[redacted]

Elko Redevelopment Project

Interconnection System Impact Study

Report #: T&S Planning 2015-052

February 2016

British Columbia Hydro and Power Authority

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This report was prepared and reviewed by T&D, Interconnection Planning and approved by both Interconnection Planning and Transmission Generator Interconnections.

Revision Table

Revision Number	Date of Revision	Revised By

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Executive Summary

[redacted] is to redevelop Elko Generating Station (ELK) on behalf of BC Hydro to replace the two existing 6 MW units with two 10.4 MW units. ELK is located in East Kootenay area and the project will be connected to the existing Elko substation 60 kV bus. The maximum injection to the system from this project is 20.8 MW, and the proposed Commercial Operation Date (COD) is December 1, 2019.

This report documents the evaluation of the system impact of interconnecting the proposed generating facility and identifies the required system modifications to obtain acceptable system performance with the interconnection of the proposed project.

To interconnect Elko Redevelopment Project and its facilities to the existing Elko substation 60 kV bus, this System Impact Study (SIS) has identified the following conclusions and requirements:

- With the ELK generation output increased from 12 MW to 20.8 MW, no abnormal bus voltage or branch over loading was observed during system normal with the Alberta to BC export no more than the present long term firm commitment of 249 MW. No transmission line upgrading work in the BC Hydro system has been proposed.
- Overloading on a number of 60 kV circuits was observed under a few single contingencies during light load and high Elko and Aberfeldie generation outputs. Heavy import above the long term firm commitment from Alberta under system normal may also cause over loading of 60L289 under light summer load and high Elko and Aberfeldie generation condition. A local generation run back scheme will be needed to resolve the over loading issues.
- No transient stability concern in the area due to addition of the Elko generation has been observed under single system contingencies.
- Local 60 kV transmission line protection changes are required to accommodate Elko Redevelopment Project.
- It will be necessary to replace the existing telecom radios with new low capacity microwave radios to accommodate the project's telecommunication requirements.
- The non-binding good-faith cost estimate for Interconnection Network Upgrades required to interconnect the proposed project to BC Hydro Transmission System is $4.3 million and the estimated time to implement after project approval is 30 months. The work required within the IC facilities is not part of Interconnection Network Upgrades.

The Interconnection Facilities Study report will provide greater details of the Interconnection Network Upgrade requirements and associated cost estimate and estimated construction timeline for this project.

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1. Introduction

The project reviewed in this system impact study is as described in table 1-1 below.

Table 1-1: Summary Project Information

Project Name	Elko Redevelopment Project	
Interconnection Customer	[redacted]	
Point of Interconnection	Existing Elko substation 60 kV Bus	
IC Proposed COD	December 1, 2019	
Type of Interconnection Service	NRIS ☒	ERIS ☐
Maximum Power Injection (MW)	20.8 (Summer)	20.8 (Winter)
Number of Generator Units	2	
Plant Fuel	Hydro	

[redacted] is to redevelop Elko power plant on behalf of BC Hydro to replace the two existing 6 MW units with two 10.4 MW units. Elko is located in East Kootenay area and the project will be connected to the existing Elko substation 60 kV bus. The maximum injection to the system from this project is 20.8 MW.

The proposed generating facilities consist of the following equipment:

- Two 11.6 MVA generators at Elko;
- A 69/6.9 kV step-up transformer at Elko, which is rated at 15/20/25 MVA (T1);
- A 0.12 km 6.9 kV overhead line from Elko power house to Elko 60 kV substation.

The key parameters for the generators, the step-up transformer and the line are shown in Appendix B.

The following figures show the single line diagram and geographical locations of the facilities in the area, including Elko Redevelopment Project.

