#T40 South Harrington 225 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

– Option #1 (South Harrington 138 kV bus)

The T40 project was studied as a 225 MW Capacity injection into the South Harrington 138 kV bus. Project T40 was evaluated for compliance with reliability criteria for summer peak conditions in 2012. Potential network impacts were as follows:

NETWORK IMPACTS

Local Transmission System Impacts

(Normal system conditions with all facilities in service, and contingency analysis per documented Reliability Criteria, generally FERC Form 715, for Transmission Owner's underlying system)

1. The Harrington – South Harrington 69kV line loads from **62.0% to 104.4%** of its emergency rating (91MVA) for the loss of the Cheswold – Kent 69kV line (Ckt. 6768) with the discrete unit outage of the NRG Dover generation complex at the Kent Substation. The T40 project contributes approximately **41 MVA.**

2. The Harrington - Wells 69kV line loads from **33.9% to 101.7%** of its emergency rating (59MVA) for the loss of the Cheswold – Kent 69kV line (Ckt. 6768) with the discrete unit outage of the NRG Dover generation complex at the Kent Substation. The T40 project contributes approximately **40 MVA.**

Generator Deliverability

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

3. The Red Lion - Keeney 230kV line loads from **95.8% to 100.9%** [1,2] of its emergency rating (932MVA) for the single line contingency outage of Keeney – Red Lion 500 kV line (PJM64). This project contributes approximately **47.2 MW**[1,2] to cause this thermal violation.

General Notes for all overloads:

Note 1: The first project to cause an overload has cost responsibility. If not the first project to cause the overload, a threshold of 1% overloading and 5.0 MW contribution are required for cost allocation responsibility.

Note 2: If not the first project to cause the overload but both conditions under Note 1 are met, then a threshold of 5% generator DFAX (11.25 MW) or 5% of the Facility rating is also required for cost allocation responsibility. DFAX may not be equal to the contribution divided by generator MW size.

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)

4. The Oil City – Church 138kV line loads from **97.33% to 106.75%** of its emergency rating (159MVA) for the tower line outage of Keeney – Steele 230 kV CKT 1 and CKT 2 Lines (DBL_1NCB). This project contributes approximately **15.0 MW** to cause this thermal violation.

Short Circuit Analysis

Will be performed for the Impact Study.

Steady-State Voltage Requirements

(Evaluation of steady-state voltage and reactive requirements)

Will be performed for the Impact Study.

Stability and Reactive Power Requirement

(Results of the dynamic studies should be inserted here)

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)

5. The Eddystone – Island Road 230kV line loads from **113.98% to 115.00%** of its emergency rating (1410MVA) for the single line contingency outage of Ridley – Morton 230 kV line, Ridley – Macdade 230 kV line; Morton 230/13.8 kV XFMR;

and the Macdade 230/13.8 kV XFMR (PE46). This project contributes approximately **14.4 MW** to the thermal violation.

6. The Linwood - Chichester 230kV (220-39) line loads from **109.45% to 113.62%** of its emergency rating (904MVA) for the single line contingency outage of Linwood – Chichester 230 kV line, and the Machines at busses: PHLISCT1, PHLISCT2, PHLISST1 (PE39). This project contributes approximately **37.7 MW** to the thermal violation.

7. The Linwood – Chichester 230kV (220-43) line loads from **109.08% to 113.23%** of its emergency rating (904MVA) for the single line contingency outage of Linwood – Chichester CKT2 230 kV line and the Machines at busses: PHLISCT1, PHLISCT2, PHLISST1 (PE43). This project contributes approximately **37.6 MW** to the thermal violation.
8. The MacDade - Elmwood 230kV line loads from **103.66% to 104.72%** of its emergency rating (1339MVA) for the single line contingency outage of Grays Ferry – Island Rd 230 kV line; Island Rd 230/69 kV XFMR; and the Island Rd 230/13.8 kV XFMR (PE71). This project contributes approximately **14.3 MW** to the thermal violation.

9. The Elmwood – Grays Ferry 230kV line loads from **101.46% to 102.53%** of its emergency rating (1339MVA) for the single line contingency outage of Eddystone – Island Rd 230 kV line, and the Island Rd 230/13.8 kV XFMR(PE23). This project contributes approximately **14.3 MW** to the thermal violation.

