Generation Interconnection
Feasibility Study Report
Queue Position AB2-033

The Interconnection Customer (IC) has proposed a 10 MW energy (7.2 MWC) solar generating facility to be located in Accomack County, Virginia. PJM studied AB2-033 as a 10 MW injection into the Old Dominion Electric Cooperative (ODEC) system at a tap of the Tasley-Kellam 69 kV circuit 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 May 1, 2017. This in-service date cannot be accomplished due to construction schedules.

Point of Interconnection

The Interconnection Customer requested a transmission level interconnection. As a result, AB2-033 will interconnect with the ODEC system at the Tasley 69 kV substation.

Transmission Owner Attachment Facilities Scope of Work

The total estimated cost of Direct Connection Facilities needed to connect Queue AB2-033 to the ODEC 69 kV system is **$ 1,700,000** excluding any applicable state or federal taxes.

A further breakdown of the direct connection cost is as follows:

$100,000.00	Grading and Site Preparation
$170,000.00	Substation Package (steel, switches, buswork)
$100,000.00	69 kV circuit Breakers
$100,000.00	Relaying and SCADA @ AB2-033
$80,000.00	Project Management
$550,000.00	Substation Construction Labor and Contractor Supplied Materials
$150,000.00	Engineering
$60,000.00	Control Building
$100,000.00	69 kV Structures
$150,000.00	OPGW Cable to Tasley Substation
$50,000.00	Relaying, Control Wiring, and Transfer trip at Tasley
$60,000.00	Capacitor Cans and Structure
$10,000.00	Power Quality Metering
$1,700,000.00	Total Estimated Direct Connection Cost

The total estimated construction time for the Direct Connection facilities is **24 months.**

These transmission costs exclude any applicable state or federal taxes, they exclude any PJM metering costs, they exclude any land costs and they exclude the Capacitor Bank. 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 this AB2-033 Feasibility Study.

Transmission Owner Interconnection Requirements

AB2-033 Inverter and GSU modeling

The AB2-033 Interconnection Customer must provide ODEC and PJM with the transformer test reports and a model of the inverters once they are available in order to perform more detailed analyses.

AB2-033 Generator Harmonic Requirements @ Point of Interconnection

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. AB2-033 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

AB2-033 Inverter 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 AB2-033 generator may need to design its Facility to meet the following power factor requirement, depending on the outcome of the system impact study:

"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."

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 **24 months** after the execution of an ICSA. The schedule for the 69 kV transmission and substation work to accommodate AB2-033 would depend on the project start date. The work to accommodate AB2-033 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.

Interconnection Customer Scope of Work

Queue AB2-033 Interconnection Customer will be responsible for the construction of all generating station facilities on the AB2-033 side of the POI (Point of Interconnection) as shown on the Figure 1 one-line diagram of the previous page. AB2-033 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 delta on the 69 kV side and wye-ground on the low-voltage side.

Protection equipment --
The Interconnection Customer is responsible for the design and implementation of all protection equipment on the AB2-033 side of the POI (Point of Interconnection) as shown on the one line diagram of the previous page and will do so in accordance with good utility practice.

ODEC will provide relaying, a circuit breaker, and a transfer trip signal to the ODEC breaker for all 69 kV faults on the line from Tasley to Kellam. AB2-033 will provide a 69 kV interrupting device at the POI beyond which ODEC protection will no longer be a primary means of interrupting fault current. The AB2-033 device **shall not** reclose after tripping. AB2-033 is required to provide ODEC with any information necessary to set ODEC line relaying and coordinate with their protective device, and to trip the device upon receipt of the transfer trip signal.

Capacitor Bank --

AB2-033 will need to operate absorbing VARS from the system, so that when real power output decreases due to intermittent cloud cover, the resulting decrease in VAR withdrawal will maintain system voltage. To put it another way, the VARS needed for the step-up transformer will need to come from the system side of the interconnection. Therefore ODEC will need to install a capacitor bank on the 69 kV side to supply these VARS. The exact size will depend on system conditions and will be determined during the System Impact Study.

