Revised

Generation Interconnection

System Impact Study Report

for

Queue Project AE2-276

SULLIVAN 345KV

50 MW Capacity / 50 MW Energy

August, 2022

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1 Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances, 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 Interconnection Customer seeking to interconnect a wind 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.

PJM utilizes manufacturer models to ensure the performance of turbines is properly captured during the simulations performed for stability verification and, where applicable, for compliance with low voltage ride through requirements. Turbine manufacturers provide such models to their customers. The list of manufacturer models PJM has already validated is contained in Attachment B of Manual 14G. Manufacturer models may be updated from time to time, for various reasons such as to reflect changes to the control systems or to more accurately represent the capabilities turbines and controls which are currently available in the field. Additionally, as new turbine models are developed, turbine manufacturers provide such new models which must be used in the conduct of these studies. PJM needs adequate time to evaluate the new models in order to reduce delays to the System Impact Study process timeline for the Interconnection Customer as well as other Interconnection Customers in the study group. Therefore, PJM will require that any Interconnection Customer with a new manufacturer model must supply that model to PJM, along with a $10,000 fully refundable deposit, no later than three (3) months prior to the starting date of the System Impact Study (See Section 4.3 for starting dates) for the Interconnection Request which shall specify the use of the new model. The Interconnection Customer will be required to submit a completed dynamic model study request form (Attachment B-1 of Manual 14G) in order to document the request for the study.

2 General

The Interconnection Customer has proposed a Storage generating facility located in Sullivan County, Indiana. The installed facilities will have a total capability of 50 MW with 50 MW of this output being recognized by PJM as Capacity. The Point of Interconnection is at direct connection to Sullivan 345kV substation. In addition, the Interconnection Customer has indicated that at times they will charge the batteries from the grid. The AE2-276 project will share the same generator lead with AC2-157 (see figure 1).The proposed in-service date for this project is 12/31/2020. This study does not imply a TO commitment to this in-service date.

The objective of this System Impact Study is to determine budgetary cost estimates and approximate construction timelines for identified transmission facilities required to connect the proposed generating facilities to the AEP transmission system. These reinforcements include the Attachment Facilities, Local Upgrades, and Network Upgrades required for maintaining the reliability of the AEP transmission system.

Queue Number	AE2-276
Project Name	SULLIVAN 345KV
State	Indiana
County	Sullivan
Transmission Owner	AEP
MFO	50
MWE	50
MWC	50
Fuel	Storage
Basecase Study Year	2022

2.1 Point of Interconnection

AE2-276 will interconnect with the AEP transmission system at the Sullivan 345kV station. This project taps on the #AC2-157, a 200MW solar generator lead line.

Note: It is assumed that the 345 kV revenue metering system, gen lead and Protection & Control Equipment installed for #AC2-157 will be adequate for the additional storage facility connection requested at the AE2-276 generator lead line. Depending on the timing of the completion of the AE2-276 interconnection construction relative to the AE2-276 completion, there may (or may not) be a need to review and revise relay settings for the increased generation of AE2-276.

2.2 Cost Summary

The AE2-276 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$0
Direct Connection Network Upgrade	$0
Non Direct Connection Network Upgrades	$0
Allocation for New System Upgrades	$0
Contribution for Previously Identified Upgrades	$25,000
Total Costs	**$25,000**

The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements.

3 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.

None

4 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.

None

5 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.

None

6 Incremental Capacity Transfer Rights (ICTRs)

Will be determined at a later study phase

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 generally be between 24 to 36 months after signing Agreement execution.

8 Interconnection Customer Requirements

It is understood that Invenergy Solar Project Development LLC is responsible for all costs associated with this interconnection. The costs above are reimbursable to AEP. The cost of Invenergy Solar Project Development LLC's generating plant and the costs for the line connecting the generating plant to the Sullivan 345kV circuit are not included in this report; these are assumed to be Invenergy Solar Project Development LLC 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.

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.

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 Section 8 of Attachment O.