10. The Eddystone - Printz 230kV line loads from **105.23% to 106.46%** of its emergency rating (1193MVA) for the single line contingency outage of Eddystone – Island Rd 230 kV line, and the Island rd 230/13.8 kV XFMR (PE23). This project contributes approximately **14.7 MW** to the thermal violation.

11. The Chichester - Eddystone 230kV line loads from **108.77% to 111.01%** of its emergency rating (1235MVA) for the single line contingency outage of Foulk – Chichester 230 kV line, Foulk 230/13.8 kV XFMR (PE4). This project contributes approximately **27.7 MW** to the thermal violation.

12. The Chichester - Foulk 230kV line loads from **100.41% to 102.34%** of its emergency rating (1335MVA) for the single line contingency outage of Eddystone – Chichester 230 kV line (PE36). This project contributes approximately **25.8 MW** to the thermal violation.

13. The Raphael Road - Northeast 230kV (2337) line loads from **134.41% to 135.75%** of its emergency rating (758MVA) for the single line contingency outage of Raphael Road – Northeast 230 kV line, Northeast 230/115 kV XFMR (BG8). This project contributes approximately **10.2 MW** to the thermal violation.

14. The Raphael Road – Northeast (2315) 230kV line loads from **131.73% to 133.06%** of its emergency rating (758MVA) for the single line contingency outage of Northeast – Raphael Road 230 kV line (BG18). This project contributes approximately **10.0 MW** to the thermal violation.

15. The Conastone – North Northwest 500kV line loads from **161.11% to 164.10%** of its normal rating (2078MVA) for **non-contingency condition**. This project contributes approximately **62.0 MW** to the thermal violation. **Also See Network Impact number 29.**

16. The Peach Bottom – Conastone 500kV line loads from **155.93% to 159.50%** of its emergency rating (2598MVA) for the single line contingency outage of Conastone – Peach Bottom CKT 1 500 kV line (PJM17). This project contributes approximately **92.8 MW** to the thermal violation.

17. The Northwest - Granite 230kV line loads from **164.65% to 167.32%** of its emergency rating (641MVA) for the single line contingency outage of Kemptown – North Northwest 500 kV line (PJM13B_NNWEST_B). This project contributes approximately **17.1 MW** to the thermal violation.

18. The Conastone – Mt Carmel (2322) 230kV line loads from **141.09% to 142.94%** of its emergency rating (923MVA) for the single line contingency outage of North Northwest – Conastone 500 kV line (PJM13B_NNWEST_A). This project contributes approximately **17.0 MW** to the thermal violation.

19. The Conastone – Mt Carmel (2310) 230kV line loads from **141.09% to 142.94%** of its emergency rating (923MVA) for the single line contingency outage of North Northwest – Conastone 500 kV line (PJM13B_NNWEST_A). This project contributes approximately **17.0 MW** to the thermal violation.

20. The Mt Carmel – Northwest (2322) 230kV line loads from **138.80% to 140.64%** of its emergency rating (923MVA) for the single line contingency outage of North Northwest – Conastone 500 kV line (PJM13B_NNWEST_A). This project contributes approximately **17.0 MW** to the thermal violation.

21. The Mt Carmel – Northwest (2310) 230kV line loads from **138.80% to 140.64%** of its emergency rating (923MVA) for the single line contingency outage of North Northwest – Conastone 500 kV line (PJM13B_NNWEST_A). This project contributes approximately **17.0 MW** to the thermal violation.

22. The Milford - Steele 230kV line loads from **150.05% to 176.73%** of its emergency rating (551MVA) for the tower line outage of Red Lion – Cedar CK 230 kV line; and the Red Lion – Cartanza 230 kV line (DBL_4NCA). This project contributes approximately **147.0 MW** to the thermal violation.

23. The Indian River - Nelson 138kV line loads from **114.50% to 121.15%** of its emergency rating (193MVA) for the tower line outage of Red Lion – Cedar CK 230 kV line; and the Red Lion – Cartanza 230 kV line (DBL_4NCA). This project contributes approximately **12.8 MW** to the thermal violation.

