

#R38 Milford 547 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 R38 project was studied as a 547 MW (109 MW capacity) injection at Milford 230 kV substation. Project R38 was evaluated for compliance with reliability criteria for summer peak conditions in 2011. Potential network impacts were as follows:

NETWORK IMPACTS

Generator Deliverability

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

No problems were 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 Townsend – Church 138 kV line is overloaded from 90% to 124% of its emergency rating (224 MVA) for the **tower** outage Red Lion - Cedar Creek 230 kV line and Red Lion - Cartanza 230 kV line (Cont Id. DBL_4NC). The R38 contributes approximately **77 MW** to cause the thermal violation.
2. The Middletown Tap - Townsend 138 kV line is overloaded from 76% to 105% of its emergency rating (226 MVA) for the **tower** outage Red Lion - Cedar Creek 230 kV line and Red Lion - Cartanza 230 kV line (Cont Id. DBL_4NC). The R38 contributes approximately **77 MW** to cause the thermal violation.
3. The Red Lion – Cedar Creek 230 kV line is overloaded from 73% to 104% of its emergency rating (679 MVA) for the **tower** outage of #1 & #2 Keeney - Steele 230 kV ckt (Cont Id. DBL_1NCB). The R38 contributes approximately **210 MW** to cause the thermal violation.
4. The Steele - Keeney ckt#2 230 kV line is overloaded from 75% to 108% of its emergency rating (805 MVA) for the tower outage of Red Lion - Cedar Creek 230 kV line and Red Lion - Cartanza 230 kV line (Cont Id. DBL_4NC). The R38 contributes approximately **259 MW** to cause the thermal violation.
5. The Middletown Tap – Mt Pleasant 138 kV line is overloaded from 87% to 128% of its emergency rating (226 MVA) for the **tower** outage Red Lion - Cedar Creek

230 kV line and Red Lion - Cartanza 230 kV line (Cont Id. DBL_4NC). The R38 contributes approximately **91 MW** to cause the thermal violation.

Short Circuit

Will be performed for the Impact Study

Stability Analysis, Voltage Criteria and Low-Voltage Ride –Through

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)

6. The Linwood - Chichester ckt#2 230 kV line is overloaded at 110% of its emergency rating (904 MVA) for the outage of Chichester – Linwood ckt. 1 230 kV line (Cont. PE39). The R38 project contributes approximately **19 MW** to this overload.
7. The Linwood - Chichester ckt#1 230 kV line is overloaded at 110% of its emergency rating (904 MVA) for the outage of Chichester – Linwood ckt. 2 230 kV line (Cont. PE43). The R38 project contributes approximately **19 MW** to this overload.
8. The Ridley – Printz 230 kV line is overloaded at 106% of its emergency rating (1432 MVA) for the outage of Eddystone – Island Road 230 kV line (Cont. PE23). The R38 project contributes approximately **7 MW** to this overload.
9. The Island Road - Eddystone 230 kV line is overloaded at 103% of its emergency rating (1411 MVA) for the outage of Ridley to Morton to Macdade 230 kV line (Cont. PE46). The R38 project contributes approximately **7 MW** to this overload.
10. The Conastone – Mt Carmel (2322 line) 230 kV line is overloaded at 169% of its emergency rating (803 MVA) for the **tower** outage of Brighton to Doubs 500 kV line and Brighton to Conastone 500 kV line (Cont. AP5). The R38 project contributes approximately **33 MW** to this overload.
11. The Conastone - Mt Carmel (2310 line) 230 kV line is overloaded at 150% of its emergency rating (923 MVA) for the **tower** outage of Brighton to Doubs and Brighton to Conastone 500 kV line (Cont Id. AP5). The R38 project contributes approximately **33 MW** to this overload.
12. The Northwest - Mt Carmel (2322 line) 230 kV line is overloaded at 166% of its emergency rating (803 MVA) for the **tower** outage of Brighton to Doubs and

