

***PJM Generator Interconnection Request
Queue #U2-046
Roseland 500kV HVDC
Feasibility Study***

**550118
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Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the impact study is performed.

The Feasibility Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners,

U2-046 Roseland 500kV HVDC Feasibility Study Report

General

Brookfield Power US Holding America Co. (Brookfield) proposed installing a +/- 450kV DC 660 MW net delivery HVDC interconnection between the proposed new Roseland 500kV substation and New York City. The project has requested being evaluated as a 670 MW Firm Withdrawal and a 660 MW Firm Injection at the Roseland 500kV bus. One HVDC converter terminal will be located in Roseland, Essex County, New Jersey ties via a HVDC line to a second converter located on the New Jersey side of the Hudson River with an AC connection to Con Ed's 49th Street station. The project is proposed to be in-service by December, 2013.

Direct Connection

The U2-046 project will be connected to the Roseland 500V station via two (2) 500kV circuit breakers added to a new bay in the substation. See Figure #1. The following facilities will need to be installed in the new 500-kV bay, 2 – 500-kV breakers, 4 – 500-kV disconnects, 500-kv Line and ground disconnect, 3-ccvts and associated metering equipment.

The estimated cost for the substation work is **\$11,000,000** based upon open-air construction. Since design is on-going for the Susquehanna-Roseland project, the location of the new 500kV station has not been finalized. There is also a strong possibility the substation will be a Gas Insulated (GIS) design. If a GIS design is chosen it will increase the cost of the interconnection for the U2-046 project. In addition, since the Susquehanna-Roseland project does not have complete authorization from the states of Pennsylvania and New Jersey to proceed at this time, there is the possibility that the Roseland station will not be completed in 2013.

Brookfield will be responsible for constructing the 500kV circuit from the HVDC converter terminal site to Roseland 500kV station.

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 Kitatinny-Newton 230kV line (from bus 2535 to bus 2553 ckt 1) loads from 96.84% to 101.06% (DC power flow) of its emergency rating (925MVA) for the tower line outage of the Portland – Greystone 230kV line, the Kittatinny – Pohatcong 230kV line, and the Pohatcong 34.5/230 kV transformer (5JC) as a result of U2-046’s firm withdrawal. This project contributes approximately 39.0MW to cause this thermal violation.

Short Circuit

The analysis found 2 new breakers, to be over-duty in the PSEG transmission area. The new over-duty breakers are listed below:

BUS_NO	BUS	BREAKER	Rating Type	Duty Percent With U2-46_PSEG	Duty Percent Without U2-46_PSEG	Duty Percent Difference
4962	BRANCHBG 230.kV	61H	S	100.10%	100.00%	0.10%
4962	BRANCHBG 230.kV	81H	S	100.10%	100.00%	0.10%

The analysis showed no significant fault contribution to breakers, which were already identified as over-duty.

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)

4. The Sewaren-Woodbridge 138kV line (from bus 5021 to bus 5182 ckt 1) loads from 101.7% to 109.5% (DC power flow) of its normal rating (249MVA) for non-contingency condition as a result of U2-046’s firm withdrawal. This project contributes approximately 19.4MW to increase this thermal violation.

5. The Woodbridge-New Dover Road 138kV line (from bus 5182 to bus 5115 ckt 1) loads from 104.7% to 112.5% (DC power flow) of its normal rating (249MVA) for non-contingency condition as a result of U2-046’s firm withdrawal. This project contributes approximately 19.4MW to increase this thermal violation.

