Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AD2-016

Biers Run - Circleville 138kV

July 2018

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 (IC) proposes to increase the generation of its previous PJM Projects #AC2-059 and #AD1-072 request, a combined 147.00 MW (76.23 MW Capacity) solar generating facility in Ross County, Ohio by 127.0 MW (62.5 MW Capacity). The primary point of interconnection is to the proposed 138 kV switching station connecting to AEP's Biers Run – Circleville 138 kV circuit to be constructed by PJM Project #AC2-059. The Secondary Point of interconnection is separate connection to the proposed 138kV switching station to be constructed by PJM Project #AC2-059. The output of the three requests is summarized below:

	AC2-059	AD1-072	AD2-016
Maximum Facility Output (MW)	127	20	127
Capacity (MW)	62.5	13.73	62.5
Planned Backfeed	October 1, 2019	N/A	N/A
Planned In-Service	December 31, 2019	June 1, 2020	December 31, 2020

Attachment Facilities

Primary Point of Interconnection (Biers Run-Circleville 138 kV)

To be constructed by PJM Project #AC2-059.

Note: It is assumed that the 138 kV revenue metering and gen lead installed for the #AC2-059 will be adequate for the additional generation since AD2-016 will be utilizing the same gen lead.

Secondary Point of Interconnection (Biers Run-Circleville 138 kV)

To accommodate a separate point of interconnection at the proposed 138 kV Switching Station connecting to the Biers Run – Circleville 138kV circuit to be constructed by PJM Project #AC2-059 for PJM Project #AD2-016, installation of one (1) additional 138 kV circuit breaker will be required. Installation of associated protection and control equipment, 138 kV line risers, and 138 kV revenue metering will also be required. AEP reserves the right to specify the final acceptable configuration considering design practices, future expansion, and compliance requirements.

Interconnection Customer Requirements

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.

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 – Option 1

The Queue Project AD2-016 was evaluated as a 127.0 MW (Capacity 62.5 MW) uprate to the AD1-072 Queue Project which is tapping the Biers Run to Circleville 138kV line in the AEP area. Project AD2-016 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD2-016 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Analysis - 2021

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
AEP_P1-2_#5808	OPEN BRANCH FROM BUS 243522 TO BUS 243593 CKT 1 / 243522 05HARRIS 138 243593 05ZUBER 138 1 END
'AEP_P7-1_#8126_B_B'	CONTINGENCY 'AEP_P7-1_#8126_B_B' OPEN BRANCH FROM BUS 937230 TO BUS 243483 CKT 1 / 937230 AD2-162 TAP 138 243483 05CRCLVS 138 1 OPEN BRANCH FROM BUS 246889 TO BUS 246890 CKT 1 / 246889 05BIERSR 138 246890 05HOPETN 138 1 END
'AEP_P7-1_#8126_B_A'	CONTINGENCY 'AEP_P7-1_#8126_B_A' OPEN BRANCH FROM BUS 932410 TO BUS 937230 CKT 1 / 932410 AC2-059 TAP 138 937230 AD2-162 TAP 138 1 OPEN BRANCH FROM BUS 246889 TO BUS 246890 CKT 1 / 246889 05BIERSR 138 246890 05HOPETN 138 1 END
'AEP_P1-2_#349'	CONTINGENCY 'AEP_P1-2_#349' OPEN BRANCH FROM BUS 242528 TO BUS 248005 CKT 1 / 242528 05SPORN 345 248005 06KYGER 345 1 END
AEP_P1-2_#5764	OPEN BRANCH FROM BUS 243522 TO BUS 243550 CKT 1 / 243522 05HARRIS 138 243550 05OBETZ 138 1 OPEN BRANCH FROM BUS 243539 TO BUS 243550 CKT 1 / 243539 05MARION 138 243550 05OBETZ 138 1 END

Table 1

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)

AD2-016 Multiple Facility contingency															
	Contingency		Affected		Bus				Loading		Rating		MW	FG
#	Type	Name	Area	Facility Description	From	To	Ckt.	PF	Initial	Final	Type	MVA	Con.	App.
1	DCTL	'AEP_P7-1_#8126_B_B'	AEP - AEP	05BIERSR 138/69 kV transformer	246889	246893	1	DC	93.47	103.26	ER	130	12.73	
2	DCTL	'AEP_P7-1_#8126_B_A'	AEP - AEP	05BIERSR 138/69 kV transformer	246889	246893	1	DC	93.55	103.34	ER	130	12.73	

