Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AC1-040

Rockport 345 kV

April 2017

Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

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. 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 Feasibility 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

The Interconnection Customer proposes to install PJM Project #AC1-040, a 150.0 MW (57.0 MW Capacity) solar generating facility in Spencer County, IN (see Figure 2). The point of interconnection will be a direct connection to AEP's Rockport 345 kV substation (see Figure 1).

The requested in service date is December 31, 2020.

Attachment Facilities

Point of Interconnection (Rockport 345 kV Substation)

To accommodate the interconnection at the Rockport 345 kV substation, the substation will have to be expanded requiring the installation of two (2) 345 kV circuit breakers, extending the two 345 kV buses, and starting a new string (see Figure 1). Installation of associated protection and control equipment, 345 kV line risers, SCADA, and 345 kV revenue metering will also be required.

Rockport Station Work:

- Expand the Rockport 345 kV substation, start a new string, extend the two 345 kV buses and install two (2) 345 kV circuit breakers (see Figure 1). Installation of associated protection and control equipment, 345 kV line risers, SCADA, and 345 kV revenue metering will also be required.
    - **Estimated Station Cost: $3,000,000**

Non-Direct Connection Cost Estimate

The total preliminary cost estimate for Non-Direct Connection work is given in the following tables below:

For AEP building Direct Connection cost estimates:

Description	Estimated Cost
345 kV Revenue Metering	**$400,000**
Upgrade line protection and controls at the expanded Rockport 345 kV substation.	**$400,000**
Upgrade line protection and control settings at the Rockport 765 kV substation to coordinate with the expanded Rockport 345 kV substation.	**$50,000**
Upgrade line protection and control settings at the Coleman 345 kV substation to coordinate with the expanded Rockport 345 kV substation.	**$50,000**
Upgrade line protection and control settings at the Duff 345 kV substation to coordinate with the expanded Rockport 345 kV	**$50,000**

substation.	
Total	**$950,000**

Table 1

It is understood that the Interconnection Customer is responsible for all costs associated with this interconnection. The cost of the Interconnection Customer's generating plant and the costs for the line connecting the generating plant to the Interconnection Customer's switching station are not included in this report; these are assumed to be the Interconnection Customer's responsibility.

The Generation Interconnection Agreement does not in or by itself establish a requirement for American Electric Power to provide power for consumption at the developer's facilities. A separate agreement may be reached with the local utility that provides service in the area to ensure that infrastructure is in place to meet this demand and proper metering equipment is installed. It is the responsibility of the developer to contact the local service provider to determine if a local service agreement is required.

Interconnection Customer Requirements

Requirement from the PJM Open Access Transmission Tariff:

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.

AEP Requirements

The Interconnection Customer will be required to comply with all AEP Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "Requirements for Connection of New Facilities or Changes to Existing Facilities Connected to the AEP Transmission System" document located at the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-aep/aep-interconnection-requirements.ashx

Network Impacts

The Queue Project AC1-040 was evaluated as a 150.0 MW (Capacity 57.0 MW) injection at the Rockport 345kV substation in the AEP area. Project AC1-040 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC1-040 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Base Case Used

Summer Peak Analysis – 2020 Case

Contingency Descriptions

The following contingencies resulted in overloads:

Option 1	
Contingency Name	**Description**
8901	CONTINGENCY '8901' OPEN BRANCH FROM BUS 243216 TO BUS 247712 CKT 1 / 243216 05DARWIN 345 247712 05SULLIVAN 345 1 OPEN BRANCH FROM BUS 243217 TO BUS 247712 CKT 1 / 243217 05DEQUIN 345 247712 05SULLIVAN 345 1 END
1760_C2_05JEFRSO 765-A	CONTINGENCY '1760_C2_05JEFRSO 765-A' OPEN BRANCH FROM BUS 243207 TO BUS 243208 CKT 1 / 243207 05GRNTWN 765 243208 05JEFRSO 765 1 OPEN BRANCH FROM BUS 242924 TO BUS 243208 CKT 1 / 242924 05HANG R 765 243208 05JEFRSO 765 1 END
363_B2_TOR1682	CONTINGENCY '363_B2_TOR1682' OPEN BRANCH FROM BUS 243208 TO BUS 243209 CKT 1 / 243208 05JEFRSO 765 243209 05ROCKPT 765 1 END
4812_B2_TOR8931	CONTINGENCY '4812_B2_TOR8931' OPEN BRANCH FROM BUS 242921 TO BUS 242924 CKT 1 / 242921 05CORNU 765 242924 05HANG R 765 1 END
4839_B1_05ROCKPT 765-1	CONTINGENCY '4839_B1_05ROCKPT 765-1' OPEN BRANCH FROM BUS 243209 TO BUS 243442 CKT 1 / 243209 05ROCKPT 765 243442 05RKG1 26.0 1 REMOVE UNIT 1H FROM BUS 243442 / 243442 05RKG1 26.0 REMOVE UNIT 1L FROM BUS 243442 / 243442 05RKG1 26.0 END
8648_C2_05JEFRSO 765-B1	CONTINGENCY '8648_C2_05JEFRSO 765-B1' OPEN BRANCH FROM BUS 243208 TO BUS 243209 CKT 1 / 243208 05JEFRSO 765 243209 05ROCKPT 765 1 OPEN BRANCH FROM BUS 243208 TO BUS 242865 CKT 2 / 243208 05JEFRSO 765 242865 05JEFRSO 345 2 OPEN BRANCH FROM BUS 242865 TO BUS 248000 CKT Z1 / 242865 05JEFRSO 345 248000 06CLIFTY 345 Z1 END
8906_C2_05SULLIVAN 345-C	CONTINGENCY '8906_C2_05SULLIVAN 345-C' OPEN BRANCH FROM BUS 243216 TO BUS 247712 CKT 1 / 243216 05DARWIN 345 247712 05SULLIVAN 345 1 OPEN BRANCH FROM BUS 243217 TO BUS 247712 CKT 1 / 243217 05DEQUIN 345 247712 05SULLIVAN 345 1

Option 1	
Contingency Name	**Description**
	END
H1TH3	CONTINGENCY 'H1TH3' /* BATH CO. REMOVE MACHINE 5 FROM BUS 315205 /*BATH UNIT #5 REMOVE MACHINE 6 FROM BUS 315206 /*BATH UNIT #6 REMOVE MACHINE 1 FROM BUS 315201 /*BATH UNIT #1 REMOVE MACHINE 2 FROM BUS 315202 /*BATH UNIT #2 END
P04	CONTINGENCY 'P04' DISCONNECT BUS 200122 /* DISCONNECT BUS 200192 /* DISCONNECT BUS 200193 /* DISCONNECT BUS 200194 /* DISCONNECT BUS 200195 /* END

Table 2

Generator Deliverability

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

None

Multiple Facility Contingency

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

AC1-040 Multiple Facility Contingency														
	Contingency				Bus				Loading		Rating		MW	FG
#	Type	Name	Affected Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	Con.	App.
1	LFFB	8648_C2_05JEFRSO 765-B1	AEP - MISO AMIL	05SULLIVAN-7CASEY 345 kV line	247712	346809	1	DC	98.37	99.99	ER	1466	23.86	

Table 3

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)

Note: Please see Appendices for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper table in the Appendix.

