#R39 Red Oak 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 #R39 project was studied as a 300 MW injection at the Red Oak substation. Project #R39 was evaluated for compliance with reliability criteria for summer peak conditions in 2011. Potential network impacts were as follows:

Note: R39 project was studied at R11 option A.

Generator Deliverability

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

1. The R39 – Red OakA 230 kV line is overloaded from 77% to 105% of its normal rating (653 MVA). This project contributes approximately 182 MW to cause the thermal violation.

2. The Raritan River – Kilmer I 230 kV line is overloaded from 86% to 102% of its emergency rating (742 MVA) for the outage of Raritan River – Kilmer W – Lk Nelson 230 kV line (Cont. PS56D). This project contributes approximately 122 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)

3. The R39 – Red OakA 230 kV line is overloaded from 98% to 128% of its emergency rating (793 MVA) for the **tower** outage of South River – Atlantic 230 kV line and Parlin – Williams – Freneau 230 kV line (Cont. 30JC). This project contributes approximately 240 MW to cause the thermal violation.

4. The Q11 – Red OakB 230 kV line is overloaded from 99% to 125% of its emergency rating (805 MVA) for the **tower** outage of Q11 – Parlin 230 kV line and Red OakA – R39 230 kV line (Cont. 31JCB_Q08OP1B_Q11A_R39OP1A). This project contributes approximately 211 MW to cause the thermal violation.

Short Circuit

The following breakers were found to be newly over-duty as a result of R11 option 1 connection.

South River 230kV - BT
South River 230kV - PB
South River 230kV - PA
South River 230kV - TA
Raritan River 230kV - W1037F

In addition, the analysis showed a significant fault contribution to 10 breakers which were already over-duty. This contribution is great enough to warrant a cost allocation. The breakers are listed below:

Raritan River 230kV - W1037E
Raritan River 230kV - G1047E
Raritan River 230kV - G1047F
Raritan River 230kV - T1034E
Raritan River 230kV - T1034F
Raritan River 230kV - BK15
Raritan River 230kV - I1023E
Raritan River 230kV - I1023F
Red Oak 2881 230kV - T1034
Red OAK 2882 230kV - G1047

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)

5. The Q11 – Parlin 230 kV line is overloaded at 140% of its emergency rating (805 MVA) for the **tower** outage of Raritan River – Red Oak A 230 kV line and Raritan River – Red Oak B 230 kV line (Cont. 31JCA_Q08OP1A). This project contributes approximately 138 MW to cause the thermal violation.

6. The Parlin – Williams 230 kV line is overloaded at 136% of its emergency rating (805 MVA) for the **tower** outage of Raritan River – Red Oak A 230 kV line and Raritan River – Red Oak B 230 kV line (Cont. 31JCA_Q08OP1A). This project contributes approximately 117 MW to cause the thermal violation.

7. The Williams - Freneau 230 kV line is overloaded at 136% of its emergency rating (805 MVA) for the **tower** outage of Raritan River – Red Oak A 230 kV line and Raritan River – Red Oak B 230 kV line (Cont. 31JCA_Q08OP1A). This project contributes approximately 117 MW to cause the thermal violation.

8. The South River – Atlantic 230 kV line is overloaded at 149% of its emergency rating (805 MVA) for the **tower** outage of Raritan River – Red Oak A 230 kV line and Raritan River – Red Oak B 230 kV line (Cont. 31JCA_Q08OP1A). This project contributes approximately 160 MW to cause the thermal violation.

9. The Red Oak A - Raritan River 230 kV line is overloaded at 198% of its emergency rating (805 MVA) for the outage of Raritan River – Red Oak B 230 kV line (Cont. JC31A_Q08OP1A). This project contributes approximately 183 MW to this overload.

10. The Red Oak B - Raritan River 230 kV line is overloaded at 198% of its emergency rating (805 MVA) for the outage of Raritan River – Red Oak A 230 kV line (Cont. JC30A_Q08OP1A). This project contributes approximately 182 MW to this overload.

11. The Red Oak A - Raritan River 230 kV line is overloaded at 129% of its normal rating (650 MVA). This project contributes approximately 96 MW to this overload.

12. The Red Oak B - Raritan River 230 kV line is overloaded at 126% of its normal rating (650 MVA). This project contributes approximately 93 MW to this overload.