Metering Equipment --
Installation of revenue grade Metering Equipment will be required at the Queue AB2-033 Point of Interconnection (POI). At the customer's discretion, ODEC will design and supply the required metering equipment but all installation cost will be borne by AB2-033. ODEC requires that power quality metering be installed to monitor compliance with industry standards for harmonics.

The Interconnection Customer is also required to provide revenue metering and real-time telemetry data to PJM in compliance with the requirements listed in PJM Manuals M-01 and M-14. At the customer's discretion, ODEC will design and supply the required telemetering equipment but all the installation cost and on-going costs will be borne by AB2-033. In the event that that AB2-033 provides the metering, AB2-033 will provide ODEC read only access to its PJM metering account for this site for verification of billing for ODEC.

Distribution Service Requirements--
The Interconnection Customer must submit a request for electric service through ANEC if back up electric service or station service power at less than 69 kV is desired.

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 90.06% to 90.64% (DC power flow) of its emergency rating (71 MVA) for the line fault with failed breaker contingency outage of 'DP56'. This project contributes approximately 0.92 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 PRESTON-TANYARD 69 kV line (from bus 232233 to bus 232821 ckt 1) loads from 30.45% to 31.01% (DC power flow) of its emergency rating (93 MVA) for the line fault with failed breaker contingency outage of 'DP11'. This project contributes approximately 1.15 MW to the thermal violation.

CONTINGENCY 'DP11' /*STEELE BUS BREAKER TO MILFORD
DISCONNECT BRANCH FROM BUS 232004 TO BUS 232000 CKT 1 /*MILFORD STEELE 230 230
DISCONNECT BRANCH FROM BUS 232000 TO BUS 232005 CKT 1 /*STEELE VIENNA 230 230
END

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

3. (DP&L - DP&L) The TODD-PRESTON 69 kV line (from bus 232234 to bus 232233 ckt 1) loads from 36.48% to 37.03% (DC power flow) of its emergency rating (93 MVA) for the line fault with failed breaker contingency outage of 'DP11'. This project contributes approximately 1.15 MW to the thermal violation.

CONTINGENCY 'DP11' /*STEELE BUS BREAKER TO MILFORD
DISCONNECT BRANCH FROM BUS 232004 TO BUS 232000 CKT 1 /*MILFORD STEELE 230 230
DISCONNECT BRANCH FROM BUS 232000 TO BUS 232005 CKT 1 /*STEELE VIENNA 230 230
END

Please refer to Appendix 3 for a table containing the generators having contribution to this flowgate.

4. (DP&L - DP&L) The LORET_69-FRUITLND 69 kV line (from bus 232275 to bus 232288 ckt 1) loads from 90.65% to 91.91% (DC power flow) of its emergency rating (137 MVA) for the line fault with failed breaker contingency outage of 'DP56'. This project contributes approximately 1.73 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 4 for a table containing the generators having contribution to this flowgate.

5. (DP&L - DP&L) The FRUITLND-PEMBERTN 69 kV line (from bus 232288 to bus 232273 ckt 1) loads from 90.98% to 92.88% (DC power flow) of its emergency rating (91 MVA) for the line fault with failed breaker contingency outage of 'DP56'. This project contributes approximately 1.73 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 5 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)

1. (DP&L - DP&L) The PINEY_69-M HERMON 69 kV line (from bus 232274 to bus 232272 ckt 1) loads from 107.37% to 109.06% (DC power flow) of its emergency rating (143 MVA) for the line fault with failed breaker contingency outage of 'DP15'. This project contributes approximately 2.41 MW to the thermal violation.

CONTINGENCY 'DP15' /*INDIAN RIVER BUS BREAKER TO PINEY GROVE
DISCONNECT BRANCH FROM BUS 232007 TO BUS 232006 CKT 1 /*PINEY GR INDRIV 4 230 230
DISCONNECT BRANCH FROM BUS 232007 TO BUS 232128 CKT 1 /*PINEY GR PINEY GR 230 138
DISCONNECT BRANCH FROM BUS 232006 TO BUS 232004 CKT 1 /*MILFORD INDIAN RIVER 230 230
END

Please refer to Appendix 6 for a table containing the generators having contribution to this flowgate.

