Generation Interconnection
Feasibility Study Report
Queue Position X4-014

The Interconnection Customer (IC) has proposed a 20 MW energy only (0 MWC; 20 MW MFO) energy storage facility to be located in Northampton County, Virginia. PJM studied X4-014 as a 20 MW injection into the Old Dominion Electric Cooperative (ODEC) system at a tap of the Eastville-Bayview 69kV (6750) circuit and evaluated the project for compliance with reliability criteria for summer peak conditions in 2015. The planned in-service date, as stated in the Attachment N, is December 31, 2013.

Point(s) of Interconnection

X4-014 will connect with the Old Dominion Electric Cooperative system as a tap of the Eastville-Bayview 69kV circuit.

Direct Connection Requirements

Direct Connection Issues

X4-014 Generator Harmonic Requirements

Harmonic Voltage Requirements

On 69 kV systems, the total harmonic distortion to the fundamental voltage wave from a single customer is limited to 1.5% of nominal. In addition, no individual harmonic component can exceed 1.0% of the fundamental system voltage.

Maximum Allowable Harmonic Voltage Distortion Table (Tariff Rule 32)		
Voltage Level	**Distortion Factor (% System Voltage)**	**Individual Harmonic (% System Voltage)**
69 kV through 138 kV	1.5	1

Harmonic current limits must comply with IEEE standard 519 (see table 10.2 and 10.3 limits for power generation). Harmonic filtering sufficient to limit harmonic current to the limits proscribed by these tables may need to be installed. X4-014 will be responsible for installing such filtering and may be disconnected until remedies are taken if these standards are violated.

Current Distortion Limits in % of 60~ Current (from IEEE 519 tables 10.2 and 10.3)						
Voltage Level	<11	11<h<17	17<h<23	23<h<35	35<h	TDD
69 kV	2.0	1.0	0.75	0.3	0.15	2.5
25 kV	4.0	2.0	1.5	0.6	0.3	5.0

Generator Flicker Requirements

X4-014 must limit the severity of voltage variation to within 0.5%, so as not to cause observable flicker to consumers. The interconnection customer's facilities are required to be able to receive or

deliver the necessary VARS during normal operation to assure that voltage does not vary more than 0.5%.

Turbine Generator Regulation or Reactive Support Requirements
As specified in Interconnection Service Agreement, Appendix 2, Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the X4-014 generator shall design its Facility to meet the following power factor requirement:

"For all new wind-powered and other non-synchronous generation facilities, if determined in the system impact study to be required for the safety or reliability of the Transmission System, the Generation Interconnection Customer shall design its Customer Facility with the ability to maintain a composite power delivery at continuous rated power output at a power factor of at least 0.95 leading to 0.95 lagging."

Impact studies from previous, less severe applications show that unit power factor operation of a variable output resource at this location causes voltage fluctuation far in excess of criteria. There is no reason to expect that unity power factor operation will be an available option for this resource. This will be analyzed in detail during the impact study.

Preliminary Schedule and Notes / Assumptions
ODEC will begin the project only after the PJM 3-party Interconnection Service Agreement (ISA) and Interconnection Construction Service Agreement (ICSA) are fully executed and ODEC receives a written authorization by PJM to commence activities. The estimated time to complete the direct connection work is approximately **48 months** after the execution of an ICSA. **The 2013 requested in-service date will not be attainable.** The schedule for the 69 kV transmission and substation work to accommodate X4-014 would depend on the project start date. The work to accommodate X4-014 will require transmission line outages. ODEC's outage windows for construction are typically available in the spring and fall of the year. Missing an outage window could result in project delays.

Notes / Assumptions
During construction, if extreme weather conditions or other system safety concerns arise, field construction may need to be rescheduled, which could possibly impact the schedule plan.

Excepting any operational, governmental and/or environmental regulatory delays, the use of additional resources, such as overtime, premiums for expedited material, and/or contractor labor, may enable ODEC to decrease this construction period. It is also assumed that all right-of-way and easements are secured without impact on anticipated construction start dates.

