Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AC2-015

Chatfield-Howard 138 kV

July 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 (IC) proposes to install PJM Project #AC2-015, a 117.0 MW (54.0 MW Capacity) solar generating facility in Crawford County, Ohio (see Figure 2). The generating facility will consist of thirty (30) 3.99 MW inverters. The primary point of interconnection is to AEP's Chatfield – Howard 138 kV section of the Howard – West End Fostoria 138 kV circuit (see Figure 1). The new switching station will be located on the north side of the Double Circuit Tower Line (DCTL) and Southeast of the Chatfield substation. The secondary point of interconnection is to AEP's Howard – Melmore 138 kV section of the Fostoria Central – Greenlawn- Howard 138 kV circuit (see Figure 3).

The requested backfeed date is September 30, 2019.
The requested in service date is December 31, 2019.

The objective of this Feasibility 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 maintaining the reliability of the AEP transmission system. Stability analysis is not included as part of this study.

Attachment Facilities

Primary Point of Interconnection (Chatfield-Howard 138 kV)

To accommodate the interconnection on the Chatfield – Howard 138 kV section of the Howard – West End Fostoria 138 kV circuit, a new three (3) circuit breaker 138 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus will be constructed (see Figure 1). Installation of associated protection and control equipment, 138 kV line risers, SCADA, 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.
New Switching Station Work:

- Construct a new three (3) circuit breaker 138 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus. Installation of associated protection and control equipment, 138 kV line risers, SCADA, and 138 kV revenue metering will also be required (see Figure 1).
    - **Estimated Station Cost: $6,300,000**

Direct Connection Cost Estimate

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

For AEP building Direct Connection cost estimates:

Description	Total Cost
Chatfield-Howard 138 kV T-Line Cut In	**$1,500,000**
Total	**$1,500,000**

Table 1

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 Non-Direct Connection cost estimates:

Description	Estimated Cost
138 kV Revenue Metering	**$250,000**
Upgrade line protection and controls at the Chatfield 138 kV substation to coordinate with the new 138 kV switching station.	**$250,000**
Upgrade line protection and controls at the Howard 138 kV substation to coordinate with the new 138 kV switching station.	**$250,000**
Upgrade line protection and controls at the Melmore 138 kV substation to coordinate with the new 138 kV switching station.	**$250,000**
Total	**$1,000,000**

Table 2

Secondary Point of Interconnection (Howard – Melmore 138 kV)

To accommodate the interconnection on the Howard – Melmore 138 kV section of the Fostoria Central – Greenlawn - Howard 138 kV circuit, a new three (3) circuit breaker 138 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus will be constructed (see Figure 3). Installation of associated protection and control equipment, 138 kV line risers, SCADA, 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.

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

Option 1

Network Impacts

The Queue Project AC2-015 was evaluated as a 117.0 MW (Capacity 54.0 MW) injection tapping the Chatfield – Howard 138 kV line in the AEP area. Project AC2-015 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-015 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Analysis – 2020

Contingency Descriptions

The following contingencies resulted in overloads:

Option 1	
Contingency Name	**Description**
C2-CEI-345-001	CONTINGENCY 'C2-CEI-345-001' /* BREAKER FAILURE ON S145 BREAKER AT AVON 345KV DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 1 /* 02LAKEAVE 345 02AVON 345 DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 2 /* 02LAKEAVE 345 02AVON 345 END
C5-CEI-345-001	CONTINGENCY 'C5-CEI-345-001' /* AVON-BEAVER #1 AND #2 345KV LINE OUTAGES DISCONNECT BRANCH FROM BUS 238551 TO BUS 239725 CKT 1 /* 02AVON 345 02LAKEAVE 345 DISCONNECT BRANCH FROM BUS 238551 TO BUS 239725 CKT 2 /* 02AVON 345 02LAKEAVE 345 END

Table 3

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)

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)

AC2-015 Contribution to Previously Identified Overloads															
	Contingency		Affected		Bus				Loading		Rating		MW	FG
#	Type	Name	Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	Con.	App.
1	LFFB	C2-CEI-345-001	FE - FE	02USSTEEL-02LRN Q2 138 kV line	239734	238915	1	DC	213.56	214.81	ER	270	7.49	2
2	DCTL	C5-CEI-345-001	FE - FE	02USSTEEL-02LRN Q2 138 kV line	239734	238915	1	DC	213.56	214.81	ER	270	7.49	

Table 4

Steady-State Voltage Requirements

None

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None

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.

AC2-015 Delivery of Energy Portion of Interconnection Request													
	Contingency		Affected		Bus			Loading		Rating		MW	FG
#	Type	Name	Area	Facility Description	From	To	Cir.	Initial	Final	Type	MVA	Con.	App.
1	Non	Non	AEP - FE	05HOWARD-02BRKSID 138 kV line	243024	238586	1	100.03	116.6	NR	167	27.68	

Table 5

New System Reinforcements

The PJM Baseline Project information has been provided below because it affects the mitigations required in the First Energy Transmission zone. Additional mitigation and costs can be found in Table 6.