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) PRESTON-TANYARD 69 kV line (from bus 232233 to bus 232821 ckt 1) overload will require replacement of a disconnect switch at the Preston Substation. The estimate to perform this work is **$36,000** and will take approximately **1 year** to complete.

3. To mitigate the (DP&L) TODD-PRESTON 69 kV line (from bus 232234 to bus 232233 ckt 1) overload will require substation reinforcements at Preston Substation and Todd Substation. The estimate to perform this work is **$67,000** and will take approximately **1 year** to complete.

4. 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 AB2-033 is not expected to have cost responsibility for this network upgrade due to cost allocation rules.

5. To mitigate the (DP&L) FRUITLND-PEMBERTN 69 kV line (from bus 232288 to bus 232273 ckt 1) overload will require completion of PJM Supplemental Project s0820. Current estimated completion date is December 31, 2016.

   Note: Queue project AB2-033 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)

1. To mitigate the (DP&L) The PINEY_69-M HERMON 69 kV line (from bus 232274 to bus 232272 ckt 1) overload will require rebuilding of the Piney Grove – Mount Hermon 69 kV transmission line and substation reinforcements at Piney Grove Substation and Mount Hermon

Substation. The estimate to perform this work is **$9,688,000** and will take approximately **3 years** to complete.

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)

To be completed during later study phases if required.

Light Load Analysis - 2020
Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

Facilities Study Estimate
(If a Facilities Study is required, provide the estimated duration and cost estimate to perform Facilities Study)

7 months: $50,000

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 PINEY138-LORETTO 138 kV line (from bus 232128 to bus 232127 ckt 1) loads from 90.43% to 92.39% (DC power flow) of its emergency rating (159 MVA) for the single line contingency outage of 'CKT 13713'. This project contributes approximately 3.12 MW to the thermal violation.

   CONTINGENCY 'CKT 13713'
   OPEN LINE FROM BUS 232129 TO BUS 232127 CIRCUIT 1 /KINGS CREEK - LORETTO 138
   END

2. (DP&L - DP&L) The POCOMOKE-T-144 TAP 138 kV line (from bus 232130 to bus 886230 ckt 1) loads from 65.92% to 67.84% (DC power flow) of its emergency rating (247 MVA) for the single line contingency outage of 'CKT 13764_B'. This project contributes approximately 4.74 MW to the thermal violation.

   CONTINGENCY 'CKT 13764_B'
   OPEN LINE FROM BUS 924680 TO BUS 232128 CIRCUIT 1 /AB2-120 TAP - PINEY GROVE 138
   END

3. (DP&L - DP&L) The N_CHURCH-AB2-120 TAP 138 kV line (from bus 232131 to bus 924680 ckt 1) loads from 105.37% to 107.52% (DC power flow) of its emergency rating (226 MVA) for the single line contingency outage of 'CKT 13713'. This project contributes approximately 4.86 MW to the thermal violation.

   CONTINGENCY 'CKT 13713'
   OPEN LINE FROM BUS 232129 TO BUS 232127 CIRCUIT 1 /KINGS CREEK - LORETTO 138
   END

4. (DP&L - DP&L) The PINEY_69-M HERMON 69 kV line (from bus 232274 to bus 232272 ckt 1) loads from 106.83% to 108.53% (DC power flow) of its emergency rating (143 MVA) for the single line contingency outage of 'CKT 23002'. This project contributes approximately 2.43 MW to the thermal violation.

   CONTINGENCY 'CKT 23002'
   DISCONNECT BUS 232007 /INDIAN RIVER - PINEY GROVE 230 & PNY GRV AT-20 XFMER
   END

5. (DP&L - DP&L) The OAKHL_69-WATTSVIL 69 kV line (from bus 232280 to bus 232281 ckt 1) loads from 98.14% to 101.93% (DC power flow) of its emergency rating (89 MVA) for the single line contingency outage of 'CKT 13789'. This project contributes approximately 3.37 MW to the thermal violation.

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

6. (DP&L - DP&L) The SHORT 1-LAUREL 69 kV line (from bus 232828 to bus 232249 ckt 1) loads from 68.74% to 70.53% (DC power flow) of its emergency rating (57 MVA) for the single line contingency outage of 'CKT 23002'. This project contributes approximately 1.02 MW to the thermal violation.