6. The North Meshoppen 230/115kV transformer (from bus 414 to bus 560 ckt 3) loads from 163.15% to 171.76% (DC power flow) of its emergency rating (157MVA) for the single line contingency outage of the North Meshoppen – East Towanda 230kV line, as well as the North Meshoppen 115/230kV transformer. (PN47B) as a result of U2-046's firm injection. This project contributes approximately 13.5MW to the thermal violation.
7. The Lackawanna-Oxbow 230kV line (from bus 3070 to bus 417 ckt 1) loads from 152.80% to 160.41% (DC power flow) of its normal rating (499MVA) for non-contingency condition as a result of U2-046's firm injection. This project contributes approximately 38.0MW to the thermal violation.
8. The Oxbow-North Meshoppen 230kV line (from bus 417 to bus 414 ckt 1) loads from 146.87% to 154.36% (DC power flow) of its normal rating (499MVA) for non-contingency condition as a result of U2-046's firm injection. This project contributes approximately 37.4MW to the thermal violation.
9. The Conastone-North Northwest 500kV line (from bus 4 to bus 119 ckt 2) loads from 146.97% to 152.58% (DC power flow) of its emergency rating (2901MVA) for the single line contingency outage of the Conastone – North Northwest 500kV circuit #1 line (PJM13B_NNWEST_A) as a result of U2-046's firm injection. This project contributes approximately 162.8MW to the thermal violation.
10. The Conastone-North Northwest 500kV line (from bus 4 to bus 119 ckt 1) loads from 146.97% to 152.58% (DC power flow) of its emergency rating (2901MVA) for the single line contingency outage Conastone – North Northwest 500kV circuit #2 line (U_queue_reinforcement_60) as a result of U2-046's firm injection. This project contributes approximately 162.8MW to the thermal violation.
11. The Red Oak A-Raritan River 230kV line (from bus 2881 to bus 2872 ckt 1) loads from 163.74% to 168.82% (DC power flow) of its emergency rating (805MVA) for the single line contingency outage of the Raritan River – Red Oak B 230kV line (JC31A_Q08OP1A) as a result of U2-046's firm withdrawal. This project contributes approximately 40.9MW to the thermal violation.
12. The Red Oak B-Raritan River 230kV line (from bus 2882 to bus 2872 ckt 1) loads from 163.68% to 168.75% (DC power flow) of its emergency rating (805MVA) for the single line contingency outage of the Raritan River – Red Oak A 230kV circuit (JC30A_Q08OP1A) as a result of U2-046's firm withdrawal. This project contributes approximately 40.8MW to the thermal violation.
13. The Meshoppen Reactor-North Meshoppen 115kV line (from bus 560 to bus 384 ckt 3) loads from 111.60% to 118.32% (DC power flow) of its emergency rating (201MVA) for the single line contingency outage of the North Meshoppen – East Towanda 230kV line, as well as the North Meshoppen 115/230kV transformer (PN47B) as a result of U2-046's firm injection. This project contributes approximately 13.5MW to the thermal violation.

14. The Aldene 230/138kV transformer (from bus 5192 to bus 4951 ckt 1) loads from 104.72% to 112.31% (DC power flow) of its normal rating (263MVA) for non-contingency condition as a result of U2-046's firm withdrawal. This project contributes approximately 20.0MW to the thermal violation.

15. The Aldene-Springfield Road 138kV line (from bus 4951 to bus 5023 ckt 1) loads from 103.54% to 111.04% (DC power flow) of its normal rating (266MVA) for non-contingency condition as a result of U2-046's firm withdraw. This project contributes approximately 20.0MW to 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. To alleviate the contingency overload on the Aldene 230/138kV transformer (L- 312) the two winding transformer T-4 (bus section 4-6) needs to be removed from Aldene station and be placed in Springfield Road substation. In doing so Springfield substation needs to be converted to a 230kV operation. The conversion will include bus works, two distribution transformers and all added equipments such as line and breaker disconnects, bus, relaying, and control room modifications. Total cost for this is estimated at **\$27 Million. This Reinforcement will also mitigate Network Impact 14 and 15.**

2. The Sewaren – Woodbridge – New Dover – Fanwood 138kV circuit overload can be mitigated by reconductoring to achieve ratings of 272N/442E MVA. The distances associated with the reconductoring are 3.3 miles from Sewaren – Woodbridge, 6.8 miles from Woodbridge – New Dover, and 4.2 miles from New Dover – Fanwood. The total cost of these upgrades is estimated to be **\$13 Million. This Reinforcement will also mitigate Network Impact 4 and 5.**

3. The Kittatinny – Newton 230kV circuit overload will be partially mitigated by the 2011 RTEP upgrade b0276. The upgrade will reductor the Kittatinny – Newton line and replace a disconnect switch at Kittatinny. In addition, the overload will require a 2000 amp wave trap at Newton to be replaced with a 3000 amp wave trap, thereby increasing the line rating to 901N/1052E MVA. The estimated cost to replace the wave trap is **\$76,500**. Note that this estimate was produced without a detailed engineering review. First Energy therefore reserves the right to revisit this estimate as a part of the System Impact Study.