9.2 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

10 Network Impacts

The Queue Project AE2-276 was evaluated as a 50.0 MW (Capacity 50.0 MW) injection at the Sullivan 345 kV substation in the AEP area. Project AE2-276 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-276 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)

#	Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	PF	Loading Initial	Loading Final	Rating Type	Rating MVA	MW Con.	FG App.
1	N-1	AEP_P1-2_#363	AEP - MISO AMIL	05SULLIVAN-J1180 TAP 345 kV line	247712	966790	1	AC	99.84	101.08	NR	1466	18.24	1

12 Multiple Facility Contingency

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

#	Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	PF	Loading Initial	Loading Final	Rating Type	Rating MVA	MW Con.	FG App.
2	DCTL	AEP_P7-1_#11042	AEP - AEP	05ROCKPT-05JEFRSO 765 kV line	243209	243208	1	AC	99.94	100.36	ER	3970	16.65	2

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 Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	PF	Loading Initial	Loading Final	Rating Type	Rating MVA	MW Con.	FG App.
3	N-1	AEP_P1-2_#363	AEP - MISO AMIL	05SULLIVAN-J1180 TAP 345 kV line	247712	966790	1	DC	126.18	127.42	NR	1466	18.24	

15 Steady-State Voltage Requirements

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

To be evaluated during the Facilities Study Phase

16 Stability and Reactive Power Requirements for Low Voltage Ride Through

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

To be evaluated during the Facilities Study Phase

17 Light Load Analysis

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

No violations

18 System Reinforcements

New System Reinforcements

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

Facility	Upgrade Description	Cost	Cost Allocation	Upgrade Number
05SULLIVAN-J1180 TAP 345 kV line (from bus 247712 to bus 966790 ckt 1)	**AEP** AEP end ratings are 1685 MVA SE. No upgrades are required. **MISO** Ameren-end SE rating are 1692 MVA SE. No upgrades are required.	$0	$0	N/A
	Total	**$0**	**$0**	

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)

Facility	Upgrade Description	Cost	Cost Allocation	Upgrade Number
05ROCKPT-05JEFRSO 765 kV line (from bus 243209 to bus 243208 ckt 1)	**AEP** AEP SE rating is 3970 MVA. **AEP Reinforcement:** **Project ID**: N6497.1 **Description**: An engineering study will need to be conducted to determine if the Rockport Relay Thermal limits 2996 Amps settings can be adjusted to mitigate the overload, Estimated Cost $25,000. New relay packages will be required if the settings cannot be adjusted. Estimated Cost for new relay packages: $1.2 M ($600,000 each). New SN/SE rating 3975/3975 MVA. **Type**: FAC **Cost:** $25,000 **Time Estimate**: 12-18 Months **Ratings**: 3975 MVA SE AE2-276 is the driver for this reinforcement.	$25,000	$25,000	N6497.1
	Total	**$25,000**	**$25,000**	

19 Contingency Descriptions

Option 1	
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_P7-1_#11042	CONTINGENCY 'AEP_P7-1_#11042' OPEN BRANCH FROM BUS 243878 TO BUS 255205 CKT 1 / 243878 05MEADOW 345 255205 17REYNOLDS 345 1 OPEN BRANCH FROM BUS 243878 TO BUS 255205 CKT 2 / 243878 05MEADOW 345 255205 17REYNOLDS 345 2 END

Affected Systems

20 Affected Systems

20.1 LG&E

None

20.2 MISO

The October 2019 AE2 Group – Preliminary MISO Report has identified impacts. Please refer to the MISO Affected System report for details.

