Generation Interconnection
Feasibility Study Report
Queue Position AB2-030

The Interconnection Customer (IC) has proposed a 4 MW energy only battery storage facility to be located in Accomack County, Virginia. PJM studied AB2-030 as a 4 MW injection into the Old Dominion Electric Cooperative (ODEC) system at the Tasley 25 kV Substation and evaluated it for compliance with reliability criteria for summer peak conditions in 2020. The planned in-service date, as requested by the IC during the project kick-off call, is December 1, 2016. This date is not achievable due to the need for additional studies and construction schedules.

Point of Interconnection

The Interconnection Customer requested a 25 kV distribution level interconnection. Distribution facilities in the area of the AB2-030 project are owned by the Accomack and Northampton Cooperative (ANEC). As a result, AB2-030 will interconnect with the ANEC system at the Tasley 25 kV Substation. The Tasley Substation is fed from the Old Dominion Electric Cooperative transmission system.

Attachment Facilities and local upgrades (if required) along with cost, schedule, and terms and conditions to interconnect AB2-030 will be specified in a separate two party interconnection agreement between the ANEC and the Interconnection Customer. The IC is responsible to contact ANEC to negotiate that interconnection agreement.

Transmission Owner Scope of Attachment FacilityWork

There is no ODEC Attachment Facility work scope for the AB2-030 project.

Electric Distribution Company (ANEC) Scope of Direct Connection Work

This scope of work will be detailed in the bilateral interconnection agreement between ANEC and the IC.

After the AB2-030 / ANEC 2-party IA and AB2-030 / PJM / ODEC three-party Interconnection Service Agreement (ISA) and Interconnection Construction Service Agreement (ICSA), if necessary, are signed and ODEC and ANEC receives written authorization by PJM to begin work, ODEC and ANEC will commence engineering design, material purchase, and construction of facilities identified above.

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 this AB2-030 Feasibility Study.

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 ANEC 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.

AB2-030 Inverter and Existing Distribution line Carrier Communications--

An AMI/LM power line carrier system operates on ANEC's distribution system at a frequency of 9.615 kHz. Harmonic or other spurious emissions which emanate from AB2-030 and interfere with the operation of this power line carrier system shall be mitigated by AB2-030 to ANEC's satisfaction.

AB2-030 Inverter and GSU modeling--

The AB2-030 Interconnection Customer must provide ODEC, ANEC, and PJM with the transformer test reports and a model of the inverters once they are available in order to perform more detailed analyses.

AB2-030 Generator Harmonic Requirements--

Harmonic Voltage Requirements:

On the 69 kV system 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. AB2-030 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
24.9 kV	4.0	2.0	1.5	0.6	0.3	5.0

AB2-030 Generator Flicker Requirements

AB2-030 must limit the severity of voltage variation to within a level which will not cause objectionable flicker to other customers. The interconnection customer's facilities are required to be able to receive the necessary reactive power during normal operation to assure that voltage does not drop below guidelines during intermittent cloud cover.

ODEC and ANEC use the General Electric flicker-irritation curve as a guideline to determine if the system is operating within acceptable limits. ODEC and ANEC will require corrective actions by the AB2-030 customer if their operation causes flicker that exceeds this guideline. One such correction could be the installation of a Static Var Compensator (SVC) to hold a constant voltage.

Interconnection Customer Scope of Work

Queue AB2-030 Interconnection Customer will be responsible for the construction of all generating facilities on the AB2-030 side of the point of ownership change between AB2-030 and ANEC as shown on Attachment 1. The AB2-030 Interconnection Customer is responsible for the cost to design, construct, own and operate the 24.9-kV line from the new ANEC 24.9 kV circuit to AB2-030. 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 bulletin 1728F-803.) ANEC requires that intertie protection relaying (IPR), and supervisory control and data acquisition (SCADA) be located at ANEC's 24.9-kV circuit breaker location (*i.e.* at the point of ownership change from AB2-030 to ANEC).

Metering / Telemetry for PJM

The Interconnection Customer will also be required to install the equipment necessary to provide revenue metering (kWh and kVArh hourly data sent once per day) and real-time data (telemetry) for the Interconnection Customer's generating resource in compliance with PJM Manuals M-01 and M-14B, and the PJM Tariff. At the IC's discretion, ANEC will design and supply the required metering equipment but all the installation cost and ongoing costs will be borne by AB2-030. In the event that AB2-030 provides the metering, AB2-030 will provide ODEC read only access to its PJM metering account for this site for verification of billing for ODEC.

