#Q77 Calvert Cliffs 1640 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 **#Q77 project was studied as an injection of 1640 MW (capacity) into the Calvert Cliffs 500 kV station.** Project #Q48 was evaluated for compliance with reliability criteria for summer peak conditions in 2011. Potential network impacts were as follows:

Generator Deliverability

1. The Waugh Chapel 500/230 kV transformer 3 is overloaded at around 104% of its emergency rating (1161 MVA) for the outage of the Chalk Point – Calvert Cliffs 500 kV line. The Q77 project contributes approximately 256 MW to the contingency facility loading.
2. The Waugh Chapel 500/230 kV transformer 2 is overloaded at around 102% of its emergency rating (1161 MVA) for the outage of the Chalk Point – Calvert Cliffs 500 kV line. The Q77 project contributes approximately 250 MW to the contingency facility loading.

Multiple Facility Contingency

3. The High Ridge – Howard (circuit 2332-A) 230 kV line is overloaded at around 105% of its emergency rating (923 MVA) for the **tower outage** of the Waugh Chapel - Brandon Shores 2342 / 2343 double circuit 230 kV towerline. The Q77 project contributes approximately 129 MW to the contingency facility loading.

Contribution to Previously Identified Overloads

4. The Conastone - Peach Bottom 500 kV line is overloaded at around 133% of its emergency rating (2598 MVA) for the **towerline outage** of the 220-90 and 220-91 (Emilie to Ford Mill) 230 kV lines. The Q77 project contributes approximately 334 MW to the contingency facility loading. **(Overload initially caused by Q65 North Anna)**
5. The Hawkins Point – Sollers Point (circuit 2344-1) 230 kV line 1 is overloaded at around 108% of its emergency rating (569 MVA) for the outage of the Riverside – Sollers Point (circuit 2345) 230 kV line. The Q77 project contributes approximately 51 MW to the contingency facility loading. **(Overload initially caused by Q65 North Anna)**
6. The Hawkins Point –Sollers Point (circuit 2344-2) 230 kV line is overloaded at around 108% of its emergency rating (569 MVA) for the outage of the Riverside – Sollers Point (circuit 2345) 230 kV line. The Q77 project contributes approximately 51 MW to the contingency facility loading. **(Overload initially caused by Q65 North Anna)**

Short Circuit

See Attachments #1A (New) and #1B (Contribution to Existing) for additional circuit breaker upgrade requirement details.

Pepco Zone

- Short circuit analysis indicates that **no new circuit breakers are overdutied as a result of Queue Q77 generation addition**. However, Q77 does contribute to the need to replace a total of thirty six 230 kV breakers which were first identified as overdutied as a result of Q48 generation addition. The overdutied breakers were as follows; At Oak Grove 230 kV substation, 13 breakers are overdutied and will require replacement by 63 ka breakers. At Chalk Point 230 kV substation, 23 breakers are overdutied and will require replacement by 80 ka breakers. Four of the 230 kV breakers at Chalk Point are owned by Mirant. The total cost for these breaker replacements was estimated at **$65.5 Million** and the replacement time was estimated at **9 years**. **Queue Q77 will be allocated a portion of this cost in accordance with the PJM Tariff procedures for circuit breaker cost allocation. Previous Queues Q48 and Q65 have also been identified for cost allocation.**

BG&E Zone

- Short circuit analysis indicates that the following circuit breakers are overdutied as a result of Queue Q77 generation addition:

  Calvert Cliffs 500 kV (existing) circuit breakers #21, #23 and #63 were found to be overdutied as a result of Q77 interconnection. Estimated upgrade cost is **$1,500,000** ($500,000 each) and can be replaced in **6-12 months**.

  Waugh Chapel 230 kV circuit breakers #21, #28 and #41 were found to be overdutied as a result of Q77 interconnection. Estimated replacement cost is **$1,500,000** ($500,000 each) and can be replaced in **18 months**.

  Wagner breaker #41 (Sync) 41 was found to be overdutied as a result of Q77 interconnection. Estimated replacement cost is **$500,000** and can be replaced in **18 months**.

