#S105 Croydon – Emilie 1200 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 S105 project was studied as a 1200 MW Capacity injection into the Croydon – Emilie 230 kV line. Project S105 was evaluated for compliance with reliability criteria for summer peak conditions in 2012. Potential network impacts were as follows:

NETWORK IMPACTS

Generator Deliverability

(Normal System with all facilities in-service and Single, or N-1, contingencies for the Capacity portion only of the interconnection)

1. The Emilie - Neshaminy 138 kV line loads from **99.7% to 159.7%** of its emergency rating (791 MVA) for the outage of Croydon – Eddington Tap 230 kV line and Emilie 230/34.5 kV transformer (PE55). This project contributes approximately **475 MW** to cause this thermal violation.

2. The Neshaminy - Byberry 138kV line loads from **97.0% to 163.1%** of its emergency rating (719 MVA) for the outage of Croydon – Eddington Tap 230 kV line and Emilie 230/34.5 kV transformer (PE55). This project contributes approximately **475 MW** to cause this thermal violation.

3. The Burlington – Mt Laurel 230kV line loads from **88.5% to 164.8%** of its emergency rating (844 MVA) for the outage of Croydon – Eddington Tap 230 kV line and Emilie 230/34.5 kV transformer (PE55). This project contributes approximately **643.9MW** to cause this thermal violation.

4. The Cox's Corner - Lumberton 230kV line loads from **85.2% to 106.4%** of its emergency rating (854 MVA) for the outage of Windsor – New Freedom 500 kV line (PJM89_NF_LOOPB). This project contributes approximately **181 MW** to cause this thermal violation.

5. The Emilie 230/138kV transformer #8 loads from **90.22% to 140.84%** of its emergency rating (525 MVA) for the outage of Emilie 230/138 kV transformer (PE206). This project contributes approximately **265.8 MW** to cause this thermal violation.

6. The Eddington Tap to Eddington 230kV line loads from **83.7% to 163%** of its emergency rating (856 MVA) for the outage of Croydon - Burlington - Mt Laurel

– Cox's Corner 230 kV line (PS59). This project contributes approximately **678.7 MW** to cause this thermal violation.

7. The Mt Laurel – Cox's Corner 230kV line loads from **80.2% to 153.9%** of its emergency rating (873 MVA) for the outage of Croydon – Eddington Tap 230 kV line and Emilie 230/34.5 kV transformer (PE55). This project contributes approximately **643.9 MW** to cause this thermal violation.

8. The Lumberton – Cookstown 230 kV line loads from **81.2% to 104.3%** of its emergency rating (717 MVA) for the outage of the Windsor – New Freedom 500 kV line (PJM89_NF_LOOPB). This project contributes approximately **166 MW** to cause this thermal violation.

9. The Croydon – Burlington 230 kV line loads from **68.3% to 156.4%** of its **normal rating** (466 MVA) for non-contingency condition. This project contributes approximately **410.8 MW** to cause this thermal violation.

10. The Byberry –Bluegrass 138 kV line loads from **84.7% to 139.1%** of its emergency rating (344 MVA) for the outage of Croydon – Eddington Tap 230 kV line and Emilie 230/34.5 kV transformer (PE55). This project contributes approximately **187.3MW** to cause this thermal violation.

11. The Holmesburg - Bluegrass 138kV line loads from **83.1% to 128.8%** of its emergency rating (323 MVA) for the outage of Emilie – Neshaminy 138 kV line and Neshaminy 138/13.8 kV transformer (PE90). This project contributes approximately **147.6 MW** to cause this thermal violation.

12. The Neshaminy – Byberry 138 kV line loads from **80.7% to 134.1%** of its **normal rating** (584 MVA) for non-contingency condition. This project contributes approximately **311.5 MW** to cause this thermal violation.

13. The Eddington – Holmsburg Tap 230kV line loads from **73.7% to 150.2%** of its emergency rating (887 MVA) for the outage of Croydon - Burlington - Mt Laurel – Cox's Corner 230 kV line (PS59). This project contributes approximately **678.7 MW** to cause this thermal violation.

14. The Holmsburg – Richmond 230kV line loads from **71.6% to 171.4%** of its **nor**mal rating (374 MVA) for non-contingency condition. This project contributes approximately 373.2MW to cause this thermal violation.

15. The Richmond Reactor – Richmond section of 230kV line loads from **71.6% to 171.4%** of its **norma**l rating (374 MVA) for non-contingency conditions. This project contributes approximately **373.2 MW** to cause this thermal violation.