Installation of revenue grade Metering Equipment will be required at the Queue AB2-030 / ANEC point of ownership change. ODEC requests that power quality metering be installed to monitor compliance with industry standards for harmonics.

Summer Peak Analysis - 2020

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, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

1. (DP&L - DP&L) The LORETTO 138/69 kV transformer (from bus 232127 to bus 232275 ckt 1) loads from 89.83% to 90.06% (AC power flow) of its emergency rating (71 MVA) for the line

fault with failed breaker contingency outage of 'DP56'. This project contributes approximately 0.37 MW to the thermal violation.

CONTINGENCY 'DP56' /*LORETTO BUS BREAKER
DISCONNECT BRANCH FROM BUS 232127 TO BUS 232117 CKT 1 /*LORETTO VIENNA 138 1380
DISCONNECT BRANCH FROM BUS 232127 TO BUS 232128 CKT 1 /*LORETTO PINEY GROVE 138 138
END

Please refer to Appendix 1 for a table containing the generators having contribution to this flowgate.

2. (DP&L - DP&L) The LORET_69-FRUITLND 69 kV line (from bus 232275 to bus 232288 ckt 1) loads from 89.65% to 90.65% (AC power flow) of its emergency rating (137 MVA) for the line fault with failed breaker contingency outage of 'DP56'. This project contributes approximately 0.69 MW to the thermal violation.

CONTINGENCY 'DP56' /*LORETTO BUS BREAKER
DISCONNECT BRANCH FROM BUS 232127 TO BUS 232117 CKT 1 /*LORETTO VIENNA 138 1380
DISCONNECT BRANCH FROM BUS 232127 TO BUS 232128 CKT 1 /*LORETTO PINEY GROVE 138 138
END

Please refer to Appendix 2 for a table containing the generators having contribution to this flowgate.

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)

None

Summer Peak Load Flow Analysis Reinforcements

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 mitigate the (DP&L) LORETTO 138/69 kV transformer (from bus 232127 to bus 232275 ckt 1) overload will require replacement of the Loretto AT1 autotransformer, which requires the reconfiguration of the 138 kV and 69 kV buses at Loretto Substation. The estimate to perform this work is **$4,377,000** and will take approximately **2 years** to complete.

2. To mitigate the (DP&L) LORET_69-FRUITLND 69 kV line (from bus 232275 to bus 232288 ckt 1) overload will require rebuilding of the Loretto – Fruitland 69 kV transmission line and substation reinforcements at Loretto Substation and Fruitland Substation. The estimate to perform this work is **$7,196,000** and will take approximately **3 years** to complete.

   Note: Queue project AB2-030 is not expected to have cost responsibility for this network upgrade due to cost allocation rules.

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)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

None

Steady-State Voltage Requirements
(Results of the steady-state voltage studies should be inserted here)

None

Short Circuit
(Summary of impacted circuit breakers)

No issues identified.

Stability and Reactive Power Requirement
(Results of the dynamic studies should be inserted here)

Not required.

Light Load Analysis - 2020

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

Delivery of Energy Portion of Interconnection Request
PJM also studied the delivery of the energy portion of this interconnection request. Any 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 Merchant Transmission Interconnection request.
Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed, which will study all overload conditions associated with the overloaded element(s) identified.

1. (DP&L - DP&L) The OAKHL_69-WATTSVIL 69 kV line (from bus 232280 to bus 232281 ckt 1) loads from 113.34% to 114.92% (AC power flow) of its emergency rating (89 MVA) for the single line contingency outage of 'CKT 13789'. This project contributes approximately 1.35 MW to the thermal violation.

   CONTINGENCY 'CKT 13789'
   OPEN LINE FROM BUS 232132 TO BUS 232133 CIRCUIT 1 /OAK HALL - WATTSVILLE 138
   END

Appendices

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact.
It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

Appendix 1

(DP&L - DP&L) The LORETTO 138/69 kV transformer (from bus 232127 to bus 232275 ckt 1) loads from 99.88% to 100.39% (AC power flow) of its emergency rating (71 MVA) for the line fault with failed breaker contingency outage of 'DP56'. This project contributes approximately 0.37 MW to the thermal violation.

