GENERATOR INTERCONNECTION

SYSTEM IMPACT STUDY REPORT

for integration of the proposed

240 MW [redacted] SOLAR PROJECT

(GI PROJECT #551)

to the

IDAHO POWER COMPANY ELECTRICAL SYSTEM

in

ELMORE COUNTY, IDAHO

for

[redacted]

Report v.2

October 21, 2020

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1.0 Introduction

[redacted] has contracted with Idaho Power Company ("Transmission Provider") to perform a Generator Interconnection System Impact Study for the integration of the proposed 240 MW [redacted] solar project (the Project). The Project location is in Idaho Power Company's (IPC's) Capital Region in Elmore County, Idaho. The project is Generation Interconnect (GI) queue number 551 (GI #551). The project has chosen in the System Impact Study to be studied as both an Energy Resource (ER) Interconnection Service and a Network Resource (NR) Interconnection Service.

The Project has applied to connect to the Transmission Provider's transmission system for an injection of 240 MW of solar with a [redacted] 230kV line on Idaho Power Company's (IPC's) [redacted] 230kV station near Mountain Home, Idaho. The Project's Generation Point of Interconnection (POI) is assumed to be at the [redacted] 230kV bus.

IPC project queue GI #530 is a senior queued project and the facilities and subsequent cost to integrate the 240 MW GI #551 240 MW [redacted] solar project are contingent on GI #530 integration facilities.

This report documents the basis for and the results of this System Impact Study for the GI #551 Generation Interconnection Customer. The report describes the proposed project, the determination of project interconnection requirements and estimated costs for integration of the Project to the Transmission Provider transmission system. This report satisfies the System Impact Study requirements of the Idaho Power Tariff.

2.0 Summary

The system impact of interconnecting the 240 MW generation project to the Transmission Provider's transmission system with a [redacted] 230kV line to [redacted] 230kV bus was evaluated. The Project's Generation Point of Interconnection (POI) is assumed to be at Idaho Power's [redacted] station's 230kV bus.

The System Impact Study determined if any additional network upgrades are required to integrate this project into the IPCo transmission system and evaluated full system impacts (thermal, voltage, transient stability, reactive margin). Generator interconnection service (either as an Energy Resource or a Network Resource) does not in any way convey any right to deliver electricity to any specific customer or point of delivery.

The project will be required to control voltage in accordance with a voltage schedule as provided by Idaho Power Grid Operations. GI #551 will be required to manage the real power output of their generation project at the POI. Also, it may be beneficial for [redacted], for their own modeling compliance requirements, to install additional PMU devices at their facilities to monitor the generation source(s).

The total "Energy Resource Interconnection Service" generation interconnection preliminary cost estimate to interconnect the project to the primary study POI is as follows:

- Energy Resource Interconnection at Primary 230kV POI - $**910,644**

See Section 6.6 Energy Resource Cost Estimate for the required Energy Resource facilities and cost breakdowns.

The total "Network Resource Interconnection Service" generation interconnection preliminary cost estimate to interconnect the [redacted] project is as follows:

- Network Resource Interconnection Service - $**910,644**
    - This does not include costs for required facilities from senior queued GI #530.

See Section 7.4 Network Resource Cost Estimate for the required Network Resource facilities and cost breakdowns. The cost estimate includes a 20% contingency and 8.5% overhead. These are cost estimates only and final charges to the customer will be based on the actual construction costs incurred. It should be noted that the preliminary cost estimates do not include the cost of the customer's owned equipment.

The schedule for designing, procuring, and constructing facilities will be developed and optimized during the Facility Study should the generation interconnection customer choose to move to that study phase of the interconnection process.

3.0 Scope of Interconnection System Impact Study

The Interconnection System Impact Study was done and prepared in accordance with the Transmission Provider's Standard Generator Interconnection Procedures to provide an evaluation of the system impact of the interconnection of the proposed generating project to the Idaho Power system. As listed in the Interconnection System Impact Study Agreement, the Interconnection System Impact Study Report provides the following information:

- identification of any circuit breaker short circuit capability limits exceeded as a result of the interconnection;
- identification of any thermal overload or voltage limit violations resulting from the interconnection;
- identification of any instability or inadequately damped response to system disturbances resulting from the interconnection and
- description and non-binding, good faith estimated cost of facilities required to interconnect the Large Generating Facility to the Transmission System and to address the identified short circuit, instability, and power flow issues.

All other proposed Generation projects prior to this project in the Generator Interconnect queue were considered in this study**.** A current list of these projects can be found in the Generation Interconnection folder located on the Idaho Power web site at the link shown below:

http://www.oatioasis.com/ipco/index.html.