- Brighton to Conastone 500 kV line (Cont Id. AP5). The R38 project contributes approximately **33 MW** to this overload.
13. The Northwest - Mt Carmel (2310 line) 230 kV line is overloaded at 147% of its emergency rating (923 MVA) for the **tower** outage of Brighton to Doubs and Brighton to Conastone 500 kV line (Cont Id. AP5). The R38 project contributes approximately 39 MW to this overload.
 14. The Graceton – Bagley – Rapheal 230 kV line is overloaded at 196% of its emergency rating (659 MVA) for the **tower** outage of Brighton to Doubs 500 kV line and Brighton to Conastone 500 kV line (Cont. AP5). The R38 project contributes approximately **39 MW** to this overload.
 15. The Milford - Steele 230 kV line is overloaded to 256% of its emergency rating (551 MVA) for the tower outage of Red Lion - Cedar Creek 230 kV line and Red Lion - Cartanza 230 kV line (Cont Id. DBL_4NC). The R38 contributes approximately **404 MW** to this overload.
 16. The Oil_City – Steele 138 kV line is overloaded to 151% of its emergency rating (159 MVA) for the **tower** outage of #1 & #2 Keeney - Steele 230 kV ckt (Cont Id. DBL_1NCB). The R38 contributes approximately **61 MW** to cause the thermal violation.
 17. The Indian River – Nelson 138 kV line is overloaded to 150% of its emergency rating (193 MVA) for the **tower** outage Red Lion - Cedar Creek 230 kV line and Red Lion - Cartanza 230 kV line (Cont Id. DBL_4NC). The R38 contributes approximately **31 MW** to this overload.
 18. The Oil_City – Church 138 kV line is overloaded to 148% of its emergency rating (159 MVA) for the **tower** outage #1 & #2 Keeney - Steele 230 kV ckt (Cont Id. DBL_1NCB). The R38 contributes approximately **52 MW** to this overload.
 19. The Three Mile Island 500/230 kV transformer is overloaded at 123% of its emergency rating (1077 MVA) for the outage of Conastone to Peach Bottom 500 kV line (Cont Id. PJM17). The R38 project contributes approximately **14 MW** to this overload.

NETWORK UPGRADE REQUIREMENTS

New System Reinforcements

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

1. Townsend – Church 138 kV Overload - This overload requires line re-conductor and rebuild at an estimated cost of **\$4.8M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
2. Middletown Tap – Townsend 138 kV Overload - This overload requires line re-conductor and rebuild at an estimated cost of **\$1.6M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
3. Red Lion – Cedar Creek 230 kV Overload - This overload requires conductor re-tensioning to increase the temperature rating of the existing conductor an estimated cost of **\$8.4M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
4. Steele - Keeney ckt#2 230 kV Overload – This overload requires addition of a second conductor per phase to bundle the conductor at a cost of about **\$20M** and can be constructed in about **24 months**.
5. Middletown Tap - Mt. Pleasant 138 kV Overload – This overload requires the rebuild of this section at a cost of about **\$2M** and it'll take about **18 months**.

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. Chichester - Linwood 230kV ckts Overload – This overload requires line reconductoring and upgrade of substation terminal equipment to increase the emergency rating for an estimated cost of **\$8M each ckt. (Note: This upgrade will also satisfy overload 7 below).**
7. Chichester - Linwood 230kV ckt #1 Overload – **See Upgrade number 6 above**
8. Ridley - Printz 230kV Overload – This overload requires replacement of terminal equipment to increase emergency rating for an estimated cost of **\$4M**.
9. Island Road - Eddystone 230kV Overload – This overload requires replacement of terminal equipment to increase emergency rating at an estimated cost of **\$4M**.
10. Northwest - Mt Carmel - Conastone Overload – This overload requires the construction of a new “North Northwest” substation with 2-500/230kV transformers, 4-500 kV breakers, 7-230 kV breakers, related substation equipment and land at a cost of **\$70M**. It also requires reconductoring of the Conastone to Northwest (#2322) 230 kV line from 1,272 kcmil ACSR to 1,590 kcmil ACSR at an estimated cost of **\$8.21M**. This work would take **36-48 months** to build the substation and **18-24 months** for the line work. **(Note: This upgrade will also satisfy overloads 11, 12 and 13).**