13. The Conastone - Mt Carmel (2322 line) 230 kV line is overloaded at 173% of its emergency rating (803 MVA) for the **tower** outage of Brighton to Doubs and Brighton to Conastone 500 kV line (Cont Id. AP5). This project contributes approximately 16 MW to this overload.

14. The Mt Carmel - NWest (2322 line) 230 kV line is overloaded at 170% of its emergency rating (803 MVA) for the **tower** outage of Brighton to Doubs and Brighton to Conastone 500 kV line (Cont Id. AP5). This project contributes approximately 16 MW to this overload.

15. The Peachbottom Tap - Graceton 230 kV line is overloaded at 117% of its emergency rating (627 MVA) for the outage of Conastone – Peachbottom 500 kV line (Cont. PJM17). This project contributes approximately 19 MW to this overload.

16. The Manor - Graceton 230 kV line is overloaded at 140% of its emergency rating (531 MVA) for the outage of Conastone – Peachbottom 500 kV line (Cont. PJM17). This project contributes approximately 19 MW to this overload.

17. The Graceton – Bagley 230 kV line is overloaded at 203% of its emergency rating (659 MVA) for the **tower** outage of Brighton - Doubs 500 kV line and Brighton - Conastone 500 kV line (Cont. AP5). This project contributes approximately 20 MW to this overload.

18. The Rapheal – Bagley 230 kV line is overloaded at 191% of its emergency rating (659 MVA) for the **tower** outage of Brighton - Doubs 500 kV line and Brighton - Conastone 500 kV line (Cont. AP5). This project contributes approximately 20 MW to this overload.

19. The Conastone - Mt Carmel (2310 line) 230 kV line is overloaded at 154% of its emergency rating (923 MVA) for the **tower** outage of Brighton to Doubs and Brighton to Conastone 500 kV line (Cont Id. AP5). This project contributes approximately 18 MW to this overload.

20. The Mt Carmel - NWest (2310 line) 230 kV line is overloaded at 151% of its emergency rating (923 MVA) for the **tower** outage of Brighton to Doubs and Brighton to Conastone 500 kV line (Cont Id. AP5). This project contributes approximately 18 MW to this overload.

21. The Whippany – Roseland 230 kV line is overloaded at 123% of its emergency rating (1646 MVA) for the outage of Kittatiny – Newton 230 kV line (Cont Id. JC4). This project contributes approximately 24 MW to this overload.

New System Reinforcements

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

1/3. The overload on the R39-Red Oak A (T1034) 230kV line can be alleviated by rebuilding the double circuit tower line (0.2 miles) with bundled 1590 kcmil 54/19 ACSS/AW and adding bundled drop loop conductors at Red Oak A and R39. The estimated cost is **$200,000**.

2. The overload on the Raritan River – Kilmer I1023 230 kV line can be alleviated by replacing the 2000 Amps wave trap at Raritan River with one rated at 3000 Amps. The estimated cost is **$117,000**.

4. The overload on the Q11-Red Oak B (G1047) 230kV line can be alleviated by rebuilding the double circuit tower line (0.2 miles) with bundled 1590 kcmil 54/19 ACSS/AW and adding bundled drop loop conductors at Red Oak B. The estimated cost is **$160,000**.

Short Circuit Reinforcements

Replacement of each of the following breakers is estimated to cost **$350,000** each.

South River 230kV - BT
South River 230kV - PB
South River 230kV - PA
South River 230kV - TA
Raritan River 230kV - W1037F

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)

4. Q11 – Parlin 230 kV (G1047) Upgrade: This overload requires reconductoring of Q11 to Parlin line from 1590 Kcmil 45/7 ACSR (1.9 mile) to 1590 Kcmil 54/19 ACSS/AW (1.71

mile) for 869/1068 MVA summer normal/emergency ratings and it requires addition of bundled drop loop conductors at Parlin and Q11 substations at an estimated cost of **$3,500,000**. (This assumes completion of items 1/3 and 4 upgrades listed above are complete).

5. Parlin - Williams 230 kV (K1025) Upgrade: This overload requires the reconductoring of Williams to Parlin line from 1590 Kcmil 45/7 ACSR (2.9 mile) to 1590 Kcmil 54/19 ACSS/AW (2.9 mile) for 869/1068 MVA summer normal/emergency ratings, addition of a disconnect switch (3000 amp) (1) and bundled drop loop conductors at Williams and Freneau substations at an estimated cost of **$3,860,400**. (this assumes that 5 above upgrades 1.2 miles of the 2.9 mile circuit.)