Turbine Generator and Existing Distribution line Carrier Communications
An AMI/LM power line carrier system operates on A&N Electric Cooperative (ANEC) distribution system at a frequency of 9.615 kHz. Harmonic or other spurious emissions which emanate from X4-014 and interfere with the operation of this power line carrier system shall be mitigated by X4-014 to ANEC's satisfaction.

Transmission Owner Scope of Work

The scope of work and estimated costs for the direct connection facilities is as follows:

New 69kV Structures	**$**	**100,000**
New 69kV switches	**$**	**50,000**
New 69kV lightning arresters	**$**	**10,000**
Power quality metering (Installed on Customer CT's and VT's)	**$**	**20,000**
Additional conduit/junction boxes/control wiring	**$**	**30,000**
Relaying modifications line #6750 (including transfer trip)	**$**	**80,000**
Engineering	**$**	**50,000**
Relay upgrades: Line 6750, 6721	**$**	**200,000**

Connection cost estimates are based on the assumptions stated in the Direct Connection Issues section. These costs exclude any applicable state or federal taxes. If at a future date Federal CIAC taxes are deemed necessary by the IRS for this project, PJM, ANEC, and ODEC shall be reimbursed by the Interconnection Customer for such taxes.

Costs for extraordinary Threatened and Endangered Species, Archaeological, Cultural, or other as yet unidentified mitigation strategies are not estimated nor included in the above estimate. No environmental, real estate, or permitting issues were reviewed for the X4-014 Impact Study.

Interconnection Customer Scope of Work

The Interconnection Customer (IC) is responsible for all design and construction related to activities on their side of the Point of Interconnection (POI). Site preparation, including grading and an access road, as necessary, is assumed to be by the IC. Route selection, line design, and right-of-way acquisition of the direct connect facilities is not included in this report, and is the responsibility of the IC.

The Interconnection Customer is required to design, construct, and own the 69 kV line from the POI to the Customer Facility. This line must be built in accordance RUS standards or an accepted national standard, be effectively grounded, and appropriately shielded from lightning. (Refer to RUS bulletins 1728f-810 and 1724E-200.) The customer's transformer shall be connected wye-ground on the 69 kV side and delta on the low-voltage side.

The IC will be required to install metering and telemetry equipment at the Point of Interconnection to provide revenue metering and real-time telemetry data to PJM. The requirements for this equipment are listed in Appendix 2, Section 8 of Attachment O to the PJM Tariff, as well as PJM Manuals 01 and 14D.

At the Interconnection Customer's discretion, ODEC will design and supply the required metering equipment but all the installation cost would be borne by the customer. ODEC requires that power quality metering be installed to monitor compliance with industry standards for harmonics.

Transmission Network Impacts

Potential transmission network impacts are as follows:

Generator Deliverability

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

None

Multiple Facility Contingency

*(Double Circuit Tower Line, Line with Failed Breaker and, Bus Fault contingencies for the **Full** energy output.*

None

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)

1. The (DP&L) Milford-Steele 230 kV line (from bus 232004 to bus 232000 ckt 1) loads from 157.12% to 157.31% (DC power flow) of its normal rating (551 MVA) for the tower line contingency 'DBL_4NC'. This project contributes approximately 6.57 MW to the thermal violation.

Short Circuit

No issues identified.

Stability and Low Voltage Ride Through Analysis

Will be performed during the System Impact study phase of the project.

System Protection

The Interconnection Customer is responsible for the design and implementation of all protection equipment on the X4-014 side of the POI (Point of Interconnection) as shown on Attachment 1 and will do so in accordance with good utility practice.

X4-014 may need to provide telephone circuits for use in transfer trip relaying from Tasley and Kellam substations, depending on the characteristics of the proposed resource. ODEC will provide sensing and a transfer trip relaying for all 69 kV faults on the lines from Bayview to Tasley. X4-014

is required to provide ODEC with any information necessary to set ODEC line relaying and coordinate with their protective device.