AC1-040 Contribution to Previously Identified Overloads															
	Contingency				Bus				Loading		Rating		MW	FG
#	Type	Name	Affected Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	Con.	App.
1	LFFB	1760_C2_05JEFRSO 765-A	AEP - OVEC	05JEFRSO-06CLIFTY 345 kV line	242865	248000	Z1	DC	116.13	118.08	ER	2045	39.78	1
2	LFFB	8648_C2_05JEFRSO 765-B1	AEP - AEP	05DARWIN-05EUGENE 345 kV line	243216	243221	1	DC	102.81	103.27	ER	1419	14.49	2
3	LFFB	8648_C2_05JEFRSO 765-B1	AEP - AEP	05SULLIVAN-05DARWIN 345 kV line	247712	243216	1	DC	102.81	103.27	ER	1419	14.49	3
4	LFFB	8906_C2_05SULLIVAN 345-C	AEP - MISO AMIL	05SULLIVAN-7CASEY 345 kV line	247712	346809	1	DC	113.94	115.18	ER	1466	18.28	4
5	DCTL	8901	AEP - MISO AMIL	05SULLIVAN-7CASEY 345 kV line	247712	346809	1	DC	113.94	115.18	ER	1466	18.28	
6	N-1	363_B2_TOR1682	AEP - BREC	05ROCKPT-7COLEMAN 345 kV line	247851	340563	1	DC	102.2	103.65	NR	1409	20.4	5
7	N-1	363_B2_TOR1682	LGEE - OVEC	7TRIMBLE-06CLIFTY 345 kV line	324114	248000	1	DC	173.17	173.86	ER	1370	9.5	6
8	Non	Non	LGEE - OVEC	7TRIMBLE-06CLIFTY 345 kV line	324114	248000	1	DC	119.85	120.16	NR	1134	3.52	
9	N-1	4812_B2_TOR8931	LGEE - OVEC	7TRIMBLE-06CLIFTY 345 kV line	324114	248000	1	DC	105.9	106.16	ER	1370	3.49	
10	Non	Non	MISO AMIL - MISO AMIL	7NEWTON-7CASEY 345 kV line	347830	346809	1	DC	110.79	110.79	NR	1200	0	7
11	LFFB	H1TH3	MISO AMIL - MISO AMIL	7NEWTON-7CASEY 345 kV line	347830	346809	1	DC	106.49	106.49	ER	1319	0	
12	N-1	P04	MISO AMIL - MISO AMIL	7NEWTON-7CASEY 345 kV line	347830	346809	1	DC	106.32	106.32	ER	1319	0	
13	N-1	4839_B1_05ROCKPT 765-1	MISO AMIL - MISO AMIL	7NEWTON-7CASEY 345 kV line	347830	346809	1	DC	106.13	106.13	ER	1319	0	

Table 4

Steady-State Voltage Requirements

None

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None

Affected System Analysis & Mitigation

MISO Impacts:

MISO Impacts to be determined during later study phases (as applicable).

Stability and Reactive Power Requirement

(Results of the dynamic studies should be inserted here)

To be determined in the System Impact Study Phase

Delivery of Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

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.

AC1-040 Delivery of Energy Portion of Interconnection Request													
	Contingency				Bus				Loading		Rating		MW
#	Type	Name	Affected Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	Con.
1	N-1	363_B2_TOR1682	AEP - AEP	05DARWIN-05EUGENE 345 kV line	243216	243221	1	DC	146.81	147.47	NR	971	14.16
2	N-1	363_B2_TOR1682	AEP - AEP	05SULLIVAN-05DARWIN 345 kV line	247712	243216	1	DC	146.81	147.47	NR	971	14.16
3	N-1	363_B2_TOR1682	AEP - AEP	05SULLIVAN-05DEQUIN 345 kV line	247712	243217	1	DC	132.52	133.04	NR	971	11.24
4	N-1	363_B2_TOR1682	AEP - MISO AMIL	05SULLIVAN-7CASEY 345 kV line	247712	346809	1	DC	105.24	107	NR	1334	23.47
5	N-1	363_B2_TOR1682	AEP - BREC	05ROCKPT-7COLEMAN 345 kV line	247851	340563	1	DC	118.63	122.44	NR	1409	53.67
6	N-1	363_B2_TOR1682	LGEE - OVEC	7TRIMBLE-06CLIFTY 345 kV line	324114	248000	1	DC	182.71	184.54	ER	1370	24.99
7	Non	Non	LGEE - OVEC	7TRIMBLE-06CLIFTY 345 kV line	324114	248000	1	DC	116.66	117.03	NR	1134	9.26
8	Non	Non	MISO AMIL - MISO AMIL	7NEWTON-7CASEY 345 kV line	347830	346809	1	DC	110.79	110.79	NR	1200	0
9	N-1	4839_B1_05ROCKPT 765-1	MISO AMIL - MISO AMIL	7NEWTON-7CASEY 345 kV line	347830	346809	1	DC	106.13	106.13	ER	1319	0
10	N-1	363_B2_TOR1682	AEP - AEP	AB2-028 TAP-05DESOTO 345 kV line	923880	243218	1	DC	106.46	106.95	NR	1016	11.03