4.0 Contingent Facilities

GI #551 Energy Resource, ER, service is not contingent upon upgrades associated with any senior queued project.

IPC project queue GI #530 is a senior queued project. Idaho Power studied GI #551 with all Network Upgrades identified in GI #530 modeled as in service (Contingent Facilities). Changes to GI #530, including in-service date and withdrawal from the queue, may trigger a restudy associated with GI #551 Network Resource (NR) service. Some of the Network Upgrades identified for GI #530 are required by GI #551. Contingent Facilities are detailed in Appendix B.

5.0 Description of Proposed Generating Project

Assumptions:

- The Point of Interconnection (POI) for GI #551 is at the [redacted] 230kV station at coordinates [redacted]

    - Approximately [redacted] 230kV lead line from the Project to [redacted] 230kV station
- 240 MW Solar Generation
- All generation in voltage regulation (Reactive capability used to regulate 230kV bus voltage – supply/absorb reactive)
- 40 MVAr 230kV Shunt Capacitor Bank at [redacted] 230kV

6.0 Energy Resource (ER) Interconnection Service

Energy Resource (ER) Interconnection Service allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's transmission system and to be eligible to deliver electric output using firm or non-firm transmission capacity on an as available basis. ER Interconnection Service in and of itself does not convey Transmission Service.

The Project has applied to connect to the Idaho Power transmission system for an injection of 240 MW with a new 230kV interconnection line terminal at the [redacted] 230kV switching station. All generation projects in the area ahead of this project in the IPC generation queue and their associated transmission system improvements were modeled in a power flow analysis to evaluate the system impact of interconnecting GI #551.

6.1 Description of Substation/Transmission Facilities

As an Energy Resource, a Transmission Service Request will be required to determine the specific Network Upgrades required to deliver the project output to a designated point of delivery. Listed below are the required transmission facilities to interconnect the Project; these facilities required for interconnection are consistent with the facilities identified in the Generation Interconnection Feasibility Study:

Substation Interconnection Facilities:

The proposed interconnection will require a new line terminal bay to be added to Idaho Power's [redacted] 230kV switching station.

The actual station layout and detailed equipment requirements will be determined in the Facility Study should the interconnection customer choose to move to that study phase of the interconnection process.

6.2 Description of Distribution Facilities

No distribution facilities are directly impacted by this project.

6.3 Short Circuit Study Results

Studies indicate that there is adequate load and short circuit interrupting capability on the Transmission Provider's existing 230kV breakers to serve this project. The results of the Fault Study are shown in Tables 1 and 2 below.

Fault Study (w/o GI #551)			
Location	SLG (A)	LTL (A)	3PH (A)
[redacted]	31479.4	32948.2	38387.8

Table 1: Fault Study results without GI #551

Fault Study (w/ GI #551)			
Location	SLG (A)	LTL (A)	3PH (A)
[redacted] Bus	32453.6	33136.8	38723.9
GI #551 Contribution	903.4	276.7	336.1

Table 2: Fault Study results with GI #551

6.4 Electric System Protection Results and Grounding Requirements

For 230kV line protection, the Transmission Provider's System Protection Department utilizes permissive and line differential protection schemes integrated with our existing digital communication infrastructure. Digital communication infrastructure for the interconnection customers 230kV line will be the responsibility of said interconnection customer.

Grounding requirements and acceptability criteria are found in Appendix A.

6.5 Energy Resource Cost Estimate

In Table 3 below a summary is provided of the generation interconnection facilities and conceptual costs required to interconnect the GI #551 solar project to the Transmission Provider's transmission system as an Energy Resource.

GI #551 [redacted] Solar Project 230kV Station Energy Resource Generation Interconnection Facilities	
	Cost
Additional [redacted] Line Terminal	$699,419
Subtotal	**$699,419**

Contingencies (~20.0%)	$139,884
Subtotal	**$839,303**
Overheads (~8.5%)	$71,341
Energy Resource – Total Estimated Cost	**$910,644**

Table 3: GI #551 Energy Resource Cost Estimate

The cost estimates include direct equipment and installation labor costs, indirect labor costs and general overheads, and a contingency allowance. These are cost estimates only and final charges to the customer will be based on the actual construction costs incurred. It should be noted that the preliminary cost estimates do not include the cost of the customer's owned equipment.

The schedule for designing, procuring, and constructing facilities will be developed and optimized during the Facility Study should the generation interconnection customer choose to move to that study phase of the interconnection process.