- Q77 interconnection also contributes to the need to replace five 500 kV breakers (#21, #22, #23, #61 and #62) at Calvert Cliff (Existing) station and four 230 kV breakers (#24, #25, #39 and #42) at Waugh Chapel which were first identified as overdutied as a result of Q48 generation addition. The total cost for these breaker replacements was estimated at **$5.5 Million** and the replacement time was estimated at **18 months. Queue Q77 will be allocated a portion of this cost in accordance with the PJM Tariff procedures for circuit breaker cost allocation.**

Dominion Zone

- Short circuit analysis indicates that **no new circuit breakers are overdutied as a result of Queue Q77 generation addition.** However, Q77 does contribute to the

need to replace the 230 kV Ox L242 and Possum Point SC192 breakers which were first identified as overdutied as a result of Q48 generation addition. Replacement of the Ox L242 breaker is estimated to cost **$305,000** and replacement of the Possum Point SC192 breaker is estimated to cost **$400,000**. Both breakers can be replaced in **18 months**. **Queue Q77 will be allocated a portion of this cost based on the PJM Tariff procedures for circuit breaker cost allocation. Previous Queues Q48 and Q65 have also been identified for cost allocation.**

New System Reinforcements

1. Waugh Chapel 500/230 kV Transformer #3 overload can be mitigated by installing a new Waugh Chapel 500/230kV 1275 MVA (nominal) transformer and associated station upgrades at an estimated cost of **$16,870,000** and will take 30 months to build. This upgrade also mitigates Network Impact number 2 (Waugh Chapel 500/230 kV transformer #2 overload). **This upgrade work will also eliminate the need to replace Waugh Chapel 230kV breakers #21, #28 and #41 identified as short circuit impacts for both Q48 and Q77.**

2. Solution to Network Impact number 1 above also satisfies Network Impact number 2 (Waugh Chapel 500/230 kV transformer #2 overload).

3. The High Ridge to Howard (circuit 2332-A) 230 kV line can be upgraded to 868/1019 MVA (SN/SE rating) by re-tensioning the 1590 kcmil 45/7 overhead conductor to increase the design temperature from 160^{O}C to 180^{O}C. This can be completed at an estimated cost of **$750,000** in a time period of **18-24 months**. It is assumed that a CPCN (Certificate of Public Convenience and Need) will not be required from the state of Maryland.

Contribution to Previously Identified Overloads

4. The Conastone to Peach Bottom 500kV overload requires the following upgrade:

   Conastone end (BG&E portion of the line): TheBG&E portion Conastone to Peach Bottom 500 kV line is rated at 4312A or 3734MVA. The contingency overload is approximately 3455 MVA, therefore the BG&E portion of line does not required upgrade. Two 500kV breakers at Conastone may exceed their continuous rating of 3000 amps (nominal). Two possible fixes may be possible:

   i. Rebuild or upgrade breaker, estimated cost is **$500,000** ($250,000 per breaker) with a required lead time of **6-12 months**, or
   ii. Replace 500kV breakers at an estimated cost of $**1,400,000** ($700,000 per breaker with required lead time of **18-24** months.

Further analysis will be performed for the Impact Study to determine if the work must be done and what needs to be done.

Peach Bottom end (PECO portion of the line): The Peach Bottom end of the Conastone to Peach Bottom 500kV line can be upgraded by replacing terminal equipment. The cost is approximately **$600,000**. The thermal limit of the bundled conductor of this line is 3254 MVA normal and 4046MVA emergency. The terminal equipment would be replaced as required to attain the new required rating. The additional circuit loading resulting from the Q77 interconnection may require the replacement of two Peach Bottom 500 kV breakers at an additional cost of **$900,000, this will be evaluated further during the Q77 Impact Study**. The upgrade work will require **9 to 12 months w/o breaker replacements (12 to 18 months with breaker replacements)** to complete.