PJM baseline project (b2559) will not eliminate the identified overloads; the new rating is 435/500 SN/SE. The actual in service date is 05/31/2017.

PJM baseline project (b2896) will eliminate the identified overloads; the new rating for the US Steel – Lorain Q2 138 kV line will be 498/593 SN/SE. The scheduled in service date is 06/1/2021.

#	Overloaded Facility	Upgrade Description	Schedule	Estimated Cost
#1	02USSTEEL-02LRN Q2 138 kV line	The proposed mitigation is to re-conductor the Lorain substation conductor (the limiting element). Once the proposed mitigation and the PJM RTEP b2896 work have been completed, the US Steel - Lorain Q2 138kV line rating would be 548/688 SN/SE. The estimated cost to re-conductor the Lorain substation conductor on the US Steel - Lorain 138kV line is $86,500 (without tax).	This is a First Energy mitigation. Schedule to be determined in the System Impact Study phase.	**$86,500**
#2	02USSTEEL-02LRN Q2 138 kV line	Same as #1	Same as #1	Same as #1
			Total New Network Upgrade	**$86,500**

The New System Reinforcement listed below is not part of the Bulk Electric System (BES), but was identified by AEP and will be required for interconnection of AC2-015.

#	Overloaded Facility	Upgrade Description	Schedule	Estimated Cost
N/A	05CARROTHR-05ST.STEPHSS 69 kV line	The following work will be required to relieve the Carrothers – Saint Stephens 69 kV line overload: 2.6 mile section of the Copper #1 conductor between Carrothers and St. Stephens 69 kV stations which will need to be rebuilt.	An approximate construction time would be 24 to 36 months after signing an interconnection agreement.	**$3.12 Million**
			Total New Network Upgrade	**$3,120,000**

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 construction of the 117.0 MW (54.0 MW Capacity) solar generating facility of IC (PJM Project #AC2-015) 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 IC generating facility.

Cost Breakdown for Primary Point of Interconnection (Chatfield - Howard 138 kV)		
Attachment Cost	New 138 kV Switching Station	**$6,300,000**
Direct Connection Cost Estimate	Howard - Chatfield 138 kV T-Line Cut In	**$1,500,000**
Non-Direct Connection Cost Estimate	138 kV Revenue Metering	**$250,000**
	Upgrade line protection and controls at the Chatfield 138 kV substation to coordinate with the new 138 kV switching station.	**$250,000**
	Upgrade line protection and controls at the Howard 138 kV substation to coordinate with the new 138 kV switching station.	**$250,000**
	Upgrade line protection and controls at the Melmore 138 kV substation to coordinate with the new 138 kV switching station.	**$250,000**
	The following work will be required to relieve the Carrothers to St. Stephens 69 kV line overload: Reconductor/Rebuild 2.6 mile COOPER ~ # 1 ~ 3 ~ Conductor Section 1	**$3,120,000**
	The proposed mitigation is to re-conductor the Lorain substation conductor (the limiting element). Once the proposed mitigation and the PJM RTEP b2896 work have been completed.	**$86,500**
	Total Estimated Cost for Project AC2-015	**$12,006,500**

Table 8

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.

Option 2

Network Impacts

The Queue Project AC2-015 was evaluated as a 117.0 MW (Capacity 54.0 MW) injection tapping the Howard – Melmore 138 kV line in the AEP area. Project AC2-015 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-015 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Analysis – 2020

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
7734_A	CONTINGENCY '7734_A' OPEN BRANCH FROM BUS 242984 TO BUS 243039 CKT 1 / 242984 05CHATFL 138 243039 05MELMOR 138 1 OPEN BRANCH FROM BUS 243024 TO BUS 931050 CKT 1 / 243024 05HOWARD 138 931050 AC2-015 TAP 138 1 END
C2-CEI-345-001	CONTINGENCY 'C2-CEI-345-001' /* BREAKER FAILURE ON S145 BREAKER AT AVON 345KV DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 1 /* 02LAKEAVE 345 02AVON 345 DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 2 /* 02LAKEAVE 345 02AVON 345 END
C5-CEI-345-001	CONTINGENCY 'C5-CEI-345-001' /* AVON-BEAVER #1 AND #2 345KV LINE OUTAGES DISCONNECT BRANCH FROM BUS 238551 TO BUS 239725 CKT 1 /* 02AVON 345 02LAKEAVE 345 DISCONNECT BRANCH FROM BUS 238551 TO BUS 239725 CKT 2 /* 02AVON 345 02LAKEAVE 345 END
C5-OEC-345-001	CONTINGENCY 'C5-OEC-345-001' /* BEAVER-LAKAVE 345 CK 1 & 2 DISCONNECT BRANCH FROM BUS 238569 TO BUS 239725 CKT 1 /* 02BEAVER 345 02LAKEAVE 345 DISCONNECT BRANCH FROM BUS 238569 TO BUS 239725 CKT 2 /* 02BEAVER 345 02LAKEAVE 345 END

