Generation Interconnection

Impact Study Report

for

Queue Project AD2-172

“LENA 138 KV”

June 2020

Table of Contents

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1 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 project developer 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.

The Interconnection Customer seeking to interconnect a wind or solar generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per Schedule H to the Interconnection Service Agreement and Section 8 of Manual 14D.

2 General

Acciona Energy USA Global LLC, the Interconnection Customer (IC), has proposed a solar generating facility to be located in Stephenson County, Illinois. The installed facilities will have a capability of 50 MW with 21 of new request MW of this output being recognized by PJM as capacity. AD2-will share the same property and Point of Interconnection with prior queue project P46. A Light Load analysis is not required for the AD2-172 project.

Queue Number	AD2-172
Project Name	LENA 138 KV

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Queue Number	AD2-172
Interconnection Customer	Acciona Energy USA Global LLC
State	Illinois
County	Stephenson
Transmission Owner	ComEd
MFO	50
MWE	50
MWC	21
Fuel	Solar
Basecase Study Year	2021

2.1 Point of Interconnection

Queue Position AD2-172, a 50 MW solar facility, will interconnect with the ComEd transmission system by connecting to the customer-owned 138 kV EcoGrove TSS 969. AD2-172 will interconnect with the ComEd transmission system at the Lena 138 kV substation via line L11904.

2.2 Cost Summary

AD2-172 will be responsible for the following costs associated with the physical interconnection of the project:

Description	Total Cost
Attachment Facilities	$200,000
Direct Connection Network Upgrade	$0
Non Direct Connection Network Upgrades	$0
Total Costs	$200,000

In addition, the AD2-172 project may be responsible for a contribution to the following costs associated with network upgrades:

Description	Total Cost
System Upgrades: None	$0

3 Transmission Owner Scope of Work

Attachment Facilities

Review and possible upgrade of SCADA, Communication, relays and metering.

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Direct Connection Network Upgrades

None

Non-Direct Connection Network Upgrades

None

4 Attachment Facilities Cost Estimate

The total preliminary cost estimate for the Attachment work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
SCADA, communication, relays and metering	$200,000
Total Attachment Facility Costs	**$200,000**

5 Direct Connection Cost Estimate

The total preliminary cost estimate for the Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Total Direct Connection Facility Costs	**$0**

6 Non-Direct Connection Cost Estimate

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Total Non-Direct Connection Facility Costs	**$0**

7 Schedule

ComEd would take approximately 18-months to review and possibly upgrade SCADA, Communication, relays and metering after the ISA / ICSA are signed.

8 Transmission Owner Analysis

See Section 3

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9 Interconnection Customer Requirements

ComEd interconnection requirements can be found at https://www.pjm.com/planning/design-engineering/to-tech-standards/private-comed.aspx

To the extent that these Applicable Technical Requirements and Standards may conflict with the terms and conditions of the Tariff, the Tariff shall control.

ComEd distribution line drops to move customer cranes and heavy equipment is not part of PJM process. The customer should directly contact ComEd New Business Group to arrange for line drops, if needed.

10 Revenue Metering and SCADA Requirements

PJM Requirements

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Section 8 of Attachment O.

11 Network Impacts

The Queue Project AD2-172 was evaluated as a 50.0 MW (Capacity 21.0 MW) injection into the Lena 138 kV substation in the ComEd area. Project AD2-172 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD2-172 was studied with a commercial probability of 1.00. Potential network impacts were as follows:

Summer Peak Load Flow

12 Generation Deliverability

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

None

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13 Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

14 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

15 Potential Congestion due to Local Energy Deliverability

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.

Note: Only the most severely overloaded conditions are listed below. 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 shall study all overload conditions associated with the overloaded element(s) identified.

1. (CE - AEP) The WILTON ;-05DUMONT 765 kV line (from bus 270644 to bus 243206 ckt 1) loads from 99.91% to 100.18% (AC power flow) of its normal rating (3555 MVA) for non-contingency condition. This project contributes approximately 13.49 MW to the thermal violation.

16 System Reinforcements

None

Light Load Analysis

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Not required

17 Flow Gate Details

The following indices 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.

None

18 Affected Systems

18.1 LG&E

None

18.2 MISO

None

18.3 TVA

None

18.4 Duke Energy Progress

None

18.5 NYISO

None

19 Contingencies

None

20 Short Circuit

The following breakers are overdutied:

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None

21 Stability Analysis

No mitigations were found to be required due to instability. See for full report below.

Executive Summary

Generator Interconnection Request AD2-172 is for an uprate of the existing Eco Grove wind farm with an additional 50 MW[1] of solar generation. The uprate increases the Maximum Facility Output (MFO) of the combined facilities from 100.0 MW to 150.0 MW. AD2-172 consists of 19 Power Electronics HEM – FS3000MU Solar inverters. The Point of Interconnection (POI) is Eco Grove 138kV substation, in the Commonwealth Edison (ComEd) region, Stephenson County, Illinois.

This report describes a dynamic simulation analysis of AD2-172 as part of the overall system impact study.

The load flow scenario for the analysis was based on the RTEP 2021 peak load case, modified to include applicable queue projects. AD2-172 has been dispatched online at maximum power output, with 1.0 p.u. voltage at the generator terminal bus.

AD2-172 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. Steady-state condition and 57 contingencies were studied, each with a 20 second simulation time period. Studied faults included:

a) Steady state operation (20 second);

b) Three-phase faults with normal clearing time on the intact network and during a scheduled outage of a transmission or generation element;

c) Single-phase bus faults with normal clearing time;

d) Three-phase faults with three-phase delayed clearing due to a stuck breaker (all gang-operated breakers);

e) Three-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.

f) Three-phase faults on a multiple-circuit tower line with normal clearing time.

No relevant high speed reclosing contingencies were identified.

The three phase faults with normal clearing time will be performed under network intact conditions and with prior outage of:

a) Lancaster – Maryland 138 kV circuit 11902,

b) Lancaster – Wempletwon 138 kV circuit 17121,

c) Lancaster – Sabrooke 138 kV circuit 19414,

[1] Based on New Services Queue page on the PJM website.

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d) Maryland – Dixon 138 kV circuit 12411.

For all simulations, the queue project under study along with the rest of the PJM system were required to maintain synchronism and with all states returning to an acceptable new condition following the disturbance.

For all of the fault contingencies tested on the 2021 peak load case:

a) AD2-172 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% for interarea modes.

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

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

The reactive power capability of AD2-172 meets the 0.95 leading and lagging PF requirement at the high side of the main transformer.

It was observed that:

The user defined model PEGEN_HEM0102 for AD2-172 QGEN and ETERM does not properly reflect the machine output when it is tripped. When tripped or dropped the model will show non-zero values for QGEN and ETERM. In order to demonstrate that the machine has tripped and is no longer providing output to the system the GSU MVA flow has been plotted for AD2-172.

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1. Introduction

Generator Interconnection Request AD2-172 is for an uprate of the existing Eco Grove wind farm with an additional 50 MW[2] solar generation. The uprate increases the Maximum Facility Output (MFO) of the combined facilities from 100.0 MW to 150.0 MW. AD2-172 consists of 19 Power Electronics HEM – FS3000MU Solar inverters. The Point of Interconnection (POI) is Eco Grove 138kV substation, in the Commonwealth Edison (ComEd) region, Stephenson County, Illinois.

This analysis is effectively a screening study to determine whether the addition of AD2-172 will meet the dynamics requirements of the NERC, ComEd, PJM and Transmission Owner reliability standards.

In this report, the AD2-172 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.

[2] Based on New Services Queue page on the PJM website.

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2. Description of Project

Generator Interconnection Request AD2-172 is for an uprate of the existing Eco Grove wind farm with an additional 50 MW solar generation. The uprate increases the Maximum Facility Output (MFO) of the combined facilities from 100.0 MW to 150.0 MW. AD2-172 consists of 19 Power Electronics HEM – FS3000MU Solar inverters. AD2-172 will be connected to the POI via a single 138/34.5/12 kV main transformer with a rating of 42/56/70 MVA. The Point of Interconnection (POI) is Eco Grove 138kV substation, in the Commonwealth Edison (ComEd) region, Stephenson County, Illinois.

Figure 1 shows the simplified one-line diagram of the AD2-172 loadflow model. Table 1 lists the parameters given in the impact study data and the corresponding parameters of the AD2-172 loadflow model.

Additional project details are provided in Appendix 1 through 3 and Attachments 1 through 3:

- Appendix 1 shows a diagram of the PSS/E model in the vicinity of AD2-172;
- Appendix 2 provides the PSS/E loadflow and dynamic models of AD2-172;
- Appendix 3 provides a list of generation dispatch in the vicinity of AD2-172;
- Attachment 1 contains the Impact Study Data which details the proposed AD2-172 project;
- Attachment 2 shows the one line diagram of the ComEd network in the vicinity of AD2-172;
- Attachment 3 presents associated plots for all studied contingencies with the legend.

