for the outage of Conastone – Peach Bottom 500 kV ckt#1 (PJM17).
4. Contribution of **78 MW** further overloads the Conastone – Peach Bottom 500 kV ckt#1 is from 133% to 136% of its emergency rating (2598 MVA) for the outage of Conastone – Peach Bottom 500 kV ckt#2 (PJM17_2).
5. Contribution of **50 MW** further overloads the Conastone – North Northwest 500 kV line from 121% to 124% of its normal rating (2078 MVA).
6. Contribution of **48 MW** further overloads the Conastone – Mt Carmel 230 kV line 2322 from 115% to 120% of its emergency rating (923 MVA) for the outage of Kempton – North Northwest 500 kV line.
7. Contribution of **48 MW** further overloads the Conastone – Mt Carmel 230 kV line 2310 from 115% to 120% of its emergency rating (923 MVA) for the outage of Kempton – North Northwest 500 kV line.
8. Contribution of **48 MW** further overloads the Mt Carmel – North Northwest 230 kV line 2310 from 112% to 118% of its emergency rating (923 MVA) for the outage of Kempton – North Northwest 500 kV line.
9. Contribution of **49 MW** further overloads the Mt Carmel – North Northwest 230 kV line 2322 from 112% to 118% of its emergency rating (923 MVA) for the outage of Kempton – North Northwest 500 kV line.
10. Contribution of 98 MW further overloads the Graceton – Bagley – Raphael Rd 230 kV line of its emergency rating (659 MVA) for the outage of Conastone – NorthWest – Mt Carmel 230 kV line.
11. Contribution of 30 MW further overloads the Conastone – Ottercreek 230 kV line of its emergency rating (531 MVA) for the outage of Conastone – Peachbottom 500 kV line.

New System Reinforcements

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

1. Graceton to Manor 230 kV line overloaded 130% of ER 531MVA (need 691 MVA) Circuit 2303

BGE Upgrade

Reconductor from Graceton to PA line - **\$700,000 ~ 3 yrs.**

Existing:

Circuit 2303 is 795 kcm 30/19 ACSR @ 125 C.

Assumptions:

- Reconductor with 1,590 kcm ACSR from Graceton to PA line.
- Length of this line section is 1.4 miles.
- Towers can be reinforced instead of replaced.

PPL Upgrade - The estimated magnitude cost for this upgrade including substation terminal equipment cost is **\$31,000,000**.

Description of Work:

In order to provide additional capacity on the Graceton – Manor 230kV line, PPL EU is proposing to rebuild the existing single circuit 230kV line to a larger conductor. Existing conductor is 795 ACSR. The rebuild will require new custom embedded steel poles to accommodate the larger conductor size. The new line will be 1590 Kcmil ACSR conductors (1 per phase) designed and operated at 230 kV. The 230 kV line will be rated for summer normal/emergency of 653/793 MVA respectively. These ratings are based on the conductor ratings and may be lower when the line is actually built.

The rebuild will be 14.4 miles long and will travel the existing right of way.

Contribution to Previously Identified System Reinforcements

(Upgrades for 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)

2. **Northwest – Granite 230 kV Upgrade** – Replace one 230 kV breaker at Northwest substation at an estimated cost of **\$383,000**.
3. **Conastone – Peach Bottom 500 kV Upgrade:** To mitigate a 52% overload of the Conastone – Peach Bottom 500 kV circuit a second circuit will need to be built.

If RIGHT OF WAY can be acquired then the following reinforcement and cost estimates apply:

PECO portion of the Conastone – Peach Bottom line:

Substation work at Peach Bottom	\$ 2,500,000
Construct 6.25 miles of 500kV line	<u>\$10,000,000</u>
	\$12,500,000

This estimate **does not include the cost of new right of way**.

Construction of the new line will take approximately **30 months** after the right of way is acquired.

Note: It should be noted that PJM Queue P04 project also requires widening of about two miles of this right of way for their direct connection line and would use the last remaining terminal position that exists at Peach Bottom substation. If Queue P04 proceeds with their project it may complicate right of way acquisition and double the substation costs at Peach Bottom.

BGE portion of the Conastone – Peach Bottom line:

1. Build a new 500 kV line adjacent to existing circuit 5012 from Conastone to Pennsylvania State Line at an estimated cost of **\$48,000,000** and a construction time of approximately **84 months**.

Assumptions:

- Acquire 150 ft. wide R/W adjacent to existing R/W, mostly rural land at \$100,000 per acre
 - 2 to 3 year Maryland CPCN process prior to land acquisition
 - Length of line 9.6 miles
2. Install one 500kV breaker at Conastone **\$1,500,000**. Breaker installation can be completed concurrently with the line construction.