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)

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)

AC2-015 Contribution to Previously Identified Overloads													
	Contingency		Affected	Facility	Bus			Loading		Rating		MW	FG
#	Type	Name	Area	Description	From	To	Cir.	Initial	Final	Type	MVA	Con.	App.
1	DCTL	C5-OEC-345-001	FE - FE	02BEAVER-02CARLIL 345 kV line	238569	238607	1	106.37	106.82	ER	1139	11.44	1
2	LFFB	C2-CEI-345-001	FE - FE	02BLKRVR-02USSTEEL 138 kV line	239728	239734	1	225.45	226.77	ER	270	7.89	2
3	DCTL	C5-CEI-345-001	FE - FE	02BLKRVR-02USSTEEL 138 kV line	239728	239734	1	225.45	226.77	ER	270	7.89	
4	LFFB	C2-CEI-345-001	FE - FE	02USSTEEL-02LRN Q2 138 kV line	239734	238915	1	213.56	214.88	ER	270	7.89	3
5	DCTL	C5-CEI-345-001	FE - FE	02USSTEEL-02LRN Q2 138 kV line	239734	238915	1	213.56	214.88	ER	270	7.89	
6	DCTL	7734_A	AEP - AEP	05GREENLAW-05E.TIFF2 69 kV line	245621	245646	1	125.66	132.43	ER	39	5.86	4
7	DCTL	7734_A	AEP - AEP	05E.TIFF2-05WROCKWSS 69 kV line	245646	245635	1	163.94	172.46	ER	31	5.86	5
8	DCTL	7734_A	AEP - AEP	05ST.STEPHSS-05CARROTHR 69 kV line	245674	245655	1	113.94	122.46	ER	31	5.86	6

Steady-State Voltage Requirements

None

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None

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.

AC2-015 Delivery of Energy Portion of Interconnection Request														
	Contingency		Affected	Facility	Bus			Loading		Rating		MW	FG
#	Type	Name	Area	Description	From	To	Cir.	Initial	Final	Type	MVA	Con.	App.
1	Non	Non	AEP - FE	05HOWARD-02BRKSID 138 kV line	243024	238586	1	100.03	114.15	NR	167	23.58	

Figure 1: Primary Point of Interconnection (Chatfield-Howard 138 kV)

