



Revised

Generation Interconnection

System Impact Study Report

for

Queue Project AE2-071

PATTON RD-SUMMER SHADE 69 KV

21 MW Capacity / 35 MW Energy

August 2022

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, a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. Cost allocation rules for network upgrades can be found in PJM Manual 14A, Attachment B. 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 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.

An Interconnection Customer 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 General

The Interconnection Customer (IC), has proposed a Solar generating facility located in Metcalfe, Kentucky. The installed facilities will have a total capability of 35 MW with 21 MW of this output being recognized by PJM as Capacity.

The proposed in-service date for this project is 12/31/2021. This study does not imply a TO commitment to this in-service date.

Queue Number	AE2-071
Project Name	PATTON RD-SUMMER SHADE 69 KV
Interconnection Customer	Carolina Solar Energy III, LLC
State	Kentucky
County	Metcalfe
Transmission Owner	EKPC
MFO	35
MWE	35
MWC	21
Fuel	Solar
Basecase Study Year	2022

2.1 Point of Interconnection

AE2-071 will interconnect with the EKPC transmission system tapping the Patton Rd. to Summer Shade 69kV line.

2.2 Cost Summary

The AE2-071 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	\$610,000
Direct Connection Network Upgrade	\$5,420,000
Non Direct Connection Network Upgrades	\$795,000
Allocation for New System Upgrades	\$310,000
Contribution for Previously Identified Upgrades	\$0
Total Costs	\$7,135,000

3 Transmission Owner Scope of Work

4 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	Total Cost
Install necessary equipment (a 69 kV isolation switch structure and associated switch, plus interconnection metering, fiber-optic connection and telecommunications equipment, circuit breaker and associated switches, and relay panel) at the new Eighty Eight switching station, to accept the IC generator lead line/bus (Estimated time to implement is 24 months)	\$610,000
Total Attachment Facility Costs	\$610,000

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
Construct a new 69 kV switching station to 161 kV standards (Eighty Eight Switching) to facilitate connection of the IC solar generation project to the existing Patton Road Junction-Summer Shade 69 kV line (Estimated time to implement is 24 months)	\$5,420,000
Total Direct Connection Facility Costs	\$5,420,000

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
Construct facilities to loop the existing Patton Road Junction-Summer Shade 69 kV line into the new Eighty Eight switching station (Estimated time to implement is 24 months)	\$560,000
Modify relays and/or settings at Summer Shade substation for the existing line to the new Eighty Eight switching station (Estimated time to implement is 9 months)	\$45,000
Modify relays and/or settings at Fox Hollow substation for the existing line to the new Eighty Eight switching station (Estimated time to implement is 9 months)	\$45,000
Install OPGW on the Eighty Eight-Summer Shade 69 kV line (1.7 miles) (Estimated time to implement is 12 months)	\$145,000
Total Non-Direct Connection Facility Costs	\$795,000

7 Incremental Capacity Transfer Rights (ICTRs)

None

8 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.

9 Revenue Metering and SCADA Requirements

9.1 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.

9.2 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>

10 Network Impacts

The Queue Project AE2-071 was evaluated as a 35.0 MW (Capacity 21.0 MW) injection at Patton Rd - Summer Shade 69kV line in the EKPC area. Project AE2-071 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-071 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

11 Generation Deliverability

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

None.

12 Multiple Facility Contingency

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

#	Contingency		Affected Area	Facility Description	Bus		Cir.	PF	Loading		Rating		MW Con.	FG App.
	Type	Name			From	To			Initial	Final	Type	MVA		
1	LFFB	EKPC_P4-2_GREEN W45-1014	EKPC - EKPC	2EDM-JBGAL J-2KNOB LICK 69 kV line	341431	341728	1	AC	96.61	101.7	ER	46	2.75	1
2	DCTL	EKPC_P7-1_COOP 161 DBL 2	EKPC - LGEE	2SOMERSET KU-2FERGUSON SO 69 kV line	342287	324531	1	AC	99.1	103.41	ER	105	3.21	2
3	DCTL	EKPC_P7-1_LAURL 161 DBL	EKPC - LGEE	5COOPER2-5ELIHU 161 kV line	342718	324141	1	AC	99.79	101.36	ER	277	4.28	3
4	LFFB	EKPC_P4-5_LAURL S50-1024	EKPC - LGEE	5COOPER2-5ELIHU 161 kV line	342718	324141	1	AC	99.78	101.35	ER	277	4.28	

13 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.

