#Q86 Hudson-Essex 230kV

Generation Interconnection

This analysis was completed to assess the reliability impact for the increase in generation interconnecting to the PJM system as a capacity resource.

Network Impacts

The #Q86 project was studied as two options. Option 1 considers the injection of 500 MW into the Hudson 230 kV substation. Option 2 considers the injection of 500MW into the tap of the A2227 (Hudson - Essex) 230 kV line. Project #Q86 was evaluated for compliance with reliability criteria for summer peak conditions in 2011. Hudson units #1 and #2 are modeled in the case. Potential network impacts were as follows:

Option #1 – Radial To Hudson 230kV Substation

Generator Deliverability

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

No problems identified

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 Hudson–South Waterfront 230 kV line is overloaded from 88.17% to 106.5% of its emergency rating (622 MVA) for the outage of the Hudson-Penhorn 230KV Double Circuit Tower Line. The Q86 project contributes approximately 123MW to cause the contingency facility overload.

2. The Bagley– Raphael 230 kV line is overloaded from 99.7% to 103.9% of its emergency rating (659 MVA) for the outage of the Conastone-Northwest Circuits #2310 & #2322 230kV. The Q86 project contributes approximately 27.6MW to cause the contingency facility overload.

3. The Mt. Carmel–Northwest 230 kV line loads from 99.2% to 106.9% of its emergency rating (803 MVA) for the outage of the Brighton-Conastone 500 kV line and the Brighton-Doubs 500 kV line. The Q86 project contributes approximately 25.6MW to cause the contingency facility overload

Short Circuit

4. The Athenia 71 H 230kV circuit breaker is overdutied to 100.7% of its 60200 amp rating due to the addition of the Q86 generation.

5. The Athenia 20 H 230kV circuit breaker is overdutied to 100.1% of its 75600 amp rating due to the addition of the Q86 generation.

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)

6. The Conastone-Mt. Carmel 230 kV line is loaded from 101.9% to 105.1% of its emergency rating (803 MVA) for the tower outage of the Brighton-Conastone 500 kV line and the Brighton-Doubs 500 kV line. The Q86 project contributes approximately 25.6 MW to the contingency facility loading. Project Q74 is the first to cause this overload.

7. The Graceton–Bagley 230 kV #1 line loads from 111.7% to 115.8% of its emergency rating (659MVA) for the outage of Conastone to Northwest Ckts #2310 & #2322. The Q86 contributes 27.6 MW to the flow on this line. Project Q42 is the first to cause this thermal violation.

8. The Hudson 1HA 230kV circuit breaker is overdutied at 196.5% of its 51,600 amp rating. The circuit breaker is initially overloaded by the O66 project.

9. The Hudson 1HB 230kV circuit breaker is overdutied at 156.9% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

10. The Hudson 1HC 230kV circuit breaker is overdutied at 175.1% of its 51,600 amp rating. The circuit breaker is initially overloaded by the O66 project.

11. The Hudson 2HA 230kV circuit breaker is overdutied at 157.3% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

12. The Hudson 2HB 230kV circuit breaker is overdutied at 147.7% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

13. The Hudson 2HC 230kV circuit breaker is overdutied at 172.1% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

14. The Hudson 3HA 230kV circuit breaker is overdutied at 156.9% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

15. The Hudson 3HB 230kV circuit breaker is overdutied at 147.7% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

16. The Hudson 3HC 230kV circuit breaker is overdutied at 146.5% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

17. The Hudson 4HA 230kV circuit breaker is overdutied at 147.2% of its 70,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

18. The Hudson 4HB 230kV circuit breaker is overdutied at 140.7% of its 70,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

19. The Hudson 4HC 230kV circuit breaker is overdutied at 147.1% of its 70,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

20. The Saddle Brook 21P 230kV circuit breaker is overdutied at 157.2% of its 37,650 amp rating. The circuit breaker is initially overloaded by the O66 project.

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 Hudson-South Waterfront 230kV line (P-2268) can be alleviated by reconductoring the underground circuit. This includes removing the existing conductor and replacing with a larger conductor with a gain in capacity of at least 10%. The exact gain and size of the conductor would be determined during the detailed engineering analysis. The estimated cost for the reconductoring is **$15 million.** The estimate provided is worst case and assumes the largest conductor.

2. The overload on the Bagley-Raphael 230kV line can be alleviated by reconductoring the circuit with 1,272 kcm conductor rated at 125 deg.C. (Summer Emergency Rating becomes 699 MVA). The estimated cost is **$2.4 Million**. It is estimated to take approximately 3 yrs to complete the work.

3. The overload on the Mt. Carmel-Northwest 230kV circuit can be alleviated by reconductoring the 2322 with 1,590kcmil 45/7 ACSR conductor at 160°C to match ratings with the 2310 circuit for the same section. This work is estimated to take 12-18 months to complete and cost **$4.1Million**.

4. The overdutied condition of the Athenia 71H 230kV circuit breaker can be alleviated by replacing the existing circuit breaker with a new circuit breaker with a higher rating. The estimated cost of the circuit breaker replacement is **$0.5 million**.