5. Hawkins Point – Sollers Point (circuit 2344-1) 230 kV line 1 overload **- See number 6 below which is a solution for Network Impacts numbers 5 and 6 overloads.**

6. The Hawkins Point –Sollers Point (circuit 2344-2) and Hawkins Point – Sollers Point (circuit 2344-1) 230 kV lines, Network Upgrades for Network Impacts numbers 5 and 6, can be upgraded by ……

Option 1: Install 1 additional Harbor Crossing cable Hawkins Point to Sollers Point, re-rate new OH sections to 180^{O}C.

Option 1 estimated cost and construction time: **$40.25 million and 8-10 years to design and complete.**

Option 2: Construct a new single circuit 230kV line from Brandon Shores to Hawkins Point Terminal and Sollers Point Terminal to Riverside which also an additional 60’ easement along west side of existing tower line. (See Fig 2 & 3 below)

Option 2 estimated costs and construction time:
New 230 kV line - **$5.0 million**
Rebuild Riverside 230kV (breaker and a half) 11 breakers **– $16 million**
Brandon Shores - **$1.5 million. .**
Total Cost = $22.5M, 8-10 years to complete

Figure 2 – Riverside Rebuild

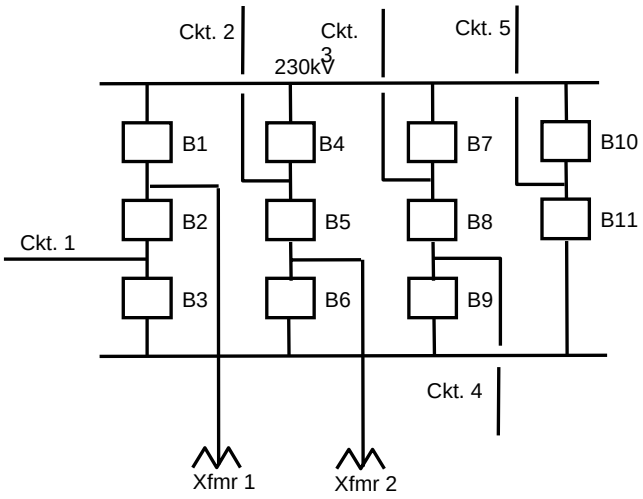
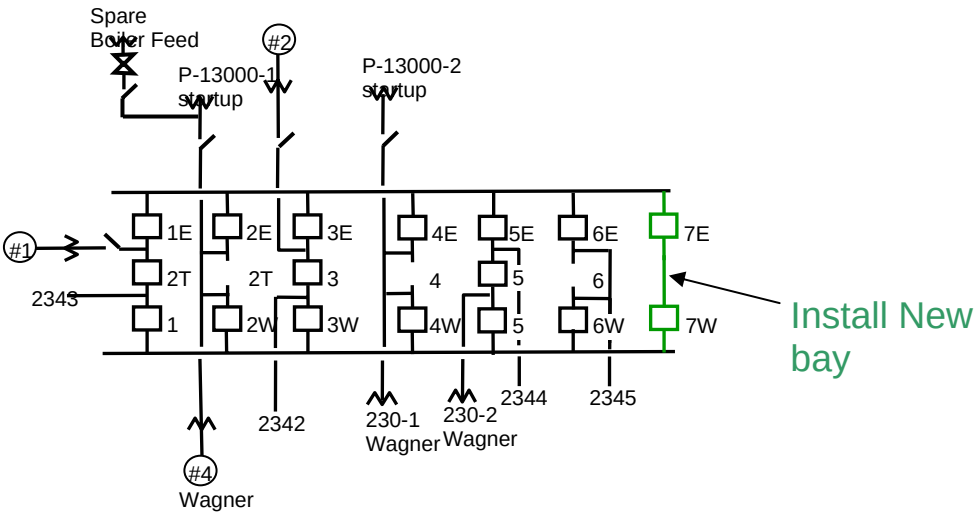


Figure 3 – Brandon Shores



Note about N-2 (e.g. maintenance outage) contingencies:

The current generator deliverability test is not performed for N-2 "maintenance outage" contingencies (one facility out of service, readjustment of the system, followed by an N-1 contingency). However, the Interconnection Customer may want to consider upgrades to allow operation for maintenance conditions where otherwise some generation may be curtailed. **Since this is not a required reliability upgrade responsibility for the generator interconnection, the Interconnection Customer must submit a "Transmission Interconnection Request" in order to get this transmission work completed.**