14 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 Area	Facility Description	Bus		Cir.	PF	Loading		Rating		MW Con.	FG App.
#	Type	Name			From	To			Initial	Final	Type	MVA		
5	N-1	EKPC_P1-2_LAUR-L DAM161	EKPC - LGEE	5COOPER2-5ELIHU 161 kV line	342718	324141	1	AC	99.54	101.11	ER	277	4.29	

15 Steady-State Voltage Requirements

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

None.

16 Stability and Reactive Power Requirements for Low Voltage Ride Through

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

See Attachment 2.

17 Light Load Analysis

Light Load Studies (applicable to wind, coal, nuclear, and pumped storage projects).

Not required

18 System Reinforcements

Facility	Upgrade Description	Cost	Cost Allocation	Upgrade Number
2EDM-JBGAL J-2KNOB LICK 69 kV line (from bus 341431 to bus 341728 ckt 1)	<p>EKPC EKPC SE rating is 46 MVA.</p> <p>EKPC Reinforcement N6494: Increase the maximum operating temperature of the 266 MCM ACSR conductor in the Edmonton/JB Galloway JctKnob Lick 6 9kV line section to 176 degrees F (5.7 miles) Project Type : FAC Cost : \$ 310,000 Time Estimate : 12 Months New Ratings: Rate A: 46 MVA Rate B: 50 MVA Rate C: 53 MVA</p> <p>AE2-071 is the driver for this reinforcement.</p>	\$310,000	\$310,000	N6494
2SOMERSET KU-2FERGUSON SO 69 kV line (from bus 342287 to bus 324531 ckt 1)	<p>EKPC No violation. EKPC SE rating is 152 MVA.</p> <p>LGEE LGEE has been identified as an Affected System. LG&E-end impacts will be determined during the Facilities Study. The customer is required to sign a LG&E Affected System Study Agreement. The affected system study is required to determine if this upgrade is required.</p> <p>LGEE Reinforcement Replace terminal equipment. \$897.613 K.</p>	\$0	\$0	N/A
5SCOOPER2-5ELIHU 161 kV line (from bus 342718 to bus 324141 ckt 1)	<p>EKPC EKPC SE rating is 298 MVA. No upgrade required</p> <p>LGEE LGEE SE rating is 277 MVA</p> <p>LGEE has been identified as an Affected System. LG&E-end impacts will be determined during the Facilities Study. The customer is required to sign a LG&E Affected System Study Agreement. The affected system study is required to determine if this upgrade is required.</p> <p>LGEE Reinforcement Upgrade line conductor. \$28.083 K. New SE rating to be 335 MVA.</p>	\$0	\$0	N/A
	Total	\$310,000	\$310,000	

Affected Systems

19 Affected Systems

19.1 LG&E

None.

19.2 MISO

None.