Single-Line Diagram

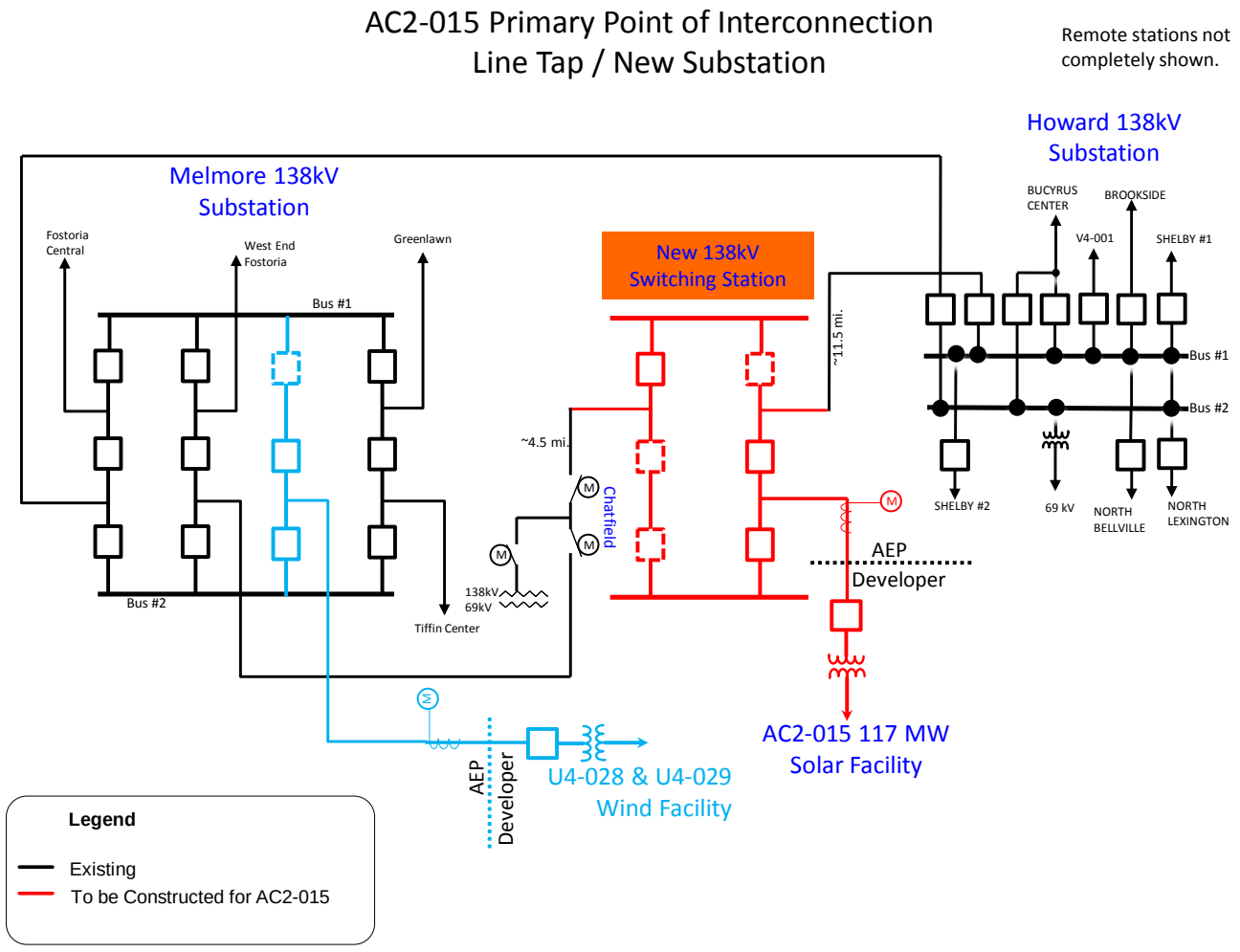
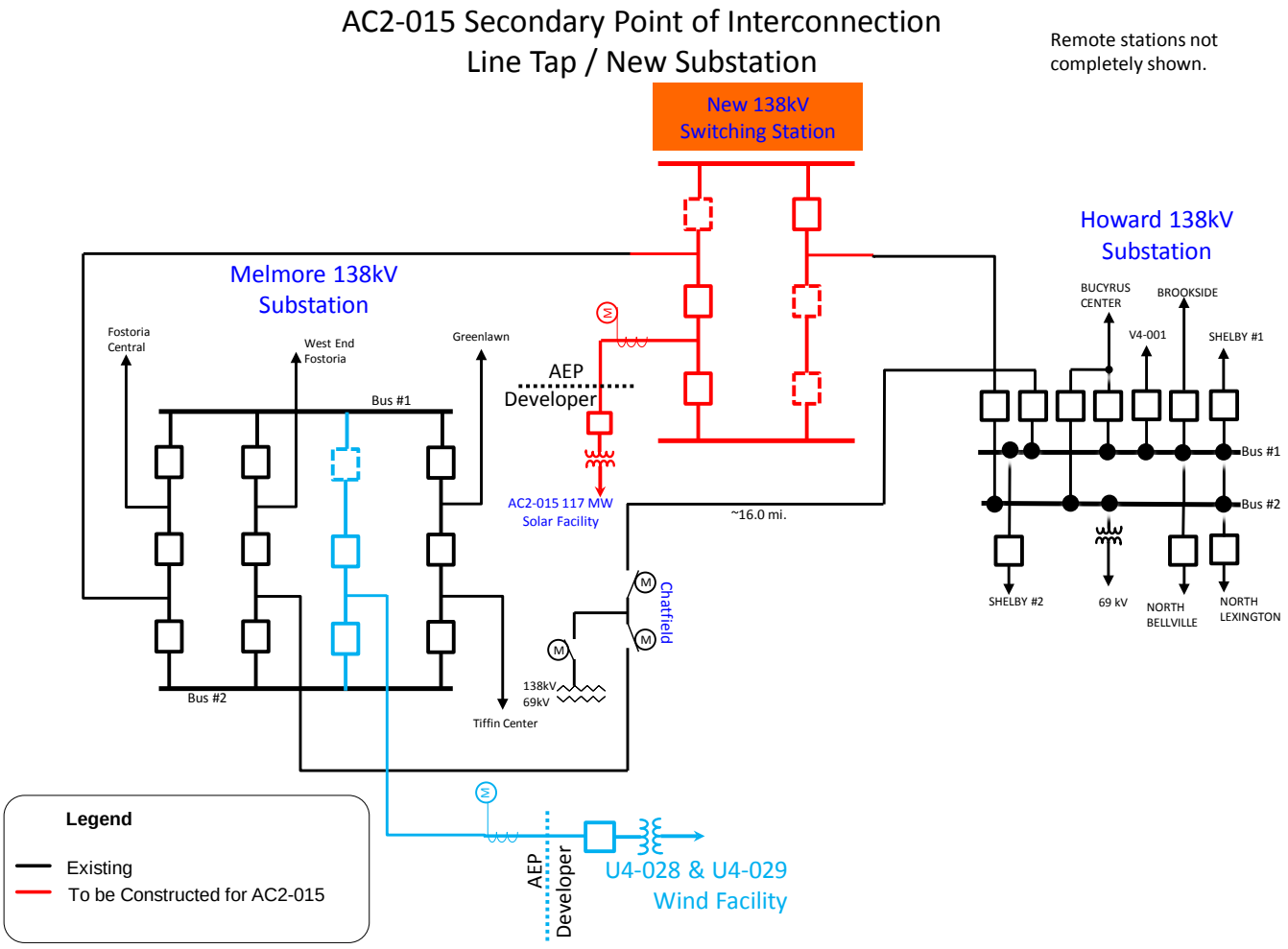


Figure 3: Secondary Point of Interconnection (Howard - Melmore 138 kV)

Single-Line Diagram



Appendices – Option 1

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 - AEP) The 05CARROTHR-05ST.STEPHSS 69 kV line (from bus 245655 to bus 245674 ckt 1) loads from 61.54% to 110.53% (**DC power flow**) of its emergency rating (31 MVA) for the tower line contingency outage of '7734'. This project contributes approximately 15.19 MW to the thermal violation.