11. **See Upgrade number 10 above.**
12. **See Upgrade number 10 above.**
13. **See Upgrade number 10 above.**
14. Graceton - Bagley - Raphael Road Overload – This overload requires the addition of six 230 kV breakers at Graceton substation at an estimated cost of **\$10M** and the addition of six 230 kV breakers at Raphael Road substation at an additional cost of **\$10M**. It also requires rebuilding of the Graceton to Raphael Rd 230 kV line to double circuit 2-conductor bundled at an estimated cost of **\$30M**. This work would take an estimate of **24-36 months** for the substation work and **60-72 months** for the line work.
15. Milford – Steele 230 kV Overload - This overload requires line re-conductor and rebuild at an estimated cost of **\$12M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
16. Oil City – Steel138 138 kV Overload – This overload requires line re-conductor and rebuild at an estimated cost of **\$0.5M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
17. Indian River – Nelson 138 kV Overload – This overload requires line re-conductor and rebuild at an estimated cost of **\$8M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
18. Oil City – Church 138 kV Overload - This overload requires line re-conductor and rebuild at an estimated cost of **\$7.5M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
19. TMI 500-230 kV transformer Overload – The estimated cost to add a second 500-230 kV transformer is **\$11,800,000** and the time required is approximately **20 months**.

OTHER ISSUES

Delivery of Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below may result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

As a result of the aggregate energy resources in the area, the following violations were identified:

1. The Milford – Cool Springs 230 kV line is to 165% of its emergency rating (679 MVA) for the outage of Indian River – Milford 230 kV line (Cont Id. CKT23069). The R38 contributes approximately 252 MW to this overload. This overload requires line re-conductor and rebuild at an estimated cost of **\$9M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
2. The Indian River – Nelson 138 kV line is overloaded to 165% of its emergency rating (193 MVA) for the outage of Milford – Steele 230 kV line (Cont Id. CKT23076). The R38 contributes approximately 40 MW to this overload. This overload requires line re-conductor and rebuild at an estimated cost of **\$8M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
3. The Conastone – Peach Bottom 500 kV line is overloaded at 162% of its normal rating (2338 MVA) for with the R38 project contributes approximately 218 MW to this overload.
4. The Graceton – Bagley 230 kV line is overloaded at 145% of its emergency rating (659 MVA) for the outage of Five Forks to Graceton 115 kV line (Cont. 11050). The R38 project contributes approximately 27 MW to this overload.
5. The Chichester ckt. 2 – Linwood 230 kV line is overloaded at 138% of its emergency rating (904 MVA) for the outage of Chichester – Linwood ckt. 1 230 kV line (Cont. PE39). The R38 project contributes approximately 94 MW to this overload.
6. The Raphael Road – Bagley 230 kV line is overloaded at 133% of its emergency rating (659 MVA) for the outage of Five Forks to Graceton 115 kV line (Cont. 110510). The R38 project contributes approximately 27 MW to this overload.
7. The Milford - Steele 230 kV line is overloaded to 165% of its emergency rating (551 MVA) for the **tower** outage of Cedar Creek - Red Lion – 230 kV line (Cont Id. CKT23030). The R38 contributes approximately 252 MW to this overload. This overload requires line re-conductor and rebuild at an estimated cost of **\$12M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
8. The Glasgow – Cecil 138 kV line is overloaded at 125% of its emergency rating (79 MVA) for the outage of Conowingo to Colora 230 kV line (Cont. PE78). The R38 project contributes approximately 6 MW to this overload. This overload is caused by power flow limitations imposed by a directional overcurrent relay with a setting of 180 MVA power flow from Glasgow to Cecil. The overcurrent relay(s) must be replaced by impedance type relays.

9. The Lorretto – Piney138 138 kV line is overloaded to 124% of its emergency rating (159 MVA) for the outage of Milford – Steele 230 kV line (Cont Id. CKT23076). The R38 contributes approximately 32 MW to cause the thermal violation. This overload requires conductor re-tensioning to increase the temperature rating of the existing conductor at an estimated cost of **\$3M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
10. The Oil_City – Church 138 kV line is overloaded from 97% to 119% of its emergency rating (159 MVA) for the outage of #2 Keeney EHV to Steele 230 kV line (Cont Id. CKT23009). The R38 contributes approximately 35 MW to cause the thermal violation. This overload requires line re-conductor and rebuild at an estimated cost of **\$7.5M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
11. The Ridley – Printz 230 kV line is overloaded at 113% of its emergency rating (1432 MVA) for the outage of Eddystone – Island Road 230 kV line (Cont. PE23). The R38 project contributes approximately 36 MW to this overload.
12. The Clayton – Edgemoor 230 kV line is overloaded at 110% of its emergency rating (805 MVA) for the outage of Linwood to Edgemoor 230 kV line (Cont Id. PE77). The R38 contributes approximately 80 MW to this overload. This overload requires line re-conductor and rebuild at an estimated cost of **\$2.8M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
13. The Vienna – Nelson 138 kV line is overloaded from 90% to 110% of its emergency rating (226 MVA) for the outage of Milford – Steele 230 kV line (Cont Id. CKT23076). The R38 contributes approximately 48 MW to cause the thermal violation. This overload requires line re-conductor and rebuild at an estimated cost of **\$7.9M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
14. The Island Road - Eddystone 230 kV line is overloaded at 110% of its emergency rating (1411 MVA) for the outage of Ridley to Morton to Macdade 230 kV line (Cont. PE46). The R38 project contributes approximately 37 MW to this overload.
15. The Red Lion – Cedar Creek 230 kV line is overloaded from 76% to 109% of its emergency rating (679 MVA) for the outage of Red Lion to Cartanza 230 kV line (Cont Id. CKT23032). The R38 contributes approximately 224 MW to cause the thermal violation. This overload requires conductor re-tensioning to increase the temperature rating of the existing conductor at an estimated cost of **\$8.4M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
16. The Linwood to Edgemoor 230 kV line is overloaded 96% to 106% of its emergency rating (827 MVA) for the outage of Claymont to Edgemoor 230 kV

