Generation Interconnection
REVISED
System Impact Study Report

For

PJM Generation Interconnection Request
Queue Position AD2-072

Van Arsdell-Mercer Industrial 69kV

September 2021

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.

General

Mercer County Solar Project, LLC, the Interconnection Customer (IC), has proposed a solar generating facility located in Mercer County, Kentucky. The installed facilities will have a total capability of 100 MW with 67.1 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is December 1, 2021. **This study does not imply a EKPC commitment to this in-service date.**

Point of Interconnection

AD2-072 will interconnect with the EKPC transmission system along the Van Arsdell - Mercer Industrial 69 kV line.

Cost Summary

The AD2-072 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 250,000
Direct Connection Network Upgrades	$ 2,000,000
Non Direct Connection Network Upgrades	$ 800,000
Allocation for New System Upgrades	$ 0
Contribution for Previously Identified Upgrades	$ 511,560
Total Costs	**$ 3,561,560**

Attachment Facilities

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	Activity Cost
Install a 69 kV switch structure at the point of demarcation, revenue metering, and attachment facility line/bus and associated hardware to accept the Interconnection Customer generator lead line/bus terminating at the AD2-072 Interconnection switching station. PJM Network Upgrade n5860.	$ 250,000
Total Attachment Facility Costs	**$ 250,000**

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	Activity Cost
Build 69kv switching station along the Van Arsdell - Mercer Industrial 69 kV line. Estimated Time: 18 months. PJM Network Upgrade n5861.	$ 2,000,000
Total Direct Connection Facility Costs	**$ 2,000,000**

Non-Direct Connection Cost Estimate

There are no Non-Direct Connection Facilities are required to support this interconnection.

Description	Activity Cost
Van Arsdell - Mercer Industrial 69 kV line: Install a line loop to the proposed AD2-072 interconnection switching station. PJM Network Upgrade n5862	$ 700,000
Adjust remote, relaying, and metering settings at Van Arsdell - 69kV Sub. PJM Network Upgrade n5863	$ 50,000
Adjust remote, relaying, and metering settings at Mercer Industrial 69 kV Sub. PJM Network Upgrade n5864	$ 50,000
Total Non-Direct Connection Facility Costs	**$ 800,000**

Interconnection Customer Requirements

1. An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.

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 Sections 24.1 and 24.2.

EKPC Requirements

The Interconnection Customer will be required to comply with all EKPC Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "EKPC Facility Connection Requirements" document located at the following link:

http://www.pjm.com/planning/design-engineering/to-tech-standards/ekpc.aspx

Network Impacts

The Queue Project AD2-072 was evaluated as a 95.0 MW (Capacity 63.7 MW) injection into a tap of the Van Arsdell – Mercer Industrial 69 kV line in the EKPC area. Project AD2-072 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD2-072 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis - 2021

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
AEP_P1-2_#363	CONTINGENCY 'AEP_P1-2_#363' OPEN BRANCH FROM BUS 243208 TO BUS 243209 CKT 1 / 243208 05JEFRSO 765 243209 05ROCKPT 765 1 END
AEP_P1-2_#4812	CONTINGENCY 'AEP_P1-2_#4812' OPEN BRANCH FROM BUS 242921 TO BUS 242924 CKT 1 / 242921 05CORNU 765 242924 05HANG R 765 1 END

Generator Deliverability

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

None

Multiple Facility Contingency

(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)

None

Short Circuit

(Summary of impacted circuit breakers)

None

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

	Contingency		Affected		Bus			Power	Loading %		Rating		MW	
#	Type	Name	Area	Facility Description	From	To	Circuit	Flow	Initial	Final	Type	MVA	Contribution	Ref
1	N-1	AEP_P1-2_#363	LGEE - OVEC	7TRIMBLE-06CLIFTY 345 kV line	324114	248000	1	AC	193.49	194.43	ER	1370	11.61	1
2	Non	Non	LGEE - OVEC	7TRIMBLE-06CLIFTY 345 kV line	324114	248000	1	AC	135.9	136.93	NR	1134	10.84	
3	N-1	AEP_P1-2_#4812	LGEE - OVEC	7TRIMBLE-06CLIFTY 345 kV line	324114	248000	1	AC	118.19	119.05	ER	1370	10.83	

*Note: Please see **Error! Reference source not found.** for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper table in the Attachment.*

Affected System Analysis & Mitigation

LGEE Impacts:
Impacts identified on the Trimble – Clifty 345 kV LG&E – PJM tie line. An LG&E Affetced System Study will be required.

MISO Impacts:
None.

Duke, Progress & TVA Impacts:
None

OVEC Impacts:
None

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

None. See Attachment 3

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

None. See Attachment 3

New System Reinforcements

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

None

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

<table>
<tr><th>Violation #</th><th>Overloaded Facility</th><th>Upgrade Description</th><th>Network Upgrade Number</th><th>Upgrade Cost</th><th>AD2-072 Allocation</th></tr>
<tr><td>1, 2, 3</td><td>Trimble – Clifty 345 kV line</td><td>To resolve the Trimble – Clifty 345 kV line overloads:

LG&E upgrade is to reconductor the line with a high temperature conductor and upgrade any necessary terminal equipment to achieve expected ratings of 2610/2610 MVA SN/SE. Cost estimate is $17.4M with a time estimate of 18 months.