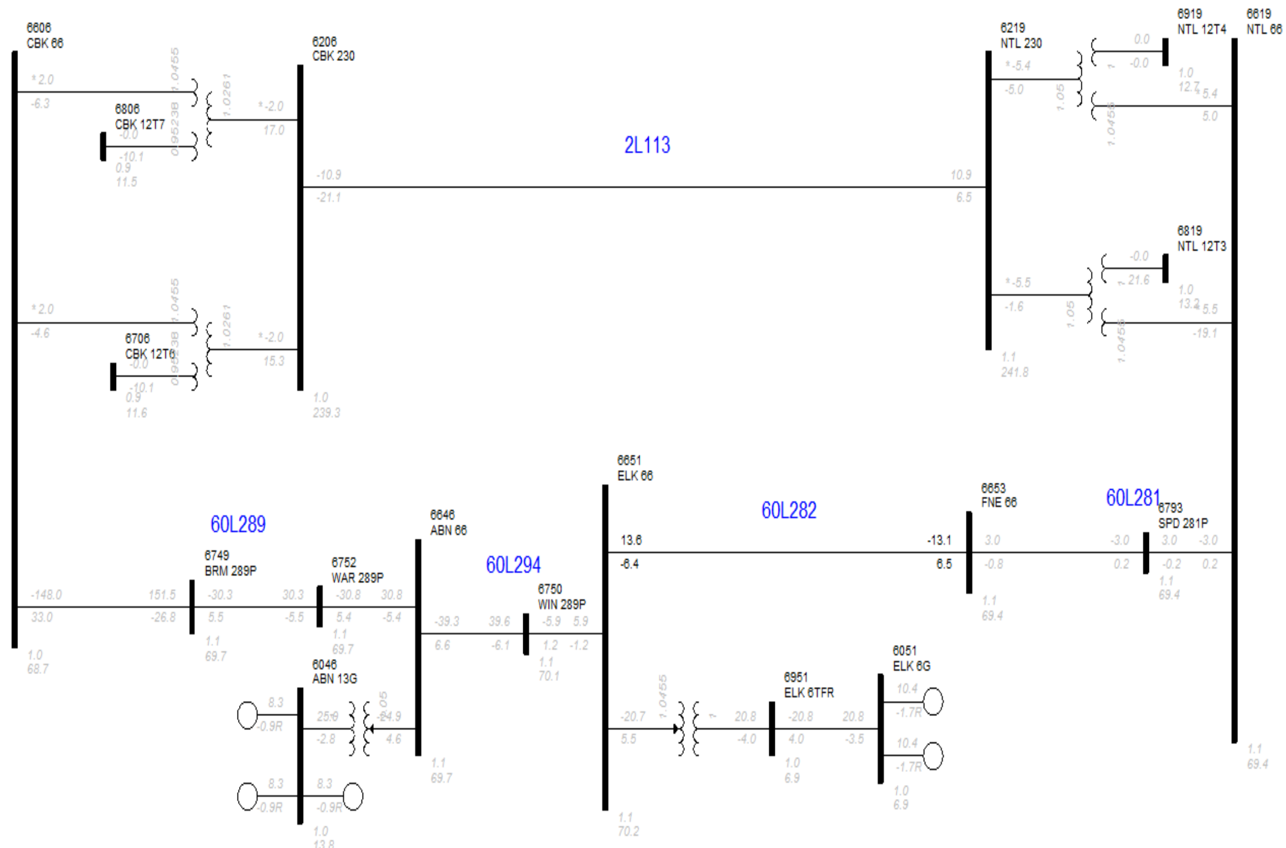

Figure 1-1: East Kootenay Area Transmission System Diagram

The Elko substation is connected to the system through two 60 kV transmission lines, one eastward to Natal (NTL) substation and the other westward to Cranbrook (CBK) substation. The above two 60 kV lines operate in parallel with 2L113 (from NTL to CBK). There is a 500kV line between CBK and Langdon substations on the Alberta side, and also two 138 kV circuits from NTL tying to the Alberta system. Those 500 kV and 138 kV circuits form the intertie between the two provinces. Due to the parallel operation of the above 60 kV, 138 kV, 230 kV and 500 kV circuits, the power flow on the two 60 kV transmission lines are also affected by power exchanges between BC and Alberta.

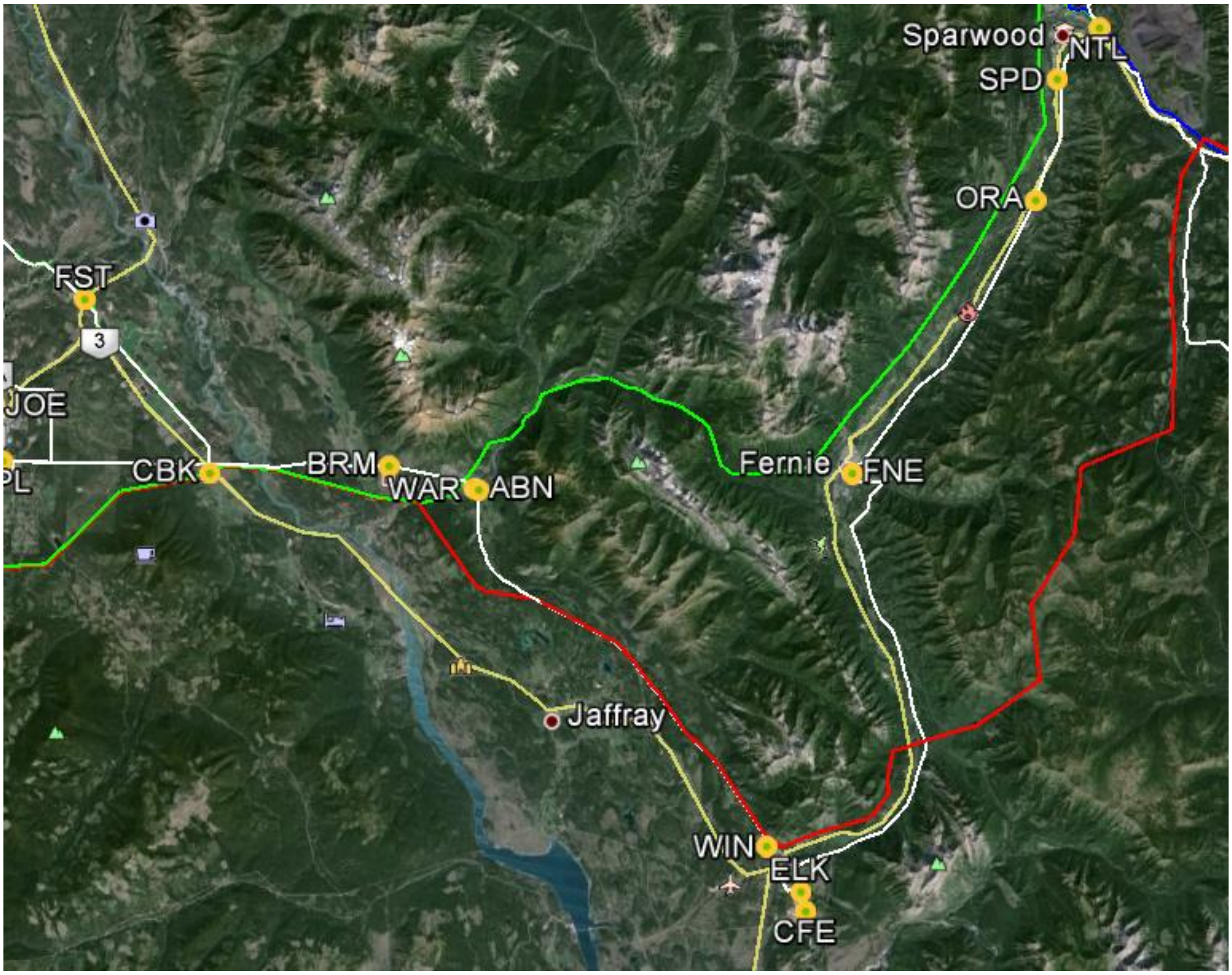

Figure 1-2: Interconnection Geographical Location Diagram

2. Study Purpose

The purpose of this SIS is to assess the impact of the interconnection of the proposed project on the BC Hydro Transmission System. This study shall identify constraints and Network Upgrades required for interconnecting the proposed generating project in compliance with the NERC/WECC reliability standards and the BC Hydro transmission planning criteria.

3. Terms of Reference

This study investigates and addresses the overloading, voltage deviation, and stability issues of the transmission network in the East Kootenay area as a result of the proposed interconnection for system normal and single contingency conditions. The studied topics include equipment thermal loading and rating requirements, system transient stability and voltage stability, transient over-voltages, protection coordination, telecom requirements. BC Hydro planning methodology and criteria are used in the studies.

The SIS does not investigate operating restrictions and other factors for possible second contingency outages. Subsequent network studies will determine the requirements for reinforcements or operating restrictions/instructions for those types of events.

The work necessary to implement the network improvements identified in this SIS report will be described in greater detail in the Interconnection Facilities Study (IFS) report for this project.

4. Assumptions

The studied power flow conditions are to include generation, transmission facilities, and load forecasts representing the BC Hydro interconnection queue position applicable to this project. Applicable seasonal conditions and the appropriate study years for the study horizon have been incorporated. As a result, BC Hydro 2019 Heavy Winter, 2020 Heavy Summer, and 2020 Light Summer power flow base cases were selected for this study. The IC's latest data submission, as of June 22, 2015, has been used in this study.

5. System Studies and Results

Power flow and transient stability studies were carried out to evaluate the impact of the proposed Elko Redevelopment Project. Studies were also performed to determine the protection, control and communication requirements and remedies.

