#S04 – Essex 230kV

Generation Interconnection

This analysis was completed to assess the reliability impact for a new wind generator interconnecting to the PJM system as a capacity resource.

Network Impacts

The Queue S04 project was studied as a 633 MW (Capacity) injection at Essex 230 kV substation. The project was evaluated for compliance with reliability criteria for summer peak conditions in 2012. Potential network impacts were as follows:

RESULTS WITHOUT Q75

(PJM has performed this evaluation without the Q75 merchant project connecting between Bergen and New York City modeled because the upgrades required for the Q75 project have not been completely identified and modeled. When the Q75 upgrades are modeled they should not have a significant impact upon what is stated in this report.)

Generator Deliverability

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

1. The Essex – Hudson 230 kV line is overloaded from 72% to 135% of its emergency rating (826 MVA) for the outage of Athenia – Cook Rd – NJT Kingsland – NJT Meadows 230 kV line (Cont Id PS20). This project contributes approximately 525 MW to cause the thermal violation.

2. The Essex – Hudson 230 kV line is overloaded from 58% to 108% of its normal rating (716 MVA). This project contributes approximately 361 MW to cause the thermal violation.

3. The Bergen – Leonia Tap ckt#2 230 kV line is overloaded from 97% to 117% of its emergency rating (557 MVA) for the outage of Bergen – Leonia Tap ckt#1 230 kV line (Cont Id. PS45). This project contributes approximately 114 MW to cause the thermal violation.

4. The Bergen – Leonia Tap ckt#1 230 kV line is overloaded from 94% to 112% of its emergency rating (557 MVA) for the outage of Bergen – Leonia T –Milford 230 kV line (Cont Id. PS45B). This project contributes approximately 105 MW to cause the thermal violation.

5. The Bergen – Leonia Tap ckt#1 230 kV line is overloaded from 95% to 112% of its normal rating (375 MVA). This project contributes approximately 64 MW to cause the thermal violation.

6. The Kearny – NJT Meadows 230 kV line is overloaded from 61% to 114% of its emergency rating (826 MVA) for the outage of Essex – Hudson 230 kV line (Cont Id. PS72). This project contributes approximately 435 MW to cause the thermal violation.

7. The NJT Meadows – Kingsland 230 kV line is overloaded from 59% to 112% of its emergency rating (826 MVA) for the outage of Essex – Hudson 230 kV line (Cont Id. PS72). This project contributes approximately 435 MW to cause the thermal violation.

8. The Cook Rd – Athenia 230 kV line is overloaded from 50% to 108% of its emergency rating (752 MVA) for the outage of Essex – Hudson 230 kV line (Cont Id. PS72). This project contributes approximately 435 MW to cause the thermal violation.

9. The Kingsland - Cook Rd 230 kV line is overloaded from 53% to 105% of its emergency rating (845 MVA) for the outage of Essex – Hudson 230 kV line (Cont Id. PS72). This project contributes approximately 435 MW to cause the thermal violation.

10. The South Waterfront – Newport 230 kV line from 91% to 112% of its normal rating (315 MVA). This project contributes approximately 65 MW to cause the 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)

11. The Linden – North Ave 138 kV line is overloaded from 98% to 152% of its emergency rating (308 MVA) for the **tower** outage of Hudson – Essex 230 kV line and NJT Meadows – Athenia 230 kV line (Cont Id 27PS). This project contributes approximately 166 MW to cause the thermal violation.

12. The Bayonne – B-M Reactor 138 kV line is overloaded from 82% to 135% of its emergency rating (311 MVA) for the **tower** outage of Hudson – Essex 230 kV line and NJT Meadows – Athenia 230 kV line (Cont Id 27PS). This project contributes approximately 165 MW to cause the thermal violation.

13. The B-M Reactor – Marion 138 kV line is overloaded from 82% to 135% of its emergency rating (311 MVA) for the **tower** outage of Hudson – Essex 230 kV line and NJT Meadows – Athenia 230 kV line (Cont Id 27PS). This project contributes approximately 165 MW to cause the thermal violation.