CONTINGENCY '7734'
OPEN BRANCH FROM BUS 242984 TO BUS 243039 CKT 1 / 242984 05CHATFL 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

Bus Number	*Bus Name*	*Full Contribution*
931051	*AC2-015 C OP*	*7.01*
931052	*AC2-015 E OP*	*8.18*
247542	*U4-001 C*	*2.47*
247934	*U4-001 E*	*16.55*
LTF	*Y3-059*	*2.87*
LTF	*AA1-074*	*1.72*
925751	*AC1-051 C*	*1.82*
925752	*AC1-051 E*	*12.2*

Appendix 2

(FE - FE) The 02BLKRVR-02USSTEEL 138 kV line (from bus 239728 to bus 239734 ckt 1) loads from 225.45% to 226.7% (**DC power flow**) of its emergency rating (270 MVA) for the line fault with failed breaker contingency outage of 'C2-CEI-345-001'. This project contributes approximately 7.49 MW to the thermal violation.

CONTINGENCY 'C2-CEI-345-001' /* BREAKER FAILURE ON S145 BREAKER AT AVON 345KV
DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 1 /* 02LAKEAVE 345 02AVON 345
DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 2 /* 02LAKEAVE 345 02AVON 345
END

Bus Number	*Bus Name*	*Full Contribution*
238564	*02BAYSG1*	*12.23*
238571	*02BEAVGA*	*1.85*
238572	*02BEAVGB*	*1.93*
240968	*02BG2 GEN*	*0.62*
240969	*02BG4 G1*	*0.16*
240970	*02BG4 G2&3*	*0.31*
240971	*02BG4 G4&5*	*0.31*
240950	*02BG5*	*1.89*
240973	*02BG6 AMPO*	*2.75*
239276	*02COLLW 11*	*-2.85*
239297	*02CPPW41*	*-3.63*
238979	*02NAPMUN*	*2.92*
240975	*02PGE GEN*	*4.26*
239175	*02WLORG-6*	*3.06*
931051	*AC2-015 C OP*	*3.46*
931052	*AC2-015 E OP*	*4.03*
931791	*AC2-103 C*	*5.09*
931792	*AC2-103 E*	*34.09*
247542	*U4-001 C*	*1.54*
247934	*U4-001 E*	*10.33*
247551	*U4-028 C*	*0.98*
247940	*U4-028 E*	*6.58*
247552	*U4-029 C*	*0.98*
247941	*U4-029 E*	*6.58*
247567	*V2-006 C*	*1.04*
247961	*V2-006 E*	*6.98*
247548	*V4-010 C*	*2.13*
247947	*V4-010 E*	*14.27*
901803	*W1-072A*	*3.45*
907062	*X1-027A E1*	*14.32*

907065	*X1-027A E2*	*14.32*
907067	*X1-027A E3*	*14.32*
907069	*X1-027A E4*	*14.32*
LTF	*Y3-032*	*18.53*
915951	*Y3-092*	*31.54*
915952	*Y3-092 E*	*31.54*
921102	*AA1-056*	*4.06*
922573	*AA2-186 E*	*1.07*
923092	*AB1-107 CT1*	*24.11*
923094	*AB1-107 CT2*	*23.77*
923096	*AB1-107 ST1*	*28.33*
923821	*AB2-019*	*1.77*
925751	*AC1-051 C*	*0.51*
925752	*AC1-051 E*	*3.39*
926941	*AC1-181*	*0.33*

Appendix 3

(FE - FE) The 02USSTEEL-02LRN Q2 138 kV line (from bus 239734 to bus 238915 ckt 1) loads from 213.56% to 214.81% (**DC power flow**) of its emergency rating (270 MVA) for the line fault with failed breaker contingency outage of 'C2-CEI-345-001'. This project contributes approximately 7.49 MW to the thermal violation.