The cost of replacing the Branchburg 61H and 81H circuit breakers and upgrading it to 63kA is **\$500,000 each** (includes cost for disconnect switches). The time estimate for to replace each breaker is 1 year.

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. The North Meshoppen 230/115 kV transformer overload can be alleviated by rearranging the North Meshoppen 230 kV bus to prevent the loss of tapped 230/115 kV transformer #4 along with the loss of North Meshoppen - East Towanda 230 kV line. This will require the addition of two 230 kV breakers and re-configuration of the North Meshoppen 230 kV station to a ring bus to place transformer #4 on its own bus position. The estimated cost for the upgrade is **\$1,500,000**. The estimated time to complete is 42 months. **This Reinforcement will also mitigate Network Impact 13.**

7. The overload on the Lackawanna-Oxbow circuit can be alleviated by the following work.

PPL PORTION:

The Lackawanna – Oxbow 230 kV line overload requires that the existing 1033.3 kcmil ACSR conductors be replaced with 1590 kcmil ACSR conductors for a rating of 653/793 MVA summer normal/summer emergency. Terminal equipment at Lackawanna 230kV substation would also be replaced with higher ratings than the conductor. PPL EU owns approximately 0.2 miles of this 19-mile long transmission line from Lackawanna to Oxbow. Please note that the description of work and the cost estimates are preliminary without any field checks and extensive engineering review and therefore are subject to change. If for some reason FE decides to use a different conductor, PPL EU would have to reevaluate the cost estimate.

The total estimated cost for the PPL portion of the upgrade is **\$700,000**. The estimated time to complete is **24 months**.

PENELEC PORTION:

To alleviate the overload on the Lackawanna – Oxbow 230kV line, a rebuild of approximately 16.33 miles of transmission line would be required (estimated to cost approximately **\$19,596,000**). This overload also requires the following terminal upgrades at Oxbow substation: replace substation conductor (estimated cost approximately **\$125,000**) and replace a disconnect switch (estimated cost approximately **\$85,000**).

8. To alleviate the overload on the Oxbow – North Meshoppen 230kV line, a rebuild of approximately 10.16 miles of transmission line would be required to support bundled conductor. Oxbow substation would require replacement of a disconnect switch and substation conductor. North Meshoppen substation would require the upgrade/replacement of two CT circuits, replacement of substation conductor, and replacement/upgrade of a line/wave trap. The estimated total cost is approximately **\$12,939,000** and to take **4-5 years** to complete after signed ISA.

9. The total estimated cost to alleviate the Conastone – N-Nwest 500kV overload is **\$220,000,000**. The lead time required for construction is **120 months**. At this point in time this Queue’s cost allocation is undetermined. If required, cost allocation will be performed for the Impact Study.

Upgrade description:

Construct 2 new single circuit lines with the following assumptions:

- A new 200 ft. wide ROW paralleling the existing Conastone to Northwest ROW

- Total ROW length = 19.6 miles
- 3 - bundle 1,590 kcm conductor
- North Northwest substation will be located 4 miles north of Northwest substation

Additional substation work to include:

- Expand North Northwest and Conastone substations to accommodate 2 new lines.

This Reinforcement will also mitigate Network Impact 10.

11. The Raritan River - Red Oak A (T1034) 230 kV and Raritan River – Red Oak B (G1047) 230kV overloads require the rebuild of 2.6 miles of 230kV double circuit tower line. The drop loop/bus conductor at Raritan River and Red Oak will also need to be replaced. The total estimated cost of these upgrades is **\$8.331 Million** and they will take **3-4 years** to complete.

This Reinforcement will also mitigate Network Impact 12.