AD2-072 will receive cost allocation as follows:
<table>
<tr><th>Queue</th><th>MW contribution</th><th>Percentage of Cost</th><th>$ cost ($17.4 M)</th></tr>
<tr><td>X3-028 MTX</td><td>131.3</td><td>33.24%</td><td>5.783</td></tr>
<tr><td>AB1-087</td><td>40.8</td><td>10.33%</td><td>1.797</td></tr>
<tr><td>AB1-088</td><td>40.8</td><td>10.33%</td><td>1.797</td></tr>
<tr><td>AC1-074</td><td>4.9</td><td>1.24%</td><td>0.216</td></tr>
<tr><td>J708</td><td>48.4</td><td>12.25%</td><td>2.132</td></tr>
<tr><td>J759</td><td>11.2</td><td>2.84%</td><td>0.493</td></tr>
<tr><td>J762</td><td>35.0</td><td>8.86%</td><td>1.542</td></tr>
<tr><td>J783</td><td>11.2</td><td>2.84%</td><td>0.493</td></tr>
<tr><td>AC2-075</td><td>1.2</td><td>0.30%</td><td>0.053</td></tr>
<tr><td>AC2-157</td><td>5.7</td><td>1.44%</td><td>0.251</td></tr>
<tr><td>J800</td><td>16.7</td><td>4.23%</td><td>0.736</td></tr>
<tr><td>J842</td><td>3.6</td><td>0.90%</td><td>0.157</td></tr>
<tr><td>J843</td><td>3.9</td><td>0.98%</td><td>0.171</td></tr>
<tr><td>J856</td><td>11.0</td><td>2.78%</td><td>0.484</td></tr>
<tr><td>AD1-134</td><td>8.1</td><td>2.05%</td><td>0.357</td></tr>
<tr><td>AD1-148</td><td>2.5</td><td>0.63%</td><td>0.110</td></tr>
<tr><td>AD2-036</td><td>3.2</td><td>0.81%</td><td>0.141</td></tr>
<tr><td>AD2-048</td><td>4.0</td><td>1.01%</td><td>0.176</td></tr>
<tr><td>AD2-072</td><td>11.6</td><td>2.94%</td><td>0.511</td></tr>
</table></td><td>N5469</td><td>$ 17,400,000</td><td>$ 511,560</td></tr>
<tr><td colspan="4"></td><td>Total New Network Upgrades</td><td>$ 511,560</td></tr>
</table>

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.

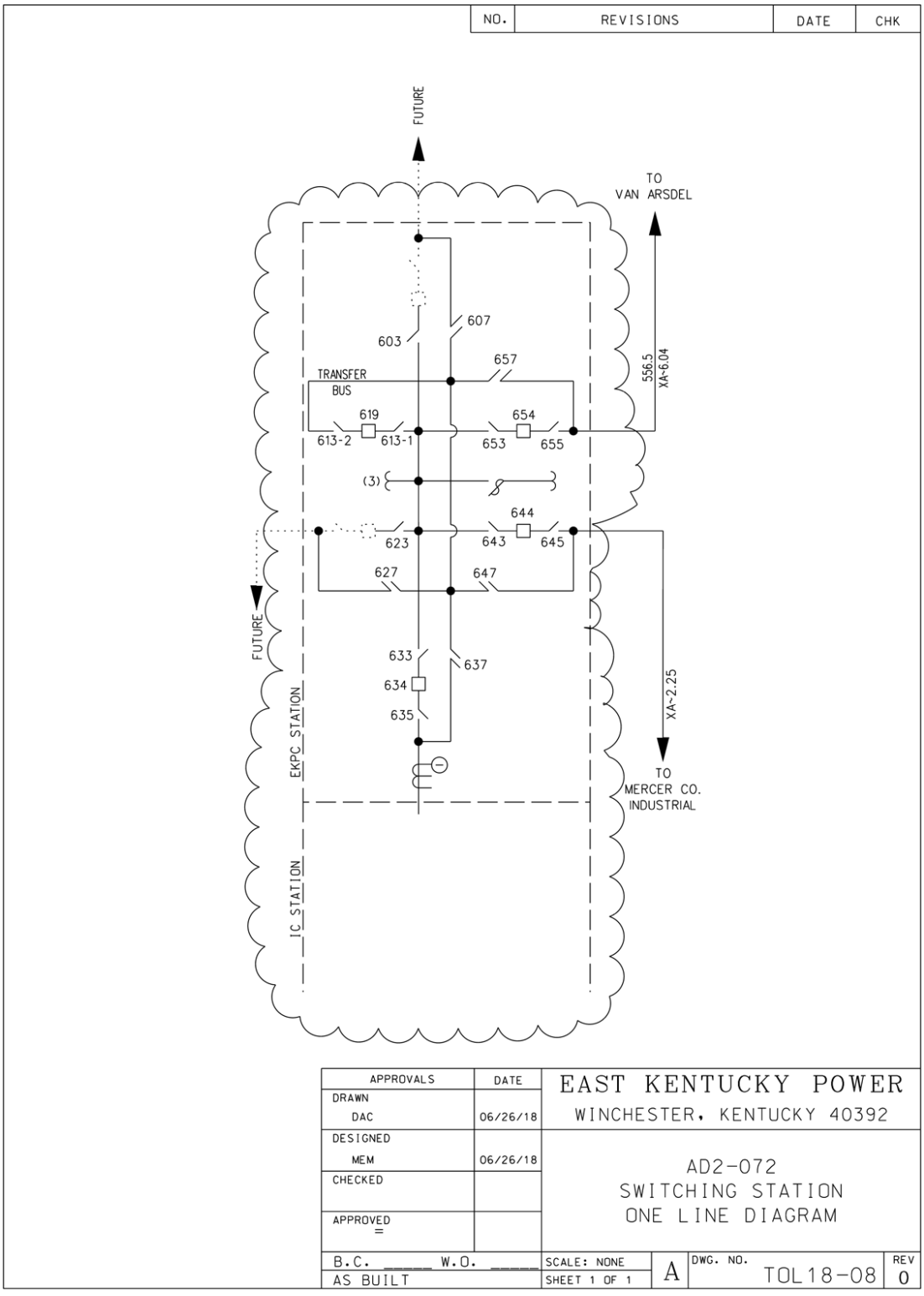
	Contingency		Affected		Bus			Power	Loading %		Rating		MW	
#	Type	Name	Area	Facility Description	From	To	Circuit	Flow	Initial	Final	Type	MVA	Contribution	Ref
4	N-1	AEP_P1-2_#363	LGEE - OVEC	7TRIMBLE-06CLIFTY 345 kV line	324114	248000	1	AC	179.64	180.99	ER	1370	17.3	
5	Non	Non	LGEE - OVEC	7TRIMBLE-06CLIFTY 345 kV line	324114	248000	1	AC	137.83	139.31	NR	1134	16.15	

