Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AE1-117

"Bethany 138 kV"

Rev 0: August 2019
Rev 1: November 2019
Rev 2: July 2021
Rev 3: May 2022

Contents

Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, 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 System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The Interconnection Customer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

General

Skipjack Offshore Energy, LLC, the Interconnection Customer (IC), has proposed a 152.0 MW Energy (41.5 MW Capacity) offshore wind generating facility to be located in the Atlantic Ocean east of Sussex County, Delaware at GPS coordinates Latitude 38.4987110, Longitude -74.6284920. PJM studied the AE1-117 project as an injection into the Delmarva Power & Light Company (DPL) transmission system at the Bethany 138 kV Substation and evaluated it for compliance with reliability criteria for summer peak conditions in 2022. The project was studied at a commercial probability of 100%. The planned in-service date, as requested by the IC, is June 1, 2022. This date may not be attainable due to required PJM studies (Facilities) and the Transmission Owner's construction schedule.

Revision History

The System Impact Study Report was revised in November 2019 to include the stability analysis results. The report was further revised in July 2021 to update the Summer Peak Analysis to reflect the results of PJM's retool study. The report was revised again in May 2022 to reflect PJM's second retool study.

Point of Interconnection

The Interconnection Customer requested a transmission level Point of Interconnection (POI) be evaluated for the AE1-117 project. As a result, the POI will be located at an Interconnection Customer owned circuit breaker within 500 feet of the Bethany 138 kV Substation where it will connect to a new bus position (see Attachment 1).

Transmission Owner Scope of Work

Substation Interconnection Estimate

Scope: Expanding DPL's Bethany 138 kV Substation to a six (6) position ring bus by constructing one (1) new 138 kV bus position to facilitate the interconnection of AE1-117.

The project will require the addition of one (1) 138 kV breaker, three (3) 138 kV disconnect switches, three (3) CT/VT combination units, and substation bus.

Estimate: $4,100,000
Construction Time: 36-48 months

Major Equipment Included in Estimate:

- Power Circuit Breaker, 138 kV, 3 cycle
  Qty. 1
- Breaker Disconnect, 138 kV
  Qty. 2
- Line Disconnect, 138 kV
  Qty. 1
- Double 1590 ACSR (325')
  Qty. 3
- Insulators, 138 kV
  Qty. 21
- Disconnect Switch Stand, Low, 138 kV, Steel
  Qty. 1
- Relay Panel, Transmission Line, FL/BU (20")
  Qty. 1
- Control Panel, 138 kV Circuit Breaker (10")
  Qty. 1
- Take-off structure, 138 kV
  Qty. 2
- 138 kV Lightning Arresters
  Qty. 3
- 138 kV Lightning Arresters Stands
  Qty. 3

Estimate Assumptions:

- Room in Control Enclosure for New Relay Panel.
- Fiber optic cable necessary is 1,000 linear feet.
- Developer to purchase additional land for substation expansion, if necessary.
- Existing AC & DC systems are adequate
- Existing ground grid and storm water management requires southward expansion.

Required Relaying and Communications

New protection relays are required for the new terminals.

Front line and back-up line protection will be required. A relay panel for the generator bus will be required with front line and back-up protection.

A breaker control relay on a breaker control panel will be required for the control and operation of each new 138 kV circuit breaker (1 total).

The project will require re-wiring and adjustment of existing relay schemes to accommodate the new 138 kV position at the substation.

Metering

A three phase 138 kV revenue metering point will need to be established within the IC facility at the POI.

The IC will purchase and install all metering instrument transformers, as well as construct a metering structure per DPL's specifications. The secondary wiring connections at the instrument transformers will be completed by the IC's contractors and inspected by DPL, while the secondary wiring work at the metering enclosure will be completed by DPL's meter technicians. The metering control cable and meter cabinets will be supplied by DPL and installed by the IC's contractors. DPL's meter technicians will program and install two solid state multi-function meters (Primary & Backup) for each new metering position. Each meter will be equipped with load profile, telemetry, and DNP outputs. The IC will be provided with one (1) meter DNP output.

The IC will be required to make provisions for a POTS (plain old telephone service) line within approximately three (3) feet of each DPL metering position to facilitate remote interrogation and data collection.

Interconnection Customer Scope of Direct Connection Work

The IC is responsible for all design and construction related to activities on their side of the Point of Interconnection. 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. Protective relaying and metering design and installation must comply with DPL's applicable standards. The IC is also required to provide revenue

metering and real-time telemetering data to PJM in conformance with the requirements contained in PJM Manuals M-01 and M-14 and the PJM Tariff.

DPL requires that an IC circuit breaker is located within 500 feet of the DPL substation to facilitate the relay protection scheme between DPL and the IC at the Point of Interconnection (POI).

Inverter Requirements

- The Interconnection Customer shall design is non-synchronous generation facility with the ability to maintain a power factor of at least 0.95 leading to 0.95 lagging measured at the Point of Interconnection.

Special Operating Requirements

1. DPL will require the capability to remotely disconnect the generator from the grid by communication from its System Operations facility. Such disconnection may be facilitated by a generator breaker, or other method depending upon the specific circumstances and the evaluation by DPL.

2. DPL reserves the right to charge the Interconnection Customer operation and maintenance expenses to maintain the Interconnection Customer attachment facilities, including metering and telecommunications facilities, owned by DPL.

Summer Peak Analysis - 2022

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 TODD-PRESTON 69 kV line (from bus 232234 to bus 232233 ckt 1) loads from 100.0% to 110.88% (AC power flow) of its emergency rating (93 MVA) for the line fault with failed breaker contingency outage of 'DPL_P4-2_DP11'. This project contributes approximately 12.08 MW to the thermal violation.

```
CONTINGENCY 'DPL_P4-2_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 Index 1 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 - PECO) The CLAY_230-LINWOOD 230 k V line (from bus 231000 to bus 213750 ckt 1) loads from 126.19% to 128.33% (AC power flow) of its emergency rating (804 MVA) for the line fault with failed breaker contingency outage of 'PECO_P4_LINWO225/* $ DELCO $ PECO_P4_LINWO225 $ STBK'. This project contributes approximately 22.42 MW to the thermal violation.