Table 2

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)

AD2-016 Contribution to previously identified overloads															
	Contingency		Affected		Bus				Loading		Rating		MW	FG
#	Type	Name	Area	Facility Description	From	To	Ckt.	PF	Initial	Final	Type	MVA	Con.	App.
1	DCTL	'AEP_P7-1_#8126_B_B'	AEP - AEP	05BIERSRUN-05SLATE 69 kV line	246893	243617	1	DC	144.03	151.41	ER	50	8.18	
2	DCTL	'AEP_P7-1_#8126_B_A'	AEP - AEP	05BIERSRUN-05SLATE 69 kV line	246893	243617	1	DC	144.23	151.61	ER	50	8.18	

Table 3

Steady-State Voltage Requirements

None

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

Bus Name	BREAKER	Breaker Capacity (Amps)	Duty Percent With AD2-016	Duty Percent Without AD2-016
05KARL 138 kV	105	16700	100.20%	99.99%

Table 4

Note: Supplemental Project S1334 will be replacing the 138kV Circuit Breakers at Karl Road by 12/31/2019.

Affected System Analysis & Mitigation

LGEE Impacts:

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

MISO Impacts:

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

Duke, Progress & TVA Impacts:

Duke Carolina, Progress, & TVA Impacts to be determined during later study phases (as applicable).

OVEC Impacts:

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

Delivery of Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.
Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed, which will study all overload conditions associated with the overloaded element(s) identified.

AD2-016 Delivery of Energy Portion of Interconnection Request															
	Contingency		Affected		Bus				Loading		Rating		MW	FG	
#	Type	Name	Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	Con.	App.	
1	N-1	AEP_P1-2_#5808	AEP - AEP	05HARRIS-05OBETZ 138 kV line	243522	243550	1	DC	102.53	119.3	ER	173	29.0		
2	Non	Non	AEP-AEP	05HARRIS-05OBETZ 138 kV line	243522	243550	1	DC	90.27	101.79	NR	138	15.9		
3	N-1	'AEP_P1-2_#5764'	AEP-AEP	05HARRIS-05ZUBER 138 kV line	243522	243593	1	DC	97.81	117.4	ER	173	33.88		
2	N-1	'AEP_P1-2_#349'	AEP - AEP	06KYGER-05SPORN 345 kV line	248005	242528	1	DC	133.46	133.83	NR	971	9.79		

Table 5

New System Reinforcements

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

The System Reinforcements listed below are not part of the Bulk Electric System (BES), but were identified by AEP and will be required for the interconnection of AD2-016.

#	Overloaded Facility	Upgrade Description	Schedule	Estimated Cost
#1	05BIERSR 138/69 kV transformer	Replace Biers Run 138/69kV transformer	An approximate construction time would be 12 to 24 months after signing an interconnection agreement.	$1,500,000
			Total Network Upgrades	**$1,500,000**

Table 6

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)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

The System Reinforcements listed below are not part of the Bulk Electric System (BES), but were identified by AEP and will be required for the interconnection of AD2-016.

#	Overloaded Facility	Upgrade Description	Schedule	Estimated Cost
#1	05BIERSRUN-05SLATE 69 kV line	The following work will be required to relieve the Biers Run – Slate 69 kV line overload 5 miles of AEP owned ACSR ~ 211.6 ~ 6/1 ~ PENGUIN (4/0)- conductor section 1 will need to Reconductor/rebuild.	An approximate construction time would be 24 to 36 months after signing an interconnection agreement.	$6,000,000
			Total Network Upgrades	**$6,000,000**