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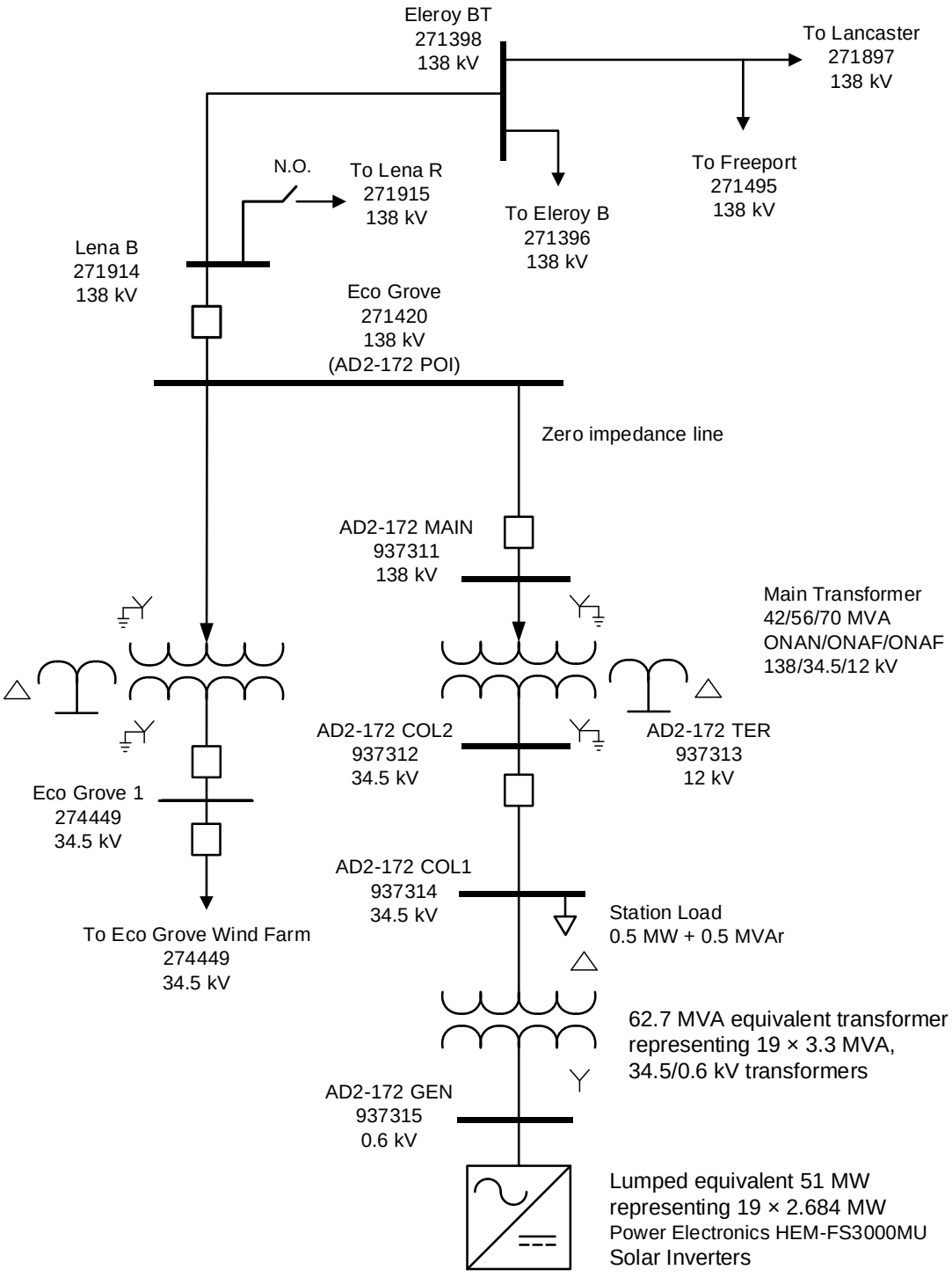

Figure 1: AD2-172 Plant Model

Table 1: AD2-172 Plant Model

	Impact Study Data	Model
Inverters	19 x 3.184 MW Power Electronics HEM – FS3000MU solar inverters MVA base = 3.3 MVA Vt = 0.600 kV Unsaturated sub-transient reactance = N/A	Lumped Equivalent representing 51[3] x 3.184 MW Power Electronics HEM – FS3000MU solar inverters Pgen = 51 MW Pmax = 51 MW Pmin = 0 MW Qmax = 36.37 MVAr Qmin = −36.37 MVAr Mbase = 62.7 MVA Zsource = 99999 + j99999 pu @ Mbase[4]
GSU Transformer	19 x 34.5/0.600 kV two winding transformer Rating = 3.3 MVA (ONAN) Transformer base = 3.3 MVA Impedance high to low = 0.0133 + j0.133 pu @ MVA base Number of taps = NA Tap step size = NA	1 x 34.5/0.600 kV two winding transformer Rating = 62.7 MVA (ONAN) Transformer base = 62.7 MVA Impedance high to low = 0.0133 + j0.133 pu @ MVA base Number of taps = 5 Tap step size = 2.5%

[3] The inverters are capable of producing 60.496 MW; however, their output is limited to meet the MFO. Each inverter real power is limited to 2.684 MW producing 51 MW total. For this real power, the plant is capable of producing 36.37 MVAr based on "HP inverter D curve.pdf".

[4] Source impedance values are set as recommended by "PSS/E Dynamic Models for HEM PV Inverter and Power Plant Controller V1.02", Power Electronics, May 2018.

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Main Transformer	1 x 138/34.5/12 kV three winding transformer Rating = 42/56/70 MVA (ONAN/ONAF/ONAF) Transformer base = 42 MVA Impedance high to low = 0.002830 + j0.0850 pu @ MVA base Impedance high to tertiary = 0.00297 + j0.08925 pu @ MVA base Impedance low to tertiary = 0.004528 + j0.136 pu @ MVA base Number of taps = N/A Tap step size = N/A	1 x 138/34.5/12 kV three winding transformer Rating = 42/56/70 MVA (ONAN/ONAF/ONAF) Transformer base = 42 MVA Impedance high to low = 0.002830 + j0.0850 pu @ MVA base Impedance high to tertiary = 0.00297 + j0.08925 pu @ MVA base Impedance low to tertiary = 0.004528 + j0.136 pu @ MVA base Number of taps = 5 Tap step size = 2.5%
Auxiliary Load	0.004 MW + 0.0045 MVAr at low voltage side of GSU	Not modelled
Station Load	0.5 MW + 0.5 MVAr at high voltage side of GSU	0.5 MW + 0.5 MVAr at high voltage side of GSU

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Transmission Line	Length = 8.17 miles 0.00599 + j 0.0367 Susceptance: j0.001165 @ 100 MVA base	Zero impedance line[5]
Collector System Equivalent	Not provided	Modelled as zero-impedance line

[5] AD2-172 will be interconnected at the existing EcoGrove Wind substation through a new main power transformer. Since 8.1 miles attachment line is existing line from EcoGrove Wind substation to Lena station, zero impedance line was modeled from AD2-172 main transformer to EcoGrove Wind substation.

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3. Reactive Power Capability Assessment

The reactive power capability of AD2-172 meets the 0.95 leading and lagging PF requirement at the high side of the main transformer.

Table 2: AD2-172 Reactive Power Capability Assessment

Generator	MFO (MW)	Required Power Factor Range		Maximum Lagging (MVAr)	Minimum Leading (MVAr)
		Lagging	Leading		
AD2-172	50	0.95	0.95		
Total Reactive Power Required				16.4	−16.4
Reactive Power From Generator				**Qmax**	**Qmin**
				36.5	−36.5
Customer Planned Compensation				0	0
Reactive Power Losses				−11.1	−11.1
Total Available Reactive Power at High Side of Main Transformer				25.4	−47.6
Deficiency in Reactive Power				Meet	Meet

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4. Loadflow and Dynamics Case Setup

The dynamics simulation analysis was carried out using PSS/E Version 33.7.0.

The load flow scenario and fault cases for this study are based on PJM's Regional Transmission Planning Process[6].

The selected load flow scenario is the RTEP 2021 peak load case with the following modifications:

a) Addition of all applicable queue projects prior to AD2-172;

b) Addition of AD2-172 queue project;

c) Removal of withdrawn and subsequent queue projects in the vicinity of AD2-172;

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

The AD2-172 initial conditions are listed in Table 3, indicating maximum power output, with the AD2-172 set to regulate the voltage at its terminals to 1.0 pu.