*Note: Please see **Error! Reference source not found.** for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper table in the Attachment.*

ICTRs

PJM has timely issued this System Impact Study without ICTR determinations. PJM will work with each customer to identify the Customer-Funded Upgrade(s) and LDAs (no more than three) for which the customer wants PJM to determine ICTRs. PJM will provide that determination as quickly as practicable following issuance of this System Impact Study.

Attachment 1. Single Line Diagram



Attachment 2. Flowgate Details

Appendices

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. All New Service Queue Requests, through the end of the Queue under study, that are contributors to a flowgate will be listed in the Appendices. Please note that there may be contributors that are subsequently queued after the queue under study that are not listed in the Appendices. Although this information is not used "as is" for cost allocation purposes, it can be used to gage the impact of other projects/generators.

It should be noted the project/generator MW contributions presented in the body of the report and appendices sections are full contributions, whereas the loading percentages reported in the body of the report, take into consideration the commercial probability of each project as well as the ramping impact of "Adder" contributions.

Appendix 1

(LGEE - OVEC) The 7TRIMBLE-06CLIFTY 345 kV line (from bus 324114 to bus 248000 ckt 1) loads from 193.49% to 194.43% (AC power flow) of its emergency rating (1370 MVA) for the single line contingency outage of 'AEP_P1-2_#363'. This project contributes approximately 11.61 MW to the thermal violation.

CONTINGENCY 'AEP_P1-2_#363'
OPEN BRANCH FROM BUS 243208 TO BUS 243209 CKT 1 / 243208 05JEFRSO 765 243209 05ROCKPT 765 1
END

Bus Number	Bus Name	Full Contribution
247287	05AND G3	0.84
243442	05RKG1	40.89
243443	05RKG2	40.27
342900	1COOPER1 G	3.28
342903	1COOPER2 G	6.36
342918	1JKCT 1G	2.57
342921	1JKCT 2G	2.57
342924	1JKCT 3G	2.57
342927	1JKCT 4G	1.71
342930	1JKCT 5G	1.7
342933	1JKCT 6G	1.71
342936	1JKCT 7G	1.71
342939	1JKCT 9G	1.75
342942	1JKCT 10G	1.75
342945	1LAUREL 1G	1.85

932551	AC2-075 C	1.09
933441	AC2-157 C	8.17
935011	AD1-134	8.11
935141	AD1-148	2.48
936281	AD2-036 C	3.24
936381	AD2-048 C	3.96
936571	AD2-072 C O1	11.61
936771	AD2-100 C O1	6.98
936821	AD2-105 C O1	3.75
936831	AD2-106 C O1	2.
936841	AD2-107 C O1	1.29
LTF	CARR	0.32
LTF	CBM-S1	40.53
LTF	CBM-S2	6.92
LTF	CBM-W1	21.77
LTF	CBM-W2	141.51
LTF	CIN	25.76
LTF	CLIFTY	94.95
LTF	CPLE	1.19
LTF	DEARBORN	0.5
LTF	IPL	15.71
981181	J708	40.83
981521	J759	9.26
981531	J762	29.44
981571	J783	9.26
938311	J795	3.67
938731	J800	15.73
938861	J829	12.54
938921	J842 C	3.98
938931	J843 C	4.32
939021	J856	9.33
274650	KINCAID ;1U	6.51
274651	KINCAID ;2U	6.49
LTF	LGEE	19.02
LTF	MEC	21.91
LTF	RENSSELAER	0.25
LTF	ROWAN /* 35% REVERSE 4479078	< 0.01
LTF	WEC	1.75
900404	X3-028 C	161.28
LTF	Z1-043	8.41
930461	AB1-087	59.14
930471	AB1-088	59.14
LTF	AB2-013	5.12
925981	AC1-074 C	4.54

Attachment 3. Dynamic Simulation Analysis

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Executive Summary

Generator Interconnection Request AD2-072 is for a 95.00 MW Maximum Facility Output (MFO) solar facility. AD2-072 consists of 38X2.5 MW TMEIC PVH-L2700GR Solar Inverters with a Point of Interconnection (POI) tapping the Van Arsdell to Mercer CO. Industrial Park 69 kV line with a new interconnection switching station in Mercer County, Kentucky, in the East Kentucky Power Cooperative (EKPC) transmission system.