5.1 Steady State N-0 and N-1 Power Flows

Steady state pre-outage (N-0) and single contingency (N-1) power flow analyses were performed to evaluate the impacts of integrating Elko Redevelopment Project on system voltages and transmission elements loadings at nearby BC Hydro substations.

With the Elko generation output increased from 12 MW to 20.8 MW, no abnormal bus voltage or branch over loading (except one marginal over loading on 60L289, 103%) was observed during system normal and during Alberta to BC export at or below the present long term firm commitment of 249 MW.

Any of the following lines out-of-service may cause over loading some of the remaining 60 kV lines that connected Elko and Aberfeldie generation plants to the system under light load and maximum Elko and Aberfeldie generation condition:

60L281 (NTL to FNE) or

60L282 (FNE to ELK) or

60L289 (CBK to ABN) or

2L113 (CBK to NTL).

Heavy import above the long term firm commitment of 249 MW from Alberta may cause over loading of 60L289 under light summer load and maximum Elko and Aberfeldie generation condition.

The power flow one-line diagrams for 2019 Heavy Winter and 2020 Light Summer and Heavy Summer base cases are provided in Appendix A.

Table 5-1: Summary of Heavy Winter Power Flow Results

	Bus Voltage (p.u.)						Line Loading (MVA)			
System Condition	ELK 66	WIN 66	ABN 66	FNE 66	CBK 66	NTL 66	60L281 NTL-FNE	60L282 FNE-ELK	60L289 ABN-CBK	60L294 ELK-ABN
	Line Summer Rating (MVA)						45.2	45.2	55.8	55.8
System Normal	1.05	1.05	1.06	1.03	1.05	1.04	5.0	11.1	26.9	3.1
60L281 OOS	1.04	1.04	1.06	1.01	1.05	1.04	N	15.9	21.5	5.6
60L282 OOS	1.05	1.05	1.06	1.04	1.05	1.04	15.6	N	37.9	12.9
60L289 OOS	1.04	1.04	1.06	1.00	1.06	1.03	21.2	36.9	N	25.2
60L294 OOS	1.04	1.06	1.06	1.03	1.06	1.04	5.1	11.8	26.2	N
2L113 OOS	1.04	1.05	1.06	1.02	1.05	1.02	2.5	13.4	24.2	3.6

Table 5-2: Summary of Light Summer Power Flow Results

	Bus Voltage (p.u.)						Line Loading (MVA)			
System Condition	ELK 66	WIN 66	ABN 66	FNE 66	CBK 66	NTL 66	60L281 NTL-FNE	60L282 FNE-ELK	60L289 ABN-	60L294 ELK-
	Line Summer Rating (MVA)						33.5	33.5	30.3	30.3
System Normal	1.06	1.06	1.05	1.05	1.04	1.04	3.1	12.7	31.3	6.1
60L281 OOS	1.07	1.07	1.06	1.06	1.04	1.05	N	10.1	34.5	9.3
60L282 OOS	1.06	1.06	1.05	1.06	1.04	1.05	9.7	N	43.1	18.7
60L289 OOS	1.05	1.05	1.07	1.01	1.04	1.04	32.8	43.9	N	25.9
60L294 OOS	1.07	1.06	1.06	1.05	1.04	1.05	9.1	19.0	25.2	N
2L113 OOS	1.07	1.07	1.05	1.07	1.04	1.07	2.9	11.1	33.9	8.8

Table 5-3: Summary of Heavy Summer Power Flow Results

	Bus Voltage (p.u.)						Line Loading (MVA)			
System Condition	ELK 66	WIN 66	ABN 66	FNE 66	CBK 66	NTL 66	60L281 NTL-FNE	60L282 FNE-ELK	60L289 ABN-CBK	60L294 ELK-ABN
	Line Summer Rating (MVA)						33.5	33.5	30.3	30.3
System Normal	1.05	1.05	1.06	1.04	1.06	1.04	1.9	10.2	27.1	4.6
60L281 OOS	1.06	1.06	1.06	1.06	1.04	1.04	N	9.4	29.9	5.6
60L282 OOS	1.06	1.06	1.05	1.05	1.04	1.04	9.0	N	37.8	14.7
60L289 OOS	1.05	1.05	1.07	1.01	1.04	1.03	28.2	38.9	N	24.8
60L294 OOS	1.05	1.06	1.06	1.04	1.04	1.04	4.8	14.1	24.9	N
2L113 OOS	1.06	1.06	1.06	1.05	1.04	1.05	1.0	10.3	28.7	4.5

5.2 Transient Stability Study

Transient stability simulations were performed on 2020 summer light load conditions.

No transient stability concern in the area due to addition of the Elko generation has been observed under single system contingencies.

A review of the slip centre of the Elko generators was also performed. Based on the data provided by the IC, the slip centre would be inside the Elko generator.

The models and parameters of the project's key components are shown in Appendix B.

Transient stability studies for 2020 Light Summer cases are presented. Selected dynamic simulation plots are presented in Appendix C.

Table 5-4: Selected transient stability results for 2020LS cases

Case	Contingency	3-Ph Fault Location	Fault Clearing (Cycles)		Performance of the ELK and ABN units	POI & nearby 60 kV station min Transient Voltage (p.u.)
			Near End	Far End		
1	60L282	ELK	7	21	All stable	1.00
2	60L282	85% from ELK	7	21	All stable	0.80
3	60L294	ELK	11	21	All stable	0.90
4	60L294	85% from ELK	7	28	All stable	0.80
5	2L113	NTL	6	6	All stable	1.0

5.3 Analytical Studies

Analytical assessment has been done and there is no over voltage, voltage dip and harmonic concerns due to the project.

5.4 Fault Analysis

The short circuit analysis for the System Impact Study is based upon the latest BC Hydro system model, which includes project equipment and impedances provided by the IC. The model included higher queued projects and planned system reinforcements but excluded lower queued projects. Thevenin impedances, including the ultimate fault levels at POI, are not included in this report but will be made available to the IC upon request.

BCH will work with the IC to provide accurate data as required during the project design phase.

5.5 Transmission Line Upgrade Requirements

No line upgrade work has been identified in this study.

5.6 Protection and Control

Protection Network Upgrades by BC Hydro Include:

- Provide new line protections for 60L287, 60L290 and 60L294 at ELK.
- Protection changes are required for ABN 60L289 and ELK 60L282.
- Provide new HV bus protection for 60B1/60B2 of ELK.
- The 60L282 and 60L289 line overload condition will be determined by the MVA rating of the line; however, due to the requirement of manually toggling on/off of MVA based line overload protection dependent on the time of the year, P&C Planning has determined to utilize a thermal based line overload protection scheme instead.