16. The Cox's Corner - Lumberton 230kV line loads from **76.3% to 101.9%** of its **normal rating** (717 MVA) for non-contingency conditions. This project contributes approximately **183.2 MW** to cause this thermal violation.

17. The Emilie 230/138kV transformer #7 loads from **80.04% to 129.18%** of its emergency rating (525 MVA) for the outage of Croydon – Eddington Tap 230 kV line and Emilie 230/34.5 kV transformer (PE55). This project contributes approximately **258 MW** to cause this thermal violation.

18. The Eddington Tap – Eddington section of 230kV line loads from **73.3% to 134.6%** of its **normal rating** (737 MVA) for non-contingency conditions. This project contributes approximately **451.8MW** to cause this thermal violation.

19. The Emilie 230/138kV transformer #8 loads from **76.98% to 120.26%** of its **normal rating** (370 MVA) for non-contingency conditions. This project contributes approximately **160.2 MW** to cause this thermal violation.

20. The Burlington – Mt Laurel 230kV line loads from **67.4% to 123.2%** of its **normal rating** (734 MVA) for non-contingency conditions. This project contributes approximately **409.5 MW** to cause this thermal violation.

21. The Emilie 230/138kV transformer #7 loads from **73.94% to 115.31%** of its normal rating (370 MVA) for non-contingency condition. This project contributes approximately **153.1 MW** to cause this thermal violation.

22. The Eddington – Holmsburg Tap 230kV line loads from **65.2% to 126.9%** of its **normal rating** (732 MVA) for non-contingency conditions. This project contributes approximately **451.8 MW** to cause this thermal violation.

23. The Mt Laurel – Cox's Corner 230kV line loads from **61.0% to 116.8%** of its **normal rating** (734 MVA) for non-contingency condition. This project contributes approximately **409.5 MW** to cause this thermal violation.

24. The Queue S105 – China Tap 230kV line loads from **34.1% to 117.1%** of its emergency rating (1410 MVA) for the outage of Emilie Transformer #8 (PE207). This project contributes approximately **1169.2 MW** to cause this thermal violation.

25. The China Tap – Croydon 230kV line loads from **33.4% to 116.3%** of its emergency rating (1410 MVA) for the outage of Emilie Transformer #8 (PE207).

This project contributes approximately **1169.2 MW** to cause this thermal violation.

26. The Raritan River - Kilmer 230kV line loads from **96.2% to 100.7%** of its emergency rating (742 MVA) for the outage of the Gillette – Green Brook – Lake Nelson - Kilmer – Raritan River 230 kV line and Gillette 230/34.5 kV transformer (JC29). This project contributes approximately **33 MW** to cause this thermal violation.

27. The Holmsburg 230/138 kV transformer # 8 loads from **71.42% to 103.88%** of its emergency rating (522 MVA) for the outage of the Emilie – Neshamany 138 kV line and Neshamany 138/13.8 kV TX (PE90). This project contributes approximately **169.4 MW** to cause this thermal violation.

28. The Queue R39 (Option #1 connection) – Red Oak 230kV line loads from **96.4% to 101.3%** of its emergency rating (805 MVA) for the outage of the Red Oak – Queue Q11 230 kV line (JC31B_Q08OP1B_Q11A). This project contributes approximately **39.7MW** to cause this thermal violation.

29. The Bluegrass – Fox Chase 138kV line loads from **41.2% to 105.1%** (DC power flow) of its emergency rating (245 MVA) for the outage of the Croydon - Burlington - Mt Laurel – Cox's Corner 230 kV line (PS59). This project contributes approximately **156.5 MW** to cause this thermal violation.

Multiple Facility Contingency

(Double Circuit Tower Line, Line with Failed Breaker and Bus Fault contingencies for the full energy output)

30. The Brunner Island - Yorkanna 230kV line loads from **96.82% to 104.72%** of its emergency rating (617 MVA) for the Conastone – Peach Bottom ckt#1 and ckt#2 tower outage (Conas_PB). This project contributes approximately **48.7MW** to cause this thermal violation.

Short Circuit Analysis

Will be performed for the Impact Study.

Stability Analysis

Will be performed for the 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)

31. The Red Oak B – Raritan River 230kV line loads from **186.08% to 190.34%** of its emergency rating (805 MVA) for the outage of the Raritan River – Red Oak A 230 kV line (JC30A_Q08OP1A). This project contributes approximately **34.3 MW** to the thermal violation.