24. The Steele – Oil City 138kV line loads from **105.94% to 115.36%** of its emergency rating (159MVA) for the tower line outage of Keeney – Steele CKT1 and CKT 2 kV 230 lines (DBL_1NCB). This project contributes approximately **15.0 MW** to the thermal violation.

25. The Three Mile Island 500/230kV transformer loads from **136.31% to 138.57%** of its emergency rating (1077MVA) for the tower line outage of Conastone – Peach Bottom CKT1 and CKT2 500 kV lines (CONAS_PB). This project contributes approximately **24.3 MW** to the thermal violation.

26. The Nottingham 230kV Line Reactor loads from **163.57% to 166.54%** of its emergency rating (627MVA) for the tower line outage of Conastone – Peach Bottom CKT1 and CKT2 500 kV lines (CONAS_PB). This project contributes approximately **18.6 MW** to the thermal violation.

27. The Nottingham – Peach Bottom tap portion of the Nottingham to Graceton 230 kV line loads from **163.54% to 166.51%** of its emergency rating (627MVA) for the tower line outage of Conastone – Peach Bottom CKT1 and CKT2 500 kV lines (CONAS_PB). This project contributes approximately **18.6 MW** to the thermal violation.

28. The Peach Bottom - Graceton 230kV line loads from **163.54% to 166.51%** of its emergency rating (627MVA) for the tower line outage of Conastone – Peach Bottom CKT1 and CKT2 500 kV lines (CONAS_PB). This project contributes approximately **18.6 MW** to the thermal violation.

29. The Conastone – North Northwest 500kV line loads from **146.16% to 148.22%** of its emergency rating (2901MVA) for the tower line outage of Conastone – Mt Carmel 230 kV line; Mt Carmel – Northwest 230 kV line; Conastone – Mt Carmel10 230 kV line; Mt Carmel10 – Northwest 230 kV line (CNSTN_NWEST). This project contributes approximately **59.8 MW** to the thermal violation. **Also see Network Impact number 15.**

30. The Conastone 500/230kV transfomer loads from **100.03% to 101.58%** of its emergency rating (1500MVA) for the single line contingency outage of North Northwest – Conastone 500 kV line (PJM13B_NNWEST_A). This project contributes approximately **23.2 MW** to the thermal violation.

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. **Harrington – S. Harrington 69kV (4.4 %) Line Overload** – This overload requires the rebuild of 1.87 miles of existing 336.4 ACSR and the replacement of a 600A disconnect switch at Harrington, at an estimated cost of **$1,400,000**. These reinforcements would take **12 to 18 months**, assuming no major regulatory or environmental impacts.

2. **Harrington – Wells 69kV Line (1.7 %) Overload** – This overload requires the rebuild of 8.42 miles of existing #4/0 CU, at an estimated cost of **$4,000,000**. These reinforcements would take **12 to 18 months**, assuming no major regulatory or environmental impacts.

3. **Red Lion to Keeney 230kV (0.9 %) Overload** - This overload requires the replacement of a 2000A line trap at an estimated cost of **$0.3M**. It would take about **12 months** assuming no major regulatory or environmental impacts.

4. **Oil City to Church 138kV (6.75 %) Overload** - This overload requires to reconductor and rebuild the existing line at an estimated cost of **$7.5M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.

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)*

5. **Eddystone to Island Road 230kV (15%) Overload** - Replace terminal equipment at both ends of the line, **$5,000,000** and **30 months** to complete.

6. **Linwood to Chichester 230kV (220-39 line) 13.62 % Overload** - Reconductor line and replace terminal equipment at both ends of the line, **$8,000,000** and **36 months** to complete.

7. **Linwood to Chichester 230kV (220-43 line) 13.23 % Overload** - Reconductor line and replace terminal equipment at both ends of the line, $**8,000,000** and **36 months** to complete.

8. **MacDade to Elmwood 230kV (4.72 %) Overload** - Replace terminal equipment at both ends of the line, **$5,000,000** and **30 months** to complete.