ABERFELDIE GENERATING STATION (ABN)

ABN 60L289

- Provide two RTD, two SEL-2600 and two SEL-2800 to the existing 60L289 line protection for the addition of Line Thermal protection.
- Revise existing ABN 60L289 line protection settings to add Line Thermal protection to detect 60L289 overload conditions.
- Provide signaling of 60L289 overloading via relay output contacts to initiate local generation run back scheme.

ELKO GENERATING STATION (ELK)

ELK 60L282

- Provide two RTD, two SEL-2600 and two SEL-2800 to the existing 60L282 line protection for the addition of Line Thermal protection.
- Revise existing ELK 60L282 line protection settings to add Line Thermal protection to detect 60L282 overload conditions.
- Provide signaling of 60L282 overloading via relay output contacts to initiate local generation run back scheme.

ELK 60L294

- Provide two new SEL-421 relays to replace the existing electromechanical relays.

ELK 60L290

- Provide two new SEL-421 relays to replace the existing electromechanical relays.

ELK 60L287

- Provide two new SEL-421 relays to replace the existing electromechanical relays.

ELK 60B1/60B2

- Provide two new SEL-487B relays for bus protection.

Area Protection Review

- Review, and revise if necessary, the surrounding line protections for 60L294, 60L290, 60L287, and 60L282 to accommodate the generation increase at ELK.

Protection Work Required by the IC:

Follow the latest 60 kV to 500 kV Technical Interconnection Requirements (TIR) for Power Generators, including but not limited to:

- Provide two sets of entrance protection and power quality protection per the "BC Hydro 60 kV to 500 kV Technical Interconnection Requirements for Power Generators" (TIR).
- Provide local protect for station equipment.
- Provide generator out-of-step protection.
- Provide entrance breaker CTs for the implementation of a high speed differential bus protection for 60B1 and 60B2. IC's consultant has agreed to the proposal and has confirmed availability of the entrance breaker CTs for BC Hydro to implement a HV bus protection scheme.

Control Network Upgrades by BC Hydro Include:

- Upgrade the existing ELK switchyard control system to the Medium Distribution Control System architecture per ES 45-Q101.
- Provide a new GE DNP3 RTU for the ELK switchyard.
- The existing ELK switchyard control room is inadequately sized for the new control equipment. A new ELK switchyard control room might be required
- Provide alarms, metering and remote data access for new relays at ABN and ELK.

Control Work Required by the IC:

- Provide plant telemetry and status information per the "BC Hydro 60 kV to 500 kV Technical Interconnection Requirements for Power Generators" (TIR) via the new GE DNP3 RTU.

5.7 Telecommunications

Telecom Requirements include:

- Telecom Management System (TMS) circuits between:
    a. Silver Star Microwave Repeater Station to Baker Mountain Microwave Repeater Station (SSR-BKR),
    b. BKR- Morrissey Ridge Microwave Station (MRR) (revision),
    c. BKR- Elko Falls Generating Station (ELK), and
    d. ELK to Elko Falls Repeater Station (ELK-ELJ).
- Corporate LAN WAP, gateway device, and VoIP telephone at ELK switchyard control building.

The details are listed below:

- At SSR, install V.35 cable from SSR TMS router to SSR Digital Access Carrier System (DACS). Revise and reissue channel auth. 8627 (256 kbps TMS WAN: SSR-BKR).
- At MRR, revise channel auth. 7959 to MRR TMS LAN: MRR-BKR.

- At BKR, replace LEDR radio terminals with 4RF Aprisa XE radio terminals. Install C2911 TMS router at BKR with two V.35 connections to BKR DACS and one V.35 connection to 4RF radio. Connect BKR TMS router to: BKR-ELK radio system management port, and BKR-ABN radio system management port.
- Add exiting ELK-ELJ fibre facility to Fibre Database.
- At ELJ, replace LEDR radio terminal with 4RF Aprisa XE radio terminal, equipped with V.35 cards and T1 card. Install C2911 TMS router and a NetGuardian. Connect local alarms to NetGuardian. Install one SI-TECH T1 to fibre converter. Install one Nebula V-FASTAS Ethernet to fiber line-driver, connect to TMS router. Remove ELJ TE-25 DACS.
- At ELK, install C2911 TMS router and ALU 7705SAR-8 equipped with Ethernet, T1, and RS232 ports. Install one SI-TECH T1 to fibre converter and connect to T1 interface of 7705. Install one Nebula V-FAST-AS fibre line driver and connect to TMS Router. Provision 256 kbps Corporate LAN off SI. For relay remote access, install Terminal Server and, if required, SI-TECH RS232 to fibre converters to extend circuit to switchyard control building. Provision 128 kbps ELK TMS network management circuit to BKR. Provision 512 kbps MPLS link to MPLS node SIC3. Provision ELK Remote Access circuit to EDM. Remove ELK TE50 DACS.
- At ELK, revise ELK SCADA OFF SIC, channel auth 8261, from ELK TE50 DACS to 7705.
- At ELK, install a wireless access point (WAP), gateway device, and VoIP telephone at the switchyard control building.
- At ELK, connect RS232 interface to new RTU.
- At South Interior Data Collection Point (SI DCP), install RS232 SCADA circuit from ELK.
- Remove any components remaining of the retired ELK-CBK single channel PLC system, including coupling capacitors, if any, and update all ELK and CBK drawings accordingly.
- Toward the end of the project, at ELK, cancel business line 250-529-7746 if it is no longer required, and remove the telephone high voltage entrance.
- At Edmonds Office (EDM), provision ELK relay remote access circuit.
- At South Interior Control Center (SIC), provision 512 kbps MPLS link to ELK.
- Integrate 4RF radio management information base with Telenium management system.
- Arrange for 4RF radio training.
- Order one maintenance-spare 4RF radio; ship to Store 74.
- At BKR, replace 900 MHz antenna mount and/or loose antenna if damaged.

This project has been identified as requiring a Telecom Facility Audit at BKR. The audit will be performed after installation and before commissioning starts. The Audit must be performed as described in the latest revision of BC Hydro Engineering Standard ES 46-R0069 and will include all Telecom equipment added or modified under this project.

5.8 Islanding

Islanded operation is not arranged for this project. Power quality protection will be required at the generating unit to detect abnormal system conditions, such as under/over voltage and under/over frequency, and subsequently trip the unit. The settings of these protective relays must conform to existing BC Hydro practice for generating plants so that the generator will not trip for normal ranges of voltages and frequencies.

5.9 Black Start Capability

BC Hydro does not require the proposed project to have black start (self-start) capability.