14. The Passaic Valley SC – Bayonne 138 kV line is overloaded from 75% to 130% of its emergency rating (299 MVA) **tower** outage of Hudson – Essex 230 kV line and NJT Meadows – Athenia 230 kV line (Cont Id 27PS). This project contributes approximately 165 MW to cause the thermal violation.

15. The Essex PAR – Stanley Terrace 230 kV line is overloaded from 56% to 121% of its emergency rating (550 MVA) **tower** outage of Hudson – Essex 230 kV line and NJT Meadows – Athenia 230 kV line (Cont Id 27PS). This project contributes approximately 356 MW to cause the thermal violation.

16. The Stanley Terrace – Aldene 230 kV line is overloaded from 56% to 121% of its emergency rating (550 MVA) **tower** outage of Hudson – Essex 230 kV line and NJT Meadows – Athenia 230 kV line (Cont Id 27PS). This project contributes approximately 356 MW to cause the thermal violation.

17. The ECRRF – Foundry St. 138 kV line is overloaded from 82% to 121% of its emergency rating (350 MVA) **tower** outage of Hudson – Essex 230 kV line and NJT Meadows – Athenia 230 kV line (Cont Id 27PS). This project contributes approximately 135 MW to cause the thermal violation.

18. The North Ave – Passaic Valley SC 230 kV line is overloaded from 67% to 112% of its emergency rating (372 MVA) **tower** outage of Hudson – Essex 230 kV line and NJT Meadows – Athenia 230 kV line (Cont Id 27PS). This project contributes approximately 166 MW to cause the thermal violation.

19. The Foundry St – Newark 138 kV line is overloaded from 64% to 101% of its emergency rating (367 MVA) **tower** outage of Hudson – Essex 230 kV line and NJT Meadows – Athenia 230 kV line (Cont Id 27PS). This project contributes approximately 135 MW to cause the thermal violation.

20. The Conastone – NNWest (2322 line) 500 kV line is loaded from 99% to 104% of its emergency rating (2901 MVA) for the outage of Conastone – NNWest ckts 2310 and 2322. This project contributes approximately 140 MW to cause the thermal violation.

21. The Hudson – South Waterfront 230 kV line from 98% to 111% of its emergency rating (622 MVA) for the **tower** outage of Hudson – Penhorn 230 kV DCTL (Cont Id. 24PS). This project contributes approximately 80 MW to cause the thermal violation.

22. The South Waterfront – Newport 230 kV line overloads from 81% to 104% of its emergency rating (490 MVA) for the **tower** outage of Hudson-Belleville 230 kV and Roseland - Kearny D 138 kV DCTL (Cont Id. 30PS). This project contributes approximately 116 MW to cause the thermal violation.

Short Circuit

The Essex 230kV - 22H breaker was over-stressed and needs to be replaced.

The S04 project increases the overdutied condition of the following breakers in the Hudson 230kV substation: 1HA, 1HB, 1HC, 2HA, 2HB, and 2HC and will have a cost allocation to their upgrade.

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)

23. Contribution of 56 MW further overloads the Hudson – South Waterfront 230 kV line from 111% to 124% of its normal rating (404 MVA).

24. Contribution of 32 MW further overloads the Lackawanna – Oxbow 230 kV line from 133% to 139% of its normal rating (499 MVA).

25. Contribution of 25 MW further overloads the Lackawanna – Oxbow 230 kV line from 138% to 143% of its emergency rating (504 MVA) for the outage of Jefferson – Lackawanna 500 kV line.

26. Contribution of 33 MW further overloads the Oxbow – N. Meshoppen 230 kV line from 133% to 139% of its normal rating (499 MVA).

27. Contribution of 37 MW further overloads the Oxbow – N. Meshoppen 230 kV line from 126% to 132% of its emergency rating (617 MVA) for the outage of Sunbury – Juniata – Susquehanna 500 kV line (Cont. PJM69).

28. Contribution of 12 MW further overloads the N. Meshoppen 230/115 kV ckt#3 transformer from 109% to 115% of its emergency rating (201 MVA) for the **tower** outage of N. Meshoppen – E. Towanda and N. Meshoppen 230/115 kV ckt#4 transformer (Cont Id. PN47B).