Distribution Service Requirements

The Interconnection Customer must submit a request for electric service through A&N Electric Cooperative (ANEC) if back up electric service at less than 69 kV is desired.

New System Reinforcements

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

None

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. Cost allocation for these overloads will be provided in the System Impact Study Report.

1. To mitigate the (DP&L) Milford-Steele 230 kV line (from bus 232004 to bus 232000 ckt 1) overload will require reconductoring the circuit. The estimated cost to perform this work is **$35,100,000** and will take **30 months** to complete.

Transmission Owner Identifed Overloads

The following overloads were identified by Old Dominion Electric Cooperative (ODEC) during their evaluation of the X4-014 project.

New Overloads

X4-014 causes the following overloads:

1. The (ODEC) V4-064 tap to W1-008 tap 69kV circuit (6721) loads from 88% to 119% of its normal rating (59 MVA) for non contingency under light load conditions.
2. The (ODEC) Kellam-Weirwood 69kV circuit (6750) loads from 75% to 105% of its normal rating (64 MVA) for the loss of the Bayview–Kendall Grove 69kV circuit under light load conditions.

3. The (ODEC) Weirwood-Kendall Grove 69kV circuit (6750) loads from 78% to 109% of its normal rating (64 MVA) for the loss of the Bayview–Kendall Grove 69kV circuit under light load conditions.

4. The (ODEC) Tasley-Belle Haven 69kV circuit (6721) loads from 80% to 122% of its normal rating (59 MVA) for non contingency under full load conditions.

5. The (ODEC) Belle Haven-Kellam 69kV circuit (6721) loads from 75% to 101% of its normal rating (59 MVA) for non contingency under full load conditions.

6. The (ODEC) Kellam-Weirwood 69kV circuit (6750) loads from 79% to 143% of its normal rating (64 MVA) for non-contingency under full load conditions.

7. The (ODEC) Oak Hall-W3-054A tap 69kV circuit (6790) loads from 92% to 110% of its emergency rating (113 MVA) for the loss of the Oak Hall–Perdue 69kV circuit along with the loss of Tasley generation under full load conditions.

8. The (ODEC) W3-054A tap–Hallwood 69kV circuit (6790) loads from 90% to 108% of its emergency rating (113 MVA) for the loss of the Oak Hall–Perdue 69kV circuit along with the loss of Tasley generation under full load conditions.

9. The (ODEC) Hallwood-Parksley 69kV circuit (6790) loads from 86% to 104% of its emergency rating (113 MVA) for the loss of the Oak Hall–Perdue 69kV circuit along with the loss of Tasley generation under full load conditions.

10. The (ODEC) Parksley-Tasley 69kV circuit (6790) loads from 90% to 114% of its emergency rating (113 MVA) for the loss of the Oak Hall–Perdue 69kV circuit along with the loss of Tasley generation under full load conditions.

New System Reinforcements

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

1. To mitigate the overload in items #1, 4 and 5 above will requiring rebuilding the Tasley-Kellam 69kV (6721) circuit. The estimated cost to perform this work is **$12M** and will take **48 months** to complete.

2. To mitigate the overload in items #2, 3 and 6 above will requiring rebuilding the Kellam-Kendall Grove 69kV (6750) circuit. The estimated cost to perform this work is **$12M** and will take **48 months** to complete.

3. To mitigate the overload in items #7, 8, 9, and 10 above will requiring rebuilding the Oak Hall-Parksley 69kV (6790) circuit. The estimated cost to perform this work is **$12M** and will take **48 months** to complete.

Contribution to Existing Overloads

X4-014 further contributes to the overloading of the following circuits:

1. The (ODEC) Oak Hall-W3-054A tap 69kV (6790) circuit loads from 132% to 143% of its normal rating (86 MVA) for non-contingency under light conditions.

2. The (ODEC) Tasley-W1-008 tap 69kV circuit (6721) loads from 120% to 149% of its normal rating (59 MVA) for non contingency under light load conditions.

3. The (ODEC) Oak Hall-Perdue 69kV circuit (6778) loads from 126% to 147% of its normal rating (121 MVA) for the loss of the Oak Hall-W3-054A tap 69kV circuit under light load conditions. X4-014 contributes to this overload in the generation mode.