Table 3: AD2-172 Initial Conditions

Bus	Name	Unit	PGEN (MW)	QGEN (MVar)	ETERM (pu)	POI Voltage (pu)
937315	AD2-172 G1	1	51.00	-1.31	1.0	1.015

Generation within the ComEd system (area 222 in the PSS/E case) and within the vicinity of AD2-172 has been dispatched online at maximum output (PMAX). The dispatch of generation in the vicinity of AD2-172 is given in Appendix 3.

[6] Manual 14B: PJM Region Transmission Planning Process, Rev 44, February 21 21, 2019, Attachment G : PJM Stability, Short Circuit and Special RTEP Practices and Procedures.

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5. Fault Cases

Tables 4 to 13 list the contingencies that were studied, with representative worst case total clearing times provided by PJM. Each contingency was studied over a 20 second simulation time interval.

The studied contingencies include:

a) Steady state operation (20 second);

b) Three-phase faults with normal clearing time on the intact network and during a scheduled outage of a transmission or generation element;

c) Single-phase bus faults with normal clearing time;

d) Three-phase faults with three-phase delayed clearing due to a stuck breaker (all gang-operated breakers);

e) Three-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.

f) Three-phase faults on a multiple-circuit tower line with normal clearing time.

No relevant bus or high speed reclosing contingencies were identified.

The three phase faults with normal clearing time will be performed under network intact conditions and with prior outage of:

a) Lancaster – Maryland 138 kV circuit 11902

b) Lancaster - Wempletown 138 kV circuit 17121

c) Lancaster - Sabrooke 138 kV circuit 19414

d) Maryland - Dixon 138 kV circuit 12411

The contingencies listed above were applied to:

- AD2-172 & Ecogrove POI 138 kV
- Lancaster 138 kV
- Maryland 138 kV

Clearing times listed in Tables 4 to 13 are as per advice from ComEd, where information was not available clearing times are as per Revision 20 of "*2017 Revised Clearing times for each PJM company"* spreadsheet.

Attachment 2 contains the one-line diagrams of the ComEd networks in the vicinity of AD2-172, showing where faults were applied.

The equivalent positive sequence fault impedances for single line to ground faults were derived from the stability case directly by using the ASCC fault calculation method and zero/positive sequence impedance ratio provided by PJM.

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Queue project generators in the vicinity of AD2-172 that have been withdrawn or have a greater queue position than the project under study, were switched off in the RTEP 2021 peak load case prior to calculating the equivalent positive sequence fault impedances.

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6. Evaluation Criteria

This study is focused on AD2-172, 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) AD2-172 is able to ride through the faults (except for faults where protective action trips a generator(s)).

b) The system with AD2-172 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.

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7. Summary of Results

Plots from the dynamic simulations are provided in Attachment 3, with results summarized in Table 4 through Table 13.

All criteria have been met for the contingencies tested.

It was found that:

- AD2-172 satisfies PJM leading and lagging power factor requirements.
- The user defined model PEGEN_HEM0102 for AD2-172 QGEN and ETERM does not properly reflect the machine output when it is tripped. When tripped or dropped the model will show non-zero values for QGEN and ETERM. In order to demonstrate that the machine has tripped and is no longer providing output to the system the GSU MVA flow has been plotted for AD2-172.

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8. Recommendations and Mitigations

No mitigations were found to be required due to instability. The PEGEN_HEM0102 model should be corrected to show proper output values when off-line.

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Table 4: Steady State Operation

Fault ID	Duration	Page No. Attachment #3
P0.01	Steady state 20 sec	2

Table 5: Three-phase Faults With Normal Clearing

Fault ID	Fault Description	Clearing Time (Cycles)	Result No Mitigation	Page No. Attachment #3
P1.01	Fault at EcoGrove 138kV (AD2-172 POI) Blue Bus on Eleroy – Lancaster - Freeport circuit 11904 resulting in loss of: • AD2-172 and Eco Grove Wind Farm • Eleroy 138/12.5kV Transformer 71. • Freeport Red Bus 138/12.5kV Transformers 72 • Freeport Red Bus 138/34kV Transformers 77.	6	Stable[7]	3
P1.02	Fault at Eleroy 138kV Blue Bus on 138/12.5kV Transformer 71 resulting in the additional loss of: • Eleroy – Freeport – Lancaster – Lena ; B – Eco Grove circuit 11904. • AD2-172 and Eco Grove Wind Farm. • Freeport Red Bus 138/12.5 kV Transformers 72. • Freeport Red Bus 138/12.5 kV Transformers 77.	6	Stable	4
P1.03	Fault at Lancaster 138 kV Red Bus on Lena – Eleroy - Maryland circuit 11902 resulting in loss of: • Lena 138/34 kV Transformer 78. • Eleroy 138/12.5 kV Transformer 73. • Maryland 138/34 kV Transformer 76.	6	Stable	5
P1.04	Fault at Lancaster 138 kV Red Bus on Freeport – Eleroy - EcoGrove (AD2-172 POI) circuit 11904 resulting in the additional loss of: • AD2-172 and Eco Grove Wind Farm • Freeport Red Bus 138/12.5kV Transformer 72. • Freeport Red Bus 138/34kV Transformer 77. • Eleroy Blue Bus 138/12.5kV Transformer 71.	6	Stable	6
P1.05	Fault at Lancaster 138 kV bus on Pecatonica - Wempletown circuit 17121 resulting in the additional loss of: • All equipment at Pecatonica.	6	Stable	7

[7] QGEN and ETERM values of AD2-172 are invalid after tripping. See the GSU MVA flow variable to confirm zero output from AD2-172.

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Fault ID	Fault Description	Clearing Time (Cycles)	Result No Mitigation	Page No. Attachment #3
P1.06	Fault at Lancaster 138 kV bus on Titan – Freeport – S. Pecatonica - Sabrooke – Pierpont – Fordam circuit 19414 resulting in the additional loss of: • All equipment at Titan Tire. • Freeport 138/12.5 kV Transformer 71. • Freeport 138/34 kV Transformer 76. • All equipment at S. Pecatonica. • Fordam 138/12.5 kV Transformer 71. • Pierpont 138/12.5kV Transformer 73.	6	Stable	8
P1.07	Fault at Freeport 138kV and Blue Bus on Lancaster - Eleroy – EcoGrove (AD2-172 POI) circuit 11904 resulting in loss of: • AD2-172 and Eco Grove Wind Farm • Eleroy 138/12.5kV Transformer 71. • Freeport Red Bus 138/12.5kV Transformers 72 • Freeport Red Bus 138/34kV Transformers 77.	6	Stable	9
P1.08	Fault at Maryland 138kV bus on Maryland (AC2-147 POI) - Eleroy - Lena - Lancaster circuit 11902 resulting in additional loss of: • Maryland 138/34kV Transformer 76, Eleroy 138/12.5kV Transformer 73, • 138/34kV Lena Transformer 78	6	Stable	10
P1.09	Fault at Maryland 138kV bus on Maryland (AC2-147 POI) - Dixon - Sterling circuit 12411 resulting in additional loss of: • Maryland 138/34kV Transformer 77, • Sterling 138/12.5kV Transformer 71.	6	Stable	11

21.1.1.1 Table 6: Single-phase Bus Faults With Normal Clearing

Fault ID	Fault Description	Clearing Time (Cycles)	Result No Mitigation	Page No. Attachment #3
P2.01	Fault at Lancaster 138 kV on Bus 5. Fault cleared with loss of: • Lancaster – Pecatonica 138kV circuit 17121. • Lancaster – Freeport – Eleroy – Lena ;B – EcoGrove (AD2-172 POI) circuit 11904. • Freeport 138/12.5 kV Transformer 72. • Freeport 138/34 kV Transformer 77. • Eleroy 138/12.5 kV Transformer 71. • Loss of AD2-172 and EcoGrove. CONTINGENCY 'COMED_P2-2_119_LN-138___5'	6	Stable	12

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Fault ID	Fault Description	Clearing Time (Cycles)	Result No Mitigation	Page No. Attachment #3
P2.02	Fault at Lancaster 138 kV on Bus 6. Fault cleared with loss of: • Lancaster – Titan Tire circuit 19414. • Lancaster – tap of Lena / Titan Tire circuit 11902. CONTINGENCY 'COMED_P2-2_119_LN-138___6' [8]	6	Stable	13
P2.03	Fault at Lancaster 138 kV on Bus 7. No additional loss of equipment.	6	Stable	14

[8] Contingency description has been updated based on the latest ComEd diagram.