```
CONTINGENCY 'PECO_P4_LINWO225/* $ DELCO $ PECO_P4_LINWO225 $
STBK'
  TRIP BRANCH FROM BUS 213750 TO BUS 231001 CKT 1              /* LINWOOD
230.00 EDGEMR5 230.00 $ DELCO $ PECO_P4_LINWO225 $ STBK
  DISCONNECT BUS 213892                                  /* PHLISL87 230.00 $
DELCO $ PECO_P4_LINWO225 $ STBK
```

DISCONNECT BUS 213888 /* PHLISCT1 18.00 $ DELCO $ PECO_P4_LINWO225 $ STBK
DISCONNECT BUS 213889 /* PHLISCT2 18.00 $ DELCO $ PECO_P4_LINWO225 $ STBK
END/* $ DELCO $ PECO_P4_LINWO225 $ STBK

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

2. (DP&L - DP&L) The EDGEMR 5-CLAY_230 230 kV line (from bus 231001 to bus 231000 ckt 1) loads from 122.14% to 124.1% (AC power flow) of its emergency rating (804 MVA) for the line fault with failed breaker contingency outage of 'PECO_P4_LINWO225/* $ DELCO $ PECO_P4_LINWO225 $ STBK'. This project contributes approximately 19.99 MW to the thermal violation.

CONTINGENCY 'PECO_P4_LINWO225/* $ DELCO $ PECO_P4_LINWO225 $ STBK'
TRIP BRANCH FROM BUS 213750 TO BUS 231001 CKT 1 /* LINWOOD 230.00 EDGEMR5 230.00 $ DELCO $ PECO_P4_LINWO225 $ STBK
DISCONNECT BUS 213892 /* PHLISL87 230.00 $ DELCO $ PECO_P4_LINWO225 $ STBK
DISCONNECT BUS 213888 /* PHLISCT1 18.00 $ DELCO $ PECO_P4_LINWO225 $ STBK
DISCONNECT BUS 213889 /* PHLISCT2 18.00 $ DELCO $ PECO_P4_LINWO225 $ STBK
END/* $ DELCO $ PECO_P4_LINWO225 $ STBK

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

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. (PJM500 - PJM500) The PCHBTM1S-CNASTONE 500 kV line (from bus 200064 to bus 200004 ckt 1) loads from 98.17% to 100.17% (AC power flow) of its emergency rating (3525 MVA) for the single line contingency outage of 'PECO_P1-2_5007_S/* $ CHESCO $ PECO_P1-2_5007_S $ L'. This project contributes approximately 61.92 MW to the thermal violation.

CONTINGENCY 'PECO_P1-2_5007_S/* $ CHESCO $ PECO_P1-2_5007_S $ L'
  TRIP BRANCH FROM BUS 200066 TO BUS 270072 CKT 1 /*
PCHBTM1N 500.00 FUR RUN_500 500.00 $ CHESCO $ PECO_P1-2_5007_S $ L
  END/* $ CHESCO $ PECO_P1-2_5007_S $ L

2. (PJM500 - PJM500) The PCHBTM1N-FUR RUN_500 500 kV line (from bus 200066 to bus 270072 ckt 1) loads from 109.9% to 112.0% (AC power flow) of its emergency rating (2931 MVA) for the single line contingency outage of 'PECO_P1-2_5012/* $ CHESCO $ PECO_P1-2_5012 $ L'. This project contributes approximately 53.14 MW to the thermal violation.

CONTINGENCY 'PECO_P1-2_5012/* $ CHESCO $ PECO_P1-2_5012 $ L'
  TRIP BRANCH FROM BUS 200064 TO BUS 200004 CKT 1 /*
PCHBTM1S 500.00 CNASTONE 500.00 $ CHESCO $ PECO_P1-2_5012 $ L
  END/* $ CHESCO $ PECO_P1-2_5012 $ L

3. (PECO - PECO) The LINWOOD-POST 230 kV line (from bus 213750 to bus 214216 ckt 1) loads from 104.63% to 105.52% (AC power flow) of its emergency rating (1593 MVA) for the single line contingency outage of 'PECO_P1-2_220-43/* $ DELCO $ PECO_P1-2_220-43 $ L'. This project contributes approximately 23.13 MW to the thermal violation.

CONTINGENCY 'PECO_P1-2_220-43/* $ DELCO $ PECO_P1-2_220-43 $ L'
  TRIP BRANCH FROM BUS 214221 TO BUS 213750 CKT 1 /*
CHIREACT_43 230.00 LINWOOD 230.00 $ DELCO $ PECO_P1-2_220-43 $ L
  END/* $ DELCO $ PECO_P1-2_220-43 $ L

4. (PECO - PECO) The LINWOOD-CHIREACT_43 230 kV line (from bus 213750 to bus 214221 ckt 1) loads from 104.99% to 105.89% (AC power flow) of its emergency rating (1593 MVA) for the single line contingency outage of 'PECO_P1-2_220-97/* $ DELCO $ PECO_P1-2_220-97 $ L'. This project contributes approximately 23.34 MW to the thermal violation.

CONTINGENCY 'PECO_P1-2_220-97/* $ DELCO $ PECO_P1-2_220-97 $ L'
  TRIP BRANCH FROM BUS 213750 TO BUS 214216 CKT 1 /* LINWOOD
230.00 POST 230.00 $ DELCO $ PECO_P1-2_220-97 $ L
  END/* $ DELCO $ PECO_P1-2_220-97 $ L

5. (PECO - PECO) The POST-CHIREACT_39 230 kV line (from bus 214216 to bus 214220 ckt 1) loads from 99.83% to 100.72% (AC power flow) of its emergency rating (1593 MVA) for the single line contingency outage of 'PECO_P1-2_220-43/* $ DELCO $ PECO_P1-2_220-43 $ L'. This project contributes approximately 23.13 MW to the thermal violation.

CONTINGENCY 'PECO_P1-2_220-43/* $ DELCO $ PECO_P1-2_220-43 $ L'
  TRIP BRANCH FROM BUS 214221 TO BUS 213750 CKT 1 /*
CHIREACT_43 230.00 LINWOOD 230.00 $ DELCO $ PECO_P1-2_220-43 $ L
  END/* $ DELCO $ PECO_P1-2_220-43 $ L

6. (PECO - PECO) The CHIREACT_39-CHICHST2 230 kV line (from bus 214220 to bus 213490 ckt 1) loads from 99.83% to 100.72% (AC power flow) of its emergency rating (1593 MVA) for the single line contingency outage of 'PECO_P1-2_220-43/* $ DELCO $ PECO_P1-2_220-43 $ L'. This project contributes approximately 23.13 MW to the thermal violation.

CONTINGENCY 'PECO_P1-2_220-43/* $ DELCO $ PECO_P1-2_220-43 $ L'
  TRIP BRANCH FROM BUS 214221 TO BUS 213750 CKT 1 /*
CHIREACT_43 230.00 LINWOOD 230.00 $ DELCO $ PECO_P1-2_220-43 $ L
  END/* $ DELCO $ PECO_P1-2_220-43 $ L

7. (PECO - PECO) The CHIREACT_43-CHICHST1 230 kV line (from bus 214221 to bus 213489 ckt 1) loads from 104.99% to 105.89% (AC power flow) of its emergency rating (1593 MVA) for the single line contingency outage of 'PECO_P1-2_220-97/* $ DELCO $ PECO_P1-2_220-97 $ L'. This project contributes approximately 23.34 MW to the thermal violation.

CONTINGENCY 'PECO_P1-2_220-97/* $ DELCO $ PECO_P1-2_220-97 $ L'
  TRIP BRANCH FROM BUS 213750 TO BUS 214216 CKT 1 /* LINWOOD 230.00 POST 230.00 $ DELCO $ PECO_P1-2_220-97 $ L
  END/* $ DELCO $ PECO_P1-2_220-97 $ L

8. (DP&L - PECO) The CLAY_230-LINWOOD 230 kV line (from bus 231000 to bus 213750 ckt 1) loads from 115.04% to 117.37% (AC power flow) of its emergency rating (804 MVA) for the single line contingency outage of 'PECO_P1-2_220-85/* $ DELCO $ 220-85 $ LC'. This project contributes approximately 22.51 MW to the thermal violation.

CONTINGENCY 'PECO_P1-2_220-85/* $ DELCO $ 220-85 $ LC'
  TRIP BRANCH FROM BUS 213750 TO BUS 231001 CKT 1 /* LINWOOD 230.00 EDGEMR5 230.00 $ DELCO $ 220-85 $ L
  END/* $ DELCO $ 220-85 $ L

9. (DP&L - PECO) The EDGEMR 5-LINWOOD 230 kV line (from bus 231001 to bus 213750 ckt 1) loads from 113.39% to 115.71% (AC power flow) of its emergency rating (804 MVA) for the single line contingency outage of 'PECO_P1-2_220-84'. This project contributes approximately 21.78 MW to the thermal violation.

CONTINGENCY 'PECO_P1-2_220-84' /* $ DELCO $ 220-84 $ LB

TRIP BRANCH FROM BUS 213750 TO BUS 231000 CKT 1 /* LINWOOD 230.00 CLAY_230 230.00 $ DELCO $ 220-84 $ L
END/* $ DELCO $ 220-84 $ L

10. (DP&L - DP&L) The EDGEMR 5-CLAY_230 230 kV line (from bus 231001 to bus 231000 ckt 1) loads from 112.48% to 115.03% (AC power flow) of its emergency rating (804 MVA) for the single line contingency outage of 'PECO_P1-2_220-85/* $ DELCO $ 220-85 $ LC'. This project contributes approximately 20.06 MW to the thermal violation.

CONTINGENCY 'PECO_P1-2_220-85/* $ DELCO $ 220-85 $ LC'
TRIP BRANCH FROM BUS 213750 TO BUS 231001 CKT 1 /* LINWOOD 230.00 EDGEMR5 230.00 $ DELCO $ 220-85 $ L
END/* $ DELCO $ 220-85 $ L

Summer Peak Load Flow Analysis Reinforcements

Index	Facility	Upgrade Description	Cost	Cost Allocated to AE1-117	NUN
2,3	CLAY_230 230.0 kV - LINWOOD 230.0 kV Ckt 1 & EDGEMR 5 230.0 kV - CLAY_230 230.0 kV Ckt 1	**B2985:** Replace the 230 kV CB #225 at Linwood Substation (PECO) with a double circuit breaker (back to back circuit breakers in one device). Projected in service date 6/1/2022. Queue Project AE1-117 presently does not receive cost allocation for this upgrade. Cost: $1,400,000 **N6926:** Increase the emergency rating of the Claymont - Linwood 230 kV line by rebuilding the line with new poles, foundations, insulators and OPGW and replacing terminal equipment at Claymont. Cost: $7,100,000 Queue Project AE1-117 presently does not receive cost allocation for this upgrade. **N8078.3**: Uprades to affected PECO facilities associated with N6926 **N6927:** Increase the emergency rating of the Edge Moor to Claymont 230 kV line by rebuilding the circuit. The rebuild will include the installation of new poles, foundations, insulators, and conductor. In addition, terminal equipment will need to be upgraded at Claymont and Edge Moor Substations. Cost: $23,000,000 Queue Project AE1-117 presently does not receive cost allocation for this upgrade. **N8078.4**: Uprades to affected PECO facilities associated with N6927 Note 1: Although Queue Project AE1-117 may not have cost responsibility for these upgrades, Queue Project AE1-117 may need these upgrades in-service to be deliverable to the PJM system. If Queue Project AE1-117 comes into service prior to completion of the upgrades, Queue Project AE1-117 will need an interim study.	$31,500,000	$0	B2985 N6926 N6927 N8078.3 N8078.4

<table>
<tr><th>Index</th><th>Facility</th><th>Upgrade Description</th><th>Cost</th><th>Cost Allocated to AE1-117</th><th>NUN</th></tr>
<tr><td>1</td><td>TODD 69.0 kV - PRESTON 69.0 kV Ckt 1</td><td><u>N5788</u>: 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. Replace 600A Disconnect Switch at each substation.

Cost: $100,000

Time Estimate: 12 months

New Rating:
Rate A: 95
Rate B: 130
Rate C: 130

<table>
<tr><th>Queue</th><th>MW</th><th>Cost %</th><th>Cost $</th><th>Type</th><th>ContName</th></tr>
<tr><td>AE1-087</td><td>7.65</td><td>38.77%</td><td>38,773</td><td>breaker</td><td>DPL_P4-2_DP11</td></tr>
<tr><td>AE1-117</td><td>12.08</td><td>61.23%</td><td>61,227</td><td>breaker</td><td>DPL_P4-2_DP11</td></tr>
</table></td><td>$100,000</td><td>$61,227</td><td>N5788</td></tr>
<tr><td></td><td></td><td>Total</td><td>$31,600,000</td><td>$61,227</td><td></td></tr>
</table>

Short Circuit

No issues identified.

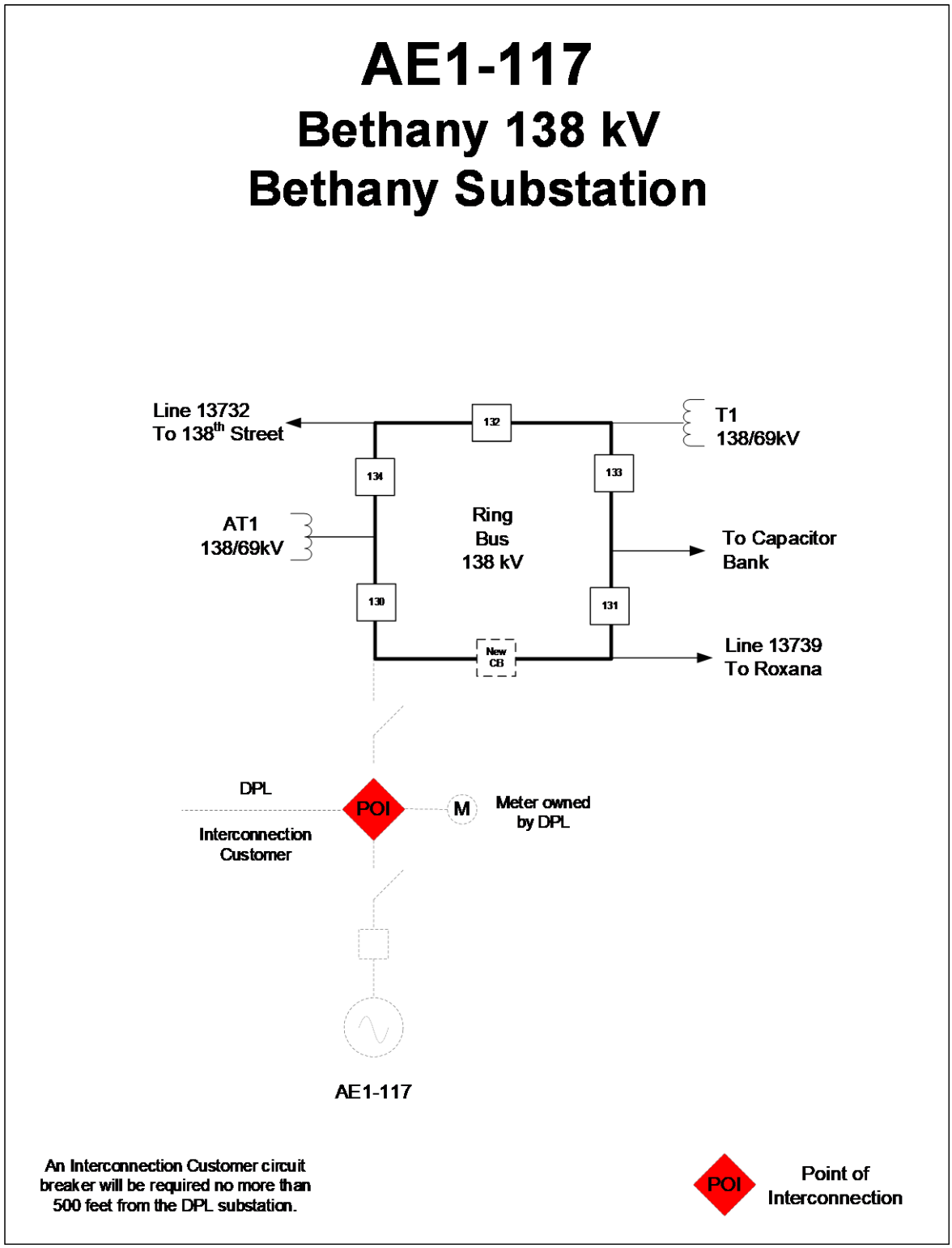
Stability Analysis

Please see Attachment 2 for results.

Light Load Analysis - 2022

No Issues identified.

Attachment 1 – Single Line Diagram



Attachment 2 - Dynamic Simulation Analysis

Executive Summary

Generator Interconnection Request AE1-117 is for a 152 MW Maximum Facility Output (MFO)[1] offshore wind generating facility, which consists of 19 Siemens Gamesa SWT42 DD 8MW wind turbines. The AE1-117 offshore wind generating facility will be located in Atlantic Ocean east of Sussex County, Delaware.

Project AE1-117 offshore wind generating facility will directly connect to the existing Bethany 138 kV substation in the Delmarva Power & Light Company (DPL) transmission system via approximately 0.01 miles 138 kV transmission cable. The Point of Interconnection (POI) will be where the Interconnection Customer gen-tie line terminates at a new line terminal in the Bethany substation.

This report describes a dynamic simulation analysis of AE1-117 as part of the overall system impact study. The load flow scenario for the analysis was based on the RTEP 2022 peak load case, modified to include applicable queue projects. AE1-117 has been dispatched online at maximum power output, with unity power factor and approximately 1.01 pu voltage at the generator terminals.
AE1-117 was tested for compliance with NERC, PJM, Transmission Owner, and other applicable criteria. 58 contingencies were studied, each with a 20 second simulation time period (with 1.0 second initial run prior to any events). Studied faults included:

a) Steady state operation (Category P0);

b) Three phase faults with normal clearing time on the intact network (Category P1);

c) Single phase to ground faults with delayed clearing due to a stuck breaker (Category P4);

d) Single phase faults placed at 80% of the line with delayed (Zone 2) clearing at line end remote from the fault due to primary communications/relay failure (Category P5).

For 58 fault contingencies tested on the 2022 peak load case:

a) AE1-117 was able to ride through the faults (except for faults where protective action trips a generator(s)).

b) Post-contingency oscillations were positively damped with a damping margin of at least 3%.

c) Following fault clearing, all bus voltages recover to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).

d) No transmission element trips, other than those either directly connected or designed to trip as a consequence of that fault.

Please also note that the project AE1-117 meets the 0.95 leading and lagging reactive power requirement at the high side of facility main transformer.

[1] The MFO of the facility is 152 MW according to "Planning Center - Submission Admin - httpsqueuepoint-internalac2prodpjmcom.pdf".

Introduction

Generator Interconnection Request AE1-117 is for a 152 MW Maximum Facility Output (MFO)[2] offshore wind generating facility, which consists of 19 Siemens Gamesa SWT42 DD 8MW wind turbines. The AE1-117 offshore wind generating facility will be located in Atlantic Ocean east of Sussex County, Delaware.

Project AE1-117 offshore wind generating facility will directly connect to the existing Bethany 138 kV substation in the Delmarva Power & Light Company (DPL) transmission system via approximately 0.01 miles 138 kV transmission cable. The Point of Interconnection (POI) will be where the Interconnection Customer gen-tie line terminates at a new line terminal in the Bethany substation.
This analysis is effectively a screening study to determine whether the addition of AE1-117 will meet the dynamic requirements of the NERC, PJM, and Transmission Owner reliability standards.

In this report the AE1-117 project and how it is proposed to be connected to the grid are first described, followed by a description of how the project is modeled in this study. The fault cases are then described and analyzed, and lastly a discussion of the results is provided.

Description of Project

Generator Interconnection Request AE1-117 is for a 152 MW Maximum Facility Output (MFO) offshore wind generating facility, which consists of 19 Siemens Gamesa SWT42 DD 8MW wind turbines. The AE1-117 offshore wind generating facility will be located in Atlantic Ocean east of Sussex County, Delaware.

Project AE1-117 offshore wind generating facility will directly connect to the existing Bethany 138 kV substation in the Delmarva Power & Light Company (DPL) transmission system via approximately 0.01 miles 138 kV transmission cable. The Point of Interconnection (POI) will be where the Interconnection Customer gen-tie line terminates at a new line terminal in the Bethany substation

The connection diagram of the AE1-117 offshore wind generating facility is shown in Figure 1. Table 1 lists the parameters given in the impact study data and the corresponding parameters of the AE1-117 loadflow model.
Additional project details are provided in Attachments 1 through 4:

- Attachment 1 contains the Impact Study Data which details the proposed AE1-117 project.
- Attachment 2 shows the one line diagram of the DPL network in the vicinity of AE1-117.
- Attachment 3 provides a diagram of the PSS/E model in the vicinity of AE1-117.
- Attachment 4 gives the PSS/E loadflow and dynamic models of the AE1-117.

[2] The MFO of the facility is 152 MW according to "Planning Center - Submission Admin - httpsqueuepoint-internalac2prodpjmcom.pdf".

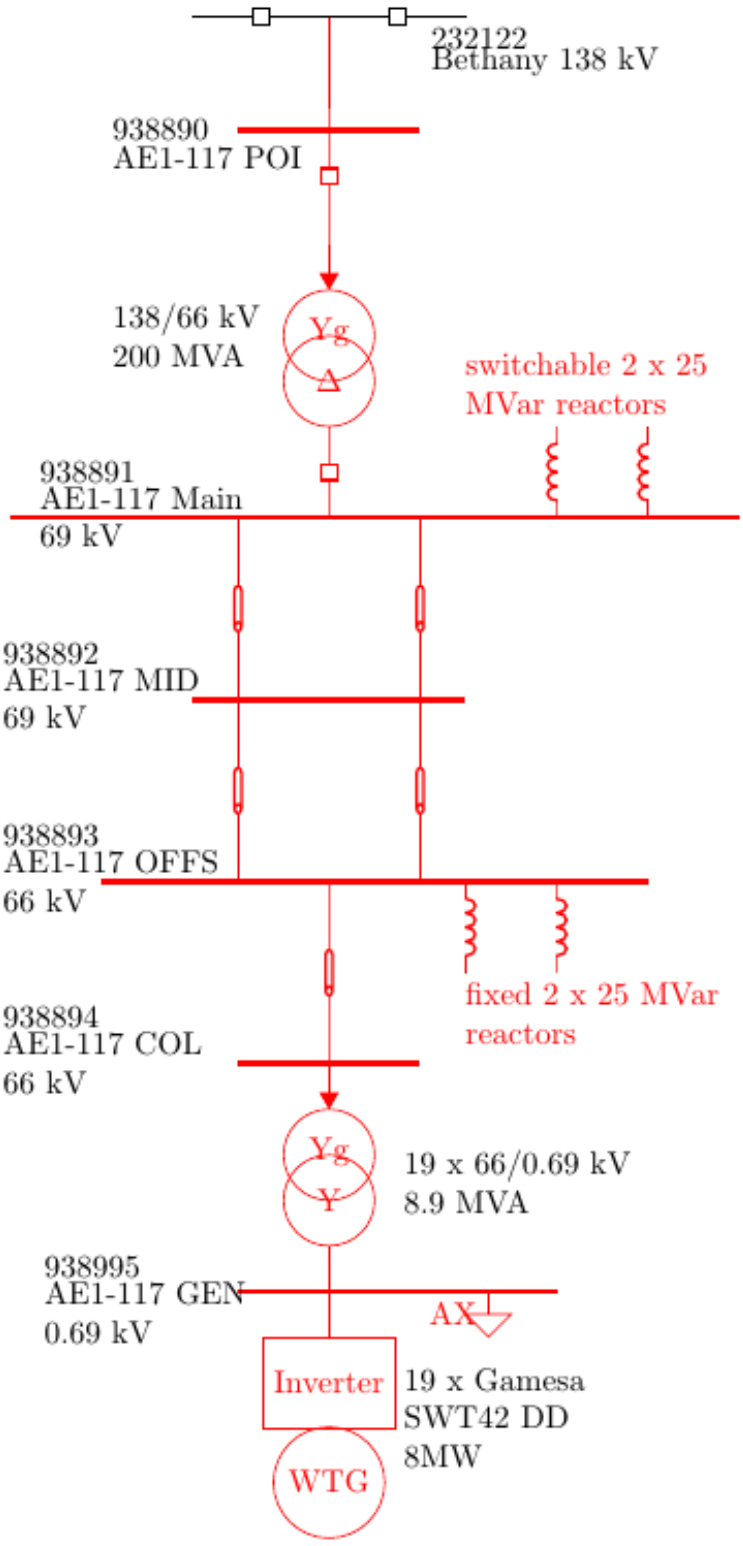


Figure 1: AE1-117 Plant Model

Table 1: AE1-117 Plant Model

	Impact Study Data	Model
Wind Turbines	19X8 MW Siemens Gamesa SWT42 DD 8MW, 60 Hz MVA base = N/A Vt = 0.69 kV Zsource = N/A Pgen[3] = 8.0 MW Qmax[4] = 4 MVAr Qmin = -4 MVAr	1 x 152 MW generator Pgen 152 MW Pmax 152 MW Pmin 0 MW Qgen 0.0 MVAr Qmax 76MVAr Qmin -76 MVAr Mbase[5]169.10 MVA Zsorce j1.0 @ Mbase
Wind Generator Step-up Transformers	19X 66/0.69 kV transformer Rating = 8.9 MVA Transformer base = 8.9 MVA Impedance = 0.0099 + j0.0693 pu @ MVA base Number of taps = N/A Tap step size = N/A	1x 66/0.69 kV two winding transformer (DYng) Rating = 169.1 MVA Transformer base = 169.1 MVA Impedance = 0.0099 + j0.0693 pu @ MVA base Number of taps = 5 Tap step size = 2.5 %
Main Transformer	1x 138/66 kV transformer Rating = 200 MVA (ONAN) Transformer base = 200 MVA Impedance = 0.001667 + j0.069980 pu @ MVA base Number of taps = N/A Tap step size = N/A	1x 138/66 kV transformer (YngD) Rating = 200 MVA Transformer base = 200 MVA Impedance = 0.001667 + j0.069980 pu @ MVA base Number of taps = 33 Tap step size = 0.625 %

[3] This information is from the document "Planning Center - Submission Admin - httpsqueuepoint-internalac2prodpjmcom_.pdf" and its attachments.
[4] The Leading and lagging values are estimated based on "SWT42_Model_PQ-Capability_SWT_DD_7.0_8.0MW_Ver_01.pdf".
[5] Machine base is from the PSSE model (AE1-117.raw) provided with the data package.

Collector System Equivalent (Offshore GL)	66 kV cable Rating = 177.2 MVA MVA base = 100 MVA Impedance = 0.001779 + j0.009519 pu @ MVA base Charging susceptance = 0.202247 pu @ MVA base	66 kV cable Rating = 177.2 MVA MVA base = 100 MVA Impedance = 0.001779 + j0.009519 pu @ MVA base Charging susceptance = 0.202247 pu @ MVA base
Collector System Equivalent (Offshore CL)	2X 66 kV offshore cable Rating = 88.6 MVA Length = 30 miles MVA base = 100 MVA Impedance = 0.024982 + j0.13371 pu @ MVA base Charging susceptance = 0.2775 pu @ MVA base	2X 66 kV offshore cable Rating = 88.6 MVA Length = 30 miles MVA base = 100 MVA Impedance = 0.024982 + j0.13371 pu @ MVA base Charging susceptance = 0.2775 pu @ MVA base
Collector System Equivalent (Onshore CL)	2X 66 kV onshore cable Rating = 98.3 MVA Length = 10 miles MVA base = 100 MVA Impedance = 0.008715 + j0.047067 pu @ MVA base Charging susceptance = 0.09104 pu @ MVA base	2X 66 kV onshore cable Rating = 98.3 MVA Length = 10 miles MVA base = 100 MVA Impedance = 0.008715 + j0.047067 pu @ MVA base Charging susceptance = 0.09104 pu @ MVA base
Transmission Cable	0.01 miles 138 kV transmission cable Rating = 0 MVA MVA base = 100 MVA Impedance = 0.0 + j0.0001 pu @ MVA base Charging susceptance = 0.0 pu @ MVA base	0.01 miles 138 kV transmission cable Rating = 0 MVA MVA base = 100 MVA Impedance = 0.0 + j0.0001 pu @ MVA base Charging susceptance = 0.0 pu @ MVA base

Auxiliary load[6]	Active power = 1.9 MW Reactive power = 1.425 MVAR	P = 1.90 MW Q = 1.425 MVAR Vt = 0.69 kV
Station Load	Active power = 0.0 MW Reactive power = 0.0 MVAR	Not modeled
Other	2X25 MVAR offshore fixed reactors 2X25 MVAR onshore switched reactors	2X25 MVAR fixed shunt reactors at high voltage side of GSU 2X25 MVAR switched shunt reactors at onshore 69 kV bus

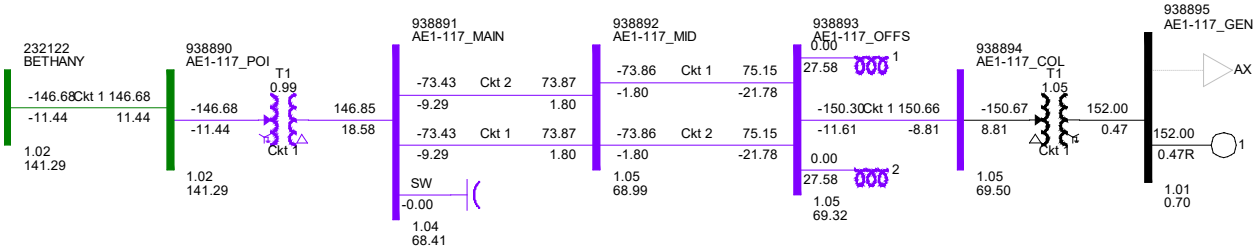


Figure 2: AE1-117 Single Line Diagram (PSS/E)

Reactive Power Assessment

AE1-117 was assessed for compliance with reactive power capability requirements using the supplied capability curves. Please note this is a new facility.

- Generation shall have the ability to maintain a power factor of at least 0.95 leading to 0.95 lagging at the high side of facility transformer or the result of the System Impact Study indicated that, for the safety and reliably of the Transmission System, no power factor requirement is required[7].[8]

Generator	MFO	Required pF Range		Maximum (Lagging)	Minimum (Leading)
		Lagging	Leading		
AE1-117	152	0.95	0.95		
Total MVAR Required				49.96	-49.96
MVAR from Generators				Qmax	Qmin
				76.0	-76.0
Customer Planned Compensation				0	-50.0
Qloss				7.91	7.91
Total Available MVAR at High Side of Facility Transformer				83.9	-118.1

[6] According to the document "Planning Center - Submission Admin - httpsqueuepoint-internalac2prodpjmcom.pdf" and its attachments", the auxiliary load and station load are connected at low voltage side of GSU

[7] As specified in the document "Reactive Power Requirements.doc", Date: 6/15/2018.

[8] As specified in Attachment O of the document "PJM Open Access Transmission Tariff" Effective Date: 4/23/2018.

Deficiency in MVAR	Meet	Meet

The offshore wind generating facility AE1-117 **meets** the reactive power requirement at the high side of facility transformer.

MFO Assessment

The MFO of AE1-117 was also assessed and found that the MFO at POI is **lower** than the requested MFO.

	Active Power (MW)
Requested Gross MW	152
Requested MFO	152
Aux+SS	1.9
Losses	5.31
MFO at the POI	144.79
Available MFO <= Requested MFO	**Yes**

The auxiliary load and station service load were switched off when performing the dynamic analysis to ensure the MFO at the POI is close enough to the requested MFO. After the station service load and the auxiliary load were switched off, the MFO at the POI increased from 144.79 MW to 146.69 MW which was close enough to meet MFO requirement.

Loadflow and Dynamics Case Setup

The dynamics simulation analysis was carried out using PSS/E Version 33.
The load flow scenario and fault cases for this study are based on DPL planning criteria[9], PJM's Regional Transmission Planning Process[10] and discussions with PJM.

The selected load flow scenario is the RTEP 2022 peak load case with the following modifications:

a) Addition of all applicable queue projects prior to AE1-117.

b) Addition of AE1-117 queue project.

c) Removal of withdrawn and subsequent queue projects in the vicinity of AE1-117.

d) Dispatch of units in the PJM system in order to maintain slack generators within limits.

In the load flow the AE1-117 generator was set to maximum power output, with unity power factor and approximately 1.0 pu voltage at the generator bus.

[9] Exelon – Transmission Planning Criteria, https://www.pjm.com/-/media/planning/planning-criteria/exelon-planning-criteria.ashx?la=en.
[10] Manual 14B: PJM Region Transmission Planning Process, Rev 44, February 21, 2019, Attachment G: PJM Stability, Short Circuit, and Special RTEP Practices and Procedures.

Table 2: AE1-117 machine initial conditions

Bus	Name	Unit	PGEN (MW)	QGEN (MVar)	ETERM (pu)	POI Voltage (pu)
938895	AE1-117_GEN	1	152.00	0.47	1.01	1.02

Generation within the vicinity (within five buses) of AE1-117 has been dispatched online at maximum output (PMAX). The dispatch within the DPL area is given in Attachment 5.

Fault Cases

The project was tested for compliance with NERC, DPL, PJM, and other applicable criteria. 58 contingencies were studied, each with a 20 second simulation time period (with 1.0 second initial run prior to any events). Contingencies to be studied include:

a) Steady state operation (Category P0);

b) Three phase faults with normal clearing time on the intact network (Category P1);

c) Single phase to ground faults with delayed clearing due to a stuck breaker (Category P4);

d) Single phase faults placed at 80% of the line with delayed (Zone 2) clearing at line end remote from the fault due to primary communications/relay failure (Category P5).

No High Speed Reclosing (HSR) contingencies were found in the vicinity of AE1-117[11]. No common tower events (Category P7) in the vicinity of AE1-117 were found to be studied.

Buses at which the faults listed above were applied are:

- AE1-117 POI 138 kV
- Bethany 138/69 kV
- Roxana 138 kV
- 138th Street 138 kV

Table 3 gives the details of typical fault clearing time[12] for 138 kV and 69 kV breakers at DPL.

Table 3: AE1-117 breaker details

TO	Circuit Breaker	Three Phase Fault Normal Clearing Time (cycles)	SLG Delayed Clearing Time due to Stuck Breaker (cycles)	SLG Delayed Clearing Time due to Primary Relay Failure (cycles)
DPL	138 kV	9	21	37
DPL	69 kV	9	22	42

[11] PJM_HighSpeedReclosing_List.xlsx