CONTINGENCY 'C2-CEI-345-001' /* BREAKER FAILURE ON S145 BREAKER AT AVON 345KV
DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 1 /* 02LAKEAVE 345 02AVON 345
DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 2 /* 02LAKEAVE 345 02AVON 345
END

Bus Number	*Bus Name*	*Full Contribution*
238564	*02BAYSG1*	*12.23*
238571	*02BEAVGA*	*1.85*
238572	*02BEAVGB*	*1.93*
240968	*02BG2 GEN*	*0.62*
240969	*02BG4 G1*	*0.16*
240970	*02BG4 G2&3*	*0.31*
240971	*02BG4 G4&5*	*0.31*
240950	*02BG5*	*1.89*
240973	*02BG6 AMPO*	*2.75*
239276	*02COLLW 11*	*-2.85*
239297	*02CPPW41*	*-3.63*
238979	*02NAPMUN*	*2.92*
240975	*02PGE GEN*	*4.26*
239175	*02WLORG-6*	*3.06*
931051	*AC2-015 C OP*	*3.46*
931052	*AC2-015 E OP*	*4.03*
931791	*AC2-103 C*	*5.09*
931792	*AC2-103 E*	*34.09*
247542	*U4-001 C*	*1.54*
247934	*U4-001 E*	*10.33*
247551	*U4-028 C*	*0.98*
247940	*U4-028 E*	*6.58*
247552	*U4-029 C*	*0.98*
247941	*U4-029 E*	*6.58*
247567	*V2-006 C*	*1.04*
247961	*V2-006 E*	*6.98*
247548	*V4-010 C*	*2.13*
247947	*V4-010 E*	*14.27*
901803	*W1-072A*	*3.45*
907062	*X1-027A E1*	*14.32*

907065	*X1-027A E2*	*14.32*
907067	*X1-027A E3*	*14.32*
907069	*X1-027A E4*	*14.32*
LTF	*Y3-032*	*18.53*
915951	*Y3-092*	*31.54*
915952	*Y3-092 E*	*31.54*
921102	*AA1-056*	*4.06*
922573	*AA2-186 E*	*1.07*
923092	*AB1-107 CT1*	*24.11*
923094	*AB1-107 CT2*	*23.77*
923096	*AB1-107 ST1*	*28.33*
923821	*AB2-019*	*1.77*
925751	*AC1-051 C*	*0.51*
925752	*AC1-051 E*	*3.39*
926941	*AC1-181*	*0.33*

Appendices – 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. 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

(FE - FE) The 02BEAVER-02CARLIL 345 kV line (from bus 238569 to bus 238607 ckt 1) loads from 106.37% to 106.82% (**DC power flow**) of its emergency rating (1139 MVA) for the tower line contingency outage of 'C5-OEC-345-001'. This project contributes approximately 11.44 MW to the thermal violation.

CONTINGENCY 'C5-OEC-345-001' /* BEAVER-LAKAVE 345 CK 1 & 2
DISCONNECT BRANCH FROM BUS 238569 TO BUS 239725 CKT 1 /* 02BEAVER 345 02LAKEAVE 345
DISCONNECT BRANCH FROM BUS 238569 TO BUS 239725 CKT 2 /* 02BEAVER 345 02LAKEAVE 345
END

Bus Number	*Bus Name*	*Full Contribution*
238564	*02BAYSG1*	*22.44*
240968	*02BG2 GEN*	*1.13*
240969	*02BG4 G1*	*0.28*
240970	*02BG4 G2&3*	*0.57*
240971	*02BG4 G4&5*	*0.57*
240950	*02BG5*	*3.45*
240973	*02BG6 AMPO*	*5.02*
238670	*02DVBSG1*	*34.4*
238979	*02NAPMUN*	*5.41*
240975	*02PGE GEN*	*7.78*
239171	*02WLORG-2*	*5.47*
239172	*02WLORG-3*	*5.62*
239173	*02WLORG-4*	*5.6*
239174	*02WLORG-5*	*5.62*
931051	*AC2-015 C OP*	*5.28*
931052	*AC2-015 E OP*	*6.16*
931791	*AC2-103 C*	*11.38*
931792	*AC2-103 E*	*76.15*
998321	*J496*	*11.23*
998571	*J537*	*14.47*
998581	*J538*	*9.63*
961591	*J589*	*10.43*
961341	*J601*	*7.39*
961351	*J602*	*11.77*
247926	*U1-059 E*	*3.51*
247551	*U4-028 C*	*1.53*
247940	*U4-028 E*	*10.23*
247552	*U4-029 C*	*1.53*
247941	*U4-029 E*	*10.23*
247567	*V2-006 C*	*1.83*