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Table 7: Single-phase Faults With Stuck Breaker

Fault ID	Fault Description	Clearing Time Normal & Delayed (Cycles)	Result No Mitigation	Page No. Attachment #3
P4.01.3B3	Fault at EcoGrove 138 kV (AD2-172 POI) resulting in additional loss of: • AD2-172 and EcoGrove Wind Farm Breaker stuck to Lancaster circuit 11904. Fault cleared with loss of: • EcoGrove - Eleroy – Lancaster - Freeport circuit 11904 • Eleroy 138/12.5 kV Transformer 71. • Freeport 138/12.5 kV Transformer 72. • Freeport 138/34 kV Transformer 77.	6 / 20	Stable	15
P4.02.3B3	Fault at Lancaster 138 kV on Titan – Freeport – S. Pecatonica - Sabrooke – Pierpont – Fordam Circuit 19414. Breaker stuck to Lancaster 138 kV bus. Fault cleared with loss of: • Lancaster – tap of Lena / Titan Tire circuit 11902 • All equipment at Titan Tire. • Freeport 138/12.5 kV Transformers 71. • Freeport 138/34 kV Transformers 76. • All equipment at S. Pecatonica. • Pierpont 138/12.5 kV Transformer 73. • Fordam 138/12.5 kV Transformer 71.	6 / 20	Stable	16
P4.03.3B3	Fault at Lancaster 138 kV on Lena – Eleroy Maryland Circuit 11902. Breaker stuck to Lancaster 138 kV bus. Fault cleared with loss of: • Lancaster – tap of Titan Tire / Freeport circuit 19414 • Lena 138/34 kV Transformer 78. • Eleroy 138/12.5 kV Transformer 73. • Maryland 138/34 kV Transformer 76.	6 / 20	Stable	17
P4.04.3B3	Fault at Lancaster 138 kV on Pecatonica - Wempletown Circuit 17121. Breaker stuck to Lancaster 138 kV bus. Fault cleared with loss of: • Lancaster – tap of EcoGrove Freeport circuit 11904 • All equipment at Pecatonica. • AD2-172 and EcoGrove Wind Farm • Eleroy 138/12.5 kV Transformer 71. • Freeport 138/12.5 kV Transformer 72. • Freeport 138/34 kV Transformer 77.	6 / 20	Stable	18

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Fault ID	Fault Description	Clearing Time Normal & Delayed (Cycles)	Result No Mitigation	Page No. Attachment #3
P4.05.3B 3	Fault at Lancaster 138kV on Freeport – Eleroy - EcoGrove (AD2-172 POI) Circuit 11904 resulting in additional loss of: • AD2-172 and Eco Grove Wind Farm Breaker stuck to Lancaster 138 kV bus. Fault cleared with loss of: • Lancaster – Pecatonica circuit 17121 • Freeport 138/34 kV Transformer 77. • Freeport 138/12.5 kV Transformer 72. • Eleroy 138/12.5 kV Transformer 71.	6 / 20	Stable	19
P4.06.3B 3	Fault at Freeport 138kV on Lancaster - Eleroy – EcoGrove (AD2-172 POI) circuit 11904 resulting in loss of: • AD2-172 and Eco Grove Wind Farm Breaker stuck to Freeport 138 kV bus. Fault cleared with loss of • Eleroy 138/12.5kV Transformer 71. • Freeport Red Bus 138/12.5kV Transformers 72 • Freeport Red Bus 138/34kV Transformers 77.	6 / 20	Stable	20

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Table 8: Single-phase Faults Placed at 80% of the Line With Delayed (Zone 2) Clearing at Line End Remote From the Fault

Fault ID	Fault Description	Clearing Time Normal & Delayed (Cycles)	Result No Mitigation	Page No. Attachment #3
P5.01	Fault at 80% of line from Lancaster 138 kV on Titan – Freeport – S. Pecatonica - Sabrooke – Pierpont – Fordam Circuit 19414. Delayed clearing at Lancaster. Fault cleared with loss of: • All equipment at Titan Tire. • Freeport 138/12.5 kV Transformer 71. • Freeport 138/34 kV Transformer 76. • All equipment at S. Pecatonica. • Pierpont 138/12.5 kV Transformer 73. • Fordam 138/12.5 kV Transformer 71.	6 / 27	Stable	21
P5.02	Fault at 80% of line from Lancaster 138 kV on Lena – Eleroy - Maryland Circuit 11902. Delayed clearing at Lancaster. Fault cleared with loss of: • Lena 138/34 kV Transformer 78. • Eleroy 138/12.5 kV Transformer 73. • Maryland 138/34 kV Transformer 76.	6 / 27	Stable	22
P5.03	Fault at 80% of line from Lancaster 138 kV on Pecatonica - Wempletown Circuit 17121. Delayed clearing at Lancaster. Fault cleared with loss of: • All equipment at Pecatonica.	6 / 27	Stable	23
P5.04	Fault at 80% of line from Lancaster on Eleroy – Lancaster – Freeport – EcoGrove 138 kV (AD2-172 POI) circuit 11904 resulting in additional loss of: • EcoGrove and AD2-172. Delayed clearing at EcoGrove and AD2-172 POI. Fault cleared with loss of: • Freeport 138/34 kV Transformer 77. • Freeport 138/12.5 kV Transformer 76. • Eleroy 138/12.5 kV Transformer 71.	6 / 27	Stable	24

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Table 9: Three-phase Faults With Loss of Multiple-Circuit Tower Line

Fault ID	Fault Description	Clearing Time Normal and Delayed (Cycles)	Result No Mitigation	Page No. Attachment #3
P7.01	Fault at EcoGrove 138kV (AD2-172 POI) Blue Bus on Eleroy – Lancaster - Freeport circuit 11904 resulting in tower failure. Fault cleared with loss of: • Lancaster - Pecatonica - Wempletown circuit 17121 • AD2-172 and Eco Grove Wind Farm • Eleroy 138/12.5kV Transformer 71. • Freeport Red Bus 138/12.5kV Transformers 72 • Freeport Red Bus 138/34kV Transformers 77. • All equipment at Pecatonica. CONTINGENCY 'COMED_P7_138-L11902_B-R_+_138-L17121_R-R '	6	Stable	25
P7.02	Fault at Lancaster 138 kV on Lena – Eleroy - Maryland circuit 11902 resulting in tower failure. Fault cleared with loss of: • Lancaster – Titan Tire – Freeport – S. Pecatonica - Sabrooke – Pierpont – Fordam circuit 19414Lena 138/34 kV Transformer 78. • Eleroy 138/12.5 kV Transformer 73. • Maryland 138/34 kV Transformer 76. • All equipment at Titan Tire. • Freeport 138/12.5 kV Transformer 71. • Freeport 138/34 kV Transformer 76. • All equipment at S. Pecatonica. • Fordam 138/12.5 kV Transformer 71. • Pierpont 138/12.5kV Transformer 73. CONTINGENCY 'COMED_P7_138-L11902_B-R_+_138-L19414GR-R '	6	Stable	26
P7.03	Fault at EcoGrove 138kV (AD2-172 POI) Blue Bus on Eleroy – Lancaster - Freeport circuit 11904 resulting in tower failure. Fault cleared with loss of: • Lancaster - Lena – Eleroy - Maryland circuit 11902 • AD2-172 and Eco Grove Wind Farm • Eleroy 138/12.5kV Transformer 71. • Freeport Red Bus 138/12.5kV Transformers 72 • Freeport Red Bus 138/34kV Transformers 77. • Lena 138/34 kV Transformer 78. • Eleroy 138/12.5 kV Transformer 73. • Maryland 138/34 kV Transformer 76. CONTINGENCY 'COMED_P7_138-L11902_B-R_+_138-L11904_B-R '	6	Stable	27

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Table 10: Three-phase Faults With Normal Clearing – Prior Outage of Lancaster – Maryland 138 kV Circuit 11902

Fault ID	Fault Description	Clearing Time (Cycles)	Result No Mitigation	Page No. Attachment #3
P6A.01	Fault at EcoGrove 138kV (AD2-172 POI) Blue Bus on Eleroy – Lancaster - Freeport circuit 11904 resulting in loss of: • AD2-172 and Eco Grove Wind Farm • Eleroy 138/12.5kV Transformer 71. • Freeport Red Bus 138/12.5kV Transformers 72 • Freeport Red Bus 138/34kV Transformers 77.	6	Stable[9]	28
P6A.02	Fault at Eleroy 138kV Blue Bus on 138/12.5kV Transformer 71 resulting in the additional loss of: • Eleroy – Freeport – Lancaster – Lena ; B – Eco Grove circuit 11904. • AD2-172 and Eco Grove Wind Farm. • Freeport Red Bus 138/12.5 kV Transformers 72. • Freeport Red Bus 138/12.5 kV Transformers 77.	6	Stable	29
P6A.03	N/A	N/A	N/A	N/A
P6A.04	Fault at Lancaster 138 kV Red Bus on Freeport – Eleroy - EcoGrove (AD2-172 POI) circuit 11904 resulting in the additional loss of: • AD2-172 and Eco Grove Wind Farm • Freeport Red Bus 138/12.5kV Transformer 72. • Freeport Red Bus 138/34kV Transformer 77. • Eleroy Blue Bus 138/12.5kV Transformer 71.	6	Stable	30
P6A.05	Fault at Lancaster 138 kV bus on Pecatonica - Wempletown circuit 17121 resulting in the additional loss of: • All equipment at Pecatonica.	6	Stable	31
P6A.06	Fault at Lancaster 138 kV bus on Titan – Freeport – S. Pecatonica - Sabrooke – Pierpont – Fordam circuit 19414 resulting in the additional loss of: • All equipment at Titan Tire. • Freeport 138/12.5 kV Transformer 71. • Freeport 138/34 kV Transformer 76. • All equipment at S. Pecatonica. • Fordam 138/12.5 kV Transformer 71. • Pierpont 138/12.5kV Transformer 73.	6	Stable	32

[9] QGEN and ETERM values of AD2-172 are invalid after tripping. See the GSU MVA flow variable to confirm zero output from AD2-172.