Table 5

Light Load Analysis - 2020

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

New System Reinforcements

#	Overloaded Facility	Upgrade Description	Schedule	Estimated Cost
#1	05JEFRSO-06CLIFTY 345 kV line	A Sag Study will be required on the 0.75 mile section of line to mitigate the overload on the Jefferson - Clifty Creek 345 kV line to determine if the line can be operated above its emergency rating of 2045 MVA. The result could prove that no additional upgrades are necessary, that some upgrades on the circuit are necessary, or that the entire 0.75 mile section of line would need to be rebuilt. This is an AEP-OVEC tie line therefore; PJM is going to have to coordinate this upgrade with OVEC as well to make sure that their equipment will not set a limit lower than what is specified here.	Sag Study: 6 to 12 months. Rebuild/Reconductor: The standard time required for construction differs from state to state. An approximate construction time would be 24 to 36 months after signing an interconnection agreement.	**$15,000**
#2	05DARWIN-05EUGENE 345 kV line	The following work will be required to relieve the Darwin – Eugene 345 kV line overload: Reconductor/Rebuild the entire 39.32 mile ACSR/PE ~ 1414 ~ 62/19 ~ Conductor Section 1 Rebuild the entire 0.09 mile ACAR ~ 2303.5 ~ 54/37 ~ Conductor Section 2	An approximate construction time would be 24 to 36 months after signing an interconnection agreement.	**$78.8 Million**
#3	05SULLIVAN-05DARWIN 345 kV line	The following work will be required to relieve the Sullivan – Darwin 345 kV line overload: Reconductor/Rebuild the entire 12.65 mile ACSR/PE ~ 1414 ~ 62/19 ~ Conductor Section 1	An approximate construction time would be 24 to 36 months after signing an interconnection agreement.	**$25.3 Million**
#4	05SULLIVAN-7CASEY 345 kV line	The following work will be required to relieve the Sullivan – Casey 345 kV line overload: AEP owns 0.6 mile section of line between Sullivan/Breed and West Casey 345 kV stations which will need to be rebuilt to increase AEP end ratings. This is an AEP-AMIL tie line therefore, PJM is going to have to coordinate this upgrade with Ameren IL. Per our records, AMIL's portion of the conductor also needs to be reconductored/rebuilt to mitigate this overload	An approximate construction time would be 24 to 36 months after signing an interconnection agreement.	**$2.0 Million**
			Total New Network Upgrades	**$106,071,000**

Table 6

Schedule

It is anticipated that the time between receipt of executed agreements and Commercial Operation may range from 12 to 18 months if no line work is required. If line work is required, construction time would be between 24 to 36 months after signing an interconnection agreement.

Note: The time provided between anticipated normal completion of System Impact, Facilities Studies, subsequent execution of ISA and ICSA documents, and the proposed Backfeed Date is shorter than usual and may be difficult to achieve.

Conclusion

Based upon the results of this Feasibility Study, the construction of the 150.0 MW (57.0 MW Capacity) solar generating facility of the Interconnection Customer (PJM Project #AC1-040) will require the following additional interconnection charges. This plan of service will interconnect the proposed solar generating facility in a manner that will provide operational reliability and flexibility to both the AEP system and the the Interconnection Customer generating facility.

Cost Breakdown for Point of Interconnection (Rockport 345 kV Substation)		
Attachment Cost	Expand Rockport 345 kV Substation	**$3,000,000**
Non-Direct Connection Cost Estimate	345 kV Revenue Metering	**$400,000**
	Upgrade line protection and controls at the expanded Rockport 345 kV substation.	**$400,000**
	Upgrade line protection and control settings at the Rockport 765 kV substation to coordinate with the expanded Rockport 345 kV substation.	**$50,000**
	Upgrade line protection and control settings at the Coleman 345 kV substation to coordinate with the expanded Rockport 345 kV substation.	**$50,000**
	Upgrade line protection and control settings at the Duff 345 kV substation to coordinate with the expanded Rockport 345 kV substation.	**$50,000**
	The following work will be required to relieve the Darwin – Eugene 345 kV line overload: Reconductor/Rebuild the entire 39.32 mile ACSR/PE ~ 1414 ~ 62/19 ~ Conductor Section 1 Rebuild the entire 0.09 mile ACAR ~ 2303.5 ~ 54/37 ~ Conductor Section 2	**$78.8 Million**
	The following work will be required to relieve the Sullivan – Darwin 345 kV line overload: Reconductor/Rebuild the entire 12.65 mile ACSR/PE ~ 1414 ~ 62/19 ~ Conductor Section 1	**$25.3 Million**