This report describes a dynamic simulation analysis of AD2-072 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. AD2-072 has been dispatched online at maximum power output, with unity power factor and approximately 1.0 pu voltage at the generator terminals.

AD2-072 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. 33 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 to ground faults with delayed clearing as a result of protection failure (Category P5).

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 33 fault contingencies tested on the 2021 peak load case:

a) AD2-072 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 mitigations were found to be required for the studied project.

Please also be noted that the studied project does not meet 0.95 leading and lagging reactive power requirement at the POI. The estimed required additional capacitive reactive power is 3.37 MVAR to fulfill the power factor requirement.

1. Introduction

Generator Interconnection Request AD2-072 is for a 95.00 MW Maximum Facility Output (MFO) solar facility. AD2-072 consists of 38X2.5 MW TMEIC PVH-L2700GR Solar Inverters with a Point of Interconnection (POI) tapping the Van Arsdell to Mercer Industrial Park 69 kV line with a new interconnection switching station in Mercer County, Kentucky, in the East Kentucky Power Cooperative (EKPC) transmission system.

This analysis is effectively a screening study to determine whether the addition of AD2-072 will meet the dynamic requirements of the NERC, PJM and Transmission Owner reliability standards.

In this report the AD2-072 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. Description of Project

Generator Interconnection Request AD2-072 is for a 95.00 MW Maximum Facility Output (MFO) solar facility. AD2-072 consists of 38X2.5 MW TMEIC PVH-L2700GR Solar Inverters with a Point of Interconnection (POI) tapping the Van Arsdell to Mercer Industrial Park 69 kV line with a new interconnection switching station in Mercer County, Kentucky, in the East Kentucky Power Cooperative (EKPC) transmission system. The connection diagram of the AD2-072 generating facility is shown in Figure 1.

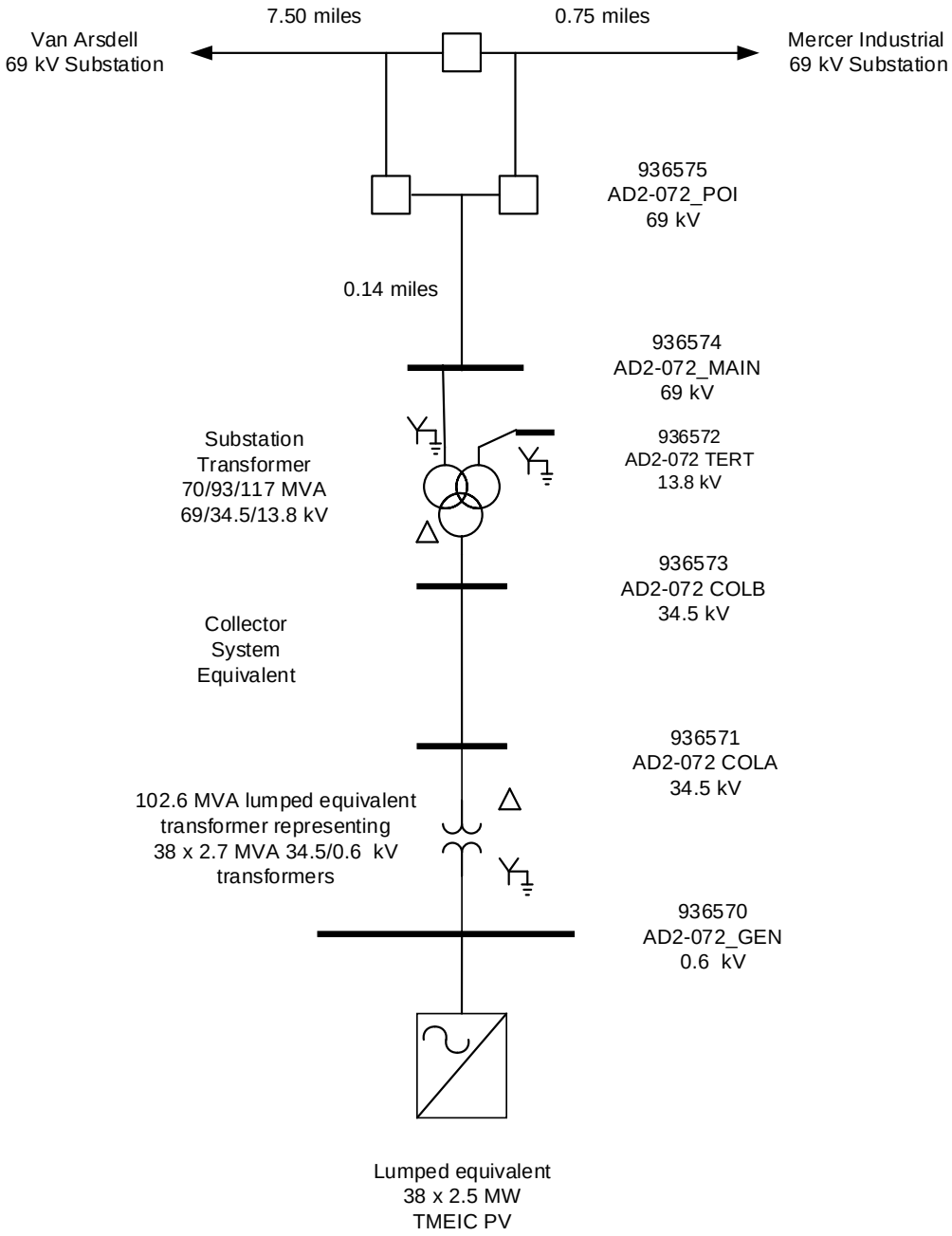

Figure 1: AD2-072 Plant Model

Table 1 lists the parameters given in the impact study data and the corresponding parameters of the AD2-072 loadflow model.