19.3 TVA

None

19.4 Duke Energy Progress

None

20 Contingency Descriptions

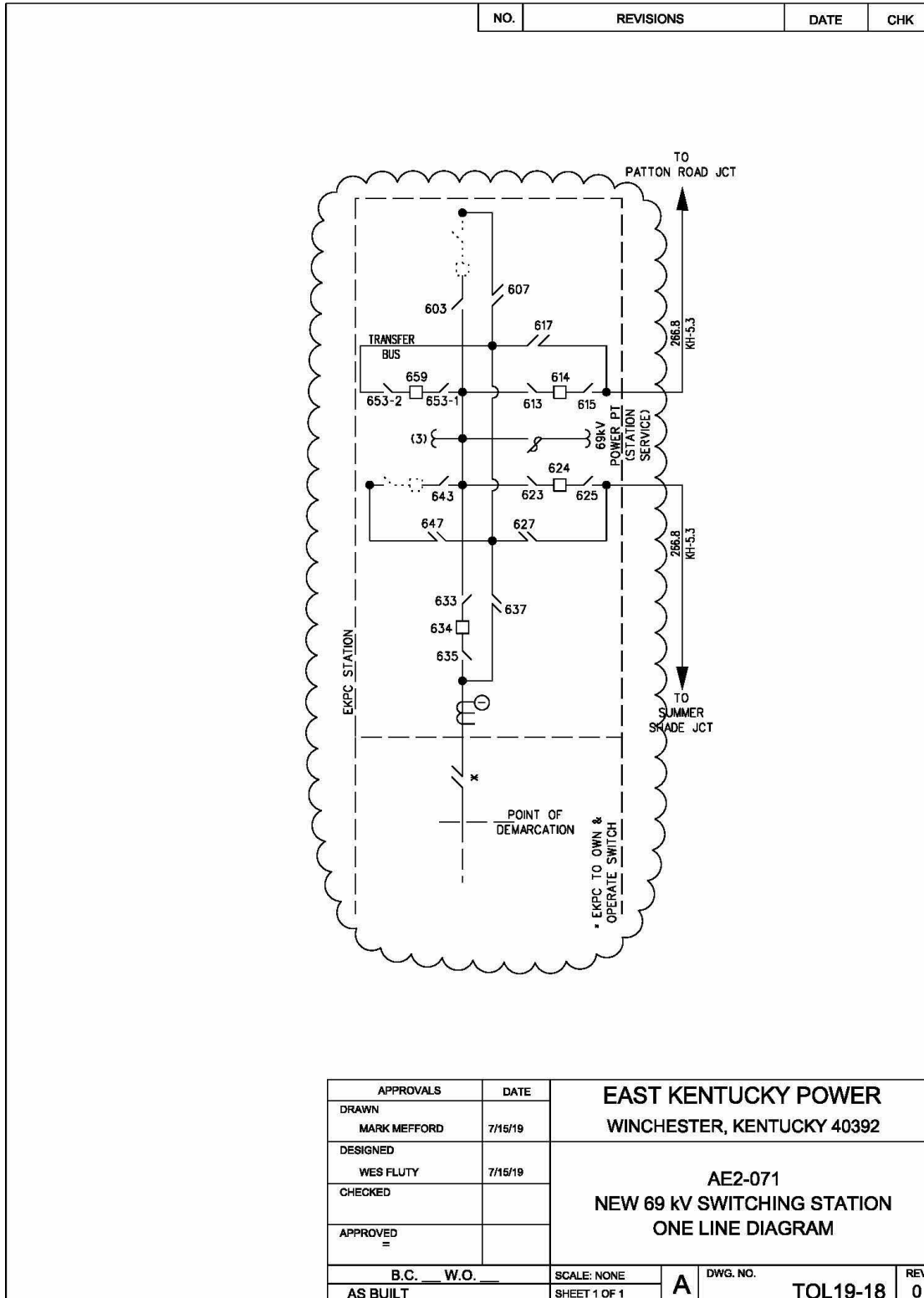
Contingency Name	Contingency Definition
EKPC_P1-2_LAUR-L DAM161	CONTINGENCY 'EKPC_P1-2_LAUR-L DAM161' /* LAUREL CO - LAUREL DAM OPEN BRANCH FROM BUS 342754 TO BUS 342757 CKT 1 /* 342754 5LAUREL CO 161.00 342757 5LAUREL DAM 161.00 END
EKPC_P4-2_GREEN W45-1014	CONTINGENCY 'EKPC_P4-2_GREEN W45-1014' /* GREEN CO OPEN BUS 342733 /* 5GREEN CO DROPS BUS OPEN BRANCH FROM BUS 342817 TO BUS 342818 CKT 1 /* 342817 5TAYLOR CO J161.00 342818 5TAYLR CO 161.00 OPEN BRANCH FROM BUS 342805 TO BUS 342817 CKT 1 /* 342805 5SALOMA T 161.00 342817 5TAYLOR CO J161.00 OPEN BRANCH FROM BUS 342802 TO BUS 342805 CKT 1 /* 342802 5SALOMA 161.00 342805 5SALOMA T 161.00 OPEN BRANCH FROM BUS 342775 TO BUS 342805 CKT 1 /* 342775 5MARION IP T161.00 342805 5SALOMA T 161.00 OPEN BRANCH FROM BUS 342772 TO BUS 342775 CKT 1 /* 342772 5MARION IP 161.00 342775 5MARION IP T161.00 OPEN BRANCH FROM BUS 342769 TO BUS 342775 CKT 1 /* 342769 5MARION CO 161.00 342775 5MARION IP T161.00 END
EKPC_P4-5_LAURL S50-1024	CONTINGENCY 'EKPC_P4-5_LAURL S50-1024' /* LAUREL CO OPEN BUS 342754 /* 5LAUREL CO DROPS BUS OPEN BRANCH FROM BUS 324688 TO BUS 342781 CKT 1 /* 324688 2PITTSKU 69.000 342781 5PITTSBURG 161.00 OPEN BRANCH FROM BUS 342781 TO BUS 342820 CKT 1 /* 342781 5PITTSBURG 161.00 342820 5TYNER 161.00 END
EKPC_P7-1_COOP 161 DBL 2	CONTINGENCY 'EKPC_P7-1_COOP 161 DBL 2' /* COOPER - ELIHU 161 & COOPER - LAUREL DAM 161 OPEN BRANCH FROM BUS 324141 TO BUS 342718 CKT 1 /* 324141 5ELIHU 161.00 342718 5COOPER2 161.00 OPEN BRANCH FROM BUS 342718 TO BUS 342757 CKT 1 /* 342718 5COOPER2 161.00 342757 5LAUREL DAM 161.00 END
EKPC_P7-1_LAURL 161 DBL	CONTINGENCY 'EKPC_P7-1_LAURL 161 DBL' /* LAUREL CO - LAUREL DAM 161 & LAUREL CO - TYNER 161 OPEN BRANCH FROM BUS 342754 TO BUS 342757 CKT 1 /* 342754 5LAUREL CO 161.00 342757 5LAUREL DAM 161.00 OPEN BRANCH FROM BUS 342754 TO BUS 342781 CKT 1 /* 342754 5LAUREL CO 161.00 342781 5PITTSBURG 161.00 OPEN BRANCH FROM BUS 342781 TO BUS 342820 CKT 1 /* 342781 5PITTSBURG 161.00 342820 5TYNER 161.0 END