247961	*V2-006 E*	*12.27*
247548	*V4-010 C*	*3.32*
247947	*V4-010 E*	*22.2*
247942	*W1-056 E*	*1.29*
901803	*W1-072A*	*6.59*
907061	*X1-027A C1*	*0.84*
907064	*X1-027A C2*	*0.84*
907066	*X1-027A C3*	*0.84*
907068	*X1-027A C4*	*0.84*
907062	*X1-027A E1*	*31.99*
907065	*X1-027A E2*	*31.99*
907067	*X1-027A E3*	*31.99*
907069	*X1-027A E4*	*31.99*
LTF	*Y3-032*	*35.02*
701261	*Y4-027 C*	*0.25*
701262	*Y4-027 E*	*0.99*
701341	*Y4-035 C*	*0.08*
701342	*Y4-035 E*	*0.33*
701421	*Y4-043 C*	*0.06*
701422	*Y4-043 E*	*0.17*
701431	*Y4-044 C*	*2.1*
701432	*Y4-044 E*	*6.29*
701491	*Y4-050 C*	*1.4*
701492	*Y4-050 E*	*4.19*
701531	*Y4-054 C*	*0.73*
701532	*Y4-054 E*	*2.18*
701571	*Y4-058*	*7.06*
701581	*Y4-059*	*21.4*
701601	*Y4-061*	*10.75*
701781	*Y4-079*	*8.65*
701791	*Y4-080*	*2.22*
701861	*Y4-087*	*6.48*
701881	*Y4-089*	*10.84*
701891	*Y4-090*	*2.04*
701901	*Y4-091*	*0.1*
921102	*AA1-056*	*7.83*
922573	*AA2-186 E*	*1.71*
923092	*AB1-107 CT1*	*44.29*
923094	*AB1-107 CT2*	*45.86*
923096	*AB1-107 ST1*	*54.65*
925751	*AC1-051 C*	*0.72*
925752	*AC1-051 E*	*4.82*
926941	*AC1-181*	*0.6*
927071	*AC1-195 C*	*0.73*
927072	*AC1-195 E*	*5.32*

Appendix 2

(FE - FE) The 02BLKRVR-02USSTEEL 138 kV line (from bus 239728 to bus 239734 ckt 1) loads from 225.45% to 226.77% (**DC power flow**) of its emergency rating (270 MVA) for the line fault with failed breaker contingency outage of 'C2-CEI-345-001'. This project contributes approximately 7.89 MW to the thermal violation.

CONTINGENCY 'C2-CEI-345-001' /* BREAKER FAILURE ON S145 BREAKER AT AVON 345KV
DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 1 /* 02LAKEAVE 345 02AVON 345
DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 2 /* 02LAKEAVE 345 02AVON 345
END

Bus Number	*Bus Name*	*Full Contribution*
238564	*02BAYSG1*	*12.23*
238571	*02BEAVGA*	*1.85*
238572	*02BEAVGB*	*1.93*
240968	*02BG2 GEN*	*0.62*
240969	*02BG4 G1*	*0.16*
240970	*02BG4 G2&3*	*0.31*
240971	*02BG4 G4&5*	*0.31*
240950	*02BG5*	*1.89*
240973	*02BG6 AMPO*	*2.75*
239276	*02COLLW 11*	*-2.85*
239297	*02CPPW41*	*-3.63*
238979	*02NAPMUN*	*2.92*
240975	*02PGE GEN*	*4.26*
239175	*02WLORG-6*	*3.06*
931051	*AC2-015 C OP*	*3.64*
931052	*AC2-015 E OP*	*4.25*
931791	*AC2-103 C*	*5.09*
931792	*AC2-103 E*	*34.09*
247542	*U4-001 C*	*1.54*
247934	*U4-001 E*	*10.33*
247551	*U4-028 C*	*0.98*
247940	*U4-028 E*	*6.58*
247552	*U4-029 C*	*0.98*
247941	*U4-029 E*	*6.58*
247567	*V2-006 C*	*1.04*
247961	*V2-006 E*	*6.98*
247548	*V4-010 C*	*2.13*
247947	*V4-010 E*	*14.27*
901803	*W1-072A*	*3.45*
907062	*X1-027A E1*	*14.32*

907065	*X1-027A E2*	*14.32*
907067	*X1-027A E3*	*14.32*
907069	*X1-027A E4*	*14.32*
LTF	*Y3-032*	*18.53*
915951	*Y3-092*	*31.54*
915952	*Y3-092 E*	*31.54*
921102	*AA1-056*	*4.06*
922573	*AA2-186 E*	*1.07*
923092	*AB1-107 CT1*	*24.11*
923094	*AB1-107 CT2*	*23.77*
923096	*AB1-107 ST1*	*28.33*
923821	*AB2-019*	*1.77*
925751	*AC1-051 C*	*0.51*
925752	*AC1-051 E*	*3.39*
926941	*AC1-181*	*0.33*

Appendix 3

(FE - FE) The 02USSTEEL-02LRN Q2 138 kV line (from bus 239734 to bus 238915 ckt 1) loads from 213.56% to 214.88% (**DC power flow**) of its emergency rating (270 MVA) for the line fault with failed breaker contingency outage of 'C2-CEI-345-001'. This project contributes approximately 7.89 MW to the thermal violation.