32. The Emilie - Neshaminy 138kV line loads from **102.22% to 158.86%** of its **normal rating** (550 MVA) for non-contingency condition. This project contributes approximately **311.5 MW** to the thermal violation.

33. The Holmsburg Tap – Richmond Reactor section of 230kV line loads from **112.63% to 264.17%** of its emergency rating (374 MVA) for the outage of the Croydon - Burlington - Mt Laurel – Cox's Corner 230 kV line (PS59). This project contributes approximately **566.8 MW** to the thermal violation.

34. The Richmond Reactor - Richmond 230kV line loads from **112.63% to 264.17%** of its emergency rating (374 MVA) for the outage of the Croydon - Burlington - Mt Laurel – Cox's Corner 230 kV line (PS59). This project contributes approximately **566.8MW** to the thermal violation.

35. The Croydon – Burlington 230kV line loads from **101.86% to 217.49%** of its emergency rating (558 MVA) for the outage of Croydon – Eddington Tap 230 kV line and Emilie 230/34.5 kV transformer (PE55). This project contributes approximately **645.2 MW** to the thermal violation.

36. The Lackawanna - Oxbow 230 kV line loads from **150.26% to 157.74%** of its emergency rating (504 MVA) for the outage of the Jefferson – Lackawanna 500 kV line (PJM JEFF-LACK 500). This project contributes approximately **37.7 MW** to the thermal violation.

37. The N. Meshoppen – Meshoppen 230/115kV transformer loads from **122.36% to 130.39%** of its emergency rating (201 MVA) for the outage of the N. Meshoppen – E. Towanda 230 kV line and N. Meshoppen 230/115 kV transformer (PN47B). This project contributes approximately **16.1 MW** to the thermal violation.

38. The Meshoppen REA –N. Meshoppen 115 kV line loads from **122.30% to 130.33%** of its emergency rating (201 MVA) for the outage of N. Meshoppen – E. Towanda 230 kV line and N. Meshoppen 230/115 kV transformer (PN47B). This project contributes approximately **16.1 MW** to the thermal violation.

39. The Lackawanna – Oxbow 230 kV line loads from **152.42% to 160.99%** of its **normal rating (**499 MVA) for non-contingency condition. This project contributes approximately **42.8 MW** to the thermal violation.

40. The Oxbow – N. Meshoppen 230 kV line loads from **152.27% to 160.84%** of its **normal rating** (499 MVA) for non-contingency conditions. This project contributes approximately **42.8 MW** to the thermal violation.

41. The Oxbow – N. Meshoppen 230 kV line loads from **126.44% to 132.94%** of its emergency rating (617 MVA) for the outage of Queue R24 - Wescosville – Alburtis 500 kV line, and Wescosville 500/138 kV transformer (PJM66_WITH_R24A). This project contributes approximately **40.1 MW** to the thermal violation.

42. The Conastone – N. Northwest 500 kV line loads from **133.97% to 146.19%** of its **normal rating** (2078 MVA) for non-contingency conditions. This project contributes approximately **253.9 MW** to the thermal violation.

43. The Northwest – Granite 230 kV line loads from **142.38% to 153.71%** of its emergency rating (641 MVA) for the outage of the Kemptown – N. Northwest 500 kV line (PJM13B_NNWEST_B). This project contributes approximately **72.6 MW** to the thermal violation.

44. The Raphael Road – Northeast 230kV (ckt #2337) line loads from **106.94% to 114.37%** of its emergency rating (758 MVA) for the outage of the Raphael Road – Northeast 230 kV ckt #2315 and Northeast 230 /115 kV transformer (BG8). This project contributes approximately **56.3 MW** to the thermal violation.

45. The Raphael Road - Northeast 230kV (ckt #2315) line loads from **105.44% to 112.76%** of its emergency rating (758 MVA) for the outage of the Northeast – Raphael Road 230 kV ckt #2337 (BG18). This project contributes approximately **55.5 MW** to the thermal violation.

46. The Conastone – Mt Carmel (ckt #2322) 230kV line loads from **119.98% to 129.27%** of its emergency rating (923 MVA) for the outage of the N. Northwest – Conastone 500 kV line (PJM13B_NNWEST_A). This project contributes approximately **85.7 MW** to the thermal violation.

47. The Conastone –Mt Carmel (ckt #2310) 230 kV line loads from **119.98% to 129.27%** of its emergency rating (923 MVA) for the outage of the N. Northwest – Conastone 500 kV line (PJM13B_NNWEST_A). This project contributes approximately **85.7 MW** to the thermal violation.