20.3 TVA

None

20.4 Duke Energy Progress

None

20.5 NYISO

None

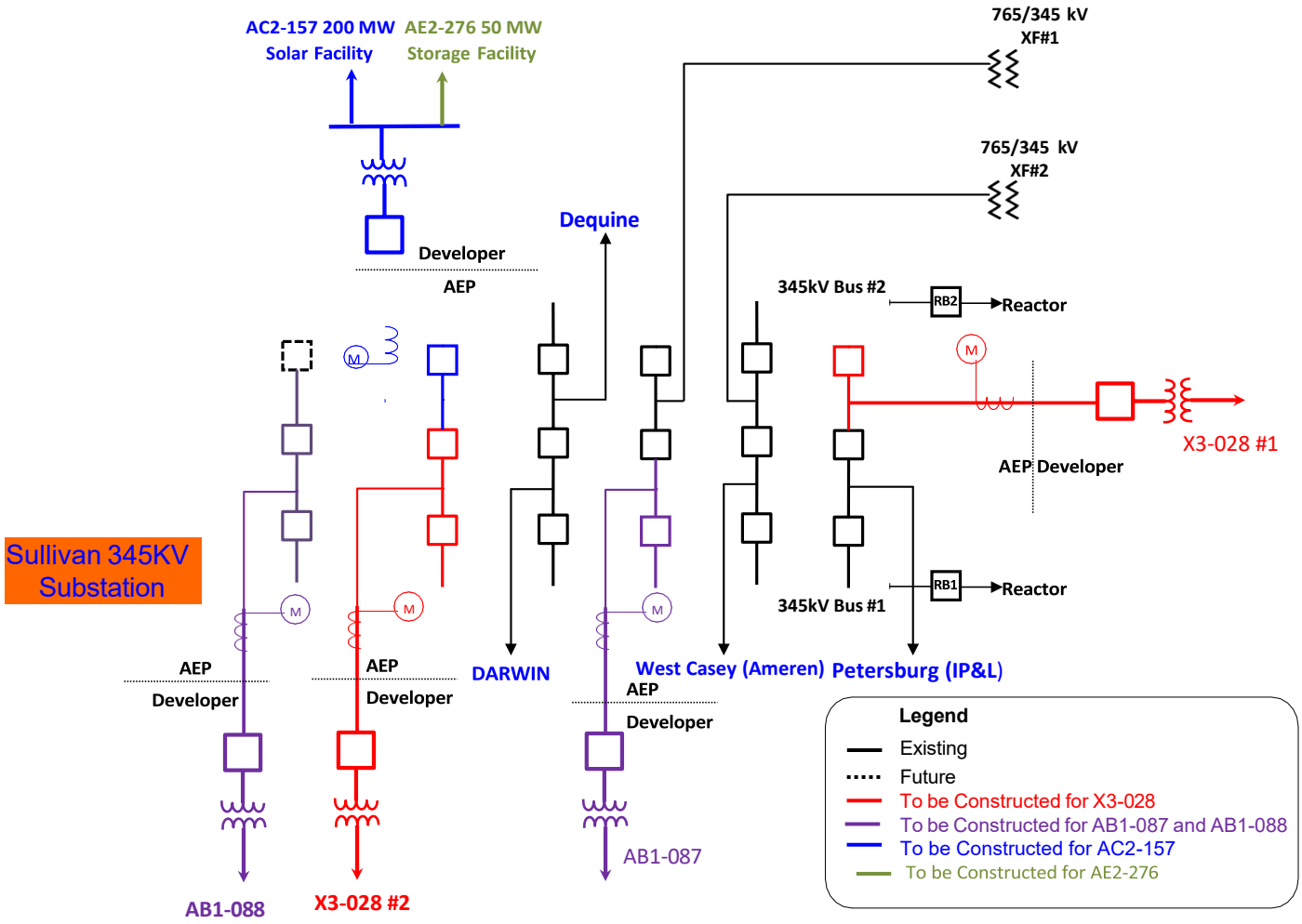
Short Circuit

21 Short Circuit

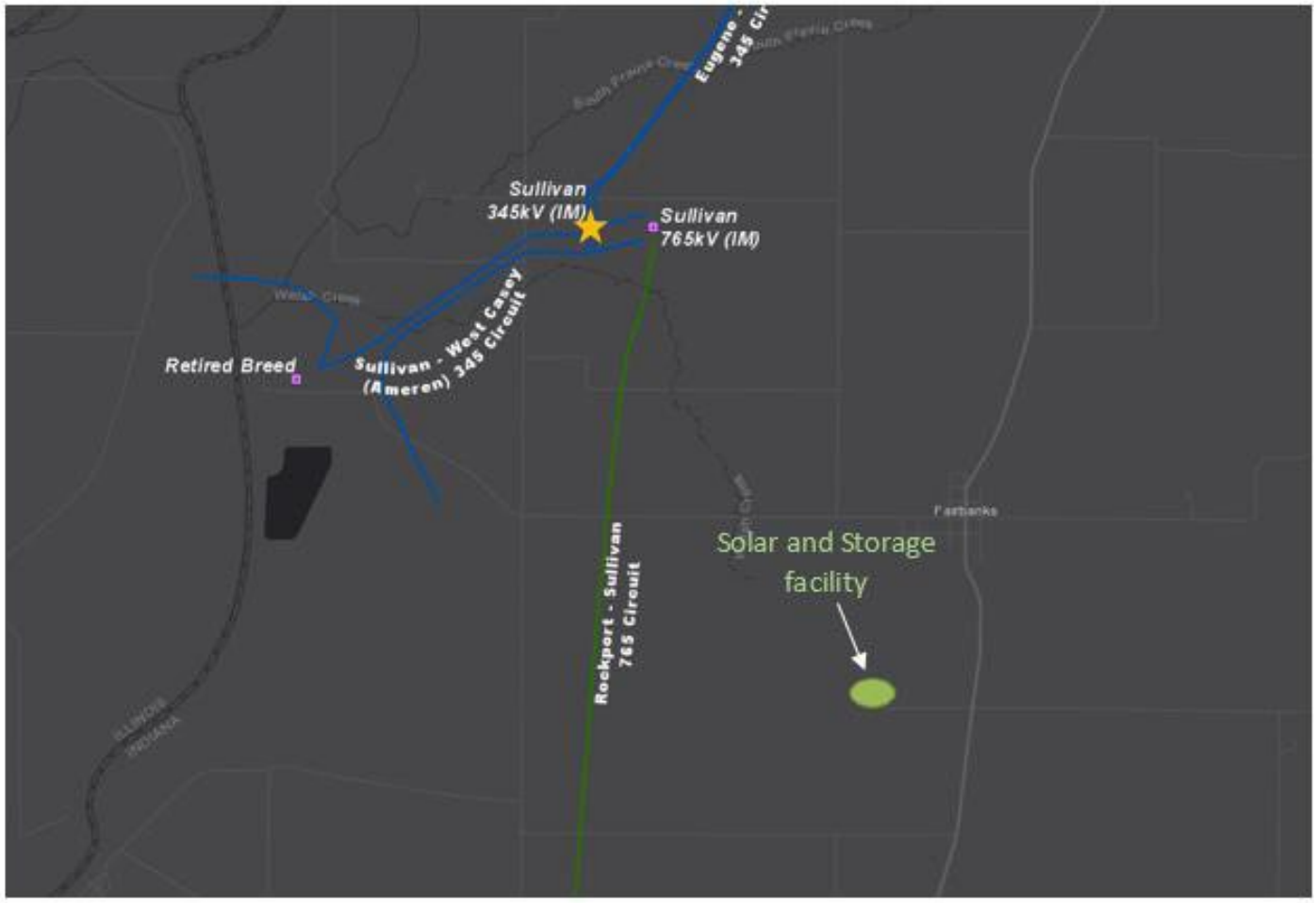
The following Breakers are over-duty

None

22 Figure 1: AE2-276 Point of Interconnection (Sullivan 345kV) Single-Line Diagram



23 Figure 2: AE2-276 Point of Interconnection Map



24 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

(AEP - MISO AMIL) The 05SULLIVAN-J1180 TAP 345 kV line (from bus 247712 to bus 966790 ckt 1) loads from 99.84% to 101.08% (AC power flow) of its normal rating (1466 MVA) for the single line contingency outage of 'AEP_P1-2_#363'. This project contributes approximately 18.24 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*
243859	*05FR-11G C*	*0.16*