[12] Rev. 20 of "2017 Revised Clearing time for each PJM company_Rev20.xls"

A complete list of the contingencies that were studied is given in Table 6 to Table 9.

Evaluation Criteria

This study is focused on AE1-117, along with the rest of the PJM system, maintaining synchronism and having all states return to an acceptable new condition following the disturbance. The recovery criteria applicable to this study are as per PJM's Regional Transmission Planning Process and Transmission Owner criteria:

a) AE1-117 is able to ride through the faults (except for faults where protective action trips the generator(s)),

b) The system with AE1-117 included is transiently stable and post-contingency oscillations should be positively damped with a damping margin of at least 3%.

c) Following fault clearing, all bus voltages recover to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).

d) No transmission element trips, other than those either directly connected or designed to trip as a consequence of that fault.

Summary of Results

Plots from the dynamic simulations are provided in Attachment 6, with results summarized in Table 6 through Table 9.

For all 58 fault contingencies tested on the 2022 peak load case:

a) AE1-117 was able to ride through the faults (except for faults where protective action trips a generator(s)).

b) Post-contingency oscillations were positively damped with a damping margin of at least 3%.

c) Following fault clearing, all bus voltages recover to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).

d) No transmission element trips, other than those either directly connected or designed to trip as a consequence of that fault.

No mitigation was found to be required.

Table 4: Summary of Machine Tripped by Protective Action

Contingency	Time [s]	Unit	Bus	Protective Action
None	-	-	-	-

Network non-convergence was also observed as summarized in Table 5.

Table 5: Summary of Network Non-Convergence

Contingency	Time [s]	Unit	Bus
P1.01*~P1.05*	1.0~1.1542	AE1-117 GEN	938895
P1.07*~P1.09*	1.1583	AE1-117 GEN	938895
P1.10*	1.0~1.2542	AE1-117 GEN	938895

Contingency	Time [s]	Unit	Bus
P1.11*	1.0~1.9209	AE1-117 GEN	938895
P1.12*	1.0~1.1750	AE1-117 GEN	938895
P1.13*	1.0, 1.1542~1.1958	AE1-117 GEN	938895
P1.14*	1.0, 1.1542~1.2667	AE1-117 GEN	938895
P1.15*	1.0, 1.1542~1.2042	AE1-117 GEN	938895
P1.16*	1.0, 1.1542~1.1833	AE1-117 GEN	938895
P1.17*	1.0, 1.1542~1.1917	AE1-117 GEN	938895
P4_1B1.01*	1.1542~1.3583	AE1-117 GEN	938895
P4_1B1.24*	1.3583~1.3708	AE1-117 GEN	938895
P4_1B1.25*	1.3583, 1.3625	AE1-117 GEN	938895
P5.01*	1.1542~1.3958	AE1-117 GEN	938895

* Non-convergence during fault that should not be a problem if it recovers back after the fault is removed.

Table 6: Steady State Operation – Category P0

Fault ID	Duration	AE1-117 No Mitigation
P0_01	Steady state 20 sec	Stable

Table 7: Three-phase Faults with Normal Clearing – Category P1

Fault ID	Fault description	Clearing Time & Reclose (Cycles)	AE1-117 No Mitigation
P1.01	3ph fault @ AE1-117 138 kV POI on AE1-117 circuit. Trips AE1-117	9	Stable
P1.02	3ph fault @ Bethany 138 kV on AE1-117 circuit, trips AE1-117	9	Stable
P1.03	3ph fault @ Bethany 138 kV on Roxana circuit 13739	9	Stable
P1.04	3ph fault @ Bethany 138 kV on 138th Street circuit 13732	9	Stable
P1.05	3ph fault @ Bethany 138 kV on 138/69 kV transformer AT1	9	Stable
P1.06	3ph fault @ Bethany 69kV on 138/69 kV transformer AT1	9	Stable
P1.07	3ph fault @ Bethany 69kV on Cedar Neck circuit 6740	9	Stable
P1.08	3ph fault @ Bethany 69kV on Dirickson	9	Stable
P1.09	3ph fault @ Bethany 69kV on 69/12 kV transformer T2	9	Stable
P1.10	3ph fault @ Roxana 138 kV on Bethany circuit 13739	9	Stable
P1.11	3ph fault @ Roxana 138 kV on Omar - Indian River circuit 13745	9	Stable
P1.12	3ph fault @ Roxana 138 kV on Bayard	9	Stable
P1.13	3ph fault @ 138th Street 138 kV on Bethany circuit 13732	9	Stable
P1.14	3ph fault @ 138th Street 138 kV on Ocean Bay circuit 13731	9	Stable
P1.15	3ph fault @ 138th Street 138 kV on 138/12 kV T1	9	Stable
P1.16	3ph fault @ 138th Street 138 kV on 138/12 kV T2	9	Stable
P1.17	3ph fault @ 138th Street 138 kV on 138/16 kV T3	9	Stable

Table 8: Single-phase Faults with Stuck Breaker – Category P4

Fault ID	Fault description	Clearing Time Normal and Delayed (Cycles)	AE1-117 No Mitigation
P4_1B1.01	SLG @ AE1-117 138 kV on Bethany circuit. Breaker stuck at AE1-117 POI. SLG @ AE1-117 138 kV due to breaker failure, fault cleared with loss of AE1-117	9/21	Stable
P4_1B1.02	SLG @ Bethany 138 kV on AE1-117 circuit. Breaker NEW stuck at Bethany. SLG @ Bethany 138 kV due to breaker failure, fault cleared with loss of AE1-117 and Roxana circuit 13739	9/21	Stable
P4_1B1.03	SLG @ Bethany 138 kV on AE1-117 circuit. Breaker 130 stuck at Bethany. SLG @ Bethany 138 kV due to breaker failure, fault cleared with loss of AE1-117 and Bethany 138/69 kV AT1	9/21	Stable
P4_1B1.04	SLG @ Bethany 138 kV on Roxana circuit 13739. Breaker NEW stuck at Bethany. SLG @ Bethany 138 kV due to breaker failure, fault cleared with loss of AE1-117	9/21	Stable
P4_1B1.05	SLG @ Bethany 138 kV on Roxana circuit 13739. Breaker 130 stuck at Bethany. SLG @ Bethany 138 kV due to breaker failure, fault cleared with loss of Bethany 138 kV capacitor banks	9/21	Stable
P4_1B1.06	SLG @ Bethany 138 kV on 138/12 kV TR#1. Breaker 133 stuck at Bethany. SLG @ Bethany 138 kV due to breaker failure, fault cleared with loss of Bethany 138 kV capacitor banks	9/21	Stable
P4_1B1.07	SLG @ Bethany 138 kV on 138/12 kV TR#1. Breaker 132 stuck at Bethany. SLG @ Bethany 138 kV due to breaker failure, fault cleared with loss of 138th Street circuit 13732	9/21	Stable
P4_1B1.08	SLG @ Bethany 138 kV on 138th Street circuit 13732. Breaker 132 stuck at Bethany. SLG @ Bethany 138 kV due to breaker failure, fault cleared with loss of Bethany 138/12 kV TR#1	9/21	Stable

Fault ID	Fault description	Clearing Time Normal and Delayed (Cycles)	AE1-117 No Mitigation
P4_1B1.09	SLG @ Bethany 138 kV on 138th Street circuit 13732. Breaker 134 stuck at Bethany. SLG @ Bethany 138 kV due to breaker failure, fault cleared with loss of Bethany 138/69 kV AT1	9/21	Stable
P4_1B1.10	SLG @ Bethany 138 kV on 138/69 kV AT1. Breaker 134 stuck at Bethany. SLG @ Bethany 138 kV due to breaker failure, fault cleared with loss of 138th Street circuit 13732	9/21	Stable
P4_1B1.11	SLG @ Bethany 138 kV on 138/69 kV AT1. Breaker 130 stuck at Bethany. SLG @ Bethany 138 kV due to breaker failure, fault cleared with loss of AE1-117 circuit	9/21	Stable
P4_1B1.12	SLG @ Bethany 69 kV on 138/69 kV AT1, Breaker 7560 stuck at Bethany. SLG @ Bethany 69 kV due to breaker failure, fault cleared with loss Dirickson circuit	9/22	Stable
P4_1B1.13	SLG @ Bethany 69 kV on 138/69 kV AT1, Breaker 7510 stuck at Bethany. SLG @ Bethany 69 kV due to breaker failure, fault cleared with loss Bethany 69/12 kV TR#2	9/22	Stable
P4_1B1.14	SLG @ Bethany 69 kV on Dirickson circuit, Breaker 7560 stuck at Bethany. SLG @ Bethany 69 kV due to breaker failure, fault cleared with loss Bethany 138/69 kV AT1	9/22	Stable
P4_1B1.15	SLG @ Bethany 69 kV on Dirickson circuit, Breaker 7530 stuck at Bethany. SLG @ Bethany 69 kV due to breaker failure, fault cleared with loss Cedar Neck circuit 6740	9/22	Stable
P4_1B1.16	SLG @ Bethany 69 kV on Cedar Neck circuit 6740, Breaker 7530 stuck at Bethany. SLG @ Bethany 69 kV due to breaker failure, fault cleared with loss Dirickson circuit	9/22	Stable
P4_1B1.17	SLG @ Bethany 69 kV on Cedar Neck circuit 6740, Breaker 7540 stuck at Bethany. SLG @ Bethany 69 kV due to breaker failure, fault cleared with no additional element loss	9/22	Stable

Fault ID	Fault description	Clearing Time Normal and Delayed (Cycles)	AE1-117 No Mitigation
P4_1B1.18	SLG @ Bethany 69 kV on 69/12 kV TR#2, Breaker 7510 stuck at Bethany. SLG @ Bethany 69 kV due to breaker failure, fault cleared with Bethany 138/69 kV AT1	9/22	Stable
P4_1B1.19	SLG @ Bethany 69 kV on 69/12 kV TR#2, Breaker 7550 stuck at Bethany. SLG @ Bethany 69 kV due to breaker failure, fault cleared with Bethany 69 kV capacitor banks	9/22	Stable
P4_1B1.20	SLG @ Roxana 138 kV on Bethany circuit 13739, Breaker 131 stuck at Roxana. SLG @ Roxana 138 kV due to breaker failure, fault cleared with loss Omar-Indian River circuit 13745	9/21	Stable
P4_1B1.21	SLG @ Roxana 138 kV on Bethany circuit 13739, Breaker 132 stuck at Roxana. SLG @ Roxana 138 kV due to breaker failure, fault cleared with loss Bayard circuit	9/21	Stable
P4_1B1.22	SLG @ Roxana 138 kV on Omar - Indian River circuit 13745, Breaker 131 stuck at Roxana. SLG @ Roxana 138 kV due to breaker failure, fault cleared with loss Bethany circuit 13739	9/21	Stable
P4_1B1.23	SLG @ Roxana 138 kV on Omar - Indian River circuit 13745, Breaker 130 stuck at Roxana. SLG @ Roxana 138 kV due to breaker failure, fault cleared with loss Bayard circuit	9/21	Stable
P4_1B1.24	SLG @ Roxana 138 kV on Bayard circuit, Breaker 130 stuck at Roxana. SLG @ Roxana 138 kV due to breaker failure, fault cleared with loss Omar - Indian River circuit 13745	9/21	Stable
P4_1B1.25	SLG @ Roxana 138 kV on Bayard circuit, Breaker 132 stuck at Roxana. SLG @ Roxana 138 kV due to breaker failure, fault cleared with loss Bethany circuit 13739	9/21	Stable
P4_1B1.26	SLG @ 138th Street 138 kV on Bethany circuit 13732, Breaker 130 stuck at 138th Street. SLG @ 138th Street 138 kV due to breaker failure, fault cleared with loss 138th Street 138/12 kV TR#1	9/21	Stable

Fault ID	Fault description	Clearing Time Normal and Delayed (Cycles)	AE1-117 No Mitigation
P4_1B1.27	SLG @ 138th Street 138 kV on 138th Street 138/12 kV TR#1, Breaker 130 stuck at 138th Street. SLG @ 138th Street 138 kV due to breaker failure, fault cleared with loss Bethany circuit 13732	9/21	Stable
P4_1B1.28	SLG @ 138th Street 138 kV on 138th Street 138/12 kV TR#1, Breaker 131 stuck at 138th Street. SLG @ 138th Street 138 kV due to breaker failure, fault cleared with loss Bethany circuit 13732, T3, T2, and Ocean Bay circuit 13731	9/21	Stable
P4_1B1.29	SLG @ 138th Street 138 kV on Ocean Bay circuit 13731, Breaker 132 stuck at 138th Street. SLG @ 138th Street 138 kV due to breaker failure, fault cleared with loss T3, T2	9/21	Stable

Table 9: Single-phase Faults with Delayed (Zone 2) Clearing due to Primary Communication/Relay Failure – Category P5

Fault ID	Fault description	Clearing Time (Cycles)	AE1-117 No Mitigation
P5.01	SLG @ 80% of 138 kV circuit from AE1-117 POI to Bethany	9/37	Stable
P5.02	SLG @ 80% of 138 kV circuit from Bethany to AE1-117	9/37	Stable
P5.03	SLG @ 80% of 138 kV circuit 13732 from Bethany to 138th Street	9/37	Stable
P5.04	SLG @ 80% of 138 kV circuit 13739 from Bethany to Roxana	9/37	Stable
P5.05	SLG @ 80% of 69 kV circuit 6740 from Bethany to Cedar Neck	9/42	Stable
P5.06	SLG @ 80% of 69 kV circuit 6735 from Bethany to Dirickson	9/42	Stable
P5.07	SLG @ 80% of 138 kV circuit 13739 from Roxana to Bethany	9/37	Stable
P5.08	SLG @ 80% of 138 kV circuit 13745 from Roxana to Omar - Indian River	9/37	Stable
P5.09	SLG @ 80% of 138 kV circuit from Roxana to Bayard	9/37	Stable
P5.10	SLG @ 80% of 138 kV circuit 13732 from 138th Street to Bethany	9/37	Stable
P5.11	SLG @ 80% of 138 kV circuit 13731 from 138th Street to Ocean Bay	9/37	Stable

Flow Gate Details

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.

Index 1

DP&L - DP&L) The TODD-PRESTON 69 kV line (from bus 232234 to bus 232233 ckt 1) loads from 100.0% to 110.88% (AC power flow) of its emergency rating (93 MVA) for the line fault with failed breaker contingency outage of 'DPL_P4-2_DP11'. This project contributes approximately 12.08 MW to the thermal violation.