48. The Northeast 230/115kV transformer loads from **105.88% to 112.66%** of its emergency rating (378 MVA) for the outage of the Northeast – Riverside ckt

#2317 and ckt #2339 (NORTHEAST_RIVERSIDE). This project contributes approximately **25.6 MW** to the thermal violation.

49. The Three Mile Island 500/230kV transformer loads from **120.87% to 130.88%** of its emergency rating (1077 MVA) for the **tower** outage of the Conastone – Peach Bottom 500 kV ckt #1 and ckt #2 (Conas_PB). This project contributes approximately **107.9MW** to the thermal violation.

50. The Conastone – N. Northwest 500kV line loads from **122.35% to 132.43%** of its emergency rating (2901 MVA) for the **tower** outage of the Conastone – Northwest ckt #2310 and ckt #2322 (CNSTN_NWEST_NNWEST_A). This project contributes approximately **292.3 MW** to the thermal violation.

51. The Nottingham – Nottingham Reactor section of the Nottingham to Graceton 230 kV line loads from **127.86% to 143.83%** of its emergency rating (627 MVA) for the **tower** outage of the Conastone – Peach Bottom 500 kV ckt #1 and ckt #2 (Conas_PB). This project contributes approximately **100.1 MW** to the thermal violation.

52. The Nottingham Reactor – Peach Bottom Tap section of the Nottingham to Graceton 230kV line loads from **127.80% to 143.77%** of its emergency rating (627 MVA) for the **tower** outage of the Conastone – Peach Bottom 500 kV ckt #1 and ckt #2 (Conas_PB). This project contributes approximately **100.1 MW** to the thermal violation.

53. The Peach Bottom Tap - Graceton 230kV line loads from **127.80% to 143.77%** of its emergency rating (627 MVA) for the **tower** outage of the Conastone – Peach Bottom 500 kV ckt #1 and ckt #2 (Conas_PB). This project contributes approximately **100.1 MW** to the thermal violation.

54. The Peach Bottom - Conastone 500kV line loads from **130.10% to 143.56%** of its emergency rating (2598 MVA) for the outage of the Conastone – Peach Bottom 500 kV ckt #2 (PJM17_2). This project contributes approximately **349.5 MW** to the thermal violation.

55. The Peach Bottom – Conastone 500kV line loads from **130.10% to 143.56%** of its emergency rating (2598 MVA) for the outage of the Conastone – Peach Bottom 500 kV ckt #1 (PJM17). This project contributes approximately **349.5 MW** to the thermal violation.

NETWORK UPGRADE REQUIREMENTS

** **Note**: Upgrade plans, cost and time estimates have not been developed for Network Impacts 3, 4, 7, 8, 16, 20, 23, 26, 28,30, 36, 37, 38, 39 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51 and 52 because the number and cost of upgrade requirements already developed for Queue S105 already exceeded a reasonable scope and cost. Undeveloped upgrade plans, cost and time estimates will be developed for the Impact Study if needed.*

New System Reinforcements

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

1. Neshaminy to Emilie 138 kV line upgrade - Rebuild the line to 230 kV double circuit, high capacity and operate both sides of the tower line at 138 kV to achieve rating of 1490MVA (normal) / 1690MVA (emergency). 4.4 miles @ $2.5M per mile plus modifications at both substations for a total estimated cost of **$21,000,000** and **four years** to complete.

2. Byberry to Neshaminy 138kV line upgrade - Rebuild the line to 230 kV double circuit, high capacity and operate both sides of the tower line at 138 kV to achieve rating of 1490MVA (normal) / 1690MVA (emergency). 4.4 miles @ $2.5M per mile plus modifications at both substations, **$21,000,000** and **four years** to complete. ***(Note: This upgrade also satisfies overload 12)***

3. Upgrade plan, cost and time estimate will be provided for the Impact Study if needed*.

4. Upgrade plan, cost and time estimate will be provided for the Impact Study if needed*.

5. Emilie #7 and #8 230/138 kV transformer overload upgrade- Parallel existing transformers #7 and #8 with new transformers to increase rating, $8M plus $5M for substation modifications for a total cost of **$13,000,000** and **two years** to complete. ***(Note: This upgrade also satisfies overloads 17, 19, and 21)***