5. The overdutied condition of the Bergen 20H 230kV circuit breaker can be alleviated by replacing the existing circuit breaker with a new circuit breaker with a higher rating. The estimated cost of the circuit breaker replacement is **$0.5 million**.

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)

6. The Conastone-Mt. Carmel 230kV overload can be alleviated by reconductoring the Conastone – Mount Carmel 2322 with 1,590kcmil 45/7 ACSR conductor at 160°C to match ratings with 2310 for the same section. This work is estimated to take 12-18 months to complete and cost **$3.8 Million**.

7. The overload on the Graceton-Bagley 230kV #1 circuit can be alleviated by reconductoring the circuit with 1,590kcmil 45/7 ACSR at 125°C (rating: 650/805MVA SN/SE). This will require significant rebuild of the towers to support the larger wire at higher tensions. The larger wire and taller structures will require a CPCN. The work will take an estimated 42-48 months to complete. Estimated costs are **$13.4 Million**. Project Q42 is the first project to cause this overload.

8. The overdutied condition of the Hudson 1HA breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.13)

9. The overdutied condition of the Hudson 1HB breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.5)

10. The overdutied condition of the Hudson 1HC breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$150,000**. (Upgrade n0666.12) This breaker is presently scheduled to be replaced with a 63kA breaker in 2009 (Upgrade b0184)

11. The overdutied condition of the Hudson 2HA breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.3)

12. The overdutied condition of the Hudson 2HB breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.10)

13. The overdutied condition of the Hudson 2HC breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.2)

14. The overdutied condition of the Hudson 3HA breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.4)

15. The overdutied condition of the Hudson 3HB breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.8)

16. The overdutied condition of the Hudson 3HC breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.9)

17. The overdutied condition of the Hudson 4HA breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.6)

18. The overdutied condition of the Hudson 4HB breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.11)

19. The overdutied condition of the Hudson 4HC breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.7)

20. The overdutied condition of the Saddle Brook 21P breaker can be alleviated by replacing the present circuit breaker with a breaker rated 63 kA. The estimated cost is **$350,000**. (Upgrade n0667)

Option #2 – New 3-breaker ring bus in the Hudson-Essex circuit

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

1. The Q86-Hudson 230kV circuit loads from 99.7% to 153.0% (AC power flow) of its emergency rating (826MVA) for the single line contingency outage of the Athenia – Cook Rd – Kingsland – NJT Meadows 230 kV line. This project contributes approximately 446.1MW to cause this thermal violation.

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)

2. The Hudson-South Waterfront 230 kV line is overloaded from 88.17% around 102.64% of its emergency rating (622 MVA) for the outage of the Hudson-Penhorn 230KV

Double Circuit Tower Line 230 kV. The Q86 project contributes approximately 97.3MW to cause the contingency facility overload.

3. The Q86–Hudson 230 kV line is loaded from 94.4% to 146.8% of its emergency rating (826 MVA) for the outage of the Athenia-NJT Meadows 230KV & Roseland-Kearny "G" 138KV Double Circuit Tower Line. The Q86 project contributes approximately 437.3 MW to cause the contingency facility overload.

4. The Bagley– Raphael 230 kV line is overloaded from 99.7% to 103.9% of its emergency rating (659 MVA) for the outage of the Conastone-Northwest Circuits #2310 & #2322 230kV. The Q86 project contributes approximately 27.6MW to cause the contingency facility overload.

5. The Mt. Carmel–Northwest 230 kV line loads from 99.2% to 102.4% of its emergency rating (803 MVA) for the outage of the Brighton-Conastone 500 kV line and the Brighton-Doubs 500 kV line. The Q86 project contributes approximately 25.6MW to cause the contingency facility overload

Short Circuit

6. The Athenia 71 H 230kV circuit breaker is overdutied to 100.7% of its 60200 amp rating due to the addition of the Q86 generation.

7. The Athenia 20 H 230kV circuit breaker is overdutied to 100.1% of its 75600 amp rating due to the addition of the Q86 generation.

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)

8. The Conastone-Mt. Carmel 230 kV line is loaded from 101.9% to 105.1% of its emergency rating (803 MVA) for the tower outage of the Brighton-Conastone 500 kV line and the Brighton-Doubs 500 kV line. The Q86 project contributes approximately 25.6 MW to the contingency facility loading. Project Q74 is the first to cause this overload.

9. The Graceton–Bagley 230 kV #1 line loads from 111.7% to 115.8% of its emergency rating (659MVA) for the outage of Conastone to Northwest Ckts #2310 & #2322. The Q86 contributes 27.6 MW to the flow on this line. Project Q42 is the first to cause this thermal violation.

10. The Hudson 1HA 230kV circuit breaker is overdutied at 196.5% of its 51,600 amp rating. The circuit breaker is initially overloaded by the O66 project.