Additional project details are provided in Attachments 1 through 4:

- Attachment 1 contains the Impact Study Data which details the proposed AD2-072 project.
- Attachment 2 shows the one line diagram of the EKPC network in the vicinity of AD2-072.
- Attachment 3 provides a diagram of the PSS/E model in the vicinity of AD2-072.
- Attachment 4 gives the AD2-072 PSS/E loadflow and dynamic models of the AD2-072.

Table 1: AD2-072 Plant Model

	Impact Study Data	Model
Solar Inverters Lumped Equivalent (PV)	38 x 2.5 MW TMEIC PVH-L2700GR 2.7 MVA Solar Inverters MVA base = 2.7 MVA Vt = 0.6 kV Stator resistance = 0 Saturated sub-transient reactance = 9999 p.u	1 Lumped equivalent representing 38 x 2.5 MW TMEIC PVH-L2700GR 2.7 MVA Solar Inverters Pgen 95.00 MW Pmax 95.00 MW Pmin 0 MW Qmax 38.7525 Mvar Qmin - 38.7525 Mvar Mbase 102.6 MVA R 0 p.u X 9999 p.u
Inverter Based Step-Up Transformer (T1)	38 x 34.5/0.6 kV solar inverter step-up transformers Rating = 2.7 MVA Transformer MVA base = 2.7 MVA Impedance = 0.005720 + j 0.057200 p.u. Number of taps = N/A Tap step size = N/A	1 x Lumped equivalent representing 38 x 34.5/0.6 kV solar inverter step-up transformers Rating = 102.6 MVA Transformer MVA base = 102.6 MVA Impedance = 0.005720 + j 0.057200 p.u. Number of taps = N/A Tap step size = N/A

	Impact Study Data	Model
Inverter Based Main Transformer (MPT-1)	1 x 69/34.5/13.8 kV Rating = 70/93/117 MVA Transformer MVA base = 70 MVA Impedance: High to Low = 0.002 + j 0.06 p.u High to Tert = 0.0019 + j 0.0573 p.u Low to Tert = 0.0015 + j 0.043 p.u Number of taps = N/A Tap step size = N/A	1 x 69/34.5/13.8 kV Rating = 70/93/117 MVA Transformer MVA base = 70 MVA Impedance: High to Low = 0.002 + j 0.06 p.u High to Tert = 0.0019 + j 0.0573 p.u Low to Tert = 0.0015 + j 0.043 p.u Number of taps = N/A Tap step size = N/A
Auxiliary Load	0.00 MW + 0.00 MVAr at low side of the GSU	None
Station Load	0.00 MW + 0.00 MVAr at low side of the GSU	None
Collector System Equivalent (Collector 1)	34.5 kV line Impedance = 0.006640 + j 0.006270 p.u Charging susceptance = j 0.010300 p.u (Impedance on 100 MVA Base)	34.5 kV line Impedance = 0.006640 + j 0.006270 p.u Charging susceptance = j 0.010300 p.u (Impedance on 100 MVA Base)
Attachment Line	0.14 mile 69 kV line Impedance = 0.000180 + j 0.001870 p.u Charging susceptance = j0.000000 p.u (Impedance on 100 MVA Base)	0.14 mile 69 kV line Impedance = 0.000180 + j 0.001870 p.u Charging susceptance = j0.000000 p.u (Impedance on 100 MVA Base)

3. Reactive Power Assessment

AD2-072 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 POI or the result of the System Impact Study indicated that, for the safety and relialbity of the Transmission System, no power factor requirement is required[1].[2]

Generator	MFO	Required pF Range		Maximum (Lagging)	Minimum (Leading)
		Lagging	Leading		
AD2-072	95	0.95	0.95		
Total MVAR Required				31.22	-31.22
MVAR from Generators				Qmax	Qmin
				38.75	-38.75
Customer Planned Compensation				0	0
Qloss				-10.9	-15.4
Total Available MVAR at POI				27.9	-54.1
Deficiency in MVAR				3.37	Meet

AD2-072 **does not** meet the reactive power requirement at POI.

[1] As specified in the document “Reactive Power Requirements.doc”, Date: 6/15/2018.
[2] As specified in Attachment O of the document “PJM Open Access Transmission Tariff” Effective Date: 4/23/2018.

4. 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 PJM's Regional Transmission Planning Process[3].

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 AD2-072.

b) Addition of AD2-072 queue project.

c) Removal of withdrawn and subsequent queue projects in the vicinity of AD2-072.

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

The AD2-072 initial conditions are listed in **Table 2**, indicating maximum power output, with unity power factor and approximately 1.0 pu voltage at the generator terminals. The POI voltage is at 1.0145 pu (per the PJM scheduled voltage at 70 kV).

Table 2: AD2-072 machine initial conditions

Bus	Name	Unit	PGEN	QGEN	ETERM	POI Voltage
936570	AD2-072_GEN	1	95.0 MW	0.86 MVAR	1.00 pu	1.0145 pu

Generation within the vicinity of AD2-072 has been dispatched online at maximum output (PMAX). The dispatch within the EKPC area is given in Attachment 5.

[3] Manual 14B: PJM Region Transmission Planning Process, Rev 37, April 28 2017, Attachment G : PJM Stability, Short Circuit, and Special RTEP Practices and Procedures.