CONTINGENCY 'CKT 23002'
DISCONNECT BUS 232007 /INDIAN RIVER - PINEY GROVE 230
& PNY GRV AT-20 XFMER
END

7. (DP&L - DP&L) The T-144 TAP-COSTEN 138 kV line (from bus 886230 to bus 232807 ckt 1) loads from 65.92% to 67.84% (DC power flow) of its emergency rating (247 MVA) for the single line contingency outage of 'CKT 13764_B'. This project contributes approximately 4.74 MW to the thermal violation.

   CONTINGENCY 'CKT 13764_B'
   OPEN LINE FROM BUS 924680 TO BUS 232128 CIRCUIT 1 /AB2-120 TAP - PINEY GROVE 138
   END

8. (DP&L - DP&L) The AB2-120 TAP-PINEY138 138 kV line (from bus 924680 to bus 232128 ckt 1) loads from 105.28% to 107.43% (DC power flow) of its emergency rating (226 MVA) for the single line contingency outage of 'CKT 13713'. This project contributes approximately 4.86 MW to the thermal violation.

   CONTINGENCY 'CKT 13713'
   OPEN LINE FROM BUS 232129 TO BUS 232127 CIRCUIT 1 /KINGS CREEK - LORETTO 138
   END

9. (DP&L - DP&L) The AB2-120 TAP-PINEY138 138 kV line (from bus 924680 to bus 232128 ckt 1) loads from 80.32% to 82.14% (DC power flow) of its normal rating (172 MVA) for non-contingency condition. This project contributes approximately 3.14 MW to the thermal violation.

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 90.06% to 90.64% (DC power flow) of its emergency rating (71 MVA) for the line fault with failed breaker contingency outage of 'DP56'. This project contributes approximately 0.92 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
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Bus Number	*Bus Name*	*Full Contribution*
232926	*CRISFLD1*	*0.34*
904212	*V4-022E*	*0.28*
901004	*W1-003 E*	*0.43*
901014	*W1-004 E*	*0.43*
901024	*W1-005 E*	*0.43*
901034	*W1-006 E*	*0.43*
907052	*X1-032 E*	*0.58*
907323	*X1-096 C*	*0.66*
907324	*X1-096 E*	*16.04*
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*
924681	*AB2-120 C OP*	*3.12*
924682	*AB2-120 E OP*	*5.1*
925071	*AB2-164 C OP*	*0.7*
925072	*AB2-164 E OP*	*1.14*
925081	*AB2-165 C OP*	*0.7*
925082	*AB2-165 E OP*	*1.14*
925101	*AB2-167 C*	*0.35*
925102	*AB2-167 E*	*0.58*

925311	*AB2-192 C OP*	*0.7*
925312	*AB2-192 E OP*	*1.14*

Appendix 2

(DP&L - DP&L) The PRESTON-TANYARD 69 kV line (from bus 232233 to bus 232821 ckt 1) loads from 30.45% to 31.01% (DC power flow) of its emergency rating (93 MVA) for the line fault with failed breaker contingency outage of 'DP11'. This project contributes approximately 1.15 MW to the thermal violation.

CONTINGENCY 'DP11' /*STEELE BUS BREAKER TO MILFORD
DISCONNECT BRANCH FROM BUS 232004 TO BUS 232000 CKT 1 /*MILFORD STEELE 230 230
DISCONNECT BRANCH FROM BUS 232000 TO BUS 232005 CKT 1 /*STEELE VIENNA 230 230
END