9. **Elmwood to Grays Ferry 230kV (2.53 %) Overload** - Replace terminal equipment at both ends of the line, **$5,000,000** and **30 months** to complete.

10. **Eddystone to Printz 230kV (6.46 %) Overload** - Replace terminal equipment at both ends of the line, **$5,000,000** and **30 months** to complete.

11. **Chichester to Eddystone 230kV (11.01 %) Overload** - Replace terminal equipment at both ends of the line, **$5,000,000** and **30 months** to complete.

12. **Chichester to Foulke 230kV (2.34 %) Overload** - Replace terminal equipment at both ends of the line, **$5,000,000** and **30 months** to complete.

13. **(BG&E) Raphael Road to Northeast (2337) 34.41 % line Overload** -

    Estimated line upgrade cost is $3,000,000; substation terminals cost is $1,000,000 for a total cost of **$4,000,000.** Lead Time is **60 months**.

    Existing Conductor is 2,167 ACSR @ 125˚C. Transmission line is 3.9 miles long. Requires increasing Rated Conductor temp to 150˚C , which attains 1105 MVA SE Approx. 7 spans have ground clearance less than 35 ft. Assume replacement of 5 double circuit steel poles.

    Upgrade 13 also satisfies upgrade requirement number 14 below.

14. **(BG&E) Raphael Road to Northeast (2315) 31.73 % line Overload** –

    See upgrade number 13 above.

15. **See Network Upgrade number 29 for the same facility.**

16. **Peach Bottom to Conastone 500kV (59.5 %) Overload** - Many projects impact this line and its right of way. The final disposition for all queued generator interconnection projects will dictate the number of 500kV lines that will be required between Peach Bottom and Conastone.

    220-08 line will be relocated to underground to facilitate construction of the first additional 500kV line. Remove existing 5012 line towers to clear the south side of the right of way for new 500kV double circuit tower line, **$1,500,000** (6.25 mile PECO portion) and **6 months**. And, construct a new double circuit 500kV line in the south side of the right of way from Peach Bottom to Maryland state line, approximately **$17,000,000** (6.25 mile PECO portion @ $2.7M/mile) and **30 months** to complete after the removal of the existing 500 kV tower line. Upgrade 5012 line substation equipment to achieve the new higher rating, **$3,000,000** and **18 months** to complete.

Expand 500kV substations (north and south) at Peach Bottom to accommodate additional 500kV lines, approximately **$18,000,000** and **30 months** to complete. Please note that the substation work may have to be coordinated with refueling outages at Peach Bottom and that the overall project may overstress several 500 kV circuit breakers. Above work will be required to be completed in stages.

17. (BG&E) **Northwest to Granite 230 kV line (67.32 %) Overload** -

    Line upgrade cost is $23,000,000, Substation terminals upgrade cost is $600,000 for a total cost of **$23,600,000**. Lead time is **72 months**.

    Scope of line construction/upgrade: Existing conductor is 1590 45/7 ACSR, rated at 160˚C. Line is 8.7 miles long. To attain 1105 MVA (SE rating) need to re-conductor with 2,167 ACSR @ 150˚C (or two-1033 ACSR @ 110˚C, attaining 1120 MVA SE). Assume rebuilding of double circuit transmission line.

18. (BG&E) **Conastone to Mt Carmel 230 kV (2322) 42.94 % line Overload** -

    At the future North Northwest substation install two 500/230 kV transformers, four 500 kVcircuit breakers, seven 230 kV circuit breakers and related substation equipment and land. Estimated total cost is $70,000,000. Lead times 36-48 months for substation work and 18-24 months for the line work.

    Upgrade number 18 also satisfies upgrade requirements 19, 20 and 21 below.

19. (BG&E) **Conastone to Mt Carmel 230 kV (2310) 42.94 % line Overload** -

    See upgrade number 18 above.

20. (BG&E) **Mt Carmel to Northwest 230 kV (2322) 40.64 % line Overload** -

    See upgrade number 18 above.

21. (BG&E) **Mt Carmel to Northwest 230 kV (2310) 40.64 % line Overload** -

    See upgrade number 18 above.

22. **Milford to Steele 230kV Overload** - This overload requires to rebuild the existing conductor at an estimated cost of **$12.0M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.