243862	*05FR-12G C*	*0.15*
243864	*05FR-21G C*	*0.16*
243866	*05FR-22G C*	*0.16*
243870	*05FR-3G C*	*0.32*
243873	*05FR-4G C*	*0.25*
243442	*05RKG1*	*76.84*
243443	*05RKG2*	*73.67*
933441	*AC2-157 C*	*27.73*
941341	*AE2-130 C*	*175.15*
942601	*AE2-276*	*18.24*
LTF	*BAYOU /* 35% REVERSE 4392716*	*< 0.01*
LTF	*BIG CAJUN1 /* 35% REVERSE 4646887 4392735*	*< 0.01*
LTF	*CALDERWOOD*	*1.24*
LTF	*CARR*	*0.01*
LTF	*CATAWBA*	*0.49*
LTF	*CHEOAH*	*1.13*
LTF	*CHILHOWEE*	*0.41*
LTF	*CIN*	*8.17*
LTF	*COFFEEN*	*8.32*
LTF	*COTTONWOOD*	*10.8*
LTF	*DUCKCREEK*	*7.21*
LTF	*EDWARDS*	*2.8*
LTF	*FARMERCITY*	*2.39*
LTF	*HAMLET*	*0.72*
LTF	*IPL*	*11.74*
965811	*J1069 C*	*2.15*
950161	*J401*	*1.52*
951731	*J446 C*	*1.79*
951811	*J513 C*	*0.95*
952811	*J759*	*4.23*
952861	*J783 C*	*4.07*
953351	*J805*	*14.07*