4. The (ODEC) Tasley-Perdue 69kV circuit (6778) loads from 157% to 182% of its normal rating (93 MVA) for the loss of the Oak Hall-W3-054A tap 69kV circuit under light load conditions. X4-014 contributes to this overload in the generation mode.

5. The (ODEC) Oak Hall-W3-054A tap 69kV circuit (6790) loads from 175% to 193% of its normal rating (113 MVA) for the loss of the Oak Hall-Perdue 69kV circuit under light load conditions.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. Cost allocation for these overloads will be provided in the System Impact Study Report.

1. To mitigate the overload in items #1, and 5 above will requiring rebuilding the Oak Hall-Parksley 69kV (6790) circuit. The estimated cost to perform this work is **$12M** and will take **48 months** to complete.

2. To mitigate the overload in item #2 above will requiring rebuilding the Tasley-Kellam 69kV (6721) circuit. The estimated cost to perform this work is **$12M** and will take **48 months** to complete.

3. To mitigate the overload in items #3, and 4 above will requiring building a second 69kV circuit from the W3-054A site to Oak Hall a distance of approximately 1 mile. The estimated cost to perform this work is **$1.5M** and will take **48 months** to complete.

Potential Congestion due to Local Energy Deliverability

(PJM also studied the delivery of the energy portion of the surrounding generation. Any potential problems identified below are likely to 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 Transmission Interconnection Request. Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full deliverability for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which analyzes all overload conditions associated with the identified overloaded element(s). As a result of the aggregate energy resources in the area, the following violations were identified:

These are ***not*** required reliability upgrades.

1. The BELLHAVN-V4-064 TAP 69 kV line (from bus 232903 to bus 900450 ckt 1) loads from 66.26% to 100.16% (DC power flow) of its normal rating (59 MVA) for non-contingency condition. This project contributes approximately 20 MW to the thermal violation.

2. The KELLAM-BELLHAVN 69 kV line (from bus 232286 to bus 232903 ckt 1) loads from 73.27% to 104.52% (DC power flow) of its normal rating (64 MVA) for non-contingency condition. This project contributes approximately 20 MW to the thermal violation.

3. The OAK HALL-POCOMOKE 138 kV line (from bus 232132 to bus 232130 ckt 1) loads from 102.23% to 106.93% (DC power flow) of its normal rating (289 MVA) for the single line contingency ('CKT 23002'). This project contributes approximately 13.6 MW to the thermal violation.

4. The N_CHURCH-PINEY138 138 kV line (from bus 232131 to bus 232128 ckt 1) loads from 111.72% to 115.08% (DC power flow) of its normal rating (172 MVA) for non-contingency condition. This project contributes approximately 5.78 MW to the thermal violation.

5. The OAKHL_69-WATTSVIL 69 kV line (from bus 232280 to bus 232281 ckt 1) loads from 107.87% to 117.13% (DC power flow) of its normal rating (68 MVA) for non-contingency condition. This project contributes approximately 6.3 MW to the thermal violation.

6. The POCOMOKE-T-144 TAP 138 kV line (from bus 232130 to bus 886230 ckt 1) loads from 112.93% to 118.43% (DC power flow) of its normal rating (247 MVA) for the single line contingency ('CKT 23002'). This project contributes approximately 13.6 MW to the thermal violation.

7. The T-144 TAP-COSTEN 138 kV line (from bus 886230 to bus 232807 ckt 1) loads from 119.15% to 124.66% (DC power flow) of its normal rating (247 MVA) for the single line contingency ('CKT 23002'). This project contributes approximately 13.6 MW to the thermal violation.

8. The PINEY GR 230/138 kV transformer (from bus 232128 to bus 232007 ckt 1) loads from 121.18% to 125.13% (DC power flow) of its normal rating (424 MVA) for the single line contingency ('CKT 13713'). This project contributes approximately 16.73 MW to the thermal violation.