5.10 Cost Estimate and Schedule

The non-binding good-faith cost estimate for Interconnection Network Upgrades required to interconnect the proposed project to BC Hydro Transmission System is $4.3 million. A detailed project schedule will be developed in the next phase of the project.

The ELK switchyard control room may be inadequately sized for the new equipment. The cost of a new control room or room extension is not included in this estimate. Revenue Metering if needed for this project, is not a part of the interconnection Network Upgrades.

It is expected that the BC Hydro work can be completed in approximately 30 months from project approval.

6. Revenue Metering

No revenue metering work is required for the proposed project.

7. Conclusions and Discussion

To interconnect Elko Redevelopment Project and its facilities to the existing Elko substation 60 kV bus, this System Impact Study (SIS) has identified the following conclusions and requirements:

1. With the ELK generation output increased from 12 MW to 20.8 MW, no abnormal bus voltage or branch over loading (except one marginal over loading on 60L289) was observed during system normal and during Alberta to BC export at or below the present long term firm commitment of 249 MW. BC Hydro transmission line upgrading work will not be necessary.

   Any of the following lines out-of-service may cause over loading of 60L281, 60L282 or 60L289 under light load and maximum Elko and Aberfeldie generation condition:

   60L281 (NTL to FNE) or

   60L282 (FNE to ELK) or

   60L289 (CBK to ABN) or

   2L113 (CBK to NTL).

   Heavy import above the long term firm commitment of 249 MW from Alberta may cause over loading of 60L289 under light summer load and maximum Elko and Aberfeldie generation condition.

2. No transient stability concern in the area due to addition of the Elko generation has been observed under single system contingencies.
3. A local generation run back scheme will be needed to resolve the above line over loading issues.
4. Generator out of step protection will be needed to trip unstable units by the 6.9 kV generator unit breakers after a more severe system disturbance.
5. The Elko generating station is not arranged for islanded operation. Power quality type protection is required in the station to trip the units if an advertent islanding does occur.
6. Entrance protection must be provided by the Interconnection Customer (IC).
7. Local 60 kV transmission line protection changes are required to accommodate Elko Redevelopment Project.
8. Plant telemetry and status information is to be provided by the IC.
9. It will be necessary to replace the existing telecom radios with new low capacity microwave radios to accommodate the project's telecommunication requirements.
10. The non-binding good-faith cost estimate for Interconnection Network Upgrades required to interconnect the proposed project to BC Hydro Transmission System is $4.3 million and the estimated time to implement after project approval is 30 months. The work required within the IC facilities is not part of Interconnection Network Upgrades. The work for Revenue Metering is also not included.

The Interconnection Facilities Study report will provide greater details of the Interconnection Network Upgrade requirements and associated cost estimate and estimated construction timeline for this project.