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Fault ID	Fault Description	Clearing Time (Cycles)	Result No Mitigation	Page No. Attachment #3
P6A.07	Fault at Freeport 138kV and AD2-172 POI Blue Bus on Lancaster - Eleroy – EcoGrove circuit 11904 resulting in loss of: • AD2-172 and Eco Grove Wind Farm • Eleroy 138/12.5kV Transformer 71. • Freeport Red Bus 138/12.5kV Transformers 72 • Freeport Red Bus 138/34kV Transformers 77.	6	Stable	33
P6A.08	Fault at Maryland 138kV bus on Maryland (AD1-117 POI) - Eleroy - Lena - Lancaster circuit 11902 resulting in additional loss of: • Maryland 138/34kV Transformer 76, Eleroy 138/12.5kV Transformer 73, • 138/34kV Lena Transformer 78	6	Stable	34
P6A.09	Fault at Maryland 138kV bus on Maryland (AD1-117 POI) - Dixon - Sterling circuit 12411 resulting in additional loss of: • Maryland 138/34kV Transformer 77, • Sterling 138/12.5kV Transformer 71.	6	Stable	35

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Table 11: Three-phase Faults With Normal Clearing – Prior Outage of Lancaster – Wempletown 138 kV Circuit 17121

Fault ID	Fault Description	Clearing Time (Cycles)	Result No Mitigation	Page No. Attachment #3
P6B.01	Fault at EcoGrove 138kV (AD2-172 POI) Blue Bus on Eleroy – Lancaster - Freeport circuit 11904 resulting in loss of: • AD2-172 and Eco Grove Wind Farm • Eleroy 138/12.5kV Transformer 71. • Freeport Red Bus 138/12.5kV Transformers 72 • Freeport Red Bus 138/34kV Transformers 77.	6	Stable[10]	36
P6B.02	Fault at Eleroy 138kV Blue Bus on 138/12.5kV Transformer 71 resulting in the additional loss of: • Eleroy – Freeport – Lancaster – Lena ; B – Eco Grove circuit 11904. • AD2-172 and Eco Grove Wind Farm. • Freeport Red Bus 138/12.5 kV Transformers 72. • Freeport Red Bus 138/12.5 kV Transformers 77.	6	Stable	37
P6B.03	Fault at Lancaster 138 kV Red Bus on Lena – Eleroy - Maryland circuit 11902 resulting in loss of: • Lena 138/34 kV Transformer 78. • Eleroy 138/12.5 kV Transformer 73. • Maryland 138/34 kV Transformer 76.	6	Stable	38
P6B.04	Fault at Lancaster 138 kV Red Bus on Freeport – Eleroy - EcoGrove (AD2-172 POI) circuit 11904 resulting in the additional loss of: • AD2-172 and Eco Grove Wind Farm • Freeport Red Bus 138/12.5kV Transformer 72. • Freeport Red Bus 138/34kV Transformer 77. • Eleroy Blue Bus 138/12.5kV Transformer 71.	6	Stable	39
P6B.05	N/A	N/A	N/A	N/A
P6B.06	Fault at Lancaster 138 kV bus on Titan – Freeport – S. Pecatonica - Sabrooke – Pierpont – Fordam circuit 19414 resulting in the additional loss of: • All equipment at Titan Tire. • Freeport 138/12.5 kV Transformer 71. • Freeport 138/34 kV Transformer 76. • All equipment at S. Pecatonica. • Fordam 138/12.5 kV Transformer 71. • Pierpont 138/12.5kV Transformer 73.	6	Stable	40

[10] QGEN and ETERM values of AD2-172 are invalid after tripping. See the GSU MVA flow variable to confirm zero output from AD2-172.

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Fault ID	Fault Description	Clearing Time (Cycles)	Result No Mitigation	Page No. Attachment #3
P6B.07	Fault at Freeport 138kV and AD2-172 POI Blue Bus on Lancaster - Eleroy – EcoGrove circuit 11904 resulting in loss of: • AD2-172 and Eco Grove Wind Farm, • Eleroy 138/12.5kV Transformer 71, • Freeport Red Bus 138/12.5kV Transformers 72, • Freeport Red Bus 138/34kV Transformers 77.	6	Stable	41
P6B.08	Fault at Maryland 138kV bus on Maryland (AD1-117 POI) - Eleroy - Lena - Lancaster circuit 11902 resulting in additional loss of: • Maryland 138/34kV Transformer 76, Eleroy 138/12.5kV Transformer 73, • 138/34kV Lena Transformer 78.	6	Stable	42
P6B.09	Fault at Maryland 138kV bus on Maryland (AD1-117 POI) - Dixon - Sterling circuit 12411 resulting in additional loss of: • Maryland 138/34kV Transformer 77, • Sterling 138/12.5kV Transformer 71.	6	Stable	43

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Table 12: Three-phase Faults With Normal Clearing – Prior Outage of Lancaster – Sabrooke 138 kV Circuit 19414

Fault ID	Fault Description	Clearing Time (Cycles)	Result No Mitigation	Page No. Attachment #3
P6C.01	Fault at EcoGrove 138kV (AD2-172 POI) Blue Bus on Eleroy – Lancaster - Freeport circuit 11904 resulting in loss of: • AD2-172 and Eco Grove Wind Farm • Eleroy 138/12.5kV Transformer 71, • Freeport Red Bus 138/12.5kV Transformers 72, • Freeport Red Bus 138/34kV Transformers 77.	6	Stable[11]	44
P6C.02	Fault at Eleroy 138kV Blue Bus on 138/12.5kV Transformer 71 resulting in the additional loss of: • Eleroy – Freeport – Lancaster – Lena ; B – Eco Grove circuit 11904. • AD2-172 and Eco Grove Wind Farm, • Freeport Red Bus 138/12.5 kV Transformers 72, • Freeport Red Bus 138/12.5 kV Transformers 77.	6	Stable	45
P6C.03	Fault at Lancaster 138 kV Red Bus on Lena – Eleroy - Maryland circuit 11902 resulting in loss of: • Lena 138/34 kV Transformer 78, • Eleroy 138/12.5 kV Transformer 73, • Maryland 138/34 kV Transformer 76.	6	Stable	46
P6C.04	Fault at Lancaster 138 kV Red Bus on Freeport – Eleroy - EcoGrove (AD2-172 POI) circuit 11904 resulting in the additional loss of: • AD2-172 and Eco Grove Wind Farm • Freeport Red Bus 138/12.5kV Transformer 72, • Freeport Red Bus 138/34kV Transformer 77, • Eleroy Blue Bus 138/12.5kV Transformer 71.	6	Stable	47
P6C.05	Fault at Lancaster 138 kV bus on Pecatonica - Wempletown circuit 17121 resulting in the additional loss of: • All equipment at Pecatonica.	6	Stable	48
P6C.06	N/A	N/A	N/A	N/A
P6C.07	Fault at Freeport 138kV and AD2-172 POI Blue Bus on Lancaster - Eleroy – EcoGrove circuit 11904 resulting in loss of: • AD2-172 and Eco Grove Wind Farm, • Eleroy 138/12.5kV Transformer 71, • Freeport Red Bus 138/12.5kV Transformers 72, • Freeport Red Bus 138/34kV Transformers 77.	6	Stable	49

[11] QGEN and ETERM values of AD2-172 are invalid after tripping. See the GSU MVA flow variable to confirm zero output from AD2-172.