Table 7

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

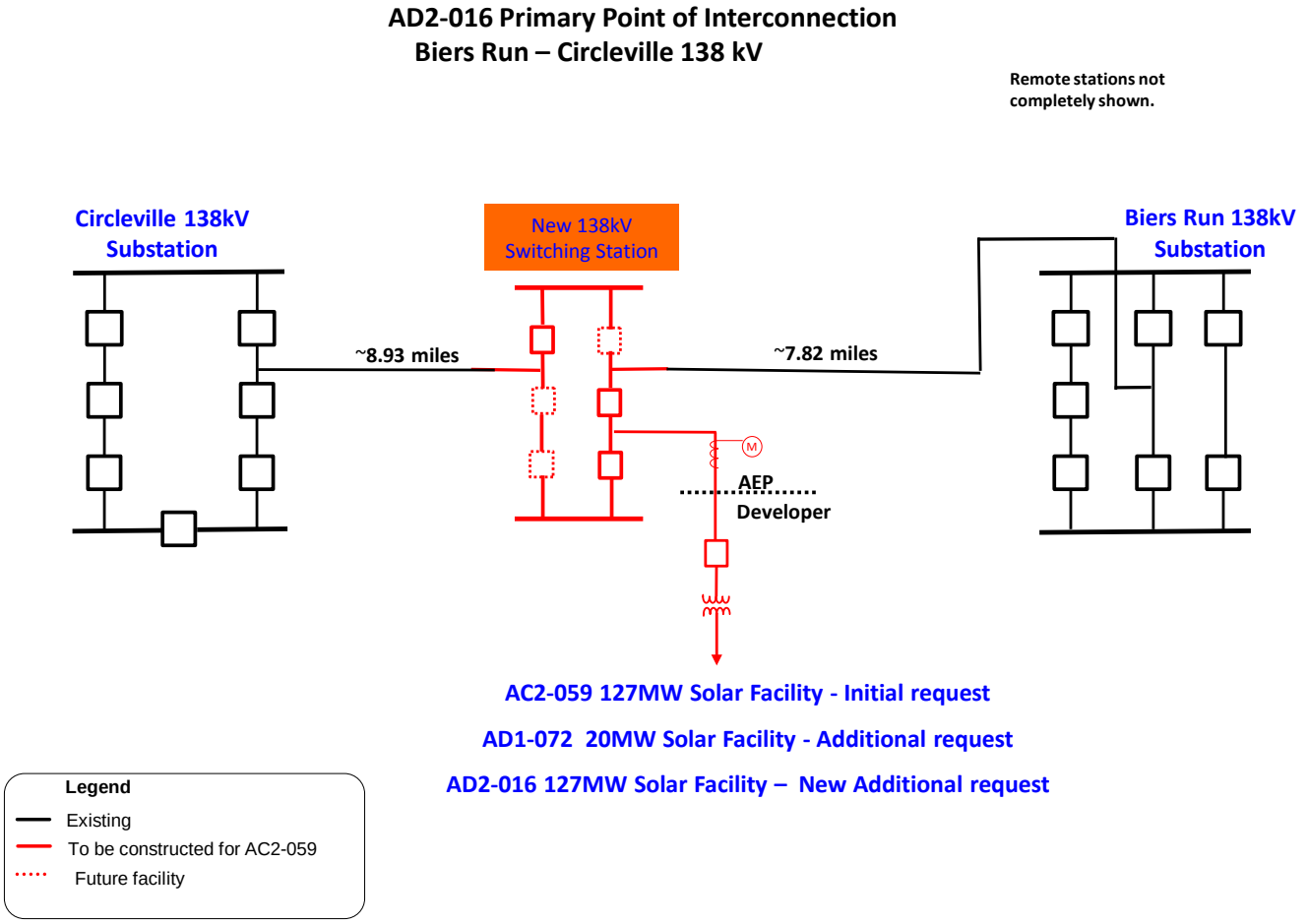
Based upon the results of this Feasibility Study, the increase of 127.0 MW (PJM Project #AD2-016) solar generation to the previous requests (PJM Project #AC2-059 and #AD1-072) will require additional interconnection charges.

Cost Breakdown for Primary Point of Interconnection (Biers Run – Circleville 138kV)		
Attachment Cost	PJM Project AC2-059 will pay for the necessary direct connection work required. Project AC2-059, AD1-072 and AD2-016 will share the same Generator lead to the new 138 kV interconnection switching station being constructed for PJM Project AC2-059.	PJM Project #AC2-059 to pay for Attachment Facilities
Non-Direct Connection Cost Estimate	Replace Biers Run 138/69kV transformer	$1,500,000
	The following work will be required to relieve the Biers Run – Slate 69 kV line overload: 5 miles of AEP owned ACSR ~ 211.6 ~ 6/1 ~ PENGUIN (4/0) - conductor section 1 will need to Reconductor/rebuild.	$6,000,000
	Total Estimated Cost for Project AD2-016	**$7,500,000**

Table 8

Network Impacts – Option 2

The study results are the same for the primary and secondary point of interconnections requested.