Bus Number	*Bus Name*	*Full Contribution*
232926	*CRISFLD1*	*0.24*
293670	*O-025 C*	*0.16*
297076	*V2-028 C*	*0.1*
297077	*V2-028 E*	*0.81*
904212	*V4-022E*	*0.36*
232919	*VN10*	*0.61*
232907	*VN8*	*4.45*
901003	*W1-003 C*	*0.07*
901004	*W1-003 E*	*0.52*
901013	*W1-004 C*	*0.07*
901014	*W1-004 E*	*0.52*
901023	*W1-005 C*	*0.07*
901024	*W1-005 E*	*0.52*
901033	*W1-006 C*	*< 0.01*
901034	*W1-006 E*	*0.52*
907052	*X1-032 E*	*0.47*
907323	*X1-096 C*	*0.46*
907324	*X1-096 E*	*11.19*
910571	*X3-008 C*	*0.57*
910572	*X3-008 E*	*4.78*
910591	*X3-015 C*	*0.41*
910592	*X3-015 E*	*3.43*
913411	*Y1-080 C*	*0.07*
913412	*Y1-080 E*	*0.56*
915541	*Y3-058 C*	*0.17*
915542	*Y3-058 E*	*1.43*
920582	*Z1-076 C*	*0.61*

920583	*Z1-076 E*	*1.*
920592	*Z1-077 C*	*0.44*
920593	*Z1-077 E*	*0.71*
916441	*Z1-100*	*0.09*
916451	*Z1-101*	*0.09*
916461	*Z1-102*	*0.09*
920602	*Z1-103*	*0.09*
917082	*Z2-012 E*	*1.42*
920763	*Z2-076 E*	*0.18*
920773	*Z2-077 E*	*0.18*
920952	*AA1-025*	*0.08*
920962	*AA1-026*	*0.08*
920972	*AA1-027*	*0.08*
920982	*AA1-028*	*0.08*
921122	*AA1-059 C*	*0.52*
921123	*AA1-059 E*	*0.2*
921142	*AA1-061 C*	*4.87*
921143	*AA1-061 E*	*2.4*
918831	*AA1-102*	*0.88*
921592	*AA1-140 C*	*0.67*
921593	*AA1-140 E*	*1.1*
921602	*AA1-141 C*	*0.65*
921603	*AA1-141 E*	*1.07*
922213	*AA2-129 E*	*2.29*
922222	*AA2-130*	*0.24*
922752	*AB1-056 C OP*	*4.91*
922753	*AB1-056 E OP*	*14.*
922762	*AB1-057 C*	*4.99*
922763	*AB1-057 E*	*14.23*
923282	*AB1-137 C*	*1.14*
923283	*AB1-137 E*	*0.49*
923902	*AB2-030 E*	*0.46*
923931	*AB2-033 C*	*0.82*
923932	*AB2-033 E*	*0.33*
924361	*AB2-084 C*	*0.45*
924362	*AB2-084 E*	*0.73*
924461	*AB2-095 C*	*1.16*
924462	*AB2-095 E*	*1.89*
924681	*AB2-120 C OP*	*4.32*
924682	*AB2-120 E OP*	*7.04*
924781	*AB2-130 C OP*	*4.57*
924782	*AB2-130 E OP*	*7.46*
924831	*AB2-136 C OP*	*7.47*
924832	*AB2-136 E OP*	*10.6*
925071	*AB2-164 C OP*	*0.87*

925072	*AB2-164 E OP*	*1.42*
925081	*AB2-165 C OP*	*0.87*
925082	*AB2-165 E OP*	*1.42*
925091	*AB2-166 C*	*0.26*
925092	*AB2-166 E*	*0.45*
925101	*AB2-167 C*	*0.61*
925102	*AB2-167 E*	*1.*
925151	*AB2-172 C OP*	*7.33*
925152	*AB2-172 E OP*	*11.96*
925231	*AB2-177 C*	*0.29*
925232	*AB2-177 E*	*0.47*
925261	*AB2-180 C*	*2.15*
925262	*AB2-180 E*	*0.92*
925311	*AB2-192 C OP*	*0.87*
925312	*AB2-192 E OP*	*1.42*

Appendix 3

(DP&L - DP&L) The TODD-PRESTON 69 kV line (from bus 232234 to bus 232233 ckt 1) loads from 36.48% to 37.03% (DC power flow) of its emergency rating (93 MVA) for the line fault with failed breaker contingency outage of 'DP11'. This project contributes approximately 1.15 MW to the thermal violation.

```
CONTINGENCY 'DP11'                                  /*STEELE BUS BREAKER TO MILFORD
  DISCONNECT BRANCH FROM BUS 232004 TO BUS 232000 CKT 1          /*MILFORD
STEELE 230 230
  DISCONNECT BRANCH FROM BUS 232000 TO BUS 232005 CKT 1          /*STEELE
VIENNA 230 230
  END
```