7.0 Network Resource (NR) Interconnection Service

Network Resource Interconnection Service allows the Interconnection Customer to integrate its Generating Facility with the Transmission Provider's Transmission System in a manner comparable to that in which the Transmission Provider integrated its generating facilities to serve native load customers. The transmission system is studied under a variety of conditions to determine the transmission improvements/upgrades which are necessary. Network Resource Interconnection Service in and of itself does not convey Transmission Service.

7.1 Description of Power Flow Cases

For the Network Resource Interconnection Service study, three power flow cases were used to study the Transmission Provider's transmission system with westbound and eastbound transmission flows to determine the required Network Transmission Upgrades.

The WECC 2019 Heavy Summer case was chosen as a power flow base case for the study. The case was modified to represent a summer month with high west to east (eastbound) transfers across Midpoint West.

For the second case, a WECC 2019 Light Winter operating case, was modified to represent a shoulder month condition with high east to west (westbound) transfers across Midpoint West.

For the third case the WECC 2019 Heavy Summer case was modified to represent a summer month with high solar, wind, and gas generation east of Boise with high transfers into the

Boise area.

7.2 Network Resource Transmission Upgrades

From the power flow/contingency analysis, no additional Network Transmission upgrades were identified for the integration of GI #551 in addition to the Energy Resource generation interconnection facilities.

IPC project queue GI #530 is a senior queued project. Idaho Power studied GI #551 with all Network Upgrades identified in GI #530 modeled as in service (Contingent Facilities). Changes to GI #530, including in-service date and withdrawal from the queue, may trigger a restudy associated with GI #551 Network Resource (NR) service. Some of the Network Upgrades identified for GI #530 are required by GI #551. Contingent Facilities are detailed in Appendix B.

7.3 Network Resource Cost Estimate

Table 4 below is a summary of the Network Transmission generation interconnection facilities and conceptual costs required to interconnect the GI #551 solar project to the Transmission Provider's transmission system as a Network Resource.

GI #551 [redacted] 240 MW Solar **Network Upgrades** **Network Resource Generation Interconnection Facilities**	
Network Resource Transmission Upgrades:	**Cost**
Network Transmission – Total Estimated Cost	**$0**
Energy Resource – Total Estimated Cost	$910,644
Network Resource – Total Estimated Cost	**$910,644**

Table 4: GI #551 Network Resource Cost Estimate

8.0 Voltage Stability Analysis

A Voltage Stability study was performed using the WECC 2019 Light Winter case with Midpoint West East-to-West flows stressed up to 2940 MW (105% of the Path Rating). All contingencies solved successfully so there were no Voltage Stability issues found for the Project.

9.0 Transient Stability Analysis

The WECC 2019 Heavy Summer case modified to represent a summer month with high solar, wind, and gas generation east of Boise with high transfers into the Boise area was used along with PowerWorld's Transient Stability Analysis tool to perform the transient stability analysis for the Project.

Seven transient stability runs were performed with the Project on the system to validate model and system performance:

1. 5.0 Cycle [redacted] 230kV Breaker 201A 3-phase fault, loss of [redacted] – [redacted] 230kV Line and [redacted] 230kV/138kV Transformer T232
2. 5.0 Cycle [redacted] – [redacted] 230kV Line 3-phase fault, loss of [redacted] – [redacted] 230kV Line
3. 5.0 Cycle [redacted] – [redacted] 230kV Line 3-phase fault, loss of [redacted] – [redacted] 230kV Line
4. 5.0 Cycle [redacted] – [redacted] 230kV Line 3-phase fault, loss of [redacted] – [redacted] – [redacted] 230kV Line
5. 5.0 Cycle [redacted] – [redacted] 230kV Line 3-phase fault, loss of [redacted] – [redacted] 230kV Line
6. 4.0 Cycle [redacted] – [redacted] 500kV Line 3-phase fault, loss of [redacted] – [redacted] 500kV Line
7. 4.0 Cycle [redacted] – [redacted] 500kV Line 3-phase fault, loss of [redacted] – [redacted] 500kV Line

Two transient stability runs were performed with the Project turned off to verify that the Project was not causing any issues seen:

1. 5.0 Cycle [redacted] – [redacted] 230kV Line 3-phase fault with the Project turned off, loss of [redacted] – [redacted] 230kV Line
2. 4.0 Cycle [redacted] – [redacted] 500kV Line 3-phase fault with the Project turned off, loss of [redacted] – [redacted] 500kV Line

The results showed no transient stability violations. Appendix B contains the transient stability plots for the [redacted] – [redacted] 230kV and [redacted] – [redacted] 500kV faults with and without the Project.