6. Eddington - Holmesburg - Richmond 230 kV line upgrade - Construct a second 230 kV line along railroad rights of way. 15.7 miles @ $2.5M per mile, **$39,000,000** and **three years** to complete. Modify Eddington, Holmesburg, and Richmond substations to accommodate new line, **$10,000,000** and **three years** to complete. ***(Note: This upgrade also satisfies overloads 13, 14, 15, 18, and 22***

7. Upgrade plan, cost and time estimate will be provided for the Impact Study if needed*.

8. Upgrade plan, cost and time estimate will be provided for the Impact Study if needed*.

9. Croydon to Burlington 230 kV line upgrade

   PECO Energy portion of line:
   Rebuild the line as a high capacity 230 kV line, 1243 MVA (normal) / 1411 MVA (emergency). Line upgrade is 1.4 miles @ $1.5M per mile plus new Delaware river crossing, approx **$22,000,000** and **three years** to complete. PECO portion only.

   PSE&G portion of line:

   Upgrade plan, cost and time estimate will be provided for the Impact Study if needed*.

10. Byberry to Bluegrass 138 kV line upgrade. - Rebuild the line to achieve a rating of 440 MVA (normal) / 524 MVA (emergency). Line cost for 5 miles @ $1.5M per mile plus modifications at both substations for a total of **$13,000,000** and **three years** to complete.

11. Holmesburg to Bluegrass 138 kV line - Rebuild the line to achieve a rating of 440 MVA (normal) / 524 MVA (emergency). Line cost for 2.7 miles @ $1.5M per mile plus modifications at both substations for a total of **$7,000,000** and **three years** to complete.

12. See Network Upgrade 2.

13. See Network Upgrade 6.

14. See Network Upgrade 6.

15. See Network Upgrade 6.

16. Upgrade plan, cost and time estimate will be provided for the Impact Study if needed*.

17. See Network Upgrade 5.

18. See Network Upgrade 6.

19. See Network Upgrade 5.

20. Upgrade plan, cost and time estimate will be provided for the Impact Study if needed*.

21. See Network Upgrade 5.

22. See Network Upgrade 6.

23. Upgrade plan, cost and time estimate will be provided for the Impact Study if needed.

24. Croydon to China Tap 230 kV line upgrade. - Build a new high capacity 230 kV line, 1243 MVA (normal) / 1411 MVA (emergency) from Queue S105 to Croydon. (1.25 miles @ $1.5M per mile) plus modifications at Croydon for a total cost of **$5,000,000** and **two years** to complete. ***(Note: This upgrade also satisfies overload 25)***

25. See Network Upgrade 24.

26. Upgrade plan, cost and time estimate will be provided for the Impact Study if needed*.

27. Holmesburg #8 230/138 kV transformer - Parallel existing transformer with a new transformer, $4M (new transformer) plus $3M (substation modifications) for a total estimated cost of **$7,000,000** and **two years** to construct.

28. Upgrade plan, cost and time estimate will be provided for the Impact Study if needed*.

29. Blue Grass to Fox Chase 138 kV line - Reconductor one mile to achieve emergency rating of 340 MVA, $1M and 1.5 years to complete.

30. Upgrade plan, cost and time estimate will be provided for the Impact Study if needed*.

Contribution to Previously Identified System Reinforcements *(This project contributes to the Network Impact causing the need for these Network Upgrades. This project will be allocated a cost to be determined during the Impact Study)*

31. Upgrade plan, cost and time estimate will be provided for the Impact Study if needed*.

32. See Network Upgrade 1.

33. See Network Upgrade 6.

34. See Network Upgrade 6.

35. See Network Upgrade 9.

36. 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51 and 52.

    Upgrade plans, cost and time estimates will be provided for the Impact Study if needed*

53. Nottingham - Peach Bottom - Graceton 230 kV line upgrade. - A portion of this line must be relocated to underground to facilitate the construction of additional 500 kV lines between Peach Bottom and Conastone, this is estimated to cost **$61,000,000** and **three years** to construct.

    Also, must rebuild Nottingham to Peach Bottom portion as a high capacity 230 kV line, 1243MVA (normal) / 1411MVA (emergency), 13.6 miles @ $1.5M per mile plus new Susquehanna river crossing for a total cost of **$40,000,000** and **four years** to complete.

54. Peach Bottom to Conastone 500 kV line upgrade. – Add a new line rated 3366 MVA (normal) / 4183 MVA (emergency) between these substations and terminal equipment at Peach Bottom and Conastone substations. Approx **$62,000,000** and about **seven years** to construct. ***(Note: This upgrade also satisfies overload 55)***

55. See Network Upgrade 54.