Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AA2-161

Yukon Robbins 138 kV

May 2016

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 Interconnected Transmission Owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, 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, if any, is included in the System Impact Study.

The 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 associated with them will be addressed when seeking an Interconnection Agreement as outlined below. Developer will also be responsible for providing and installing metering equipment in compliance with applicable PJM and Transmission Owner standards.

General

Invenergy Thermal Development ("Interconnection Customer" or "Invenergy") has proposed a combined cycle natural gas generating facility located near the intersection of Henderson Road and Great Allegheny Passage North in Buena Vista, Allegheny County, Pennsylvania. The installed facilities will have a total capability of 541 MW with 513 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is June 1, 2020. **This study does not imply a West Penn Power Company commitment to this in-service date.**

Point of Interconnection (POI)

For AA2-161 project, the connection from the West Penn Power transmission system to Invenergy's facilities will be provided by looping in/out the Yukon-Robins and the Wycoff-Springdale 138 kV lines to a new to-be-constructed six-breaker ring bus substation as shown in Appendix 2. The POI is located at this new substation. Invenergy is responsible for installing the 0.5 miles long generator lead to the point of interconnection.

Transmission Owner Scope of Work and Costs Estimation

West Penn Power attachment facilities and network upgrades as well as related costs estimates required for AA2-161 interconnection project are shown and described in below table. Please note that Contributions in Aid of Construction (*CIAC) tax gross-up is not included.*

AA2-161 Project Costs Description	Amount
Attachment Facilities • Installation of metering equipment • Installation of attachment line from the point of interconnection to the bus disconnect inside the substation	$ 53,000
Direct Connection Network Upgrades *NUN* — *Description* n5027 — Buena Vista SS – Construct 6-breaker ring bus substation, *$7,100,000.* n5028 — Huntingdon-Yukon 138kV, Install a loop to the proposed 6-breaker ring bus, *$415,400*. n5029 — Springdale-Yukon 138kV, Install a loop to the proposed 6-breaker ring bus, *$357,500*.	$ 7,872,900
Non-Direct Connection Network Upgrades *NUN* — *Description* n5030 — Yukon SS – Install new relay panels and carrier equipment on the Huntingdon and Springdale 138kV, *$360,000.* n5031 — Springdale SS – Install new relay panels and carrier equipment on the Yukon 138kV line, *$180,100.* n5032 — Huntingdon SS – Install new relay panels and carrier equipment on the Yukon 138kV line, *$180,100.* n5033 — All Dam 6 Tap-Kittanning 138kV, Reconductor ~6.4 miles with 795 kcmil ACSR conductor *$6,622,300*.	$ 7,342,500

AA2-161 Project Costs Description -Continued	Amount
Overduetied Breaker Replacements, *$4,935,600.* Yukon Breaker Replacements: Replace 5 138kV overdutied breakers with 3000A 80KA breaker, as follows: *NUN* — *Bus #* — *Bus Name* — *Breaker* n1380 — 20858 — YUKON 138.kV — CAP n1364 — 20858 — YUKON 138.kV — Y-1(YOUNGWD) n1381 — 20858 — YUKON 138.kV — Y-6(HEMPFLD) n1365 — 20858 — YUKON 138.kV — Y3(LYN-YNGD) n1373 — 20858 — YUKON 138.kV — Y7(HTDN-HMF) • Replace breaker foundations and control cables. • Reinforce 138kV bus structures and foundations, ground grid as required for new fault duty requirements. Refer to Appendix 6 for details. The following overdutied breaker upgrades fall under the Regional Transmission Expansion Plan (RTEP) reinforcements and therefore Invenergy will not be responsible for their costs upgrades: Replace 9 138kV breaker disconnect switches with V-type switches for clearances.	
Contributions for Previously Identified Upgrades None.	$ 0
Total Costs	**$ 20,204,000**