Cost Breakdown for Point of Interconnection (Rockport 345 kV Substation)		
	The following work will be required to relieve the Sullivan – Casey 345 kV line overload: AEP owns 0.6 mile section of line between Sullivan/Breed and West Casey 345 kV stations which will need to be rebuilt to increase AEP end ratings. This is an AEP-AMIL tie line therefore, PJM is going to have to coordinate this upgrade with Ameren IL. Per our records, AMIL's portion of the conductor also needs to be reconductored/rebuilt to mitigate this overload	**$2.0 Million**
	A Sag Study will be required on the 0.75 mile section of line to mitigate the overload on the Jefferson - Clifty Creek 345 kV line to determine if the line can be operated above its emergency rating of 2045 MVA. The result could prove that no additional upgrades are necessary, that some upgrades on the circuit are necessary, or that the entire 0.75 mile section of line would need to be rebuilt. This is an AEP-OVEC tie line therefore; PJM is going to have to coordinate this upgrade with OVEC as well to make sure that their equipment will not set a limit lower than what is specified here.	**$15,000**
	Total Estimated Cost for Project AC1-040	**$110,021,000**

Table 7

The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. The cost of remediation for sag limited conductors is not included in this estimate. Final estimates will require an on-site review and coordination to determine final construction requirements.

Appendices

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact.

It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

Appendix 1

(AEP - OVEC) The 05JEFRSO-06CLIFTY 345 kV line (from bus 242865 to bus 248000 ckt Z1) loads from 116.13% to 118.08% (**DC power flow**) of its emergency rating (2045 MVA) for the line fault with failed breaker contingency outage of '1760_C2_05JEFRSO 765-A'. This project contributes approximately 39.78 MW to the thermal violation.

CONTINGENCY '1760_C2_05JEFRSO 765-A'
OPEN BRANCH FROM BUS 243207 TO BUS 243208 CKT 1 / 243207 05GRNTWN 765 243208 05JEFRSO 765 1
OPEN BRANCH FROM BUS 242924 TO BUS 243208 CKT 1 / 242924 05HANGR 765 243208 05JEFRSO 765 1
END

Bus Number	*Bus Name*	*Full Contribution*
247900	*05FR-11G E*	*5.24*
247901	*05FR-12G E*	*5.16*
247902	*05FR-21G E*	*5.51*
247903	*05FR-22G E*	*5.28*
247904	*05FR-3G E*	*10.69*
247905	*05FR-4G E*	*8.04*
247906	*05MDL-1G E*	*9.18*
247907	*05MDL-2G E*	*4.55*
247912	*05MDL-3G E*	*4.76*
247913	*05MDL-4G E*	*4.54*
243442	*05RKG1*	*82.23*
243443	*05RKG2*	*80.99*
274832	*ANNAWAN ; 1U*	*5.56*
294401	*BSHIL;1U E*	*4.46*
294410	*BSHIL;2U E*	*4.46*
274890	*CAYUG;1U E*	*6.82*