Short Circuit

21 Short Circuit

None

Attachment 1. Single Line Diagram (Primary POI)



Attachment 2. Stability Study Report Results

Executive Summary

Generator Interconnection Request AE2-071 is for a 35.0 MW Maximum Facility Output (MFO) solar generation plant. AE2-071 consists of 8×4.375 MW, SMA Solar Technology SC4400 UP solar PV inverters with a total capacity of 35.0 MW. The Point of Interconnection (POI) is at a tap on Patton Rd – Summer Shade 69 kV circuit in the East Kentucky Power Cooperative (EKPC) transmission system, Metcalfe county, Kentucky.

This report describes a dynamic simulation analysis of AE2-071 as part of the overall system impact study.

The loadflow scenario for the analysis was based on the RTEP 2022 peak load case, modified to include applicable queue projects. AE2-071 has been dispatched online at maximum power output. AE2-071 does not have any reactive power capability since it operates with unity power factor as specified by the developer.

AE2-071 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. Steady-state condition and 38 contingencies were studied, each with a 20 second simulation time period. Studied faults included:

- a) Steady-state operation (20 second run);
- b) Three-phase faults with normal clearing time;
- c) Single-phase faults with stuck breaker;
- d) Single-phase faults placed at 80% of the line with delayed (Zone 2) clearing at line end remote from the fault due to primary communications/relay failure;

No relevant bus faults, multiple-circuit tower line faults and high-speed reclosing (HSR) schemes were identified for this study.

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 the fault contingencies tested on the 2022 peak load case:

- a) AE2-071 was able to ride through the faults (except for faults where protective action trips a generator(s)),
- b) The system with AE2-071 included is transiently stable and post-contingency oscillations were positively damped with a damping margin of at least 3% for interarea and local 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 AE2-071 does not meet the 0.95 lagging and leading PF requirement at the high-voltage side of the main transformer.

22 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

(EKPC - EKPC) The 2EDM-JBGAL J-2KNOB LICK 69 kV line (from bus 341431 to bus 341728 ckt 1) loads from 96.61% to 101.7% (AC power flow) of its emergency rating (46 MVA) for the line fault with failed breaker contingency outage of 'EKPC_P4-2_GREEN W45-1014'. This project contributes approximately 2.75 MW to the thermal violation.

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CONTINGENCY 'EKPC_P4-2_GREEN W45-1014'                /* GREEN CO
OPEN BUS 342733                /* 5GREEN CO DROPS BUS
OPEN BRANCH FROM BUS 342817 TO BUS 342818 CKT 1        /* 342817 5TAYLOR CO J161.00 342818
5TAYLR CO 161.00
OPEN BRANCH FROM BUS 342805 TO BUS 342817 CKT 1        /* 342805 5SALOMA T 161.00 342817 5TAYLOR
CO J161.00
OPEN BRANCH FROM BUS 342802 TO BUS 342805 CKT 1        /* 342802 5SALOMA 161.00 342805 5SALOMA T
161.00
OPEN BRANCH FROM BUS 342775 TO BUS 342805 CKT 1        /* 342775 5MARION IP T161.00 342805
5SALOMA T 161.00
OPEN BRANCH FROM BUS 342772 TO BUS 342775 CKT 1        /* 342772 5MARION IP 161.00 342775 5MARION
IP T161.00
OPEN BRANCH FROM BUS 342769 TO BUS 342775 CKT 1        /* 342769 5MARION CO 161.00 342775
5MARION IP T161.00
END