Appendix A – Selected Power Flow Diagrams

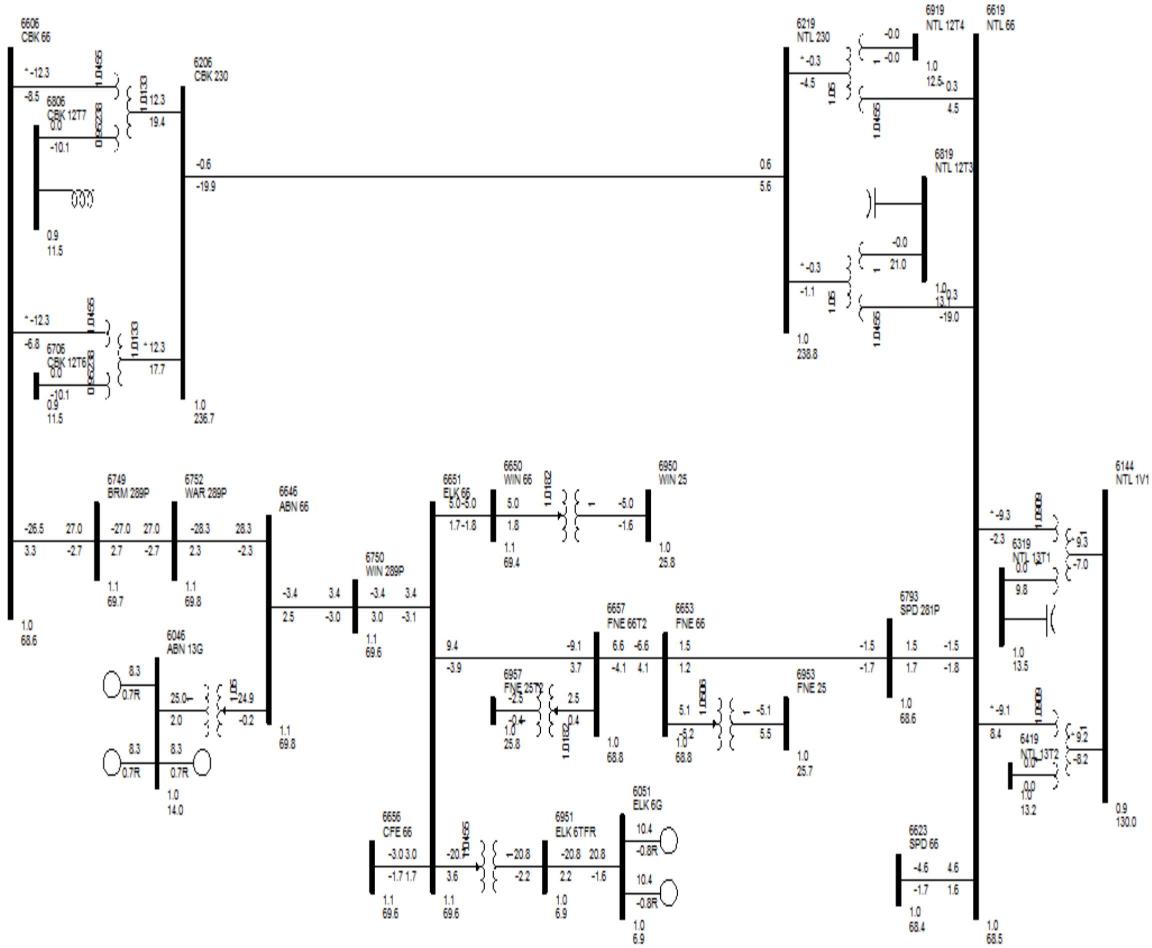

Figure A-1: 2020 Heavy Summer System Normal Condition

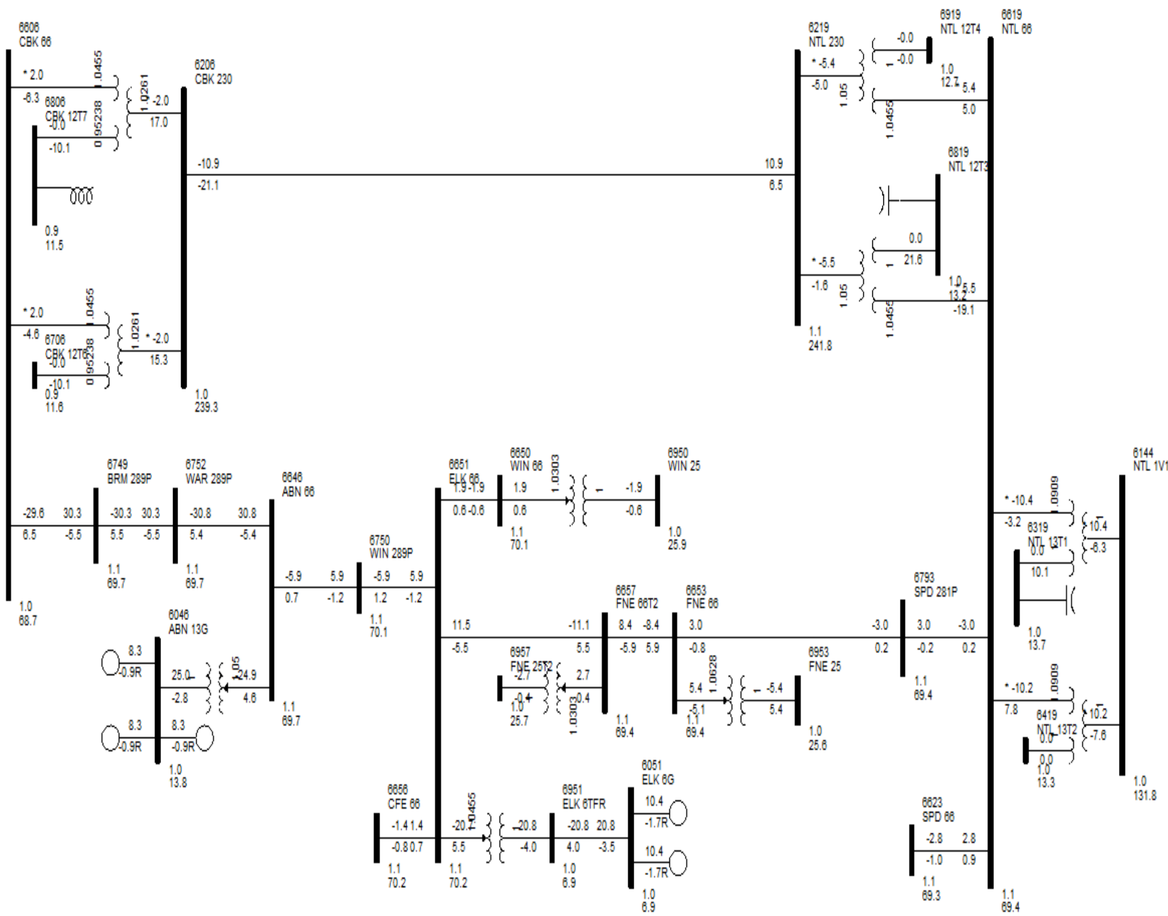

Figure A-2: 2020 Light Summer System Normal Condition

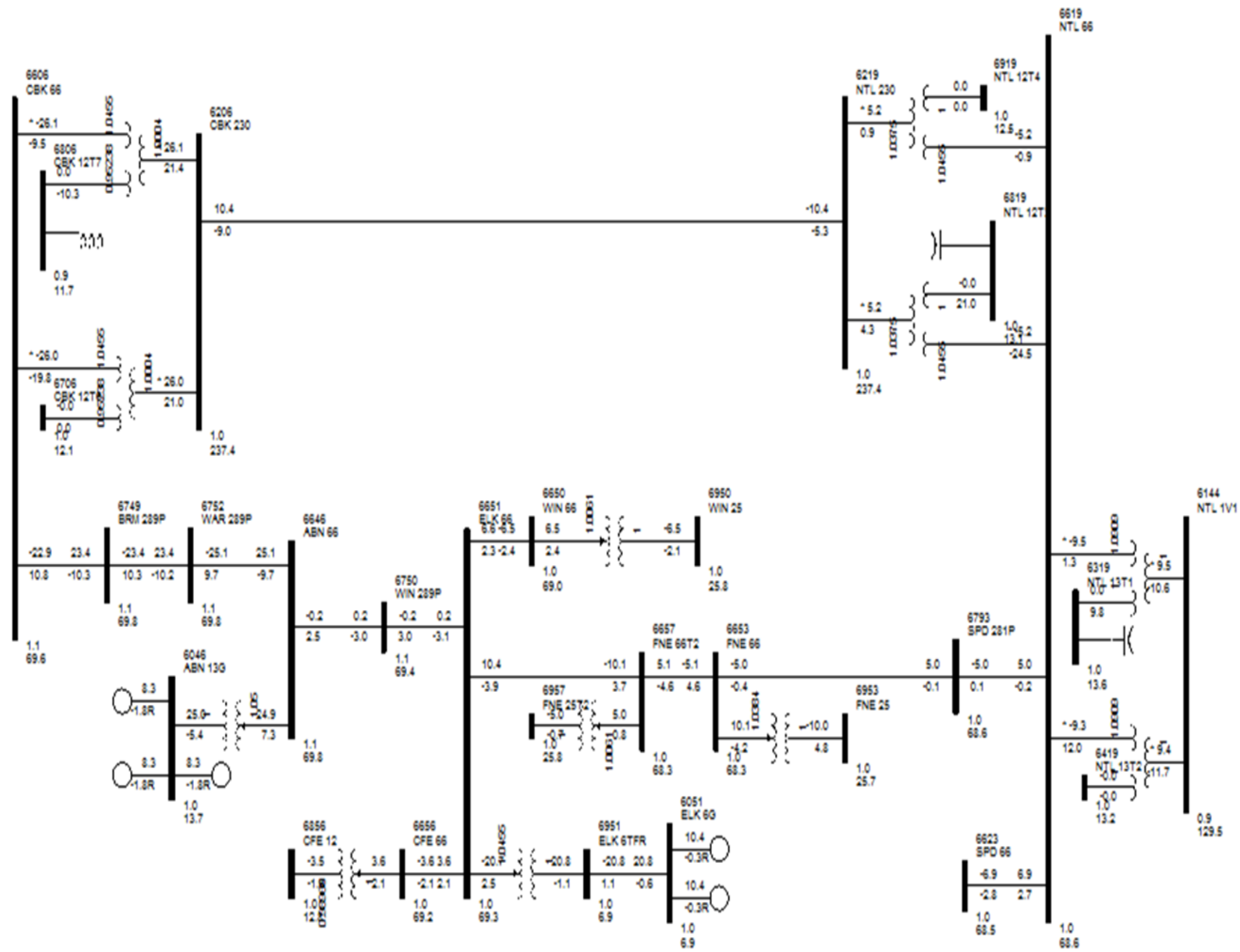

Figure A-3: 2019 Heavy Winter System Normal Condition

Appendix B – Power Flow Data and Dynamic Models

Table B-1: Generator Data

Generator	Rated MVA/MW	Base KV	Power Factor (Lag/Lead)	Xd	X'd	X"d
G1	11.6 /10.4	6.9	0.9 / 0.95	1.00	0.25	0.20
G2	11.6 /10.4	6.9	0.9 / 0.95	1.00	0.25	0.20