** NUN means Network Upgrade Number*

Interconnection Customer Requirements

In addition to the Interconnected Transmission Owner facilities, will be responsible for meeting all criteria as specified in the applicable sections of the Interconnected Transmission Owner "Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of a fully rated circuit breaker on the high side of the AA2-161 step-up transformer.
2. The purchase and installation of a lockable switch at the point of interconnection. This switch must be accessible by West Penn Power.
3. The purchase and installation of the minimum required generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.
4. The purchase and installation of a 138 kV interconnection metering instrument transformer. West Penn Power will provide the ratio and accuracy specifications based on the customer load and generation levels.
5. The purchase and installation of a revenue class meter to measure the power delivered in compliance with the FirstEnergy standards.
6. The purchase and installation of supervisory control and data acquisition (SCADA) equipment to provide information in a compatible format to the FirstEnergy Transmission System Control Center. The RTU, the communications channel and all related equipment will be furnished and maintained by the IC. The RTU must communicate with the FirstEnergy EMS via DNP 3.0 protocol.
7. The establishment of dedicated communication circuits for SCADA report to the FirstEnergy Transmission System Control Center.
8. A compliance with the FirstEnergy and PJM generator power factor and voltage control requirements.
9. The execution of a back-up retail service agreement with the electric distribution company to serve the customer load supplied from the IC's interconnection point when the units are out-of-service.
10. The rough grade of the property for the AA2-161 138 kV interconnection substation and an access road for the delivery of equipment to this site.

The above requirements are in addition to any metering required by PJM.

Schedule of Work

Based on the scope of interconnection attachment facilities, direct and non-direct system upgrades, it is expected to take a minimum of thirty (30) months from the date of a fully executed Interconnection Construction Service Agreement to complete the installation. This includes a preliminary payment that compensates the Interconnected Transmission Owner for the first three months of the engineering design work that is related to the interconnection facilities of the Project. It also assumes that the Interconnection Customer will provide the property for the Project direct connection facilities and all right-of-way, permits, easements, etc. that will be needed. A further assumption is that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined direct connection facilities and that transmission system outages will be possible when requested.

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 Interconnection Customer's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

Transmission Owner Requirements

The Interconnection Customer will be required to comply with all Interconnected Transmission Owner revenue metering requirements for generation interconnection customers. The Interconnected Transmission Owner revenue metering requirements may be found in the Interconnection Transmission Owner "Requirements for Transmission Connected Facilities" document located at the following links:

www.firstenergycorp.com/feconnect

www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Network Impacts

The Queue Project AA2-161 was evaluated as a 541.0 MW (Capacity 513.0 MW) injection into a double tap of the Yukon – Robbins 138 kV line and the Springdale – Wycoff 138 kV line in the APS area. Project AA2-161 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AA2-161 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis - 2019

Generator Deliverability

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

1. (AP - AP) The 01AL&D6T-01KITTAN 138 kV line (from bus 235139 to bus 235204 ckt 1) loads from 83.26% to 108.74% (AC power flow) of its emergency rating (151 MVA) for the single line contingency outage of 'AP_B2_531'. This project contributes approximately 40.13 MW to the thermal violation.

```
CONTINGENCY 'AP_B2_531'                 / KISKI VALLEY-SHAFFERS CORNER
  OPEN BUS 235137
  OPEN BUS 235131
  END
```

Please refer to Appendix 3 for a table containing the generators having contribution to this flowgate.

2. (AP - AP) The 01AL&D6T-01KITTAN 138 kV line (from bus 235139 to bus 235204 ckt 1) loads from 74.18% to 100.75% (AC power flow) of its emergency rating (151 MVA) for the single line contingency outage of 'APS_B_G144'. This project contributes approximately 41.79 MW to the thermal violation.

```
CONTINGENCY 'APS_B_G144'                / 235137 01AL 2J 138 235202 01KISKIV 138 1
  OPEN BRANCH FROM BUS 235137 TO BUS 235202 CKT 1
  END
```

Multiple Facility Contingency

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

1. (AP - AP) The AA2-161 TAP-01YUKON 138 kV line (from bus 920570 to bus 235277 ckt 1) loads from 10.12% to 105.41% (AC power flow) of its emergency rating (287 MVA) for the tower line contingency outage of 'AP_C5_113_A'. This project contributes approximately 326.84 MW to the thermal violation.

```
CONTINGENCY 'AP_C5_113_A'              /YU-SP_YU-ROB
  OPEN BRANCH FROM BUS 235238 TO BUS 920570 CKT 1
                                       /ROBBIN 138KV-AA2-161_TAP 138KV
  OPEN BUS 235275
  OPEN BUS 235283
  END
```

Please refer to Appendix 4 for a table containing the generators having contribution to this flowgate.