Bus Number	*Bus Name*	*Full Contribution*
274891	*CAYUG;2U E*	*6.82*
274849	*CRESCENT ;1U*	*3.04*
990901	*L-005 E*	*6.83*
293516	*O-009 E1*	*4.38*
293517	*O-009 E2*	*2.22*
293518	*O-009 E3*	*2.45*
293715	*O-029 E*	*4.68*
293716	*O-029 E*	*2.56*
293717	*O-029 E*	*2.36*
293771	*O-035 E*	*3.3*
296308	*R-030 C1*	*1.99*
296271	*R-030 C2*	*1.99*
296125	*R-030 C3*	*2.02*
296309	*R-030 E1*	*7.97*
296272	*R-030 E2*	*7.97*
296128	*R-030 E3*	*8.07*
247556	*T-127 C*	*1.16*
247943	*T-127 E*	*4.66*
274853	*TWINGROVE;U1*	*10.38*
274854	*TWINGROVE;U2*	*10.38*
276150	*W2-048 E*	*4.54*
920173	*W3-046 E*	*11.01*
905081	*W4-005 C*	*3.18*
905082	*W4-005 E*	*21.28*
909052	*X2-022 E*	*13.72*

Bus Number	*Bus Name*	*Full Contribution*
900404	*X3-028 C*	*266.22*
900405	*X3-028 E*	*354.96*
913222	*Y1-054 E*	*-1.33*
247629	*Y3-038*	*11.71*
915662	*Y3-099 E*	*0.14*
915672	*Y3-100 E*	*0.14*
LTF	*Z1-043*	*14.28*
916182	*Z1-065 E*	*0.37*
LTF	*Z1-112*	*5.99*
920792	*Z2-087 C*	*1.56*
920793	*Z2-087 E*	*10.46*
LTF	*AA1-001*	*5.96*
LTF	*AA1-071*	*3.99*
921702	*AA2-039 C*	*1.09*
921703	*AA2-039 E*	*7.28*
922592	*AB1-006 C*	*1.49*
922593	*AB1-006 E*	*10.*
922972	*AB1-086 C*	*33.03*
922973	*AB1-086 E*	*1.5*
922982	*AB1-087 C OP*	*97.61*
922983	*AB1-087 E OP*	*4.44*
922992	*AB1-088 C OP*	*97.61*
922993	*AB1-088 E OP*	*4.44*
LTF	*AB2-013*	*8.4*
924041	*AB2-047 C OP*	*1.97*

Bus Number	*Bus Name*	*Full Contribution*
924042	*AB2-047 E OP*	*13.19*
924261	*AB2-070 C OP*	*1.86*
924262	*AB2-070 E OP*	*12.48*
925242	*AB2-178 E*	*1.42*
LTF	*AC1-002*	*41.44*
925581	*AC1-033 C*	*0.73*
925582	*AC1-033 E*	*4.89*
927331	*AC1-040 C*	*15.12*
927332	*AC1-040 E*	*24.66*
925771	*AC1-053 C*	*1.86*
925772	*AC1-053 E*	*12.48*
926821	*AC1-168 C OP*	*0.54*
926822	*AC1-168 E OP*	*3.64*
926841	*AC1-171 C OP*	*0.63*
926842	*AC1-171 E OP*	*4.23*
927201	*AC1-214 C*	*1.1*
927202	*AC1-214 E*	*3.33*

Appendix 2

(AEP - AEP) The 05DARWIN-05EUGENE 345 kV line (from bus 243216 to bus 243221 ckt 1) loads from 102.81% to 103.27% (**DC power flow**) of its emergency rating (1419 MVA) for the line fault with failed breaker contingency outage of '8648_C2_05JEFRSO 765-B1'. This project contributes approximately 14.49 MW to the thermal violation.

CONTINGENCY '8648_C2_05JEFRSO 765-B1'
OPEN BRANCH FROM BUS 243208 TO BUS 243209 CKT 1 / 243208 05JEFRSO 765 243209 05ROCKPT 765 1
OPEN BRANCH FROM BUS 243208 TO BUS 242865 CKT 2 / 243208 05JEFRSO 765 242865 05JEFRSO 345 2
OPEN BRANCH FROM BUS 242865 TO BUS 248000 CKT Z1 / 242865 05JEFRSO 345 248000 06CLIFTY 345 Z1
END

Bus Number	*Bus Name*	*Full Contribution*
243442	*05RKG1*	*28.96*
243443	*05RKG2*	*28.52*
900404	*X3-028 C*	*257.82*
900405	*X3-028 E*	*343.76*
247629	*Y3-038*	*4.12*
922982	*AB1-087 C OP*	*94.53*
922983	*AB1-087 E OP*	*4.3*
922992	*AB1-088 C OP*	*94.53*
922993	*AB1-088 E OP*	*4.3*
927331	*AC1-040 C*	*5.51*
927332	*AC1-040 E*	*8.99*