```
CONTINGENCY 'DPL_P4-2_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*
932161	*AC2-023 C*	*4.39*
932162	*AC2-023 E*	*3.2*
938651	*AE1-087 C*	*6.12*
938652	*AE1-087 E*	*1.53*
938891	*AE1-117 C O1*	*3.3*
938892	*AE1-117 E O1*	*8.78*
939151	*AE1-145 C1*	*2.21*
232905	*BAYVIEW1*	*0.2*
LTF	*BLUEG*	*0.38*
LTF	*CALDERWOOD*	*0.04*
LTF	*CANNELTON*	*0.02*
LTF	*CARR*	*0.02*
LTF	*CATAWBA*	*0.03*
LTF	*CHEOAH*	*0.04*
LTF	*CHILHOWEE*	*0.01*
LTF	*COFFEEN*	*0.04*
LTF	*COTTONWOOD*	*0.16*
232926	*CRISFLD1*	*0.17*
LTF	*DUCKCREEK*	*0.09*
LTF	*EDWARDS*	*0.04*
LTF	*FARMERCITY*	*0.03*
LTF	*G-007*	*0.05*
LTF	*GIBSON*	*0.02*
LTF	*HAMLET*	*0.04*
LTF	*NEWTON*	*0.11*
293670	*O-025 C*	*0.11*
LTF	*O-066*	*0.34*
232912	*OH NUG1*	*0.5*
232914	*OH NUG3*	*0.5*