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Fault ID	Fault Description	Clearing Time (Cycles)	Result No Mitigation	Page No. Attachment #3
P6C.08	Fault at Maryland 138kV bus on Maryland (AD1-117 POI) - Eleroy - Lena - Lancaster circuit 11902 resulting in additional loss of: • Maryland 138/34kV Transformer 76, Eleroy 138/12.5kV Transformer 73, • 138/34kV Lena Transformer 78.	6	Stable	50
PC.09	Fault at Maryland 138kV bus on Maryland (AD1-117 POI) - Dixon - Sterling circuit 12411 resulting in additional loss of: • Maryland 138/34kV Transformer 77, • Sterling 138/12.5kV Transformer 71.	6	Stable	51

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Table 13: Three-phase Faults With Normal Clearing – Prior Outage of Maryland – Dixon 138 kV Circuit 12411

Fault ID	Fault Description	Clearing Time (Cycles)	Result No Mitigation	Page No. Attachment #3
P6D.01	Fault at EcoGrove 138kV (AD2-172 POI) Blue Bus on Eleroy – Lancaster - Freeport circuit 11904 resulting in loss of: • AD2-172 and Eco Grove Wind Farm, • Eleroy 138/12.5kV Transformer 71, • Freeport Red Bus 138/12.5kV Transformers 72, • Freeport Red Bus 138/34kV Transformers 77.	6	Stable[12]	52
P6D.02	Fault at Eleroy 138kV Blue Bus on 138/12.5kV Transformer 71 resulting in the additional loss of: • Eleroy – Freeport – Lancaster – Lena ; B – Eco Grove circuit 11904, • AD2-172 and Eco Grove Wind Farm, • Freeport Red Bus 138/12.5 kV Transformers 72, • Freeport Red Bus 138/12.5 kV Transformers 77.	6	Stable	53
P6D.03	Fault at Lancaster 138 kV Red Bus on Lena – Eleroy - Maryland circuit 11902 resulting in loss of: • Lena 138/34 kV Transformer 78, • Eleroy 138/12.5 kV Transformer 73, • Maryland 138/34 kV Transformer 76.	6	Stable	54
P6D.04	Fault at Lancaster 138 kV Red Bus on Freeport – Eleroy - EcoGrove (AD2-172 POI) circuit 11904 resulting in the additional loss of: • AD2-172 and Eco Grove Wind Farm, • Freeport Red Bus 138/12.5kV Transformer 72, • Freeport Red Bus 138/34kV Transformer 77, • Eleroy Blue Bus 138/12.5kV Transformer 71.	6	Stable	55
P6D.05	Fault at Lancaster 138 kV bus on Pecatonica - Wempletown circuit 17121 resulting in the additional loss of: • All equipment at Pecatonica.	6	Stable	56

[12] QGEN and ETERM values of AD2-172 are invalid after tripping. See the GSU MVA flow variable to confirm zero output from AD2-172.

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Fault ID	Fault Description	Clearing Time (Cycles)	Result No Mitigation	Page No. Attachment #3
P6D.06	Fault at Lancaster 138 kV bus on Titan – Freeport – S. Pecatonica - Sabrooke – Pierpont – Fordam circuit 19414 resulting in the additional loss of: • All equipment at Titan Tire, • Freeport 138/12.5 kV Transformer 71, • Freeport 138/34 kV Transformer 76, • All equipment at S. Pecatonica, • Fordam 138/12.5 kV Transformer 71, • Pierpont 138/12.5kV Transformer 73.	6	Stable	57
P6D.07	Fault at Freeport 138kV and AD2-172 POI Blue Bus on Lancaster - Eleroy – EcoGrove circuit 11904 resulting in loss of: • AD2-172 and Eco Grove Wind Farm, • Eleroy 138/12.5kV Transformer 71, • Freeport Red Bus 138/12.5kV Transformers 72, • Freeport Red Bus 138/34kV Transformers 77.	6	Stable	58
P6D.08	Fault at Maryland 138kV bus on Maryland (AD1-117 POI) - Eleroy - Lena - Lancaster circuit 11902 resulting in additional loss of: • Maryland 138/34kV Transformer 76, Eleroy 138/12.5kV Transformer 73, • 138/34kV Lena Transformer 78.	6	Stable	59
P6D.09	N/A	N/A	N/A	N/A

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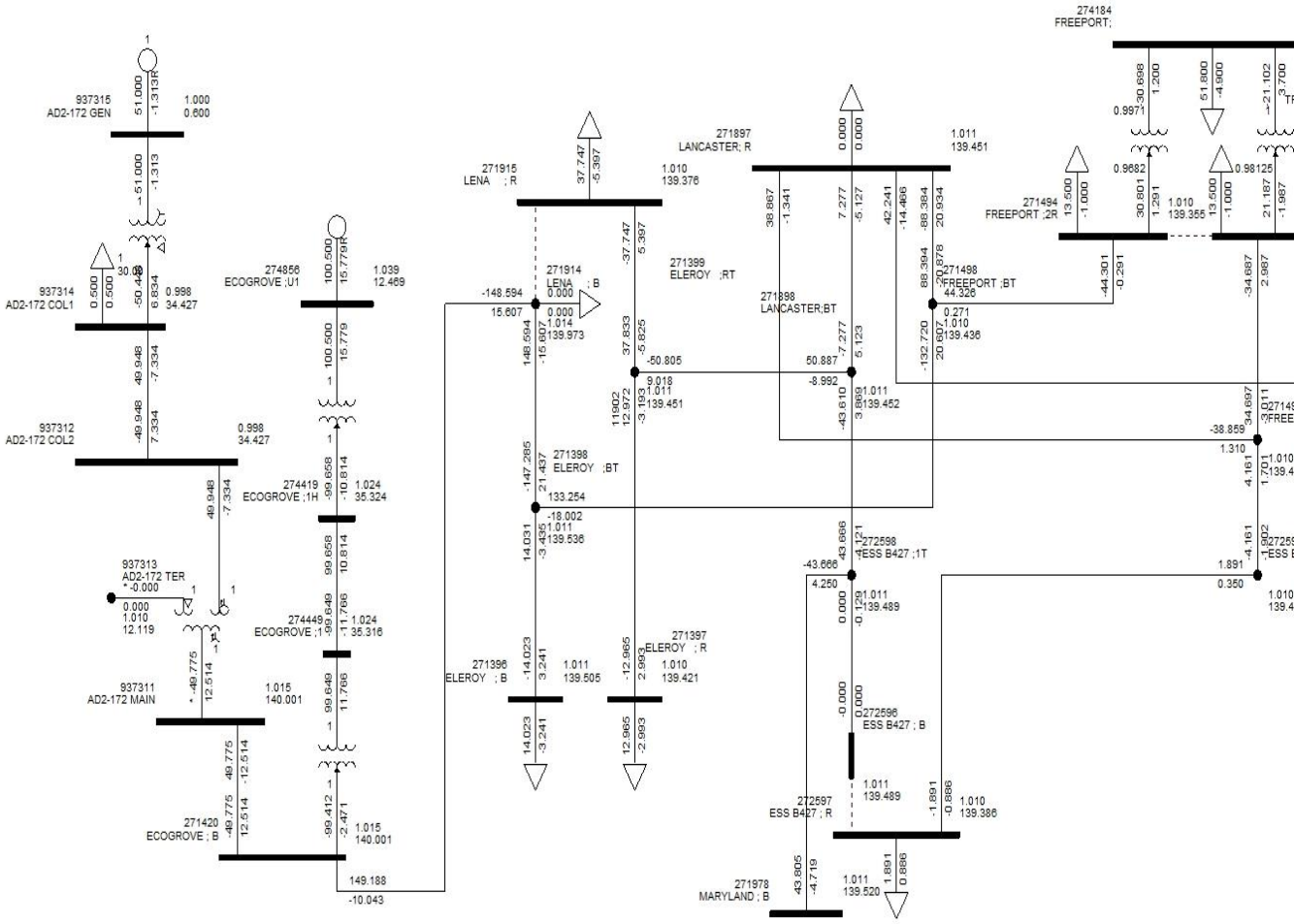
Appendix 1. PSS/E Model One Line Diagram



Appendix 2. AD2-172 PSS/E Loadflow and Dynamic Model

1. Loadflow Model (IDEV)

VERSION 33

RDCH

1

937311,'AD2-172 MAIN', 138.0000,1, 222, 6, 1,1.01450, 56.7266,1.10000,0.90000,1.10000,0.90000

937312,'AD2-172 COL2', 34.5000,1, 222, 6, 1,0.99788, 62.4853,1.10000,0.90000,1.10000,0.90000

937313,'AD2-172 TER ', 12.0000,1, 222, 6, 1,1.00988, 28.0048,1.10000,0.90000,1.10000,0.90000

937314,'AD2-172 COL1', 34.5000,1, 222, 6, 1,0.99788, 62.4853,1.10000,0.90000,1.10000,0.90000

937315,'AD2-172 GEN ', 0.6000,2, 222, 6, 1,1.00000, 38.7252,1.10000,0.90000,1.10000,0.90000

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937314,'1 ',1, 222, 6, 0.500, 0.500, 0.000, 0.000, 0.000, 0.000, 1,1,0