5. Fault Cases

Table 4 to **Table 7** 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 (with 1.0 second initial run prior to any events).

The studied contingencies 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 to ground faults with delayed clearing as a result of protection failure (Category P5);

No high Speed Reclosing (HSR) contingencies at the vicinity of AD2-072 were found[4]:

Buses at which the faults listed above will be applied are:

- AD2-072 POI 69 kV
- South Anderson 69 kV
- Hunt Farm JCT. 69 kV

Table 3 gives the details of worst fault clearing time[5] for 69 kV, 115 kV, and 230 kV breakers at EKPC.

Table 3: 345 kV and 138 kV 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)
EKPC	69 kV	8	19	45
EKPC	115 kV	6	14/15	35
EKPC	230 kV	6	14/15	35

A complete list of the contingencies that will be studied is given in **Table 4** to **Table 7**.

The positive sequence fault impedances for single line to ground faults were derived through the procedure described in *SLG fault equivalent impedance estimation for stability study,* dated 02/10/17.

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

6. Evaluation Criteria

This study is focused on AD2-072, 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) AD2-072 is able to ride through the faults (except for faults where protective action trips a generator(s)),

b) the system with AD2-072 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.

7. Summary of Results

Plots from the dynamic simulations are provided in Attachment 6, with results summarized in Table 4 through **Table 7**.

For all 33 of the fault contingencies tested on the 2021 peak load case:

a) AD2-072 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.

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Table 4: Steady State Operation – Category P0

Fault ID	Duration	AD2-072 No Mitigation
P0_01	Steady state 20 sec	Stable

Table 5: Three-phase Faults With Normal Clearing – Category P1

Fault ID	Fault description	Clearing Time & Reclose (Cycles)	AD2-072 No Mitigation
P1.01	3ph fault on AD2-072 POI 69 kV, normal clear loss of AD2-072	8	Stable
P1.02	3ph fault at AD2-072 POI 69 kV on South Anderson Circuit, normal clear loss of Van Arsdel-Clay Lick-South Anderson Circuit (TAP1)	8	Stable
P1.03	3ph fault at AD2-072 POI 69 kV on Hunt Farm JCT. Circuit, normal clear loss of Mercer CO. Industrial-H.T.Adams-Hunt Farm JCT. Circuit (TAP2)	8	Stable
P1.04	3ph fault at Hunt Farm JCT. 69 kV on AD2-072 POI Circuit, normal clear loss of AD2-072 POI-Mercer CO. Industrial-H.T.Adams Circuit	8	Stable
P1.05	3ph fault at Hunt Farm JCT. 69 kV on North Springfield Circuit, normal clear loss of Perryville-Mackville-North Springfield Circuit	8	Stable
P1.06	3ph fault at Hunt Farm JCT. 69 kV on Dale Station Circuit, normal clear loss of Ballard-Toddville-Dale Station Circuit	8	Stable
P1.07	3ph fault at South Anderson 69 kV on North Springfield Circuit, normal clear loss of Sinai-Chaplin-Bloomfield-North Springfield Circuit	8	Stable
P1.08	3ph fault at South Anderson 69 kV on AD2-072 POI Circuit, normal clear loss of AD2-072 POI-Van Arsdel-Clay Lick Circuit	8	Stable
P1.09	3ph fault at South Anderson 69 kV on Powell Taylor Circuit, normal clear loss of Powell Taylor Circuit	8	Stable
P1.10	3ph fault at South Anderson 69 kV on Bonds Mill Circuit 1, normal clear loss of Bonds Mill Circuit 1	8	Stable
P1.11	3ph fault at South Anderson 69 kV on Bonds Mill Circuit 2, normal clear loss of Bonds Mill Circuit 2	8	Stable

Table 6: Single-phase Faults With Stuck Breaker (Single-Phase Delayed Fault Clear) – Category P4

Fault ID	Fault description	Clearing Time Normal and Delayed (Cycles)	AD2-072 No Mitigation
P4_1B1.01	SLG @ AD2-072 POI on AD2-072 Generator. AD2-072 Breaker 654 stuck. Fault cleared with additional loss of Van Arsdel-Clay Lick-South Anderson Circuit and Mercer CO. Industrial Park-H.T.Adams-Hunt Farm JCT. Circuit.	8/19	Stable
P4_1B1.02	SLG @ AD2-072 POI on AD2-072 Generator. AD2-072 Breaker 644 stuck. Fault cleared with additional loss of Van Arsdel-Clay Lick-South Anderson Circuit and Mercer CO. Industrial Park-H.T.Adams-Hunt Farm JCT. Circuit.	8/19	Stable
P4_1B1.03	SLG @ AD2-072 POI on Van Arsdel-Clay Lick-South Anderson Circuit. AD2-072 Breaker 654 stuck. Fault cleared with additional loss of AD2-072 and Mercer CO. Industrial Park-H.T.Adams-Hunt Farm JCT. Circuit.	8/19	Stable
P4_1B1.04	SLG @ AD2-072 POI on Mercer CO. Industrial Park-H.T.Adams-Hunt Farm JCT. Circuit. AD2-072 Breaker 644 stuck. Fault cleared with additional loss of AD2-072 and Van Arsdel-Clay Lick-South Anderson Circuit.	8/19	Stable
P4_1B1.05	SLG @ AD2-072 POI on Van Arsdel-Clay Lick-South Anderson Circuit. AD2-072 Breaker 634 stuck. Fault cleared with additional loss of AD2-072 and Mercer CO. Industrial Park-H.T.Adams-Hunt Farm JCT. Circuit.	8/19	Stable
P4_1B1.06	SLG @ AD2-072 POI on Mercer CO. Industrial Park-H.T.Adams-Hunt Farm JCT. Circuit. AD2-072 Breaker 634 stuck. Fault cleared with additional loss of AD2-072 and Van Arsdel-Clay Lick-South Anderson Circuit.	8/19	Stable
P4_1B1.07	SLG @ South Anderson on AD2-072 POI-Van Arsdel-Clay Lick Circuit. South Anderson Breaker 644 stuck. Fault cleared with additional loss of Powell-Taylor Circuit, Bonds Mill Circuit 1, Bonds Mill Circuit 2 and Sinai-Chaplin-Bloomfield-North Springfield Circuit.	8/19	Stable
P4_1B1.08	SLG @ South Anderson on Powell-Taylor Circuit. South Anderson Breaker 614 stuck. cleared with additional loss of AD2-072 POI-Van Arsdel-Clay Lick Circuit, Bonds Mill Circuit 1, Bonds Mill Circuit 2 and Sinai-Chaplin-Bloomfield-North Springfield Circuit.	8/19	Stable
P4_1B1.09	SLG @ South Anderson on Sinai-Chaplin-Bloomfield-North Springfield Circuit. South Anderson Breaker 614 stuck. Fault cleared with additional loss of Bonds Mill Circuit 1, Bonds Mill Circuit 2, AD2-072 POI-Van Arsdel-Clay Lick Circuit and Powell-Taylor Circuit.	8/19	Stable