CONTINGENCY 'C2-CEI-345-001' /* BREAKER FAILURE ON S145 BREAKER AT AVON 345KV
DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 1 /* 02LAKEAVE 345 02AVON 345
DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 2 /* 02LAKEAVE 345 02AVON 345
END

Bus Number	*Bus Name*	*Full Contribution*
238564	*02BAYSG1*	*12.23*
238571	*02BEAVGA*	*1.85*
238572	*02BEAVGB*	*1.93*
240968	*02BG2 GEN*	*0.62*
240969	*02BG4 G1*	*0.16*
240970	*02BG4 G2&3*	*0.31*
240971	*02BG4 G4&5*	*0.31*
240950	*02BG5*	*1.89*
240973	*02BG6 AMPO*	*2.75*
239276	*02COLLW 11*	*-2.85*
239297	*02CPPW41*	*-3.63*
238979	*02NAPMUN*	*2.92*
240975	*02PGE GEN*	*4.26*
239175	*02WLORG-6*	*3.06*
931051	*AC2-015 C OP*	*3.64*
931052	*AC2-015 E OP*	*4.25*
931791	*AC2-103 C*	*5.09*
931792	*AC2-103 E*	*34.09*
247542	*U4-001 C*	*1.54*
247934	*U4-001 E*	*10.33*
247551	*U4-028 C*	*0.98*
247940	*U4-028 E*	*6.58*
247552	*U4-029 C*	*0.98*
247941	*U4-029 E*	*6.58*
247567	*V2-006 C*	*1.04*
247961	*V2-006 E*	*6.98*
247548	*V4-010 C*	*2.13*
247947	*V4-010 E*	*14.27*
901803	*W1-072A*	*3.45*
907062	*X1-027A E1*	*14.32*

907065	*X1-027A E2*	*14.32*
907067	*X1-027A E3*	*14.32*
907069	*X1-027A E4*	*14.32*
LTF	*Y3-032*	*18.53*
915951	*Y3-092*	*31.54*
915952	*Y3-092 E*	*31.54*
921102	*AA1-056*	*4.06*
922573	*AA2-186 E*	*1.07*
923092	*AB1-107 CT1*	*24.11*
923094	*AB1-107 CT2*	*23.77*
923096	*AB1-107 ST1*	*28.33*
923821	*AB2-019*	*1.77*
925751	*AC1-051 C*	*0.51*
925752	*AC1-051 E*	*3.39*
926941	*AC1-181*	*0.33*

Appendix 4

(AEP - AEP) The 05GREENLAW-05E.TIFF2 69 kV line (from bus 245621 to bus 245646 ckt 1) loads from 125.66% to 132.43% (**DC power flow**) of its emergency rating (39 MVA) for the tower line contingency outage of '7734_A'. This project contributes approximately 5.86 MW to the thermal violation.

CONTINGENCY '7734_A'
OPEN BRANCH FROM BUS 242984 TO BUS 243039 CKT 1 / 242984 05CHATFL 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 931050 CKT 1 / 243024 05HOWARD 138 931050 AC2-015 TAP 138 1
END

Bus Number	*Bus Name*	*Full Contribution*
931051	*AC2-015 C OP*	*2.7*
931052	*AC2-015 E OP*	*3.15*
247551	*U4-028 C*	*0.65*
247940	*U4-028 E*	*4.36*
247552	*U4-029 C*	*0.65*
247941	*U4-029 E*	*4.36*
247548	*V4-010 C*	*1.42*
247947	*V4-010 E*	*9.51*

Appendix 5

(AEP - AEP) The 05E.TIFF2-05WROCKWSS 69 kV line (from bus 245646 to bus 245635 ckt 1) loads from 163.94% to 172.46% (**DC power flow**) of its emergency rating (31 MVA) for the tower line contingency outage of '7734_A'. This project contributes approximately 5.86 MW to the thermal violation.

CONTINGENCY '7734_A'
OPEN BRANCH FROM BUS 242984 TO BUS 243039 CKT 1 / 242984 05CHATFL 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 931050 CKT 1 / 243024 05HOWARD 138 931050 AC2-015 TAP 138 1
END

Bus Number	*Bus Name*	*Full Contribution*
931051	*AC2-015 C OP*	*2.7*
931052	*AC2-015 E OP*	*3.15*
247551	*U4-028 C*	*0.65*
247940	*U4-028 E*	*4.36*
247552	*U4-029 C*	*0.65*
247941	*U4-029 E*	*4.36*
247548	*V4-010 C*	*1.42*
247947	*V4-010 E*	*9.51*
LTF	*Y3-032*	*1.82*

Appendix 6

(AEP - AEP) The 05ST.STEPHSS-05CARROTHR 69 kV line (from bus 245674 to bus 245655 ckt 1) loads from 113.94% to 122.46% (**DC power flow**) of its emergency rating (31 MVA) for the tower line contingency outage of '7734_A'. This project contributes approximately 5.86 MW to the thermal violation.

CONTINGENCY '7734_A'
OPEN BRANCH FROM BUS 242984 TO BUS 243039 CKT 1 / 242984 05CHATFL 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 931050 CKT 1 / 243024 05HOWARD 138 931050 AC2-015 TAP 138 1
END

Bus Number	*Bus Name*	*Full Contribution*
931051	*AC2-015 C OP*	*2.7*
931052	*AC2-015 E OP*	*3.15*
247551	*U4-028 C*	*0.65*
247940	*U4-028 E*	*4.36*
247552	*U4-029 C*	*0.65*
247941	*U4-029 E*	*4.36*
247548	*V4-010 C*	*1.42*
247947	*V4-010 E*	*9.51*
LTF	*Y3-032*	*1.82*