232915	*OH NUG4*	*0.5*
232916	*OH NUG5*	*0.5*
LTF	*PRAIRIE*	*0.2*
LTF	*RENSSELAER*	*0.02*
LTF	*SANTEETLA*	*0.01*
LTF	*SMITHLAND*	*0.02*
232921	*TASLEY2G*	*0.34*
LTF	*TATANKA*	*0.05*
LTF	*TILTON*	*0.05*
LTF	*TRIMBLE*	*0.04*
LTF	*TVA*	*0.13*
LTF	*UNIONPOWER*	*0.06*
232919	*VN10*	*0.31*
232907	*VN8*	*3.26*
901003	*W1-003 C*	*0.25*
901004	*W1-003 E*	*0.5*
901013	*W1-004 C*	*0.25*
901014	*W1-004 E*	*0.5*
901023	*W1-005 C*	*0.25*
901024	*W1-005 E*	*0.5*
901033	*W1-006 C*	*0.25*
901034	*W1-006 E*	*0.5*
907052	*X1-032 E*	*0.46*
910571	*X3-008 C*	*0.42*
910572	*X3-008 E*	*4.75*
913411	*Y1-080 C*	*0.05*
913412	*Y1-080 E*	*0.57*
915541	*Y3-058 C*	*0.13*
915542	*Y3-058 E*	*1.41*
917081	*Z2-012 C*	*0.12*
917082	*Z2-012 E*	*1.37*
917432	*Z2-076 E*	*0.18*
917442	*Z2-077 E*	*0.18*
918831	*AA1-102 C*	*0.99*
918832	*AA1-102 E*	*10.93*
930202	*AB1-056 E O1*	*13.54*
924831	*AB2-136 C*	*7.74*
924832	*AB2-136 E*	*8.21*
925151	*AB2-172 C*	*7.27*
925152	*AB2-172 E*	*11.86*
925261	*AB2-180 C*	*2.12*
925262	*AB2-180 E*	*0.91*
927031	*AC1-190 C*	*12.81*
927032	*AC1-190 E*	*5.49*