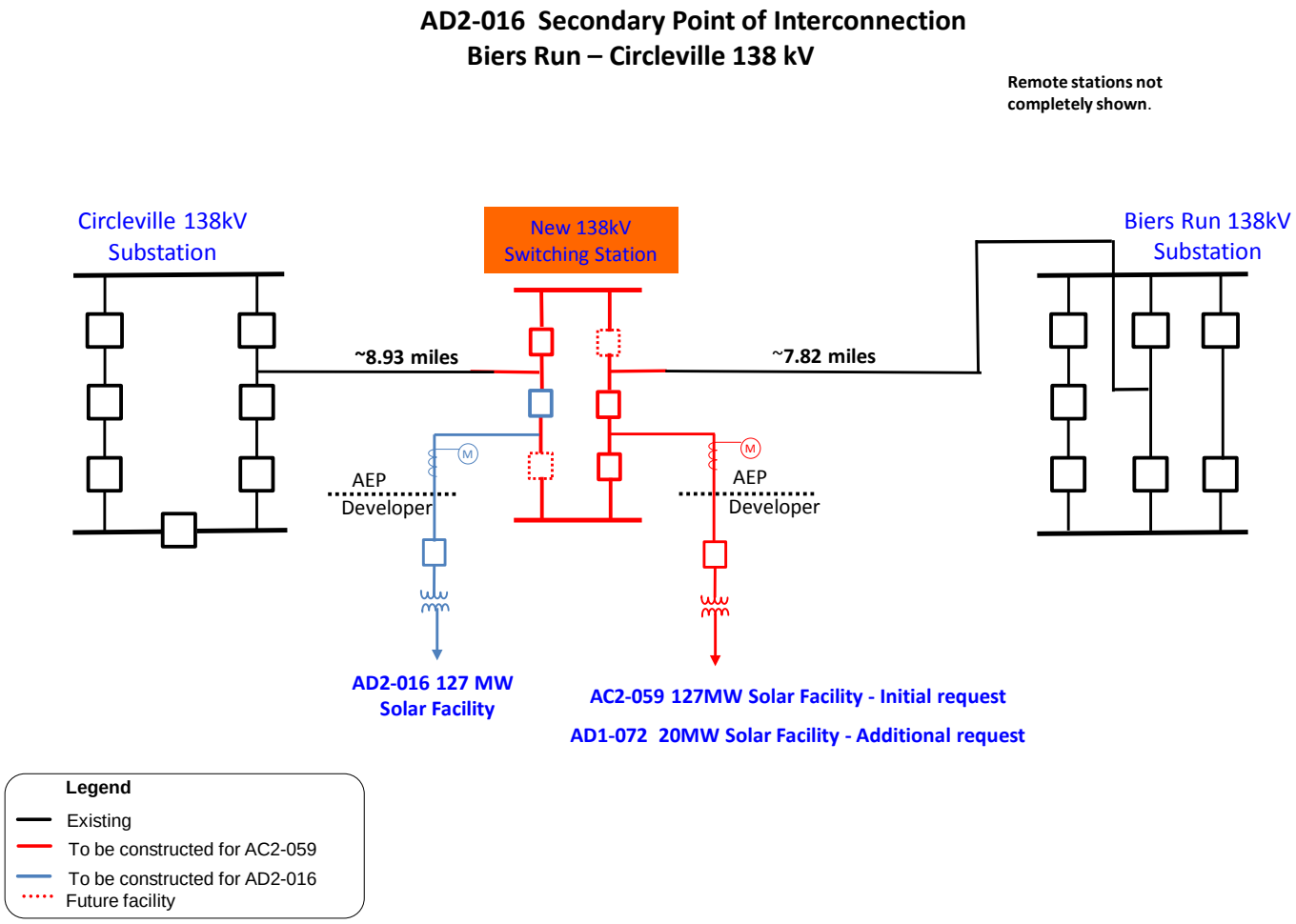


Primary Point of Interconnection (Biers Run – Circleville 138kV)

Single Line Diagram

Secondary Point of Interconnection (Biers Run – Circleville 138kV)

Single Line Diagram



Appendices – The same for Option 1 and Option 2

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

(AEP - AEP) The 05BIERSR 138/69 kV transformer (from bus 246889 to bus 246893 ckt 1) loads from 93.47% to 103.26% (**DC power flow**) of its emergency rating (130 MVA) for the tower line contingency outage of 'AEP_P7-1_#8126_B_B'. This project contributes approximately 12.73 MW to the thermal violation.