Bus Number	*Bus Name*	*Full Contribution*
232926	*CRISFLD1*	*0.24*
293670	*O-025 C*	*0.16*
297076	*V2-028 C*	*0.1*
297077	*V2-028 E*	*0.81*
904212	*V4-022E*	*0.36*
232919	*VN10*	*0.61*
232907	*VN8*	*4.45*
901003	*W1-003 C*	*0.07*
901004	*W1-003 E*	*0.52*
901013	*W1-004 C*	*0.07*
901014	*W1-004 E*	*0.52*
901023	*W1-005 C*	*0.07*
901024	*W1-005 E*	*0.52*
901033	*W1-006 C*	*< 0.01*

901034	*W1-006 E*	*0.52*
907052	*X1-032 E*	*0.47*
907323	*X1-096 C*	*0.46*
907324	*X1-096 E*	*11.19*
910571	*X3-008 C*	*0.57*
910572	*X3-008 E*	*4.78*
910591	*X3-015 C*	*0.41*
910592	*X3-015 E*	*3.43*
913411	*Y1-080 C*	*0.07*
913412	*Y1-080 E*	*0.56*
915541	*Y3-058 C*	*0.17*
915542	*Y3-058 E*	*1.43*
920582	*Z1-076 C*	*0.61*
920583	*Z1-076 E*	*1.*
920592	*Z1-077 C*	*0.44*
920593	*Z1-077 E*	*0.71*
916441	*Z1-100*	*0.09*
916451	*Z1-101*	*0.09*
916461	*Z1-102*	*0.09*
920602	*Z1-103*	*0.09*
917082	*Z2-012 E*	*1.42*
920763	*Z2-076 E*	*0.18*
920773	*Z2-077 E*	*0.18*
920952	*AA1-025*	*0.08*
920962	*AA1-026*	*0.08*
920972	*AA1-027*	*0.08*
920982	*AA1-028*	*0.08*
921122	*AA1-059 C*	*0.52*
921123	*AA1-059 E*	*0.2*
921142	*AA1-061 C*	*4.87*
921143	*AA1-061 E*	*2.4*
918831	*AA1-102*	*0.88*
921592	*AA1-140 C*	*0.67*
921593	*AA1-140 E*	*1.1*
921602	*AA1-141 C*	*0.65*
921603	*AA1-141 E*	*1.07*
922213	*AA2-129 E*	*2.29*
922222	*AA2-130*	*0.24*
922752	*AB1-056 C OP*	*4.91*
922753	*AB1-056 E OP*	*14.*
922762	*AB1-057 C*	*4.99*
922763	*AB1-057 E*	*14.23*
923282	*AB1-137 C*	*1.14*
923283	*AB1-137 E*	*0.49*
923902	*AB2-030 E*	*0.46*

923931	*AB2-033 C*	*0.82*
923932	*AB2-033 E*	*0.33*
924361	*AB2-084 C*	*0.45*
924362	*AB2-084 E*	*0.73*
924461	*AB2-095 C*	*1.16*
924462	*AB2-095 E*	*1.89*
924681	*AB2-120 C OP*	*4.32*
924682	*AB2-120 E OP*	*7.04*
924781	*AB2-130 C OP*	*4.57*
924782	*AB2-130 E OP*	*7.46*
924831	*AB2-136 C OP*	*7.47*
924832	*AB2-136 E OP*	*10.6*
925071	*AB2-164 C OP*	*0.87*
925072	*AB2-164 E OP*	*1.42*
925081	*AB2-165 C OP*	*0.87*
925082	*AB2-165 E OP*	*1.42*
925091	*AB2-166 C*	*0.26*
925092	*AB2-166 E*	*0.45*
925101	*AB2-167 C*	*0.61*
925102	*AB2-167 E*	*1.*
925151	*AB2-172 C OP*	*7.33*
925152	*AB2-172 E OP*	*11.96*
925231	*AB2-177 C*	*0.29*
925232	*AB2-177 E*	*0.47*
925261	*AB2-180 C*	*2.15*
925262	*AB2-180 E*	*0.92*
925311	*AB2-192 C OP*	*0.87*
925312	*AB2-192 E OP*	*1.42*