Index 2

(DP&L - PECO) The CLAY_230-LINWOOD 230 kV line (from bus 231000 to bus 213750 ckt 1) loads from 126.19% to 128.33% (AC power flow) of its emergency rating (804 MVA) for the line fault with failed breaker contingency outage of 'PECO_P4_LINWO225/* $ DELCO $ PECO_P4_LINWO225 $ STBK'. This project contributes approximately 22.42 MW to the thermal violation.

```
CONTINGENCY 'PECO_P4_LINWO225/* $ DELCO $ PECO_P4_LINWO225 $ STBK'
  TRIP BRANCH FROM BUS 213750 TO BUS 231001 CKT 1              /* LINWOOD 230.00
EDGEMR5 230.00 $ DELCO $ PECO_P4_LINWO225 $ STBK
  DISCONNECT BUS 213892                                       /* PHLISL87 230.00 $ DELCO $
PECO_P4_LINWO225 $ STBK
  DISCONNECT BUS 213888                                       /* PHLISCT1 18.00 $ DELCO $
PECO_P4_LINWO225 $ STBK
  DISCONNECT BUS 213889                                       /* PHLISCT2 18.00 $ DELCO $
PECO_P4_LINWO225 $ STBK
  END/*         $ DELCO $ PECO_P4_LINWO225 $ STBK
```

Bus Number	*Bus Name*	*Full Contribution*
932161	*AC2-023 C*	*4.03*
932162	*AC2-023 E*	*2.94*
933631	*AC2-185 C*	*2.01*
933632	*AC2-185 E*	*3.27*
933641	*AC2-186 C*	*2.77*
933642	*AC2-186 E*	*4.51*
934681	*AD1-097 3*	*-2.73*
934691	*AD1-097 4*	*-1.62*
936452	*AD2-059 E*	*0.18*
936611	*AD2-076 C O1*	*3.1*
936612	*AD2-076 E O1*	*5.06*
938651	*AE1-087 C*	*2.5*
938652	*AE1-087 E*	*0.63*
938811	*AE1-107 C*	*5.64*
938812	*AE1-107 E*	*4.02*
938891	*AE1-117 C O1*	*6.12*
938892	*AE1-117 E O1*	*16.3*
939151	*AE1-145 C1*	*3.01*
LTF	*BLUEG*	*0.38*
LTF	*CALDERWOOD*	*0.02*
LTF	*CANNELTON*	*0.02*
LTF	*CARR*	*0.61*
LTF	*CATAWBA*	*< 0.01*
LTF	*CHEOAH*	*0.02*