Table B-2: Transformer Data

Transformer	ONAN Rating	Max Rating	Impedance (% on ONAN Rating)	Voltage (HV/LV Winding)	Connection HV	Connection LV
T1	15.0	25.0	8.00	69 / 6.9	YG	Delta

Table B-3: Line Data

Line	Voltage	Length	R	X
Power house to Elko Substation	6.9 kV	0.12 km	0.0026 Ohm	0.063 Ohm

Table B-4: Generator Model GENTPJU1

CONs	G1 Value	G2 Value	Description
0	4.5	4.5	T'_{do} >0 (sec)
1	0.03	0.03	T''_{do} >0 (sec)
2	0.00	0.00	T'_{qo} (sec)
3	0.06	0.06	T''_{qo} >0 (sec)
4	2.1	2.1	H, Inertia (Turbine and Generator)
5	0.0	0.0	D, Speed Damping
6	1	1	X_d
7	0.6	0.6	X_q
8	0.25	0.25	X'_d
9	0.6	0.6	X'_q
10	0.2	0.2	X''_d
11	0.2	0.2	X''_q
12	0.08	0.08	X_L
13	0.15	0.15	S(1.0)
14	0.4	0.4	S(1.2)
15	0.00	0.00	K_{IS}

Table B-5: Exciter Model ESAC8B

CONs	G1 Value	G2 Value	Description
0	0.004	0.004	T_R (sec)
1	80	80	K_P
2	20	20	K_I
3	10	10	K_D
4	0.02	0.02	T_D
5	1.00	1.00	K_A
6	0.004	0.004	T_A
7	4.92	4.92	V_{RMAX}
8	0.00	0.00	V_{RMIN}
9	0.6	0.6	T_E
10	1.00	1.00	K_E
11	2.78	2.78	E_1
12	0.08	0.08	S_{E1}
13	3.70	3.70	E_2
14	0.33	0.33	S_{E2}