CONTINGENCY 'DP56' /*LORETTO BUS BREAKER
 DISCONNECT BRANCH FROM BUS 232127 TO BUS 232117 CKT 1 /*LORETTO VIENNA 138 1380
 DISCONNECT BRANCH FROM BUS 232127 TO BUS 232128 CKT 1 /*LORETTO PINEY GROVE 138 138
 END

Bus Number	*Bus Name*	*Full Contribution*
232926	*CRISFLD1*	*0.34*
904212	*V4-022E*	*0.28*
901004	*W1-003 E*	*1.18*
901014	*W1-004 E*	*1.18*
901024	*W1-005 E*	*1.18*
901034	*W1-006 E*	*1.18*
907052	*X1-032 E*	*0.58*
907323	*X1-096 C*	*0.66*

907324	*X1-096 E*	*22.51*
920582	*Z1-076 C*	*0.35*
920583	*Z1-076 E*	*0.57*
920592	*Z1-077 C*	*0.25*
920593	*Z1-077 E*	*0.41*
917082	*Z2-012 E*	*1.14*
921122	*AA1-059 C*	*0.74*
921123	*AA1-059 E*	*0.29*
918831	*AA1-102*	*1.27*
922213	*AA2-129 E*	*1.83*
922222	*AA2-130*	*0.35*
923902	*AB2-030 E*	*0.37*
923931	*AB2-033 C*	*0.66*
923932	*AB2-033 E*	*0.26*
924361	*AB2-084 C*	*0.55*
924362	*AB2-084 E*	*0.9*

Appendix 2

(DP&L - DP&L) The LORET_69-FRUITLND 69 kV line (from bus 232275 to bus 232288 ckt 1) loads from 99.56% to 100.09% (AC power flow) of its emergency rating (137 MVA) for the line fault with failed breaker contingency outage of 'DP56'. This project contributes approximately 0.69 MW to the thermal violation.

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CONTINGENCY 'DP56'                                  /*LORETTO BUS BREAKER
  DISCONNECT BRANCH FROM BUS 232127 TO BUS 232117 CKT 1          /*LORETTO
VIENNA 138 1380
  DISCONNECT BRANCH FROM BUS 232127 TO BUS 232128 CKT 1          /*LORETTO
PINEY GROVE 138 138
  END
```

Bus Number	*Bus Name*	*Full Contribution*
232905	*BAYVIEW1*	*0.43*
232926	*CRISFLD1*	*0.64*
232912	*OH NUG1*	*1.53*
232913	*OH NUG2*	*1.51*
232914	*OH NUG3*	*1.53*
232915	*OH NUG4*	*1.53*
232916	*OH NUG5*	*1.53*
232917	*OH NUG6*	*1.52*
232918	*OH NUG7*	*1.52*
232921	*TASLEY2G*	*1.05*
904210	*V4-022C*	*0.06*
904212	*V4-022E*	*0.54*

901003	*W1-003 C*	*0.55*
901004	*W1-003 E*	*2.23*
901013	*W1-004 C*	*0.55*
901014	*W1-004 E*	*2.23*
901023	*W1-005 C*	*0.55*
901024	*W1-005 E*	*2.23*
901033	*W1-006 C*	*0.55*
901034	*W1-006 E*	*2.23*
907052	*X1-032 E*	*1.1*
907323	*X1-096 C*	*1.25*
907324	*X1-096 E*	*42.57*
920582	*Z1-076 C*	*0.67*
920583	*Z1-076 E*	*1.09*
920592	*Z1-077 C*	*0.48*
920593	*Z1-077 E*	*0.78*
916441	*Z1-100*	*0.15*
916451	*Z1-101*	*0.15*
916461	*Z1-102*	*0.15*
920602	*Z1-103*	*0.15*
917081	*Z2-012 C*	*0.26*
917082	*Z2-012 E*	*2.15*
920952	*AA1-025*	*0.13*
920962	*AA1-026*	*0.13*
920972	*AA1-027*	*0.13*
920982	*AA1-028*	*0.13*
921122	*AA1-059 C*	*1.4*
921123	*AA1-059 E*	*0.55*
918831	*AA1-102*	*2.41*
921602	*AA1-141 C*	*0.52*
921603	*AA1-141 E*	*0.85*
922213	*AA2-129 E*	*3.46*
922222	*AA2-130*	*0.65*
923902	*AB2-030 E*	*0.69*
923931	*AB2-033 C*	*1.24*
923932	*AB2-033 E*	*0.49*
924361	*AB2-084 C*	*1.04*
924362	*AB2-084 E*	*1.7*