With the addition of Q48 (1640 MW) and Q77 (1640 MW) projects at BGE's Calvert Cliffs 500kV substation and the existing capacity (1750 MW) there will be approximately 5000 MW at the station. Currently there are only three 500 kV circuits connected at the Calvert Cliffs substation (2 circuits to Waugh Chapel & one circuit to Chalk Point) for delivering the 5000 MW of generation.. With transmission maintenance outage of one of the 500 kV circuits from Calvert Cliffs, there is not adequate transmission capability to allow full plant operation and some of Calvert Cliffs generation will be curtailed, pre-contingency, due to redispatch by PJM System Operations to comply with N-1 operating criteria.

A second Calvert Cliffs – Chalk Point 500 kV circuit will likely allow full output operation (approximately 5000 MW net Calvert Cliffs generation) for a maintenance outage of one existing Calvert Cliffs 500 kV circuit. A ballpark estimate to provide a second Calvert Cliffs – Chalk Point 500 kV circuit is as follows:

- The cost for the second 500kV circuit from Calvert Cliffs to Chalk Point is estimated to cost approximately $70 million. This cost includes replacing approximately 20 miles of the existing structures and circuit and replacing it with a double circuit structures to accommodate two 500kV circuits on the same right-of-way. The estimated time to complete this work is approximately 60 months. The time required to obtain all necessary certificates and permits and to schedule the necessary outages will affect this estimate.

- The substation work to connect the two circuits at Chalk Point is estimated to cost approximately $12 million. This costs includes the installation of a new bay and two 500kV breakers and associated disconnect switches, etc at Chalk Point. The construction period is approximately 24 - 36 months.

- The substation work at Calvert Cliffs is estimated to cost $1,630,000 (in 2015 dollars) to add a 500 kV breaker, line position, etc.

ATTACHMENT #1A

(Q77 Breaker "**new**" Upgrade Details)

"New" Circuit Breaker Upgrade Requirements

Station	Voltage	T.O.	Breaker	Int Rating Amps	Rating Basis	Calculation Method	Calculated Short Circuit Current				Upgrade Cost	Upgrade Time	Upgrade Type
							Before Q77		After Q77				
							3-phase	Ph-Gnd	3-phase	Ph-Gnd			
Calvert Cliffs	500kV	BG&E	21	55769.4	Total I	IEEE Std. C37.5					$500,000	18 mos[1]	upgrade breaker to 63kA
Calvert Cliffs	500kV	BG&E	23	51999.6	Total I	IEEE Std. C37.5					$500,000	18 mos[1]	upgrade breaker to 63kA
Calvert Cliffs	500kV	BG&E	63	51999.6	Total I	IEEE Std. C37.5					$500,000	18 mos[1]	upgrade breaker to 63kA
Waugh Chapel	230kV	BG&E	21	75600.3	Total I	IEEE Std. C37.5					$500,000	18 mos[1]	Replace breaker with 63kA
Waugh Chapel	230kV	BG&E	28	75600.3	Total I	IEEE Std. C37.5					$500,000	18 mos[1]	Replace breaker with 63kA
Waugh Chapel	230kV	BG&E	41	75600.3	Total I	IEEE Std. C37.5					$500,000	18 mos[1]	Replace breaker with 63kA
Wagner	230kV	BG&E	41		Total I	IEEE Std. C37.5					$500,000	18 mos[1]	Replace breaker with 63kA

Note 1 These 6 breakers can be replaced / upgraded concurrently in an 18 month timeframe

ATTACHMENT #1B

(Q77 Breaker "Contribution to previous" Upgrade Details)