2. (AP - AP) The AA2-161 TAP-01YUKON 138 kV line (from bus 920570 to bus 235277 ckt 1) loads from 13.8% to 101.1% (AC power flow) of its emergency rating (287 MVA) for the tower line contingency outage of 'AP_C5_100'. This project contributes approximately 326.84 MW to the thermal violation.

```
CONTINGENCY 'AP_C5_100'                /YU-HN_YU-SP
  OPEN BRANCH FROM BUS 235195 TO BUS 235238 CKT 1
  OPEN BUS 235275
  OPEN BUS 235283
  END
```

3. (AP - AP) The AA2-161 TAP-01ROBBIN 138 kV line (from bus 920570 to bus 235238 ckt 1) loads from 13.73% to 100.22% (AC power flow) of its emergency rating (287 MVA) for the stuck breaker contingency outage of 'AA2-161_1'. This project contributes approximately 254.01 MW to the thermal violation.

```
CONTINGENCY 'AA2-161_1'
  OPEN BRANCH FROM BUS 920570 TO BUS 235277 CKT 1
  OPEN BRANCH FROM BUS 920580 TO BUS 235283 CKT 1
  END
```

Please refer to Appendix 5 for a table containing the generators having contribution to this flowgate.

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

Steady-State Voltage Requirements

None

Short Circuit
Short circuit study results identified fifteen (15) overduetied breakers, nine (9) of which are upgrades under the Regional Transmission Expansion Plan (RTEP) and therefore no costs will be allocated for these nine breaker upgrades. The other (5) overdutied breakers are responsibility of this project. Please refer to table in Appendix 6 for rating details.

Affected System Analysis & Mitigation

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.

1. (AP - AP) The 01AL&D6T-01KITTAN 138 kV line (from bus 235139 to bus 235204 ckt 1) loads from 83.26% to 107.08% (AC power flow) of its emergency rating (151 MVA) for the single line contingency outage of 'AP_B2_531'. This project contributes approximately 42.32 MW to the thermal violation.

```
CONTINGENCY 'AP_B2_531'                 / KISKI VALLEY-SHAFFERS CORNER
  OPEN BUS 235137
  OPEN BUS 235131
  END
```

Light Load Analysis - 2019
Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

System Reinforcements

Short Circuit

- Replace 5 138kV over-dutied breakers with 3000A 80KA breakers.
- Replace 9 138kV breaker disconnect switches with V-type switches for clearances
- Replace breaker foundations and control cables.
- Reinforce 138kV bus structures and foundations, ground grid as required for new fault duty requirements

Stability and Reactive Power Requirement

No mitigations were found to be required.

Summer Peak Load Flow Analysis Reinforcements

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

1. To relieve the All Dam 6 – Kittanning 138 kV line overloads: Re-Conductor line with 795 ACSR and upgrade risers at All Dam 6. Cost estimate is $6,622,300. New expected ratings to be 293/343 MVA SN/SE. PJM Network Upgrade Number: n5033.
2. To relieve the AA2-161 - Yukon 138 kV line overloads: Overload is mitigated by Direct Connection scope at Yukon (relay replacements). New expected ratings to be 254/320 MVA SN/SE. PJM Network Upgrade Number: n5030.
3. To relieve the AA2-161 - Robbin 138 kV line overload: Overload is mitigated by Direct Connection scope at Yukon and Huntingdon (relay replacements). New expected ratings to be 254/320 MVA SN/SE. PJM Network Upgrade Numbers: n5031 and n5032.