9. The TASLEY-PERDUE 69 kV line (from bus 232284 to bus 232846 ckt 1) loads from 105.96% to 127.46% (DC power flow) of its normal rating (93 MVA) for the single line contingency ('CKT 6790'). This project contributes approximately 20 MW to the thermal violation.

10. The M HERMON-NSALSBRY 69 kV line (from bus 232272 to bus 232271 ckt 1) loads from 123.12% to 127.67% (DC power flow) of its normal rating (140 MVA) for the single line contingency ('CKT 23002'). This project contributes approximately 6.37 MW to the thermal violation.

11. The KINGS CK-LORETTO 138 kV line (from bus 232129 to bus 232127 ckt 1) loads from 126.3% to 129.15% (DC power flow) of its normal rating (275 MVA) for non-contingency condition. This project contributes approximately 7.84 MW to the thermal violation.

12. The V4-064 TAP-W1-008 TAP 69 kV line (from bus 900450 to bus 901040 ckt 1) loads from 99.55% to 133.45% (DC power flow) of its normal rating (59 MVA) for non-contingency condition. This project contributes approximately 20 MW to the thermal violation.

13. The KINGS CK-LORETTO 138 kV line (from bus 232129 to bus 232127 ckt 1) loads from 132.97% to 136.84% (DC power flow) of its normal rating (351 MVA) for the single line contingency ('CKT 23002'). This project contributes approximately 13.6 MW to the thermal violation.

14. The V3-061 TAP-WEIRWOOD 69 kV line (from bus 894820 to bus 232847 ckt 1) loads from 108.73% to 139.98% (DC power flow) of its normal rating (64 MVA) for non-contingency condition. This project contributes approximately 20 MW to the thermal violation.

15. The W3-054A TAP-OAKHL_69 69 kV line (from bus 903690 to bus 232280 ckt 1) loads from 133.63% to 145.24% (DC power flow) of its normal rating (86 MVA) for non-contingency condition. This project contributes approximately 9.99 MW to the thermal violation.

16. The TASLEY-PARKSLEY 69 kV line (from bus 232284 to bus 232845 ckt 1) loads from 124.74% to 150.05% (DC power flow) of its normal rating (79 MVA) for the single line contingency ('CKT 6778'). This project contributes approximately 20 MW to the thermal violation.

17. The W3-054A TAP-OAKHL_69 69 kV line (from bus 903690 to bus 232280 ckt 1) loads from 147.35% to 165.04% (DC power flow) of its normal rating (113 MVA) for the single line contingency ('CKT 6778'). This project contributes approximately 20 MW to the thermal violation.

18. The OAKHL_69-WATTSVIL 69 kV line (from bus 232280 to bus 232281 ckt 1) loads from 158.02% to 165.12% (DC power flow) of its normal rating (89 MVA) for the single line contingency ('CKT 137AC'). This project contributes approximately 6.32 MW to the thermal violation.

19. The W1-008 TAP-TASLEY 69 kV line (from bus 901040 to bus 232284 ckt 1) loads from 133.24% to 167.14% (DC power flow) of its normal rating (59 MVA) for non-contingency condition. This project contributes approximately 20 MW to the thermal violation.

20. The PINEY_69-M HERMON 69 kV line (from bus 232274 to bus 232272 ckt 1) loads from 166.34% to 170.79% (DC power flow) of its normal rating (143 MVA) for the single line contingency ('CKT 23002'). This project contributes approximately 6.37 MW to the thermal violation.

21. The N_CHURCH-PINEY138 138 kV line (from bus 232131 to bus 232128 ckt 1) loads from 166.44% to 170.82% (DC power flow) of its normal rating (226 MVA) for the single line contingency ('CKT 13713'). This project contributes approximately 9.91 MW to the thermal violation.

22. The WEIRWOOD-KELLAM 69 kV line (from bus 232847 to bus 232286 ckt 1) loads from 212.22% to 278.88% (DC power flow) of its normal rating (30 MVA) for non-contingency condition. This project contributes approximately 20 MW to the thermal violation.