Appendix C – Selected Plots of Stability Studies

Figure C-1: 2020 Light Summer Base Case Machine Relative Angle Plots 1

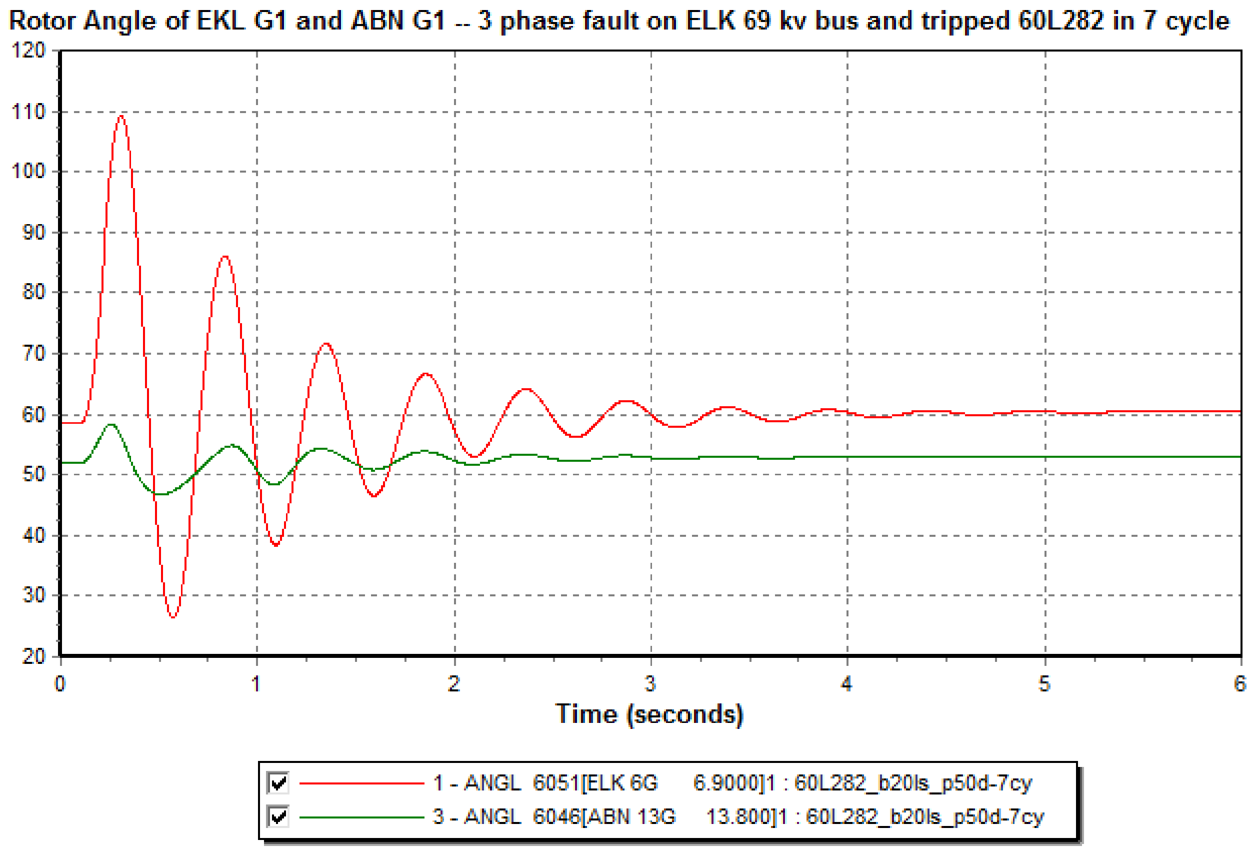

Figure C-2: 2020 Light Summer Base Case Bus Voltage Plots 1

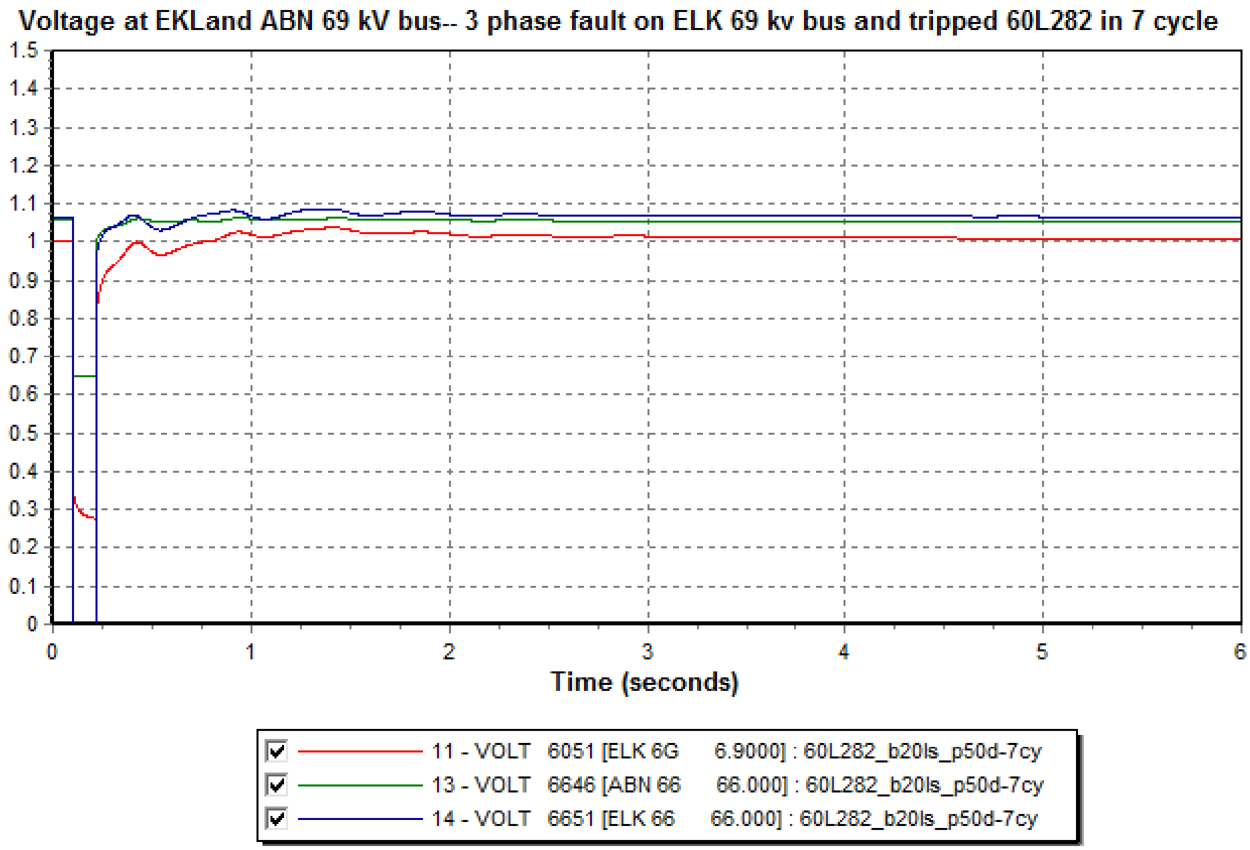

Figure C-3: 2020 Light Summer Base Case Machine Relative Angle Plots 2

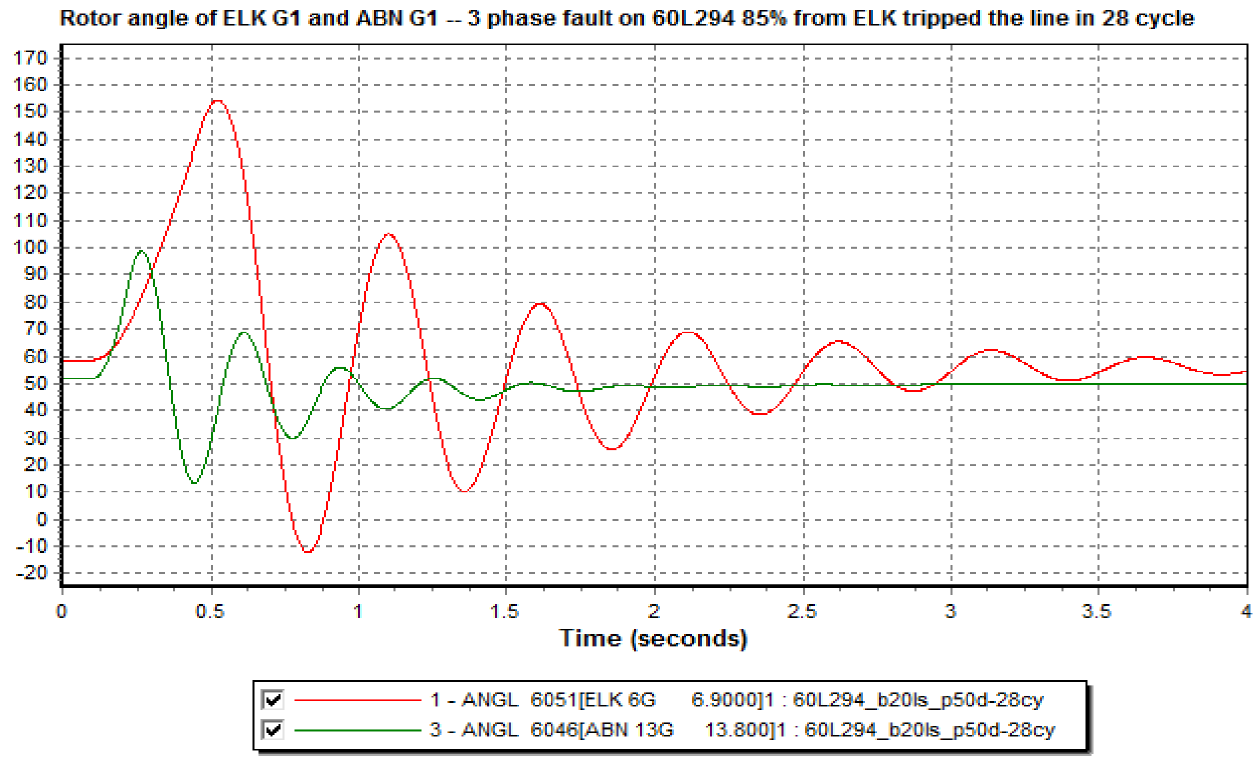

Figure C-4: 2020 Light Summer Base Case Bus Voltage Plots 2