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)

None

Light Load Load Flow Analysis Reinforcements

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

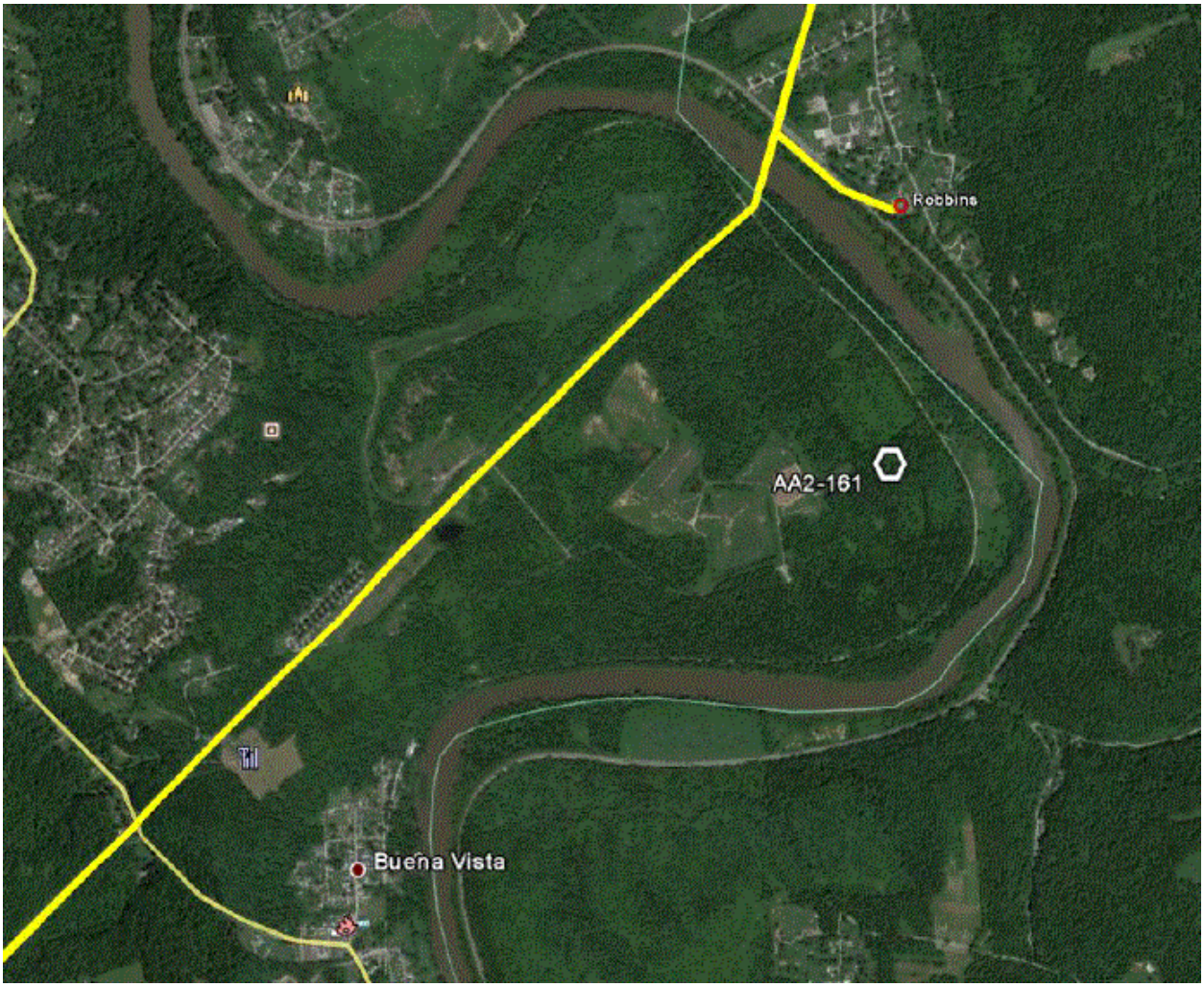
None

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)

None.