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<i>Bus Number</i>	<i>Bus Name</i>	<i>Full Contribution</i>
940831	AE2-071 C	1.65
940832	AE2-071 E	1.1
LTF	BLUEG	0.77
LTF	CANNELTON	0.07
LTF	CBM-N	< 0.01
LTF	CBM-S1	0.71
LTF	CBM-S2	0.22
LTF	CBM-W1	0.08
LTF	CBM-W2	3.16
LTF	CPL	0.07
LTF	G-007A	0.02
LTF	GIBSON	0.02
LTF	MEC	0.33
LTF	NYISO	0.02
LTF	TILTON	0.01
LTF	TRIMBLE	0.08
LTF	VFT	0.06
LTF	WEC	< 0.01

Appendix 2

(EKPC - LGEE) The 2SOMERSET KU-2FERGUSON SO 69 kV line (from bus 342287 to bus 324531 ckt 1) loads from 99.1% to 103.41% (AC power flow) of its emergency rating (105 MVA) for the tower line contingency outage of 'EKPC_P7-1_COOP 161 DBL 2'. This project contributes approximately 3.21 MW to the thermal violation.

CONTINGENCY 'EKPC_P7-1_COOP 161 DBL 2' /* COOPER - ELIHU 161 & COOPER - LAUREL DAM 161
 OPEN BRANCH FROM BUS 324141 TO BUS 342718 CKT 1 /* 324141 5ELIHU 161.00 342718 5COOPER2
 161.00
 OPEN BRANCH FROM BUS 342718 TO BUS 342757 CKT 1 /* 342718 5COOPER2 161.00 342757 5LAUREL
 DAM 161.00
 END

<i>Bus Number</i>	<i>Bus Name</i>	<i>Full Contribution</i>
342900	1COOPER1 G	4.87
342903	1COOPER2 G	9.45
939131	AE1-143 C	6.45
939132	AE1-143 E	3.2
940041	AE1-246 C O1	6.26
940042	AE1-246 E O1	3.05
940831	AE2-071 C	1.93
940832	AE2-071 E	1.28
LTF	CARR	0.03
LTF	CBM-S1	2.58
LTF	CBM-S2	0.28
LTF	CBM-W1	1.01
LTF	CBM-W2	13.23
LTF	CIN	0.5
LTF	CPL	0.06
LTF	G-007	0.08
LTF	IPL	0.23
LTF	LGE-0012019	5.14
LTF	MEC	1.69
LTF	O-066	0.52
LTF	RENSSELAER	0.02
LTF	WEC	0.13

Appendix 3

(EKPC - LGEE) The 5COOPER2-5ELIHU 161 kV line (from bus 342718 to bus 324141 ckt 1) loads from 99.79% to 101.36% (AC power flow) of its emergency rating (277 MVA) for the tower line contingency outage of 'EKPC_P7-1_LAURL 161 DBL'. This project contributes approximately 4.28 MW to the thermal violation.

CONTINGENCY 'EKPC_P7-1_LAURL 161 DBL' /* LAUREL CO - LAUREL DAM 161 & LAUREL CO -
 TYNER 161
 OPEN BRANCH FROM BUS 342754 TO BUS 342757 CKT 1 /* 342754 5LAUREL CO 161.00 342757 5LAUREL
 DAM 161.00
 OPEN BRANCH FROM BUS 342754 TO BUS 342781 CKT 1 /* 342754 5LAUREL CO 161.00 342781
 5PITTSBURG 161.00
 OPEN BRANCH FROM BUS 342781 TO BUS 342820 CKT 1 /* 342781 5PITTSBURG 161.00 342820 5TYNER
 161.00
 END

<i>Bus Number</i>	<i>Bus Name</i>	<i>Full Contribution</i>
342900	1COOPER1 G	10.01
342903	1COOPER2 G	19.48
342945	1LAUREL 1G	6.06
939131	AE1-143 C	10.07
939132	AE1-143 E	4.99
940041	AE1-246 C O1	9.07
940042	AE1-246 E O1	4.42
940831	AE2-071 C	2.57
940832	AE2-071 E	1.71
LTF	CARR	0.06
LTF	CBM-S1	3.77
LTF	CBM-S2	0.42
LTF	CBM-W1	1.16
LTF	CBM-W2	18.82
LTF	CIN	0.56
LTF	CPL	0.09
LTF	G-007	0.16
LTF	IPL	0.23
LTF	LGE-0012019	7.96
LTF	MEC	2.28
LTF	O-066	1.06
LTF	RENSSELAER	0.05
LTF	TRIMBLE	0.02
LTF	WEC	0.15