6. Williams - Freneau 230 kV (K1025) Upgrade: This overload requires reconductoring of Freneau to Williams line from 1590 Kcmil 45/7 ACSR (7.7 mile) to 1590 Kcmil 54/19 ACSS/AW (7.7 mile) for 869/1068 MVA summer normal/emergency ratings, addition of a disconnect switch (3000 amp) (1) at Freneau substation, addition of a disconnect switch (3000 amp) (1) at Williams substation and the addition of bundled drop loop conductors at Freneau substation and at Williams substation at an estimated cost of **$15,300,000**.

7. South River - Atlantic 230 kV (P1030) Upgrade: This overload requires the reconductoring of Atlantic to South River line from 1590 Kcmil 45/7 ACSR (18.7 mile) to 1590 Kcmil 54/19 ACSS/AW (18.7 mile) for 869/1068 MVA summer normal/emergency ratings, the addition of a disconnect switch (3000 amp) (1), a line trap (3000 amp) (1) and bundled drop loop conductors at Atlantic substation and bundled drop loop conductors and new Line Trap (3000 amp) (1) at South River substation at an estimated cost of **$20,660,800**.

9/10/11/12. Raritan River – Red OakA 230 kV (T1034) and Raritan River – Red OakA 230 kV (G1047) Upgrade: This overload requires the reconductoring of Double Circuit Tower line from 1590 Kcmil 45/7 ACSR (2.58 mile) to 1590 Kcmil 54/19 ACSS/AW (2.58 mile) for 869/1068 MVA summer normal/emergency ratings, addition of bundled conductor at Raritan River substation and at Red Oak substation at an estimated cost of **$8,251,000**. also requires adding bundled drop loop conductors at Raritan River and Red Oak substations on the G1047 line at an estimated cost of **$80,000.**

13, 14, 19 & 20. The Conastone-Mt. Carmel 2310 230kV circuit, the Conastone-Mt. Carmel 2322 230kV circuit, the Mt.Carmel-North Northwest 2310 230kV circuit and the Mt.Carmel-North Nortwest 2322 230kV circuit can be alleviated by installing a new 500kVstation mamed North Northwest that includes 2-500/230kV xfmrs 4-500 kV bkrs, 7-230 kV Bkrs and related substation equipment and land at a cost of **$70 million**. It also requires tthe reconductor of the Conastone to Northwest #2322 with 1,272kcmil ACSR 1,590kcmil ACSR with an estimated cost of **$8.21 million**. This work would take 3-4 years to build substation and 18-24 months for the line work and by adding a single circuit 500kV line at an estimated cost of $ 109 million and estimated time of 10 yrs and installing a 1 breaker bay at Conastone, estimated cost $3.2 million, and a two

breaker bay at North Northwest, estimated cost $6.4 million for a total upgrade cost of **$118.6 million**.

15/16/17/18. Graceton - Bagley - Raphael Upgrade – This overload requires Graceton station to add 6-230kV breakers with an estimated cost of **$10,000,000** and Raphael Road station to add 6-230kV breakers **$10,000,000**. It requires rebuilding the Graceton to Raphael Rd circuit to double circuit 2-conductor bundled at an estimated cost of **$30**,**000,000**. This work would take an estimate of 2-3 years for the substation work and 5-6 years for the line work. **(Note: This upgrade will suffice the overload 16 too)**.

21. Whippany – Roseland 230 kV (A941) Upgrade: This overload requires rebuilding existing Whippany to Roseland line from 1033.5 Kcmil 54/7 ACSR (2) (2.7 mile) to 1590 Kcmil 54/19 ACSS/AW (2) (2.7 mile) for 1303/1601 MVA (JC) summer normal/emergency ratings and addition of a line trap (4000 amp) (1) and bundled drop loop conductors at Whippany substation at an estimated cost of **$5,580,400**.

Short Circuit Reinforcements
Replacement of each of the following breakers is estimated to cost **$350,000** each.

Raritan River 230kV - W1037E
Raritan River 230kV - G1047E
Raritan River 230kV - G1047F
Raritan River 230kV - T1034E
Raritan River 230kV - T1034F
Raritan River 230kV - BK15
Raritan River 230kV - I1023E
Raritan River 230kV - I1023F
Red Oak 2881 230kV - T1034
Red Oak 2882 230kV - G1047