11. The Hudson 1HB 230kV circuit breaker is overdutied at 156.9% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

12. The Hudson 1HC 230kV circuit breaker is overdutied at 175.1% of its 51,600 amp rating. The circuit breaker is initially overloaded by the O66 project.

13. The Hudson 2HA 230kV circuit breaker is overdutied at 157.3% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

14. The Hudson 2HB 230kV circuit breaker is overdutied at 147.7% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

15. The Hudson 2HC 230kV circuit breaker is overdutied at 172.1% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

16. The Hudson 3HA 230kV circuit breaker is overdutied at 156.9% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

17. The Hudson 3HB 230kV circuit breaker is overdutied at 147.7% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

18. The Hudson 3HC 230kV circuit breaker is overdutied at 146.5% of its 60,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

19. The Hudson 4HA 230kV circuit breaker is overdutied at 147.2% of its 70,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

20. The Hudson 4HB 230kV circuit breaker is overdutied at 140.7% of its 70,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

21. The Hudson 4HC 230kV circuit breaker is overdutied at 147.1% of its 70,000 amp rating. The circuit breaker is initially overloaded by the O66 project.

22. The Saddle Brook 21P 230kV circuit breaker is overdutied at 157.2% of its 37,650 amp rating. The circuit breaker is initially overloaded by the O66 project.

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 Q86-Hudson 230kV line can be alleviated by re-conductoring the circuit with 2x1033 ACSS at an estimated cost of **$20-25M**. This may require significant tower reinforcement/replacement, which would be determined during detailed analysis.

2. The overload on the Hudson-South Waterfront 230kV line (P-2268) can be alleviated by reconductoring the underground circuit. This includes removing the existing conductor and replacing with a larger conductor with a gain in capacity of at least 10%. The exact gain and size of the conductor would be determined during the detailed engineering analysis. The estimated cost for the reconductoring is **$15 million.** The estimate provided is worst case and assumes the largest conductor.

3. Same as #1

4. The overload on the Bagley-Raphael 230kV line can be alleviated by reconductoring the circuit with 1,272 kcm conductor rated at 125 deg.C. (Summer Emergency Rating becomes 699 MVA). The estimated cost is **$2.4 Million**. It is estimated to take approximately 3 yrs to complete the work.

5. The overload on the Mt. Carmel-Northwest 230kV circuit can be alleviated by reconductoring the 2322 with 1,590kcmil 45/7 ACSR conductor at 160°C to match ratings with the 2310 circuit for the same section. This work is estimated to take 12-18 months to complete and cost **$4.1Million**.

6. The overdutied condition of the Athenia 71H 230kV circuit breaker can be alleviated by replacing the existing circuit breaker with a new circuit breaker with a higher rating. The estimated cost of the circuit breaker replacement is **$0.5 million**.

7. The overdutied condition of the Bergen 20H 230kV circuit breaker can be alleviated by replacing the existing circuit breaker with a new circuit breaker with a higher rating. The estimated cost of the circuit breaker replacement is **$0.5 million**.

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)

8. The Conastone-Mt. Carmel 230kV overload can be alleviated by reconductoring the Conastone – Mount Carmel 2322 with 1,590kcmil 45/7 ACSR conductor at 160°C to match ratings with 2310 for the same section. This work is estimated to take 12-18 months to complete and cost **$3.8 Million**.

9. The overload on the Graceton-Bagley 230kV #1 circuit can be alleviated by reconductoring the circuit with 1,590kcmil 45/7 ACSR at 125°C (rating: 650/805MVA SN/SE). This will require significant rebuild of the towers to support the larger wire at higher tensions. The larger wire and taller structures will require a CPCN. The work will take an estimated 42-48 months to complete. Estimated costs are **$13.4 Million**. Project Q42 is the first project to cause this overload.

10. The overdutied condition of the Hudson 1HA breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.13)

11. The overdutied condition of the Hudson 1HB breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.5)

12. The overdutied condition of the Hudson 1HC breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$150,000**. (Upgrade n0666.12) This breaker is presently scheduled to be replaced with a 63kA breaker in 2009 (Upgrade b0184)

13. The overdutied condition of the Hudson 2HA breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.3)

14. The overdutied condition of the Hudson 2HB breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.10)

15. The overdutied condition of the Hudson 2HC breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.2)

16. The overdutied condition of the Hudson 3HA breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.4)

17. The overdutied condition of the Hudson 3HB breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.8)

18. The overdutied condition of the Hudson 3HC breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.9)

19. The overdutied condition of the Hudson 4HA breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.6)

20. The overdutied condition of the Hudson 4HB breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.11)

21. The overdutied condition of the Hudson 4HC breaker can be alleviated by replacing the present circuit breaker with a breaker rated 80 kA. The estimated cost is **$500,000**. (Upgrade n0666.7)

22. The overdutied condition of the Saddle Brook 21P breaker can be alleviated by replacing the present circuit breaker with a breaker rated 63 kA. The estimated cost is **$350,000**. (Upgrade n0667)