23. **Indian River to Nelson 138kV (76.73 %) Overload** - This overload requires to reconductor and rebuild the existing line at an estimated cost of **$8.0M**. It would take **18 to 24 months** assuming no major regulatory or environmental impacts.

24. **Oil City to Steele 138kV (15.36 %) Overload** - This overload requires to rebuild the existing conductor at an estimated cost of **$0.5M**. It would take **18 to 24 months** assuming no major regulatory or environmental.

25. **TMI 500-230 kV transformer (38.57 %) Overload** – This overload requires the addition of a second 500-230 kV transformer at TMI. The estimated cost to add a second 500-230 kV transformer is **$15,000,000** and the time required is approximately **36 months**.

26. **Nottingham Reactor** (piece of the Nottingham – Peach Bottom Tap – Graceton three terminal 230 kV line #220-08) **66.54 % Overload** - Replace the line reactor with a higher rated reactor. The estimated magnitude cost for this upgrade is **$200,000**. Estimated construction time is **12 months**.

27. **Nottingham to Peach Bottom Tap** (piece of the Nottingham – Peach Bottom Tap – Graceton three terminal 230 kV line #220-08) **66.51 % Overload** - Rebuild the Nottingham to Peach Bottom Tap portion of the 230 kV line to meet high capacity requirements. Includes $20,000,000 for a new river crossing. The estimated magnitude cost for this upgrade is **$40,000,000**. Estimated construction time is **48 months**.

28. **Peach Bottom Tap to Graceton** (piece of the Nottingham – Peach Bottom Tap – Graceton three terminal 230 kV line #220-08) **66.51 % Overload** -

    The estimated magnitude cost for this upgrade is **$61,000,000**. Estimated construction time is **48 months**.

    Description of Work:
    Relocate 220-08 line from overhead to two underground pipe type cables (this also facilitates the construction of the additional 500 kV lines between Peach Bottom and Conastone that are required for Queue S105 and previous projects) over its distance from Peach Bottom to Graceton (5.6 miles on the PECO Energy side of PA/MD border and 1.8 miles on the BG&E side).

    Note: 220-08 line is an offsite source for Peach Bottom Nuclear Generating Station and its integrity must be maintained.

29. **Conastone to North Northwest 500 kV line (48.22%) Overload**

    The estimated cost to build a second Conastone – North Northwest 500 kV line is **$118,600,000** and it will take **96 to 120 months** to construct.

    Description of Work:

Construct a second Conastone to North Northwest line parallel to the proposed first Conastone to North Northwest line on the same Right of Way. Total length is approximately 19.6 miles. Conductor will be a 3 - bundle 1,590 kcm ACSR. Estimated cost is $109,000,000. In addition, one new 500 kV breaker bay will be required at Conastone ($3,200,000) and two new 500 kV breaker bays will be required at North Northwest ($6,400,000).

Note:
The T37 queue project may have additional impacts and therefore additional cost allocation for the reinforcements associated with the installation of North North West substation which taps the existing Kemptown - Conastone 500 kV line, and the first North Northwest 500 kV line which were required for earlier queued projects. If applicable, the exact cost allocation and schedule will be included in the Impact study report.

30. **Conastone 500/230 kV Transformer (1.58 %) Overload –** For this 1.6 % emergency overload the following will be done:
    a) Recalculation of the transformer emergency rating will be performed, assuring use of the latest standards rating methodology, and
    b) Addition cooling (fans and pumps) will be considered.
    c) Look at other means of unloading the 500/230 kV transformer.

    If none of the above are a solution, a larger replacement transformer or a parallel transformer solution will be considered.

POTENTIAL ISSUES

Delivery of the 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 or other PJM generation. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request. **These are not required reliability upgrades.**

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

None identified.

Network Impacts

– Option #2 (South Harrington – North Seaford 138 kV Line)

The T40 project was studied as a 225 MW Capacity injection into the South Harrington – North Seaford 138 kV line. Project T40 was evaluated for compliance with reliability criteria for summer peak conditions in 2012. Potential network impacts were as follows:

Network Impacts and Network Upgrade Requirements are the same as Option #1.