- line (Cont. CKT23015). The R38 contributes approximately 80 MW to cause the thermal violation. This overload requires in re-conductor and rebuild at an estimated cost of **\$3.4M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
17. The Vienn138 to Vienna 138 kV line is overloaded 86% to 105% of its emergency rating (483 MVA) for the outage of Milford – Steele 230 kV line (Cont Id. CKT23076). The R38 contributes approximately 91 MW to cause the thermal violation. This overload requires conductor re-tensioning to increase the temperature rating of the existing conductor at an estimated cost of **\$0.5M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
 18. The Felton to Sharington 138 kV line is overloaded 79% to 104% of its emergency rating (242 MVA) for the outage of Cedar to Milford 230 kV line (Cont Id. CKT23031). The R38 contributes approximately 60 MW to cause the thermal violation. This overload requires conductor re-tensioning to increase the temperature rating of the existing conductor at an estimated cost of **\$2M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
 19. The Elmwood – MacDade3 230 kV line is overloaded to 103% of its emergency rating (1339 MVA) for the outage of Eddystone – Island Road 230 kV line (Cont. PE23). The R38 contributes approximately 37 MW to this overload.
 20. The Tunnel – Grays Ferry 230 kV line is overloaded 97% to 102% of its emergency rating (1222 MVA) for the outage of Concord – Lenape 230 kV line (Cont Id. PE69). The R38 contributes approximately 57 MW to cause the thermal violation.
 21. The Hares Creek – Red Lion 138 kV line is overloaded 93% to 102% of its emergency rating (336 MVA) for the outage of Keeney EHV – Red Lion 230 kV line (Cont Id. CKT23011). The R38 contributes approximately 31 MW to cause the thermal violation. This overload requires replacement of a line trap at an estimated cost of **\$0.05M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.
 22. The N.Seaford – Taylor 69 kV line is overloaded to 105% of its emergency rating (64 MVA) for the outage of the S.Harrington 138/69kV. The R38 contributes approximately 3 MW to cause the thermal violation. This overload requires conductor re-tensioning to increase the temperature rating of the existing conductor at an estimated cost of **\$0.4M**. It would take **12 to 18 months** assuming no major regulatory or environmental impacts.
 23. The Five Points - Lank 69 kV line is overloaded to 108% of its emergency rating (137 MVA) for the outage of the Indian River – Robinsonville 138kV. The R38 contributes approximately 11 MW to cause the thermal violation. This overload

requires line re-conductor at an estimated cost of **\$2.4M**. It would take **12 to 18 months** assuming no major regulatory or environmental impacts.

Potential Overloads

1. The Tunnel - Parrish 230 kV line is overloaded 95% to 99.7% of its emergency rating (1222 MVA) for the outage of Concord – Lenape 230 kV line (Cont Id. PE69). The R38 contributes approximately 57 MW to cause the thermal violation.
2. The Linwood - Clay_230 230 kV line is overloaded 89% to 99.7% of its emergency rating (827 MVA) for the Linwood to Edgemere 230 kV line (Cont Id. PE77). The R38 contributes approximately 88 MW to cause the thermal violation. This overload requires line re-conductor at an estimated cost of **\$0.5M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.

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