29. Contribution of 12 MW further overloads the N. Meshoppen - Mesh2rea ckt#3 from 109% to 115% of its emergency rating (201 MVA) for the **tower** outage of N. Meshoppen – E. Towanda and N. Meshoppen 230/115 kV ckt#4 transformer (Cont Id. PN47B).

30. Contribution of 123 MW further overloads the Conastone – NNWest (2322 line) 500 kV line from 108% to 114% of its normal rating (2078 MVA).

31. Contribution of 33 MW further overloads the N West - Granite 230 kV line from 109% to 114% of its emergency rating (803 MVA) for the outage of Kempton – NNWest 500 kV line.

32. Contribution of 38 MW further overloads the Nottingham – Nottreac 230 kV line from 113% to 119% of its emergency rating (627 MVA) for the **tower** outage of Conastone – Peach Bottom 500 kV line ckt#1 and Conastone – Peach Bottom 500 kV line ckt#2.

33. Contribution of 38 MW further overloads the Peach Bottom Tap - Graceton 230 kV line from 113% to 119% of its emergency rating (627 MVA) for the **tower** outage of

Conastone – Peach Bottom 500 kV line ckt#1 and Conastone – Peach Bottom 500 kV line ckt#2.

34. Contribution of 38 MW further overloads the Nottreac – Peach Bottom Tap 230 kV line from 113% to 119% of its emergency rating (627 MVA) for the **tower** outage of Conastone – Peach Bottom 500 kV line ckt#1 and Conastone – Peach Bottom 500 kV line ckt#2.

35. Contribution of 8 MW further overloads the Werner – Raritan River 115 kV line from 101% to 107% of its emergency rating (140 MVA) for the outage of Raritan River 230/115 kV transformer (Cont Id. JCPL101).

36. Contribution of 49 MW further overloads the Three Mile Island 500/230 kV transformer from 107% to 112% of its emergency rating (1077 MVA) for the **tower** outage of Conastone – Peach Bottom 500 kV line ckt#1 and Conastone – Peach Bottom 500 kV line ckt#2.

37. Contribution of 39 MW further overloads the Conastone – Mt Carmel 230 kV line 2322 from 105% to 109% of its emergency rating (923 MVA) for the outage of Kemptown – NNWest 500 kV line.

38. Contribution of 39 MW further overloads the Conastone – Mt Carmel 230 kV line 2310 from 105% to 109% of its emergency rating (923 MVA) for the outage of Kemptown – NNWest 500 kV line.

39. Contribution of 39 MW further overloads the Mt Carmel – NNWest 230 kV line 2310 from 103% to 107% of its emergency rating (923 MVA) for the outage of Kemptown – NNWest 500 kV line.

40. Contribution of 39 MW further overloads the Mt Carmel – NNWest 230 kV line 2322 from 103% to 107% of its emergency rating (923 MVA) for the outage of Kemptown – NNWest 500 kV line.

Potential Overloads

1. The Parlin – Williams 230 kV line is overloaded from 95% to 99% of its emergency rating (805 MVA) for the outage of Atlantic – South River 230 kV line (Cont Id JC17). This project contributes approximately 31 MW to cause the thermal violation.

New System Reinforcements

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

1. Essex – Hudson 230 kV Upgrade – Reconductor the existing Essex – Hudson 230 kV line with 1590 ACSS (6.25 miles) at an estimated cost of **$25 M** and an estimated time of 1-2 years. *(Note: This upgrade suffices to mitigate overload #2 also).*

3. Bergen – Leonia Tap ckt#2 230 kV upgrade – Install a parallel 230 kV circuit between Bergen and Leonia (approximately 3 miles) at an estimated cost of **$20 M** and an estimated time of 3 years. *(Note: This upgrade suffices to mitigate overloads 4 and 5 also).*

6. Install a new 230kV circuit between Essex and Hudson (1590 ACSS) at an estimated cost of **$10 M** and an estimated time of 2-3 years. *(Note: This upgrade suffices to mitigate overloads 7, 8, 9, 11, 12, 13 14, 15, 16, 17, 18 and 19 also).*