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0 / END OF FIXED SHUNT DATA, BEGIN GENERATOR DATA

937315,'1 ', 51.000, -1.313, 36.470, -36.470,1.00000, 0, 62.700, 9.99990E+4, 9.99990E+4, 0.00000E+0, 0.00000E+0,1.00000,1, 100.0, 51.000, 0.000, 1,1.0000, 0, 1.0, 0, 1.0, 0, 1.0,1, 1.0000

0 / END OF GENERATOR DATA, BEGIN BRANCH DATA

271420,937311,'1 ', 0.00000E+0, 1.00000E-4, 0.00000, 0.00, 0.00, 0.00, 0.00000, 0.00000, 0.00000, 0.00000,1,1, 8.17, 222,1.0000

937312,937314,'1 ', 0.00000E+0, 1.00000E-4, 0.00000, 0.00, 0.00, 0.00, 0.00000, 0.00000, 0.00000, 0.00000,1,1, 0.00, 1,1.0000

0 / END OF BRANCH DATA, BEGIN TRANSFORMER DATA

937311,937312,937313,'1 ',3,2,1, 0.00000E+0, 0.00000E+0,2,' ',1, 1,1.0000, 0,1.0000, 0,1.0000, 0,1.0000,'YN0yn0d1 '

2.83000E-3, 8.50000E-2, 42.00, 4.52800E-3, 1.36000E-1, 42.00, 2.97000E-3, 8.92500E-2, 42.00,1.00988, 58.0048

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1.00000, 34.500, 0.000, 42.00, 56.00, 70.00, 0, 0, 1.05000, 0.95000, 1.05000, 0.95000, 5, 0, 0.00000, 0.00000, 0.000

1.00000, 12.000, -30.000, 42.00, 56.00, 70.00, 0, 0, 1.05000, 0.95000, 1.05000, 0.95000, 5, 0, 0.00000, 0.00000, 0.000

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1.00000, 0.600

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0 / END OF TWO-TERMINAL DC DATA, BEGIN VSC DC LINE DATA

0 / END OF VSC DC LINE DATA, BEGIN IMPEDANCE CORRECTION DATA

0 / END OF IMPEDANCE CORRECTION DATA, BEGIN MULTI-TERMINAL DC DATA

0 / END OF MULTI-TERMINAL DC DATA, BEGIN MULTI-SECTION LINE DATA

0 / END OF MULTI-SECTION LINE DATA, BEGIN ZONE DATA

6,'PJM '

1272,'ROCK RIV '

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0 / END OF ZONE DATA, BEGIN INTER-AREA TRANSFER DATA

0 / END OF INTER-AREA TRANSFER DATA, BEGIN OWNER DATA

1,'CENT HUD '

222,'COMED '

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0 / END OF FACTS DEVICE DATA, BEGIN SWITCHED SHUNT DATA

0 / END OF SWITCHED SHUNT DATA, BEGIN GNE DATA

0 / END OF GNE DATA, BEGIN INDUCTION MACHINE DATA

0 / END OF INDUCTION MACHINE DATA

Q

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Dynamic Model (DYRE)

```
/************************************************************************
/*** Project:      AD2-172
/************************************************************************

/************************************************************************
/*****************************************************
/*** Project:      AD2-172 - 50.0 MW MFO (uprate)
/*** POI:          Eco Grove 138 kV circuit
/*** Inverter:     HEM - FS3000MU solar inverters
/*** Size:         19 x 2.684 MW  Solar PV
/*** PSSE Version:  33
/*****************************************************
//////// ELECTRICAL INTERFACE WITH PSS/E GRID
937315 'USRMDL' 1  'PEGEN_HEM0102'  101 1 1 43 4 40
      1
      1.35  1.35  1.35  1.20  1.15  0.30  0.30  0.30  0.60  0.70
      0.01  0.01  0.01  2.00  12.0  0.60  0.60  0.60  2.50  5.00
      60
      62.0  62.0  62.0  62.0  60.5  57.0  57.0  57.0  57.0  59.5
      0.1 0.1 0.1 0.1 60000 0.1 0.1 0.1 0.1 60000
      0.40   0.05/
//////// CONTROL MODEL
937315 'USRMDL' 1  'PECON_HEM0102'  102 0 4 16 7 20
      1   1   0   2
      1.00  0.02  0.02  0.50  -0.50  2.00 -2.00 0.02
      0.85  2.00  0.8134   0.5817  0.5817   0.10  2.00 2.00/
//////// POWER ELECTRONICS POWER PLANT CONTROLER
937315 'USRMDL' 1  'PEPPC_HEM0102' 103 0 7 29 8 30
      271420  937311  271420   1   1    1   0
      0.02 1.00  0.30 0.80 0.02 0.10 1.00 60.0
```


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61.0 59.0 63.0 57.0 5.0 5.0 5.0 5.0 1.0

0.10 0.00 0.10 0.5817 -0.5817 0.10 0.10

0.944 0.95 0.95 0.959 2.00/

/**

/*** Project: AD2-172 ends

/**

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Appendix 3. AD2-172 PSS/E Case Dispatch (ComEd Area)

Bus	Bus Name	ID	Stat	PGen	PMax	QMin	QGen	QMax	Vsh	Remote Bus	Remote Bus Name	AREA	Note
274856	ECOGROVE ;U112.000	W1	1	100.500	100.500	-20.407	15.779	20.407	1.0145	271420	ECOGROVE ; B138.00	222	
937315	AD2-172 GEN 0.6000	1	1	51.000	51.000	-36.470	-1.313	36.470	1.0000	0	N/A	222	
933341	AC2-147 C 138.00	1	1	7.600	7.600	-2.508	-0.641	3.648	1.0110	0	N/A	222	Netted generation
933342	AC2-147 E 138.00	1	1	12.400	12.400	-4.092	0.002	5.952	1.0110	0	N/A	222	Netted generation
932921	AC2-116 CT2116.000	21	1	180.200	180.200	-62.000	7.178	80.000	1.0109	274783	ROCKFORD ;RP138.00	222	
295110	SUBLETTE C 138.00	1	1	26.000	26.000	0.000	0.000	0.000	1.0109	0	N/A	222	Netted generation
905471	W4-084 138.00	1	1	3.950	3.950	0.000	0.000	0.000	1.0310	0	N/A	222	Netted generation
932881	AC2-115 CT1116.000	11	1	180.300	180.300	-58.000	-7.809	85.000	1.0109	932880	AC2-115 POI 138.00	222	
932882	AC2-115 CT1216.000	12	1	180.500	180.500	-58.000	-7.809	85.000	1.0109	932880	AC2-115 POI 138.00	222	
907361	X1-087 138.00	1	1	15.300	15.300	-6.270	7.448	9.120	1.0229	0	N/A	222	Netted generation
934651	AD1-096 C 138.00	1	1	7.600	7.600	-2.508	2.342	2.508	1.0229	0	N/A	222	Netted generation
919220	AA1-146_GEN 18.000	1	1	190.000	190.000	-59.000	7.880	82.000	1.0210	274714	NELSON EC;BU345.00	1	
925160	AB2-173_GEN 18.000	1	1	206.500	206.500	-75.000	59.046	111.000	1.0490	0	N/A	222	
274715	NELSON EC;1C18.000	C1	1	174.000	174.000	-57.420	7.880	83.520	1.0210	274714	NELSON EC;BU345.00	222	

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Bus	Bus Name	ID	Stat	PGen	PMax	QMin	QGen	QMax	Vsh	Remote Bus	Remote Bus Name	AREA	Note
274716	NELSON EC;1S13.800	S1	1	126.000	126.000	-41.580	7.880	60.480	1.0210	274714	NELSON EC;BU345.00	222	
274717	NELSON EC;2C18.000	C2	1	174.000	174.000	-57.420	7.880	83.520	1.0210	274714	NELSON EC;BU345.00	222	
274718	NELSON EC;2S13.800	S2	1	126.000	126.000	-41.580	7.880	60.480	1.0210	274714	NELSON EC;BU345.00	222	
926984	AC1-185 GEN713.800	7	1	85.100	85.100	-28.000	-26.045	28.000	1.0145	274768	LEE CO EC; 345.00	222	
926983	AC1-185 GEN813.800	8	1	85.100	85.100	-28.000	-26.045	28.000	1.0145	274768	LEE CO EC; 345.00	222	
926980	AC1-185 GEN113.800	1	1	86.500	86.500	-28.500	-26.045	28.000	1.0145	274768	LEE CO EC; 345.00	222	
926989	AC1-185 GEN213.800	2	1	86.200	86.200	-28.500	-26.045	28.000	1.0145	274768	LEE CO EC; 345.00	222	
926986	AC1-185 GEN513.800	5	1	86.400	86.400	-28.500	-26.045	28.000	1.0145	274768	LEE CO EC; 345.00	222	
926985	AC1-185 GEN613.800	6	1	86.800	86.800	-28.500	-26.045	28.000	1.0145	274768	LEE CO EC; 345.00	222	
926988	AC1-185 GEN313.800	3	1	86.200	86.200	-28.500	-26.045	28.000	1.0145	274768	LEE CO EC; 345.00	222	
926987	AC1-185 GEN413.800	4	1	85.800	85.800	-28.000	-26.045	28.000	1.0145	274768	LEE CO EC; 345.00	222	
924472	AB2-096 CT1 18.000	1	1	157.600	157.600	-82.000	52.410	90.000	1.0145	924470	GARDEN PR; R345.00	222	
924473	AB2-096 CT2 18.000	2	1	157.600	157.600	-82.000	52.410	90.000	1.0145	924470	GARDEN PR; R345.00	222	