Appendix 3

(AEP - AEP) The 05SULLIVAN-05DARWIN 345 kV line (from bus 247712 to bus 243216 ckt 1) loads from 102.81% to 103.27% (**DC power flow**) of its emergency rating (1419 MVA) for the line fault with failed breaker contingency outage of '8648_C2_05JEFRSO 765-B1'. This project contributes approximately 14.49 MW to the thermal violation.

CONTINGENCY '8648_C2_05JEFRSO 765-B1'
OPEN BRANCH FROM BUS 243208 TO BUS 243209 CKT 1 / 243208 05JEFRSO 765 243209 05ROCKPT 765 1
OPEN BRANCH FROM BUS 243208 TO BUS 242865 CKT 2 / 243208 05JEFRSO 765 242865 05JEFRSO 345 2
OPEN BRANCH FROM BUS 242865 TO BUS 248000 CKT Z1 / 242865 05JEFRSO 345 248000 06CLIFTY 345 Z1
END

Bus Number	*Bus Name*	*Full Contribution*
243442	*05RKG1*	*28.96*
243443	*05RKG2*	*28.52*
900404	*X3-028 C*	*257.82*
900405	*X3-028 E*	*343.76*
247629	*Y3-038*	*4.12*
922982	*AB1-087 C OP*	*94.53*
922983	*AB1-087 E OP*	*4.3*
922992	*AB1-088 C OP*	*94.53*
922993	*AB1-088 E OP*	*4.3*
927331	*AC1-040 C*	*5.51*
927332	*AC1-040 E*	*8.99*

Appendix 4

(AEP - MISO AMIL) The 05SULLIVAN-7CASEY 345 kV line (from bus 247712 to bus 346809 ckt 1) loads from 113.94% to 115.18% (**DC power flow**) of its emergency rating (1466 MVA) for the line fault with failed breaker contingency outage of '8906_C2_05SULLIVAN 345-C'. This project contributes approximately 18.28 MW to the thermal violation.

CONTINGENCY '8906_C2_05SULLIVAN 345-C'
OPEN BRANCH FROM BUS 243216 TO BUS 247712 CKT 1 / 243216 05DARWIN 345 247712 05SULLIVAN 345 1
OPEN BRANCH FROM BUS 243217 TO BUS 247712 CKT 1 / 243217 05DEQUIN 345 247712 05SULLIVAN 345 1
END

Bus Number	*Bus Name*	*Full Contribution*
243442	*05RKG1*	*36.81*
243443	*05RKG2*	*36.26*
900404	*X3-028 C*	*505.7*
900405	*X3-028 E*	*674.26*
247629	*Y3-038*	*5.24*
701421	*Y4-043 C*	*0.04*
701422	*Y4-043 E*	*0.12*
701431	*Y4-044 C*	*1.51*
701432	*Y4-044 E*	*4.53*
701491	*Y4-050 C*	*1.01*
701492	*Y4-050 E*	*3.02*
701531	*Y4-054 C*	*0.52*
701532	*Y4-054 E*	*1.57*
701571	*Y4-058*	*5.09*
701581	*Y4-059*	*15.22*
701601	*Y4-061*	*7.64*

Bus Number	*Bus Name*	*Full Contribution*
701701	*Y4-071*	*1.51*
701781	*Y4-079*	*5.32*
701791	*Y4-080*	*1.53*
701842	*Y4-085 E*	*1.*
701881	*Y4-089*	*7.61*
701891	*Y4-090*	*1.5*
916522	*Z1-108 E*	*1.2*
LTF	*AA1-051*	*6.28*
LTF	*AA1-053*	*59.97*
LTF	*AA1-055*	*185.53*
922982	*AB1-087 C OP*	*185.42*
922983	*AB1-087 E OP*	*8.43*
922992	*AB1-088 C OP*	*185.42*
922993	*AB1-088 E OP*	*8.43*
927331	*AC1-040 C*	*6.95*
927332	*AC1-040 E*	*11.33*
LTF	*AC1-056*	*16.87*

Appendix 5

(AEP - BREC) The 05ROCKPT-7COLEMAN 345 kV line (from bus 247851 to bus 340563 ckt 1) loads from 102.2% to 103.65% (**DC power flow**) of its normal rating (1409 MVA) for the single line contingency outage of '363_B2_TOR1682'. This project contributes approximately 20.4 MW to the thermal violation.