Station	Voltage	T.O.	Breaker	Int Rating Amps	Rating Basis	Calculation Method	Calculated Short Circuit Current				Upgrade Cost	Upgrade Time	Upgrade Type
							Before Q77		After Q77				
							3-phase	Ph-Gnd	3-phase	Ph-Gnd			
Oak Grove	230kV	PEPCO	2B	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Oak Grove	230kV	PEPCO	4A	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Oak Grove	230kV	PEPCO	6A	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Oak Grove	230kV	PEPCO	6C	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Oak Grove	230kV	PEPCO	7A	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Oak Grove	230kV	PEPCO	7C	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Oak Grove	230kV	PEPCO	9A	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Oak Grove	230kV	PEPCO	9B	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Oak Grove	230kV	PEPCO	9C	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Oak Grove	230kV	PEPCO	10A	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Oak Grove	230kV	PEPCO	10C	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Oak Grove	230kV	PEPCO	13A	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Oak Grove	230kV	PEPCO	13B	45243.5	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 63kA breaker
Chalk Point	230kV	PEPCO	1A	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	1B	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	2A	63000	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	2B	63000	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	2C	63000	Symm	IEEE C37.10					$1,500,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	3A	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	3B	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	3C	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	4A	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	4B	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	5A	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	5B	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	6A	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	6B	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker

Note 1 About 4 of 36 PEPCO breakers can be replaced per year. Total replacement time for 36 breakers is approximately 9 years.

Note 2 These 2 breakers can be replaced concurrently in a 9 month timeframe

Note 3 These 9 breakers can be replaced concurrently in an 18 month timeframe

Station	Voltage	T.O.	Breaker	Int Rating Amps	Rating Basis	Calculation Method	Calculated Short Circuit Current				Upgrade Cost	Upgrade Time	Upgrade Type
							Before Q77		After Q77				
							3-phase	Ph-Gnd	3-phase	Ph-Gnd			
Chalk Point	230kV	PEPCO	7B	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	8A	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	8B	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	7A	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	1C	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	4C	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	5C	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	6C	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	PEPCO	7C	63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	Mirant		63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	Mirant		63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	Mirant		63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Chalk Point	230kV	Mirant		63000	Symm	IEEE C37.10					$2,000,000	note 1	Replace with 80kA breaker
Ox	230kV	Dominion	L242	40000	Symm	IEEE C37.10					$305,000	9 mos.[2]	Replace with 63kA breaker
Possum Point	230kV	Dominion	SC192	42800	Symm	IEEE C37.10					$400,000	9 mos.[2]	Replace with 63kA breaker
Calvert Cliffs	500kV	BG&E	22	55769.4	Total I	IEEE Std. C37.5					$700,000	18 mos[3]	Replace with 63kA breaker
Calvert Cliffs	500kV	BG&E	41	55769.4	Total I	IEEE Std. C37.5					$700,000	18 mos[3]	Replace with 63kA breaker
Calvert Cliffs	500kV	BG&E	43	55769.4	Total I	IEEE Std. C37.5					$700,000	18 mos[3]	Replace with 63kA breaker
Calvert Cliffs	500kV	BG&E	61	51999.6	Total I	IEEE Std. C37.5					$700,000	18 mos[3]	Replace with 63kA breaker
Calvert Cliffs	500kV	BG&E	62	51999.6	Total I	IEEE Std. C37.5					$700,000	18 mos[3]	Replace with 63kA breaker
Waugh Chapel	230kV	BG&E	25	75600.3	Total I	IEEE Std. C37.5					$400,000	18 mos[3]	Replace with 80kA breaker
Waugh Chapel	230kV	BG&E	24	75600.3	Total I	IEEE Std. C37.5					$400,000	18 mos[3]	Replace with 80kA breaker
Waugh Chapel	230kV	BG&E	39	75600.3	Total I	IEEE Std. C37.5					$400,000	18 mos[3]	Replace with 80kA breaker
Waugh Chapel	230kV	BG&E	42	75600.3	Total I	IEEE Std. C37.5					$400,000	18 mos[3]	Replace with 80kA breaker

Note 1 About 4 of 36 PEPCO breakers can be replaced per year. Total replacement time for 36 breakers is approximately 9 years.

Note 2 These 2 breakers can be replaced concurrently in a 9 month timeframe

Note 3 These 9 breakers can be replaced concurrently in an 18 month timeframe