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Bus	Bus Name	ID	Stat	PGen	PMax	QMin	QGen	QMax	Vsh	Remote Bus	Remote Bus Name	AREA	Note
924474	AB2-096 CT3 18.000	3	1	157.600	157.600	-82.000	52.410	90.000	1.0145	924470	GARDEN PR; R345.00	222	
699152	COL G1 22.000	1	1	548.600	548.600	-54.300	48.375	254.900	1.0200	699157	COL 345 345.00	694	
699153	COL G2 22.000	2	1	552.100	552.100	-99.700	29.399	158.600	1.0200	699157	COL 345 345.00	694	
699137	CHA1 18 18.000	1	1	156.500	156.500	-47.930	45.821	100.170	1.0200	699218	CHA 138 138.00	694	
699138	CHA2 18 18.000	2	1	156.500	156.500	-47.930	45.684	100.170	1.0200	699218	CHA 138 138.00	694	
699139	CHA3 18 18.000	3	1	156.500	156.500	-47.930	45.684	100.170	1.0200	699218	CHA 138 138.00	694	
934652	AD1-096 E 138.00	1	1	12.400	12.400	-4.092	2.556	4.092	1.0229	0	N/A	222	Netted generation
934431	AD1-067 C 138.00	1	1	1.100	1.100	-0.363	0.086	0.363	1.0139	0	N/A	222	Netted generation
934432	AD1-067 E 138.00	1	1	4.625	4.625	-1.526	1.517	1.526	1.0139	0	N/A	222	Netted generation
272364	ESS H440N ;R138.00	1	1	22.000	22.000	0.000	0.000	0.000	1.0109	0	N/A	222	Netted generation
934705	AD1-098 GEN 0.6900	1	1	102.400	102.400	0.000	0.000	0.000	1.0109	934700	AD1-098 TAP 138.00	222	
274650	KINCAID ;1U20.000	1	1	625.000	625.000	29.000	92.733	252.600	1.0406	270797	KINCAID ; R345.00	222	
274651	KINCAID ;2U20.000	2	1	625.000	625.000	-87.850	92.733	328.400	1.0406	270796	KINCAID ; B345.00	222	
274654	BRAID;1U 25.000	1	1	1296.000	1296.000	-22.200	450.617	532.000	1.0348	270670	BRAIDWOOD; B345.00	222	
274655	BRAID;2U 25.000	2	1	1272.000	1272.000	-22.200	450.617	591.000	1.0348	270671	BRAIDWOOD; R345.00	222	

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Bus	Bus Name	ID	Stat	PGen	PMax	QMin	QGen	QMax	Vsh	Remote Bus	Remote Bus Name	AREA	Note
274656	BYRON ;1U25.000	1	1	1315.000	1315.000	35.000	314.652	532.000	1.0261	270678	BYRON ; B345.00	222	
274657	BYRON ;2U25.000	2	1	1291.000	1291.000	-12.000	314.652	591.000	1.0261	270679	BYRON ; R345.00	222	
274658	DRESDEN ;2U18.000	2	1	990.000	990.000	-57.000	335.514	336.000	1.0030	0	N/A	222	
274659	DRESDEN ;3U18.000	3	1	990.000	990.000	-99.000	396.580	397.000	1.0115	0	N/A	222	
274660	LASCO;1U 25.000	1	1	1239.000	1239.000	-9.000	275.196	355.000	1.0406	270802	LASCO STA; B345.00	222	
274661	LASCO;2U 25.000	2	1	1241.000	1241.000	-11.000	275.196	489.000	1.0406	270803	LASCO STA; R345.00	222	
274662	QUAD CITI;1U18.000	1	1	937.000	937.000	13.390	217.800	340.000	1.0319	270866	QUAD 6-7 345.00	222	
274663	QUAD CITI;2U18.000	2	1	937.000	937.000	80.000	217.800	350.000	1.0319	270864	QUAD 1 3-11 345.00	222	

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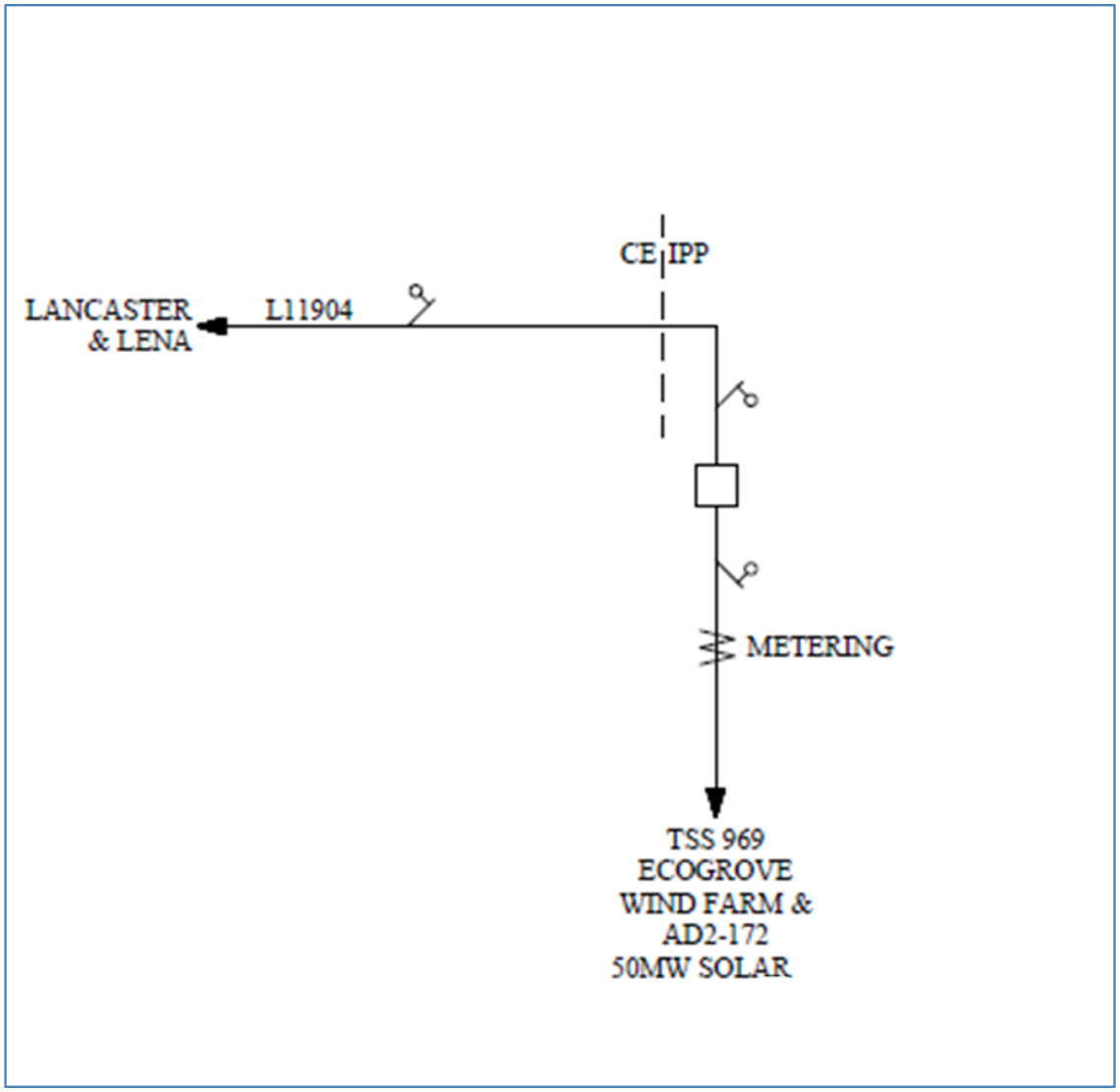
22 Single line Diagram

AD2-172



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