If RIGHT OF WAY cannot be acquired then the following reinforcement and cost estimates will apply:

The line from Graceton to Peach Bottom is about 7.5 miles long and has a normal rating of 528MVA. Assuming that we could maintain this rating with a single 230 kV pipe type cable (and we may not be able to do this), the new underground installation would cost about **\$30,000,000 plus another \$1,000,000 for terminal modifications**. It is assumed that the underground line will not need to cross any rivers or large creeks. **If a cable rating of 450 MVA is insufficient, it will cost an additional \$30,000,000 for a second cable.**

Removal of the existing 230 kV tower line is about \$1,500,000.

Construction of a double circuit 500kV line from Conastone to Peach Bottom would be about \$3.5M per mile. The line is 16.5 miles long. Total cost **\$58,000,000**.

Substation additions and modifications at Peach Bottom would cost about **\$10,000,000**.

Note: Further work is being done by PECO, BG&E and PPL to come up with reinforcements to further mitigate the overload.

4. **Upgrade #3 above also satisfies the upgrade requirement for Impact #4.**
5. **Kempton to North Northwest 500 kV - 2 single circuit lines at an estimated cost of \$279,000,000 and estimated time of 10 yrs.**

Assumptions:

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

Substation Terminations:

NNW - Install a 3 breaker bay **\$7,700,000**
Kempton - Install a 3 breaker bay **\$7,700,000**

5A. Conastone to North Northwest 500 kV - 1 single circuit line at an estimated cost of **\$109,000,000** 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 will be located 4 miles north of existing Northwest substation

Substation Terminations:

Conastone - Install a 1 breaker bay **\$3,200,000**
North Northwest - Install a 2 breaker bay **\$6,400,000**

5B. Northwest - Mt Carmel - Conastone Upgrade

This overload requires construction of a new substation to be called “North Northwest” consisting of two 500/230kV transformers, four 500 kV breakers, seven 230 kV breakers, related substation equipment and land at an estimated cost of **\$70,000,000**. It also requires reconductoring of the Conastone to Northwest circuit #2322 from 1,272kcmil ACSR to 1,590kcmil ACSR with an estimated cost of **\$8,210,000**. This work would take **3-4 years**.

Note: The above #5, #5A & #5B upgrades will also satisfy the reinforcement requirements for upgrades #6, #7, #8 and #9 Impacts.

6. Upgrades #5, #5A and #5B also satisfy Upgrade #6 requirements.
7. Upgrades #5, #5A and #5B also satisfy Upgrade #7 requirements.
8. Upgrades #5, #5A and #5B also satisfy Upgrade #8 requirements.
9. Upgrades #5, #5A and #5B also satisfy Upgrade #9 requirements.

10. Graceton - Bagley - Raphael Upgrade

This upgrade requires to add six 230kV breakers at Graceton substation at an estimated cost of **\$10,000,000** and six 230kV breakers at Raphael Road substation at an estimated cost of **\$10,000,000**. It also requires rebuilding Graceton to Raphael Rd to double circuit 2-conductor bundled with an estimated cost of **\$30,000,000**. This work would take an estimated 5-6 years with substation and line work being done concurrently.

11. Conastone – Ottercreek 230 kV Upgrade

PPL work

The proposed upgrade consists of reconductoring approximately 17.2 miles of 795 kcmil 30/19 ACSR, (current ratings 425/531 MVA Summer Normal/Emergency based on conductor temp @125 Deg C) with new 795 kcmil 30/19 ACSS (new ratings 516/632 MVA Summer Normal/Emergency, conductor operating temperature of 160 deg C)

The cost does not include upgrade of any substation terminal equipment at BG&E's Conastone 230kV Substation. No terminal equipment upgrade is required at Otter Creek; it is built with 2000 amp rating. The magnitude cost estimate to uprate is **\$8,500,000**.

This upgrade will result in minimal change to the impedance of the line.

Existing $Z = 0.0042 + j 0.0266$ pu

New $Z = 0.0048 + j 0.02676$ pu

BGE work

Reconductor from Gorsuch Mills to PA line - **\$700,000 ~ 3 yrs.**

Existing: Circuit 2302 is 1,590 kcm 45/7 ACSR from Conastone to Gorsuch Mills and 795 kcm 30/19 ACSR from Gorsuch Mills to the PA line.

Assumptions:

- Reconductor with 1,590 kcm ACSR from Gorsuch Mills to PA line to match capability of remainder of line.
- Length of this line section is 1.7 miles.
- Towers can be reinforced instead of replaced.
- Based on previous estimate by R.W.M. for PJM (B48) study on circuit 22008