CONTINGENCY 'AEP_P7-1_#8126_B_B'
OPEN BRANCH FROM BUS 937230 TO BUS 243483 CKT 1 / 937230 AD2-162 TAP 138 243483 05CRCLVS 138 1
OPEN BRANCH FROM BUS 246889 TO BUS 246890 CKT 1 / 246889 05BIERSR 138 246890 05HOPETN 138 1
END

Bus Number	*Bus Name*	*Full Contribution*
932411	*AC2-059 C*	*6.27*
932412	*AC2-059 E*	*6.47*
934481	*AD1-072 C*	*1.38*
934482	*AD1-072 E*	*0.63*
936111	*AD2-016 C*	*6.27*
936112	*AD2-016 E*	*6.47*
937231	*AD2-162 C*	*7.4*
937232	*AD2-162 E*	*3.63*
LTF	*AMIL*	*0.01*
LTF	*BAYOU*	*0.02*
LTF	*BIG_CAJUN1*	*0.03*
LTF	*BIG_CAJUN2*	*0.06*
LTF	*BLUEG*	*0.12*
LTF	*CALDERWOOD*	*< 0.01*
LTF	*CANNELTON*	*0.02*
LTF	*CBM-N*	*< 0.01*
LTF	*CBM-S2*	*0.05*

LTF	*CHEOAH*	*< 0.01*
LTF	*CHILHOWEE*	*< 0.01*
LTF	*CHOCTAW*	*0.02*
LTF	*COTTONWOOD*	*0.08*
LTF	*CPLE*	*0.01*
LTF	*DEARBORN*	*0.02*
LTF	*EDWARDS*	*0.02*
LTF	*ELMERSMITH*	*0.04*
LTF	*FARMERCITY*	*0.01*
LTF	*G-007A*	*0.05*
LTF	*GIBSON*	*0.03*
LTF	*MORGAN*	*0.03*
LTF	*NEWTON*	*0.05*
LTF	*NYISO*	*0.05*
LTF	*O-066A*	*0.02*
LTF	*PRAIRIE*	*0.09*
LTF	*SANTEETLA*	*< 0.01*
LTF	*SMITHLAND*	*< 0.01*
LTF	*TATANKA*	*0.02*
LTF	*TILTON*	*0.03*
LTF	*TRIMBLE*	*0.02*
LTF	*TVA*	*0.01*
LTF	*VFT*	*0.14*

Appendix 2

(AEP - AEP) The 05BIERSRUN-05SLATE 69 kV line (from bus 246893 to bus 243617 ckt 1) loads from 144.03% to 151.41% (**DC power flow**) of its emergency rating (50 MVA) for the tower line contingency outage of 'AEP_P7-1_#8126_B_B'. This project contributes approximately 8.18 MW to the thermal violation.

CONTINGENCY 'AEP_P7-1_#8126_B_B'
OPEN BRANCH FROM BUS 937230 TO BUS 243483 CKT 1 / 937230 AD2-162 TAP 138 243483 05CRCLVS 138 1
OPEN BRANCH FROM BUS 246889 TO BUS 246890 CKT 1 / 246889 05BIERSR 138 246890 05HOPETN 138 1
END

Bus Number	*Bus Name*	*Full Contribution*
932131	*AC2-020 C*	*0.65*
932132	*AC2-020 E*	*1.07*
932381	*AC2-055 C*	*1.63*
932382	*AC2-055 E*	*2.66*
932411	*AC2-059 C*	*4.03*
932412	*AC2-059 E*	*4.16*
932421	*AC2-060 C*	*5.77*
932422	*AC2-060 E*	*3.25*
932651	*AC2-087 C*	*4.28*
932652	*AC2-087 E*	*3.39*
934481	*AD1-072 C*	*0.88*
934482	*AD1-072 E*	*0.4*
934491	*AD1-073 C*	*1.19*
934492	*AD1-073 E*	*0.61*
936111	*AD2-016 C*	*4.03*
936112	*AD2-016 E*	*4.16*
937231	*AD2-162 C*	*4.76*

937232	*AD2-162 E*	*2.33*
LTF	*CARR*	*< 0.01*
LTF	*CBM-S1*	*0.15*
LTF	*CBM-S2*	*0.04*
LTF	*CBM-W1*	*0.43*
LTF	*CBM-W2*	*0.88*
LTF	*CIN*	*0.17*
LTF	*CPLE*	*< 0.01*
LTF	*G-007*	*0.02*
LTF	*IPL*	*0.11*
LTF	*LGEE*	*0.04*
LTF	*MEC*	*0.21*
LTF	*MECS*	*0.07*
LTF	*O-066*	*0.07*
LTF	*RENSSELAER*	*< 0.01*
LTF	*ROSETON*	*0.05*
LTF	*WEC*	*0.03*