Appendix 4

(DP&L - DP&L) The LORET_69-FRUITLND 69 kV line (from bus 232275 to bus 232288 ckt 1) loads from 90.65% to 91.91% (DC power flow) of its emergency rating (137 MVA) for the line fault with failed breaker contingency outage of 'DP56'. This project contributes approximately 1.73 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*
232905	*BAYVIEW1*	*0.42*

232926	*CRISFLD1*	*0.64*
232912	*OH NUG1*	*1.52*
232913	*OH NUG2*	*1.5*
232914	*OH NUG3*	*1.52*
232915	*OH NUG4*	*1.52*
232916	*OH NUG5*	*1.52*
232917	*OH NUG6*	*1.52*
232918	*OH NUG7*	*1.51*
232921	*TASLEY2G*	*1.05*
904210	*V4-022C*	*0.06*
904212	*V4-022E*	*0.54*
901003	*W1-003 C*	*0.12*
901004	*W1-003 E*	*0.82*
901013	*W1-004 C*	*0.12*
901014	*W1-004 E*	*0.82*
901023	*W1-005 C*	*0.12*
901024	*W1-005 E*	*0.82*
901033	*W1-006 C*	*< 0.01*
901034	*W1-006 E*	*0.82*
907052	*X1-032 E*	*1.1*
907323	*X1-096 C*	*1.25*
907324	*X1-096 E*	*30.34*
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*	*2.4*
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*
924681	*AB2-120 C OP*	*5.91*
924682	*AB2-120 E OP*	*9.64*
925071	*AB2-164 C OP*	*1.32*
925072	*AB2-164 E OP*	*2.15*
925081	*AB2-165 C OP*	*1.32*
925082	*AB2-165 E OP*	*2.15*
925101	*AB2-167 C*	*0.66*
925102	*AB2-167 E*	*1.09*
925231	*AB2-177 C*	*0.23*
925232	*AB2-177 E*	*0.38*
925311	*AB2-192 C OP*	*1.32*
925312	*AB2-192 E OP*	*2.15*

Appendix 5

(DP&L - DP&L) The FRUITLND-PEMBERTN 69 kV line (from bus 232288 to bus 232273 ckt 1) loads from 90.98% to 92.88% (DC power flow) of its emergency rating (91 MVA) for the line fault with failed breaker contingency outage of 'DP56'. This project contributes approximately 1.73 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*
232905	*BAYVIEW1*	*0.42*
232926	*CRISFLD1*	*0.64*
232912	*OH NUG1*	*1.52*
232913	*OH NUG2*	*1.5*
232914	*OH NUG3*	*1.52*
232915	*OH NUG4*	*1.52*
232916	*OH NUG5*	*1.52*
232917	*OH NUG6*	*1.52*
232918	*OH NUG7*	*1.51*
232921	*TASLEY2G*	*1.05*
904210	*V4-022C*	*0.06*
904212	*V4-022E*	*0.54*
901003	*W1-003 C*	*0.12*
901004	*W1-003 E*	*0.82*

901013	*W1-004 C*	*0.12*
901014	*W1-004 E*	*0.82*
901023	*W1-005 C*	*0.12*
901024	*W1-005 E*	*0.82*
901033	*W1-006 C*	*< 0.01*
901034	*W1-006 E*	*0.82*
907052	*X1-032 E*	*1.1*
907323	*X1-096 C*	*1.25*
907324	*X1-096 E*	*30.34*
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*	*2.4*
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*
924681	*AB2-120 C OP*	*5.91*
924682	*AB2-120 E OP*	*9.64*
925071	*AB2-164 C OP*	*1.32*
925072	*AB2-164 E OP*	*2.15*
925081	*AB2-165 C OP*	*1.32*
925082	*AB2-165 E OP*	*2.15*
925101	*AB2-167 C*	*0.66*
925102	*AB2-167 E*	*1.09*
925231	*AB2-177 C*	*0.23*
925232	*AB2-177 E*	*0.38*