Fault ID	Fault description	Clearing Time Normal and Delayed (Cycles)	AD2-072 No Mitigation
P4_1B1.10	SLG @ Hunt Farm JCT. on AD2-072 POI-Mercer CO. Industrial Park-H.T.Adams Circuit. Hunt Farm JCT. Breaker 644 stuck. Fault cleared with additional loss of South Anderson capacitor bank, Ballard-Toddville-Dale Station Circuit and Perryville-Mackville-North Springfield Circuit.	8/19	Stable
P4_1B1.11	SLG @ Hunt Farm JCT. on Ballard-Toddville-Dale Station Circuit. Hunt Farm JCT. Breaker 654 stuck. Fault cleared with additional loss of South Anderson capacitor bank, AD2-072 POI-Mercer CO. Industrial Park-H.T.Adams Circuit and Perryville-Mackville-North Springfield Circuit.	8/19	Stable
P4_1B1.12	SLG @ Hunt Farm JCT. on Perryville-Mackville-North Springfield Circuit. Hunt Farm JCT. Breaker 634 stuck. Fault cleared with additional loss of South Anderson capacitor bank, Ballard-Toddville-Dale Station Circuit and AD2-072 POI-Mercer CO. Industrial Park-H.T.Adams Circuit.	8/19	Stable
P4_1B1.13	SLG @ Hunt Farm JCT. on cap bank. Hunt Farm JCT. Breaker 62C stuck. Fault cleared with additional loss of Ballard-Toddville-Dale Station Circuit, AD2-072 POI-Mercer CO. Industrial Park-H.T.Adams Circuit and Perryville-Mackville-North Springfield Circuit.	8/19	Stable

Table 7: Single-phase Faults with Delayed (Zone 2) Clearing due to Primary Communication/Relay Failure – Category P5