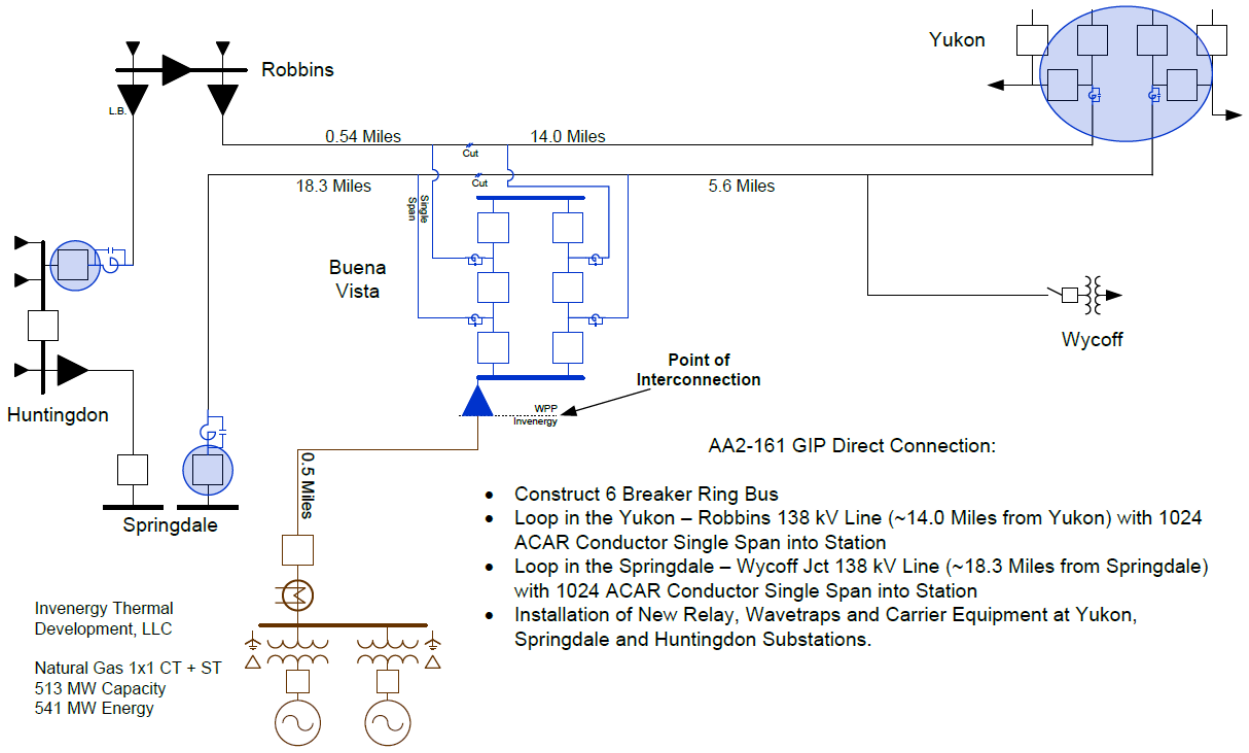
Appendix 1

Project Location



Appendix 2

System Configuration – Single Line Diagram



AA2-161 GIP Direct Connection:

- Construct 6 Breaker Ring Bus
- Loop in the Yukon – Robbins 138 kV Line (~14.0 Miles from Yukon) with 1024 ACAR Conductor Single Span into Station
- Loop in the Springdale – Wycoff Jct 138 kV Line (~18.3 Miles from Springdale) with 1024 ACAR Conductor Single Span into Station
- Installation of New Relay, Wavetraps and Carrier Equipment at Yukon, Springdale and Huntingdon Substations.

Appendix 3

CONTINGENCY 'AP_B2_531'

This appendix contains additional information about the flowgate presented in the body of the report. A description of the flowgate and its contingency is included for convenience. However, the intent of this 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 this appendix section are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

(AP - AP) The 01AL&D6T-01KITTAN 138 kV line (from bus 235139 to bus 235204 ckt 1) loads from 83.26% to 108.74% (AC power flow) of its emergency rating (151 MVA) for the single line contingency outage of 'AP_B2_531'. This project contributes approximately 40.13 MW to the thermal violation.

```
CONTINGENCY 'AP_B2_531'   / KISKI VALLEY-SHAFFERS CORNER
  OPEN BUS 235137
  OPEN BUS 235131
  END
```