925311	*AB2-192 C OP*	*1.32*
925312	*AB2-192 E OP*	*2.15*

Appendix 6

(DP&L - DP&L) The PINEY_69-M HERMON 69 kV line (from bus 232274 to bus 232272 ckt 1) loads from 107.37% to 109.06% (DC power flow) of its emergency rating (143 MVA) for the line fault with failed breaker contingency outage of 'DP15'. This project contributes approximately 2.41 MW to the thermal violation.

CONTINGENCY 'DP15' /*INDIAN RIVER BUS BREAKER TO PINEY GROVE
DISCONNECT BRANCH FROM BUS 232007 TO BUS 232006 CKT 1 /*PINEY GR INDRIV 4 230 230
DISCONNECT BRANCH FROM BUS 232007 TO BUS 232128 CKT 1 /*PINEY GR PINEY GR 230 138
DISCONNECT BRANCH FROM BUS 232006 TO BUS 232004 CKT 1 /*MILFORD INDIAN RIVER 230 230
END

Bus Number	*Bus Name*	*Full Contribution*
232905	*BAYVIEW1*	*0.59*
232926	*CRISFLD1*	*0.36*
232912	*OH NUG1*	*2.1*
232913	*OH NUG2*	*2.07*
232914	*OH NUG3*	*2.1*
232915	*OH NUG4*	*2.1*
232916	*OH NUG5*	*2.1*
232917	*OH NUG6*	*2.09*
232918	*OH NUG7*	*2.09*
232921	*TASLEY2G*	*1.46*
904210	*V4-022C*	*0.09*
904212	*V4-022E*	*0.75*
901003	*W1-003 C*	*0.15*
901004	*W1-003 E*	*1.07*
901013	*W1-004 C*	*0.15*
901014	*W1-004 E*	*1.07*
901023	*W1-005 C*	*0.15*
901024	*W1-005 E*	*1.07*
901033	*W1-006 C*	*< 0.01*
901034	*W1-006 E*	*1.07*
907052	*X1-032 E*	*0.82*
907323	*X1-096 C*	*0.71*
907324	*X1-096 E*	*17.31*
920582	*Z1-076 C*	*1.54*

920583	*Z1-076 E*	*2.52*
920592	*Z1-077 C*	*1.1*
920593	*Z1-077 E*	*1.8*
916441	*Z1-100*	*0.19*
916451	*Z1-101*	*0.19*
916461	*Z1-102*	*0.19*
920602	*Z1-103*	*0.19*
917081	*Z2-012 C*	*0.36*
917082	*Z2-012 E*	*2.99*
920952	*AA1-025*	*0.17*
920962	*AA1-026*	*0.17*
920972	*AA1-027*	*0.17*
920982	*AA1-028*	*0.17*
921122	*AA1-059 C*	*0.8*
921123	*AA1-059 E*	*0.32*
918831	*AA1-102*	*1.37*
921602	*AA1-141 C*	*1.86*
921603	*AA1-141 E*	*3.04*
922213	*AA2-129 E*	*4.76*
922222	*AA2-130*	*0.37*
923902	*AB2-030 E*	*0.97*
923931	*AB2-033 C*	*1.73*
923932	*AB2-033 E*	*0.68*
924361	*AB2-084 C*	*0.78*
924362	*AB2-084 E*	*1.27*
924681	*AB2-120 C OP*	*9.21*
924682	*AB2-120 E OP*	*15.02*
925071	*AB2-164 C OP*	*1.83*
925072	*AB2-164 E OP*	*2.99*
925081	*AB2-165 C OP*	*1.83*
925082	*AB2-165 E OP*	*2.99*
925101	*AB2-167 C*	*1.54*
925102	*AB2-167 E*	*2.53*
925231	*AB2-177 C*	*0.82*
925232	*AB2-177 E*	*1.34*
925311	*AB2-192 C OP*	*1.83*
925312	*AB2-192 E OP*	*2.99*