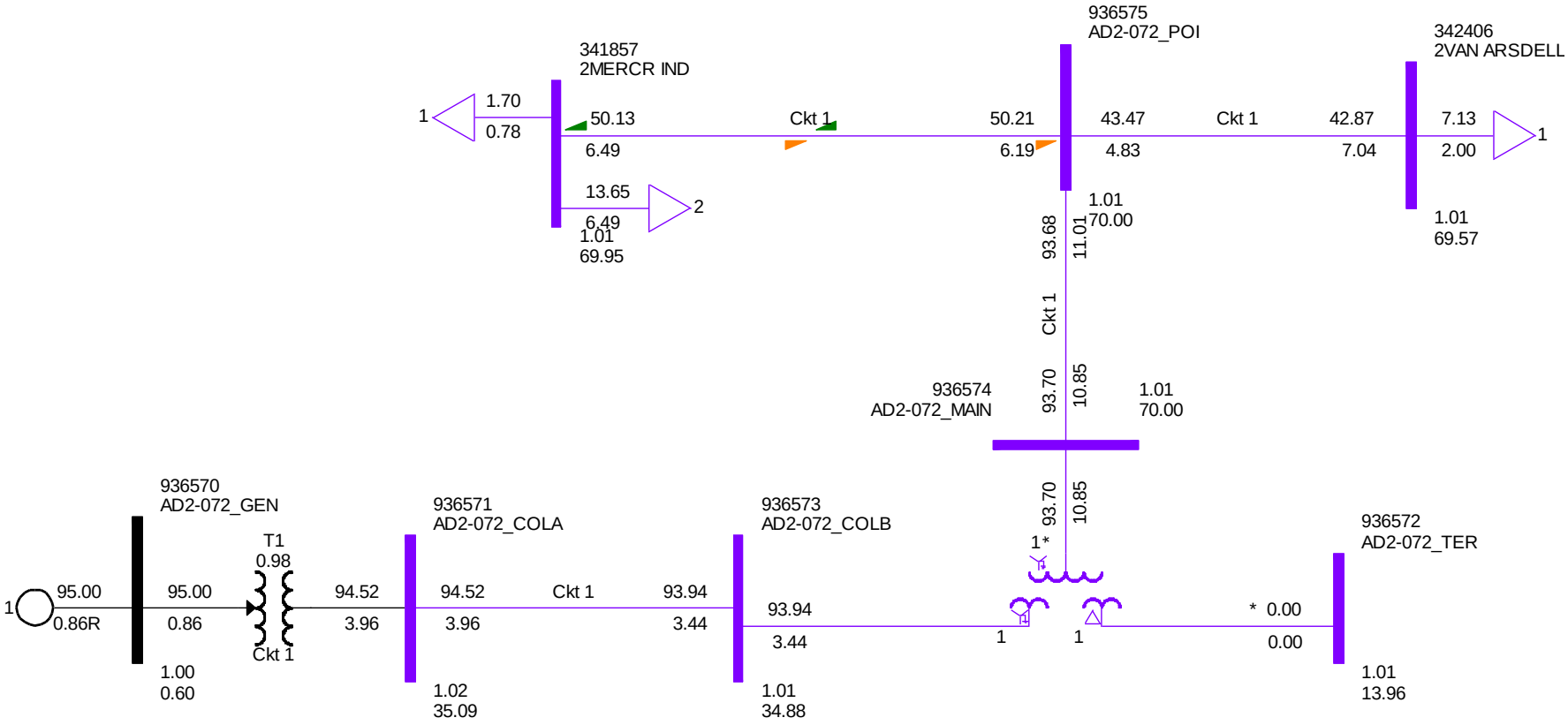
Fault ID	Fault description	Clearing Time (Cycles)	AD2-072 No Mitigation
P5.01	Fault at 80% of 69 kV line from AD2-072 POI to Van Arsdel-Clay Lick-South Anderson. Delayed clearing at AD2-072 POI.	8/45	Stable
P5.02	Fault at 80% of 69 kV line from AD2-072 POI to Mercer CO. Industrial Park-H.T.Adams-Hunt Farm JCT.. Delayed clearing at AD2-072 POI.	8/45	Stable
P5.03	Fault at 80% of 69 kV line from Hunt Farm JCT. to Ballard-Toddville-Dale Station. Delayed clearing at Hunt Farm JCT..	8/45	Stable
P5.04	Fault at 80% of 69 kV line from Hunt Farm JCT. to Perryville-Mackville-North Springfield. Delayed clearing at Hunt Farm JCT..	8/45	Stable
P5.05	Fault at 80% of 69 kV line from South Anderson to Sinai-Chaplin-Bloomfield-North Springfield. Delayed clearing at South Anderson.	8/45	Stable
P5.06	Fault at 80% of 69 kV line from South Anderson to Powell Taylor. Delayed clearing at South Anderson.	8/45	Stable

Fault ID	Fault description	Clearing Time (Cycles)	AD2-072 No Mitigation
P5.07	Fault at 80% of 69 kV line from South Anderson to Bonds Mill Circuit 1. Delayed clearing at South Anderson.	8/45	Stable
P5.08	Fault at 80% of 69 kV line from South Anderson to Bonds Mill Circuit 2. Delayed clearing at South Anderson.	8/45	Stable

Attachment 1. Impact Study Data

Attachment 2. EKPC One Line Diagram

Attachment 3. PSS/E Model One Line Diagram



Attachment 4. AD2-072 PSS/E Dynamic Model

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/*****************************************************************
/*** Project:       AD2-072
/*****************************************************************

/*****************************************************************
/*****************************************************************
/*****************************************************
/*** Project:              AD2-072  - MFO   95.00 MW
/*** POI:                          Tap on Van Arsdell - Mercer Industrial 69 kV circuit 1
/*** Inverter:             TMEIC PVH-L2700GR Solar PV Inverter
/*** Size:                         38 X 2.5 MW  Solar PV Inverter
/*** PSSE Version:     33
/*****************************************************

936570 'USRMDL' 1 'REGCAU1' 101,1,1,14,3,4,1,
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0.0,10.0,-10.0,0.0 /
936570 'USRMDL' 1 'REECBU1' 102,0,5,25,6,4,
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0.377,-0.377,1.1,0.9,0.0,
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-2.0,0.926,0.0,1.0,0.02 /
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936575 936574 936575 '1' 1 1 0
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93657001 'VTGTPAT' 936575 936570 1 -1 1.200 0 0.0 /
93657002 'VTGTPAT' 936575 936570 1 -1 1.175 0.2 0.0 /
93657003 'VTGTPAT' 936575 936570 1 -1 1.15 0.5 0.0 /
93657004 'VTGTPAT' 936575 936570 1 -1 1.10 1 0.0 /
93657005 'VTGTPAT' 936575 936570 1 0.45 5 0.155 0.0 /
93657006 'VTGTPAT' 936575 936570 1 0.65 5 0.30 0.0 /
93657007 'VTGTPAT' 936575 936570 1 0.75 5 2 0.0 /
93657008 'VTGTPAT' 936575 936570 1 0.90 5 3 0.0 /
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93657010 'FRQTPAT' 936575 936570 1 -100 60.5 600.66 0.0 /
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/**
/*** Project: AD2-072 ends
/**

Attachment 5. AD2-072 PSS/E Case Dispatch

Bus Number	Bus Name	Id	In Service	PGen (MW)	PMax (MW)	PMin (MW)	QGen (Mvar)	QMax (Mvar)	QMin (Mvar)	Mbase (MVA)
936570	AD2-072_GEN 0.6000	1	1	95	95	0	0.8644	38.753	-38.753	102.6