10. South Water Front – Newport 230 kV upgrade – Construct a 230 kV GIS station at 49th Street Rack at an estimated cost of **$50 M** and an estimated time of 2-3 years. *(Note: This upgrade suffices overloads 20, 21 and 23 too).*

22. Conastone to North Northwest 500 kV line - 1 single circuit line at an estimated cost of **$109 million** 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 located 4 miles north of Northwest

    Substation Terminations (all in 2012 dollars):
    Conastone - Install a 1 breaker bay **$3.2M**
    NNW - Install a 2 breaker bay **$6.4M**

    (Note: This upgrade suffices to mitigate overload 35 also)

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)
None

24. Lackawanna – Oxbow 230 kV line Upgrade - Lackawanna is a PP&L owned substation and any associated terminal upgrades would have to be confirmed by PP&L. This overload would require the upgrade of approximately 16.33 miles of transmission line (estimated to cost approximately **$8,165,000**). *(Note: This upgrade suffices to mitigate overload 25 also).*

26. Oxbow – N. Meshoppen 230 kV line upgrade - This overload would require the upgrade of approximately 10.16 miles of transmission line (estimated to cost approximately **$5,080,000**), a CT circuit (estimated to cost approximately **$140,000**), and substation conductor (estimated to cost approximately **$125,000**) at North Meshoppen substation. *(Note: This upgrade suffices to mitigate overload 27 also).*

28. N. Meshoppen 230/115 kV ckt#3 transformer Upgrade - The rating for the North Meshoppen 230/115 kV #3 transformer is 146 MVA N/ 157 MVA E. This overload would require the upgrade of the transmission transformer and associated equipment (circuit breaker, substation conductor, CT circuits), which is estimated to cost approximately **$4,000,000** and requires a lead time of at least 2 years. *(Note: This upgrade suffices to mitigate overload 29 also).*

30. Northwest – Granite 230 kV Upgrade – Replace 230 kV breaker at Northwest at an estimated cost of **$383K**

31. Nottingham – Peachbottom – Graceton 230 kV Upgrade -

Option 1 - No new Conastone to Peach Bottom 500 kV line(s)

Replace Nottingham reactor and upgrade substation equipment	$4M
Reconductor Nottingham to Graceton (220-08 line) to obtain a minimum emergency rating of 800 MVA 20.2 miles @ $400K/mile	$8.1M
Contingency for reconductoring the Susquehanna river crossing	$1M
Total	**$13.1M**

Option 2 - Done in conjunction with new Conastone to Peach Bottom 500 kV line(s)

Replace Nottingham reactor and upgrade substation equipment	$4M
Reconductor Nottingham to Peach Bottom (220-08 line) to obtain a minimum emergency rating of 800 MVA 13.6 miles @ $400K/mile	$5.4M
Contingency for reconductoring the Susquehanna river crossing	$1M
Install two high pressure dielectric filled 230 kV pipe type cables in the existing right of way from Peach Bottom to Graceton 2 x 7.5 mile @ $4M/mile	$60M
Total	**$70.4M**

Note: The underground estimate assumes that there are no large rivers or streams to cross. The estimate does not include substation upgrades at Graceton.

(This upgrade suffices to mitigate the overloads 32 and 33 too).

34. TMI 500-230 kV transformer Upgrade – The estimated cost to add a second 500-230 kV transformer is **$11,800,000** and the time required is approximately 20 months.

36. Northwest - Mt Carmel - Conastone upgrade –

This overload requires installation at the NNW station 2-500/230kV xfmrs 4-500 kV breakers, 7-230 kV Breakkers and related substation equipment and land at a cost of **$70M**. It also requires reconductoring of the Conastone to Northwest #2322 230kV circuit with 1,272kcmil ACSR 1,590kcmil ACSR with an estimated cost of **$8.21**. This work would take 3-4 years to build substation and 18-24 months for the line work.

(Note: This upgrade will suffice to mitigate the overloads 37, 38 and 39 also).