CONTINGENCY '363_B2_TOR1682'
OPEN BRANCH FROM BUS 243208 TO BUS 243209 CKT 1 / 243208 05JEFRSO 765 243209 05ROCKPT 765 1
END

Bus Number	*Bus Name*	*Full Contribution*
243442	*05RKG1*	*77.59*
243443	*05RKG2*	*76.42*
998111	*J468*	*1.69*
998120	*J515*	*20.58*
900405	*X3-028 E*	*286.3*
247629	*Y3-038*	*11.05*
922982	*AB1-087 C OP*	*78.73*
922992	*AB1-088 C OP*	*78.73*
927331	*AC1-040 C*	*20.4*

Appendix 6

(LGEE - OVEC) The 7TRIMBLE-06CLIFTY 345 kV line (from bus 324114 to bus 248000 ckt 1) loads from 173.17% to 173.86% (**DC power flow**) of its emergency rating (1370 MVA) for the single line contingency outage of '363_B2_TOR1682'. This project contributes approximately 9.5 MW to the thermal violation.

CONTINGENCY '363_B2_TOR1682'
OPEN BRANCH FROM BUS 243208 TO BUS 243209 CKT 1 / 243208 05JEFRSO 765 243209 05ROCKPT 765 1
END

Bus Number	*Bus Name*	*Full Contribution*
243442	*05RKG1*	*38.66*
243443	*05RKG2*	*38.08*
342900	*1COOPER1 G*	*3.1*
342903	*1COOPER2 G*	*6.02*
342910	*1DALE 3G*	*9.18*
342911	*1DALE 4G*	*8.89*
342918	*1JKCT 1G*	*2.44*
342921	*1JKCT 2G*	*2.44*
342924	*1JKCT 3G*	*2.44*
342927	*1JKCT 4G*	*1.62*
342930	*1JKCT 5G*	*1.62*
342933	*1JKCT 6G*	*1.62*
342936	*1JKCT 7G*	*1.62*
342939	*1JKCT 9G*	*1.66*
342942	*1JKCT 10G*	*1.66*
342945	*1LAUREL 1G*	*1.75*
900405	*X3-028 E*	*217.86*
LTF	*Y2-006*	*16.25*

Bus Number	*Bus Name*	*Full Contribution*
247629	*Y3-038*	*5.5*
LTF	*Z1-046*	*18.63*
LTF	*AA1-001*	*6.08*
LTF	*AA1-004*	*15.42*
922982	*AB1-087 C OP*	*59.91*
922992	*AB1-088 C OP*	*59.91*
LTF	*AB2-005*	*10.3*
924101	*AB2-054*	*57.43*
924261	*AB2-070 C OP*	*1.33*
LTF	*AB2-075*	*2.42*
LTF	*AB2-076*	*3.07*
LTF	*AC1-002*	*42.48*
927331	*AC1-040 C*	*9.5*
925771	*AC1-053 C*	*1.33*
925981	*AC1-074 C OP*	*4.67*

Appendix 7

(MISO AMIL - MISO AMIL) The 7NEWTON-7CASEY 345 kV line (from bus 347830 to bus 346809 ckt 1) loads from 110.79% to 110.79% (**DC power flow**) of its normal rating (1200 MVA) for non-contingency condition. This project contributes approximately 0.0 MW to the thermal violation.

Bus Number	*Bus Name*	*Full Contribution*
LTF	*Y2-006*	*12.9*
LTF	*Z1-046*	*12.12*
LTF	*AA1-001*	*11.88*
LTF	*AA1-004*	*12.25*
LTF	*AB2-005*	*7.69*
LTF	*AC1-002*	*76.7*