LTF	*CHILHOWEE*	*< 0.01*
231708	*CHRIST3*	*3.57*
LTF	*COFFEEN*	*0.04*
LTF	*COTTONWOOD*	*0.11*
LTF	*CPLE*	*< 0.01*
LTF	*DUCKCREEK*	*0.09*
LTF	*EDWARDS*	*0.04*
231917	*EM10*	*0.76*
231916	*EM3*	*4.56*
231901	*EM4*	*9.06*
231900	*EM5*	*32.42*
LTF	*FARMERCITY*	*0.02*
LTF	*G-007*	*2.21*
LTF	*GIBSON*	*0.02*
231908	*HR1*	*6.51*
231909	*HR2*	*6.63*
231910	*HR3*	*6.51*
231505	*HR4*	*13.33*
LTF	*NEWTON*	*0.1*
LTF	*O-066*	*14.44*
LTF	*PRAIRIE*	*0.18*
LTF	*RENSSELAER*	*0.49*
LTF	*SANTEETLA*	*< 0.01*
LTF	*SMITHLAND*	*0.01*
LTF	*TATANKA*	*0.05*
LTF	*TILTON*	*0.05*
LTF	*TRIMBLE*	*0.04*
LTF	*TVA*	*0.09*
LTF	*UNIONPOWER*	*0.04*
901004	*W1-003 E*	*0.68*
901014	*W1-004 E*	*0.68*
901024	*W1-005 E*	*0.68*
901034	*W1-006 E*	*0.68*
907052	*X1-032 E*	*0.6*
910572	*X3-008 E*	*1.94*
910822	*X3-066 E*	*0.62*
913362	*Y1-079 E*	*1.02*
913412	*Y1-080 E*	*0.33*
915542	*Y3-058 E*	*1.41*
917082	*Z2-012 E*	*1.87*
917432	*Z2-076 E*	*0.3*
917442	*Z2-077 E*	*0.3*
918832	*AA1-102 E*	*14.06*
919831	*AA2-069*	*60.58*
930202	*AB1-056 E O1*	*26.98*

930921	*AB1-141 C*	*2.26*
930922	*AB1-141 E*	*1.05*
930931	*AB1-142 C*	*2.26*
930932	*AB1-142 E*	*1.05*
931262	*AB1-176 E*	*0.93*
923921	*AB2-032 C*	*2.27*
923922	*AB2-032 E*	*1.07*
923951	*AB2-036 C*	*5.75*
923952	*AB2-036 E*	*9.41*
923961	*AB2-037 C*	*12.64*
923962	*AB2-037 E*	*20.65*
924801	*AB2-133 C O1*	*4.09*
924802	*AB2-133 E O1*	*5.18*
924821	*AB2-135 C*	*4.83*
924822	*AB2-135 E*	*5.5*
924831	*AB2-136 C*	*3.85*
924832	*AB2-136 E*	*4.08*
924971	*AB2-153 C*	*1.27*
924972	*AB2-153 E*	*2.07*
925151	*AB2-172 C*	*2.97*
925152	*AB2-172 E*	*4.84*
925251	*AB2-179 C*	*6.63*
925252	*AB2-179 E*	*2.19*
925261	*AB2-180 C*	*2.12*
925262	*AB2-180 E*	*0.91*
926131	*AC1-091 C*	*0.99*
926132	*AC1-091 E*	*1.62*
926141	*AC1-092 C*	*0.99*
926142	*AC1-092 E*	*1.62*
926151	*AC1-093 C*	*0.94*
926152	*AC1-093 E*	*1.54*
926161	*AC1-094 C*	*0.79*
926162	*AC1-094 E*	*1.31*
927031	*AC1-190 C*	*5.46*
927032	*AC1-190 E*	*2.34*

Index 3

(DP&L - DP&L) The EDGEMR 5-CLAY_230 230 kV line (from bus 231001 to bus 231000 ckt 1) loads from 122.14% to 124.1% (AC power flow) of its emergency rating (804 MVA) for the line fault with failed breaker contingency outage of 'PECO_P4_LINWO225/* $ DELCO $ PECO_P4_LINWO225 $ STBK'. This project contributes approximately 19.99 MW to the thermal violation.

```
CONTINGENCY 'PECO_P4_LINWO225/* $ DELCO $ PECO_P4_LINWO225 $ STBK'
  TRIP BRANCH FROM BUS 213750 TO BUS 231001 CKT 1              /* LINWOOD 230.00
EDGEMR5 230.00 $ DELCO $ PECO_P4_LINWO225 $ STBK
  DISCONNECT BUS 213892                                       /* PHLISL87 230.00 $ DELCO $
PECO_P4_LINWO225 $ STBK
  DISCONNECT BUS 213888                                       /* PHLISCT1 18.00 $ DELCO $
PECO_P4_LINWO225 $ STBK
  DISCONNECT BUS 213889                                       /* PHLISCT2 18.00 $ DELCO $
PECO_P4_LINWO225 $ STBK
  END/*         $ DELCO $ PECO_P4_LINWO225 $ STBK
```

Bus Number	*Bus Name*	*Full Contribution*
932161	*AC2-023 C*	*3.6*
932162	*AC2-023 E*	*2.62*
933631	*AC2-185 C*	*1.78*
933632	*AC2-185 E*	*2.91*
933641	*AC2-186 C*	*2.46*
933642	*AC2-186 E*	*4.01*
934681	*AD1-097 3*	*-2.44*
934691	*AD1-097 4*	*-1.44*
936452	*AD2-059 E*	*0.15*
936611	*AD2-076 C O1*	*2.71*
936612	*AD2-076 E O1*	*4.42*
938651	*AE1-087 C*	*2.23*
938652	*AE1-087 E*	*0.56*
938811	*AE1-107 C*	*4.71*
938812	*AE1-107 E*	*3.36*
938891	*AE1-117 C O1*	*5.46*
938892	*AE1-117 E O1*	*14.53*
939151	*AE1-145 C1*	*2.68*
LTF	*BLUEG*	*0.28*
LTF	*CALDERWOOD*	*0.01*
LTF	*CANNELTON*	*0.02*
LTF	*CARR*	*0.54*
LTF	*CBM-S2*	*0.01*
LTF	*CHEOAH*	*0.01*
LTF	*CHILHOWEE*	*< 0.01*

231919	*CHRIST1*	*0.83*
231920	*CHRIST2*	*0.82*
231708	*CHRIST3*	*2.72*
LTF	*COFFEEN*	*0.03*
LTF	*COTTONWOOD*	*0.07*
LTF	*CPLE*	*0.02*
LTF	*DUCKCREEK*	*0.07*
LTF	*EDWARDS*	*0.03*
231901	*EM4*	*6.82*
231900	*EM5*	*32.36*
LTF	*FARMERCITY*	*0.02*
LTF	*G-007*	*1.96*
LTF	*GIBSON*	*0.01*
231908	*HR1*	*4.9*
231910	*HR3*	*4.9*
231505	*HR4*	*13.3*
LTF	*NEWTON*	*0.07*
LTF	*O-066*	*12.79*
LTF	*PRAIRIE*	*0.13*
LTF	*RENSSELAER*	*0.43*
LTF	*SANTEETLA*	*< 0.01*
LTF	*SMITHLAND*	*< 0.01*
LTF	*TATANKA*	*0.03*
LTF	*TILTON*	*0.04*
LTF	*TRIMBLE*	*0.03*
LTF	*TVA*	*0.06*
LTF	*UNIONPOWER*	*0.02*
901004	*W1-003 E*	*0.61*
901014	*W1-004 E*	*0.61*
901024	*W1-005 E*	*0.61*
901034	*W1-006 E*	*0.61*
907052	*X1-032 E*	*0.54*
909411	*X2-083*	*0.09*
910572	*X3-008 E*	*1.72*
910822	*X3-066 E*	*0.54*
913362	*Y1-079 E*	*0.9*
913412	*Y1-080 E*	*0.29*
915542	*Y3-058 E*	*1.26*
917082	*Z2-012 E*	*1.66*
917432	*Z2-076 E*	*0.27*
917442	*Z2-077 E*	*0.27*
918832	*AA1-102 E*	*12.54*
919831	*AA2-069*	*53.96*
930202	*AB1-056 E O1*	*24.05*
930921	*AB1-141 C*	*1.97*

930922	*AB1-141 E*	*0.92*
930931	*AB1-142 C*	*1.97*
930932	*AB1-142 E*	*0.92*
931262	*AB1-176 E*	*0.81*
923921	*AB2-032 C*	*1.98*
923922	*AB2-032 E*	*0.93*
923951	*AB2-036 C*	*5.07*
923952	*AB2-036 E*	*8.3*
923961	*AB2-037 C*	*11.32*
923962	*AB2-037 E*	*18.5*
924801	*AB2-133 C O1*	*3.55*
924802	*AB2-133 E O1*	*4.51*
924821	*AB2-135 C*	*4.21*
924822	*AB2-135 E*	*4.8*
924831	*AB2-136 C*	*3.43*
924832	*AB2-136 E*	*3.64*
924971	*AB2-153 C*	*1.11*
924972	*AB2-153 E*	*1.81*
925151	*AB2-172 C*	*2.64*
925152	*AB2-172 E*	*4.31*
925251	*AB2-179 C*	*5.62*
925252	*AB2-179 E*	*1.85*
925261	*AB2-180 C*	*1.89*
925262	*AB2-180 E*	*0.81*
926131	*AC1-091 C*	*0.88*
926132	*AC1-091 E*	*1.44*
926141	*AC1-092 C*	*0.88*
926142	*AC1-092 E*	*1.44*
926151	*AC1-093 C*	*0.83*
926152	*AC1-093 E*	*1.37*
926161	*AC1-094 C*	*0.7*
926162	*AC1-094 E*	*1.16*
927031	*AC1-190 C*	*4.86*
927032	*AC1-190 E*	*2.08*