Bus Number	*Bus Name*	*Full Contribution*
235134	*01AL&D6*	*0.45*
235580	*01HATFD1*	*2.69*
235581	*01HATFD2*	*2.69*
235582	*01HATFD3*	*2.69*
235610	*01SPRGD1*	*0.83*
235611	*01SPRGD2*	*0.83*
235612	*01SPRGD3*	*3.17*
235613	*01SPRGD4*	*3.13*
235614	*01SPRGD5*	*3.3*
915951	*Y3-092*	*29.4*
916001	*Z1-015*	*0.49*
916321	*Z1-088*	*0.35*
916331	*Z1-089*	*0.35*
920571	*AA2-161 C*	*40.13*

Appendix 4

CONTINGENCY 'AP_C5_113_A'

This appendix contains additional information about the flowgate presented in the body of the report. A description of the flowgate and its contingency is included for convenience. However, the intent of this 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 this appendix section are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

(AP - AP) The AA2-161 TAP-01YUKON 138 kV line (from bus 920570 to bus 235277 ckt 1) loads from 10.12% to 105.41% (AC power flow) of its emergency rating (287 MVA) for the tower line contingency outage of 'AP_C5_113_A'. This project contributes approximately 326.84 MW to the thermal violation.

```
CONTINGENCY 'AP_C5_113_A'              /YU-SP_YU-ROB
  OPEN BRANCH FROM BUS 235238 TO BUS 920570 CKT 1
                                       /ROBBIN 138KV-AA2-161_TAP 138KV
  OPEN BUS 235275
  OPEN BUS 235283
  END
```

Bus Number	*Bus Name*	*Full Contribution*
235610	*01SPRGD1*	*0.78*
235611	*01SPRGD2*	*0.78*
235612	*01SPRGD3*	*2.96*
235613	*01SPRGD4*	*2.93*
235614	*01SPRGD5*	*3.09*
916001	*Z1-015*	*0.46*
920571	*AA2-161 C*	*309.92*
920572	*AA2-161 E*	*16.92*

Appendix 5

CONTINGENCY 'AA2-161_1'

This appendix contains additional information about the flowgate presented in the body of the report. A description of the flowgate and its contingency is included for convenience. However, the intent of this 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 this appendix section are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

(AP - AP) The AA2-161 TAP-01ROBBIN 138 kV line (from bus 920570 to bus 235238 ckt 1) loads from 13.73% to 100.22% (AC power flow) of its emergency rating (287 MVA) for the stuck breaker contingency outage of 'AA2-161_1'. This project contributes approximately 254.01 MW to the thermal violation.

CONTINGENCY 'AA2-161_1'
OPEN BRANCH FROM BUS 920570 TO BUS 235277 CKT 1
OPEN BRANCH FROM BUS 920580 TO BUS 235283 CKT 1
END

Bus Number	*Bus Name*	*Full Contribution*
920571	*AA2-161 C*	*240.86*
920572	*AA2-161 E*	*13.15*

Appendix 6

Yukon Breaker Replacements

Bus #	Bus Name	BREAKER	Rating Type	Breaker Capacity (Amps)	Duty Percent With AA2-161_APS	Duty Percent Without AA2-161_APS	Duty Percent Difference	Duty Amps With AA2-161_APS	Duty Amps Without AA2-161_APS	Network Upgrade Number
20858	YUKON 138.kV	CAP	S	63000	102.26%	97.84%	4.42%	64422.8	61638.6	n1380
20858	YUKON 138.kV	Y-1(YOUNGWD)	S	63000	102.26%	97.84%	4.42%	64422.8	61638.6	n1364
20858	YUKON 138.kV	Y-6(HEMPFLD)	S	63000	102.26%	97.84%	4.42%	64422.8	61638.6	n1381
20858	YUKON 138.kV	Y3(LYN-YNGD)	S	63000	102.26%	97.84%	4.42%	64422.8	61638.6	n1365
20858	YUKON 138.kV	Y7(HTDN-HMF)	S	63000	102.26%	97.84%	4.42%	64422.8	61638.6	n1373

Appendix 6 -Continued

Yukon Breaker Replacements

Replace the 138kV breakers with 80kA breakers. Modify the 138kV busses, bus supports, and ground grid as required to accommodate the new breakers.