953161	*J837 C*	*2.15*
953171	*J838 C*	*2.15*
953931	*J856*	*5.36*
954351	*J903*	*6.72*
954421	*J913*	*13.75*
964911	*J968 C*	*2.15*
LTF	*LGEE*	*0.81*
LTF	*MECS*	*1.2*
LTF	*NEWTON*	*34.05*
LTF	*PRAIRIE*	*31.45*
LTF	*RENSSELAER*	*0.01*
LTF	*SANTEETLA*	*0.33*
LTF	*SMITHLAND*	*1.23*
LTF	*TILTON*	*1.7*
LTF	*TVA*	*6.65*
LTF	*UNIONPOWER*	*3.61*
930461	*AB1-087*	*200.65*
930471	*AB1-088*	*200.65*
LTF	*AC1-056*	*12.09*

Appendix 2

(AEP - AEP) The 05ROCKPT-05JEFRSO 765 kV line (from bus 243209 to bus 243208 ckt 1) loads from 99.94% to 100.36% (AC power flow) of its emergency rating (3970 MVA) for the tower line contingency outage of 'AEP_P7-1_#11042'. This project contributes approximately 16.65 MW to the thermal violation.

CONTINGENCY 'AEP_P7-1_#11042'
OPEN BRANCH FROM BUS 243878 TO BUS 255205 CKT 1 / 243878 05MEADOW 345 255205 17REYNOLDS 345 1
OPEN BRANCH FROM BUS 243878 TO BUS 255205 CKT 2 / 243878 05MEADOW 345 255205 17REYNOLDS 345 2
END

Bus Number	*Bus Name*	*Full Contribution*
243859	*05FR-11G C*	*0.56*
247900	*05FR-11G E*	*14.29*
243862	*05FR-12G C*	*0.55*
247901	*05FR-12G E*	*14.05*
243864	*05FR-21G C*	*0.58*
247902	*05FR-21G E*	*15.02*
243866	*05FR-22G C*	*0.56*
247903	*05FR-22G E*	*14.38*
243870	*05FR-3G C*	*1.13*
247904	*05FR-3G E*	*29.13*
243873	*05FR-4G C*	*0.88*
247905	*05FR-4G E*	*21.9*
246909	*05MDL-1G C*	*1.13*
247906	*05MDL-1G E*	*29.15*
246910	*05MDL-2G C*	*0.57*
247907	*05MDL-2G E*	*14.45*
246976	*05MDL-3G C*	*0.57*
247912	*05MDL-3G E*	*15.11*
246979	*05MDL-4G C*	*1.13*
247913	*05MDL-4G E*	*14.6*
243442	*05RKG1*	*133.72*
243443	*05RKG2*	*128.2*
933441	*AC2-157 C*	*25.31*
933442	*AC2-157 E*	*41.29*
936771	*AD2-100 C O1*	*14.27*
936772	*AD2-100 E O1*	*9.52*
936971	*AD2-131 C O1*	*0.94*
936972	*AD2-131 E O1*	*4.72*
941341	*AE2-130 C*	*304.78*
941342	*AE2-130 E*	*203.18*
941571	*AE2-154 C*	*5.93*

941572	*AE2-154 E*	*39.69*
942481	*AE2-261 C*	*19.83*
942482	*AE2-261 E*	*13.22*
942601	*AE2-276*	*16.65*
LTF	*BLUEG*	*8.43*
LTF	*CARR*	*0.71*
LTF	*CATAWBA*	*0.1*
LTF	*CBM-S1*	*8.5*
LTF	*CBM-W1*	*18.7*
LTF	*CBM-W2*	*173.29*
LTF	*CHOCTAW /* 35% REVERSE 4566958 4511400*	*< 0.01*
LTF	*CIN*	*26.47*
LTF	*G-007*	*2.01*
LTF	*HAMLET*	*0.29*
LTF	*IPL*	*17.77*
966791	*J1180*	*16.04*
954761	*J468 C*	*4.19*
954762	*J468 E*	*16.78*
954681	*J949*	*22.17*
274650	*KINCAID ;1U*	*9.46*
LTF	*LGE-0092018*	*< 0.01*
LTF	*MEC*	*29.47*
LTF	*O-066*	*12.9*
LTF	*RENSSELAER*	*0.56*
247556	*T-127 C*	*0.56*
247943	*T-127 E*	*14.6*
LTF	*TRIMBLE*	*1.36*
LTF	*WEC*	*2.83*
930041	*AB1-006 C*	*0.74*
930042	*AB1-006 E*	*31.76*
930461	*AB1-087*	*183.16*
930471	*AB1-088*	*183.16*