10.0 Description of Operating Requirements

It is the Project's responsibility to provide reactive power capability to provide at a minimum a power factor operating range of at least 0.95 leading (supplying) to at least 0.95 lagging (absorbing) at the POI over the range of real power output (up to maximum output of 240 MW). At full output of 240 MW, the Project would need to be able to provide approximately +/- 78.9 MVAr reactive support at the POI.

Based on the information provided, the Project's own facilities will require approximately 78 MVAr of reactive support for 0.95 leading and 61 MVAr of reactive support for 0.95 lagging. If the installed inverters cannot supply the sum of these needs (+156.9/-17.9 MVAr), the Project will be required to install additional shunt reactive support.

Based on the P-Q Capability curve provided for the inverter model, it appears the specified inverters plus 40 MVAr shunt capacitor cannot satisfy the reactive requirements for the project. Possible solutions include installation of more inverters, a larger shunt capacitor bank, or a more efficient GSU (56 MVAr losses).

Of note is that the current GSU also overloads to 106% of its continuous rating on the low-side when the Project provides 240 MW and 78.9 MVAr at the POI.

In our review of the data provided, it appears that the collector impedance is a factor of 10 smaller than what we normally see for projects of this size. This is not to imply that the provided impedance is incorrect, but it may warrant double-checking by the developer.

GI #551 will be required to control voltage in accordance with a voltage schedule as provided by Idaho Power Grid Operations, and GI #551 will be required to manage the real power output of their stated generation at the project's POI.

The project(s) is required to comply with the applicable Voltage and Current Distortion Limits found in IEEE Standard 519-1992 *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*.

Installation of phasor measurement unit devices at the POI and maintenance costs associated with communication circuits needed to stream PMU data will also be required to be provided to interconnect GI #551. The specific costs associated with the IPC requirements for interconnection customers with aggregate facilities larger than 20 MW to provide PMU data to IPC will be identified in the Facility Study should the generation interconnection customer choose to proceed to that phase of the interconnection process. Also, it may be beneficial for [redacted], for their own modeling compliance requirements, to install additional PMU devices at their facilities to monitor the generations sources separately.

Additional operating requirements for this project may be identified in the System Impact study when it is performed.

11.0 Conclusion

GI #551 can be interconnected to the Idaho Power transmission system.

Interconnection requirements detailed in Section 6.6 totaling $**910,644** are required to interconnect the Project as an Energy Resource to the primary 230kV POI. No additional upgrades were identified for the integration of the Project as a Network Resource. However, the Network Resource connection is reliant on network facility upgrades identified in senior queued generation interconnections.

Generator interconnection service (either as an Energy Resource or a Network Resource) does not in any way convey any right to deliver electricity to any specific customer or point of delivery. A Transmission Service Request will be required to study the Transmission System Impacts.

APPENDIX A

A-1.0 Method of Study

The System Impact Study plan inserts the Project up to the maximum requested injection into the selected Western Electric Coordinating Council (WECC) power flow case and then, using Power World Simulator or GE's Positive Sequence Load Flow (PSLF) analysis tool, the impacts of the new resource on Idaho Power's transmission system (lines, transformers, etc.) within the study area are analyzed. The WECC and Idaho Power reliability criteria and Idaho Power operating procedures were used to determine the acceptability of the configurations considered. For distribution feeder analysis, Idaho Power utilizes Advantica's SynerGEE Software.

A-2.0 Acceptability Criteria

The following acceptability criteria were used in the power flow analysis to determine under which system configuration modifications may be required:

> The continuous rating of equipment is assumed to be the normal thermal rating of the equipment. This rating will be as determined by the manufacturer of the equipment or as determined by Idaho Power. Less than or equal to 100% of continuous rating is acceptable.
>
> Idaho Power's Voltage Operating Guidelines were used to determine voltage requirements on the system. This state, in part, that distribution voltages, under normal operating conditions, are to be maintained within plus or minus 5% (0.05 per unit) of nominal everywhere on the feeder. Therefore, voltages greater than or equal to 0.95 pu voltage and less than or equal to 1.05 pu voltage are acceptable.
>
> Voltage flicker during starting or stopping the generator is limited to 5% as measured at the point of interconnection, per Idaho Power's T&D Advisory Information Manual.
>
> Idaho Power's Reliability Criteria for System Planning was used to determine proper transmission system operation.
>
> All customer generation must meet IEEE 519 and ANSI C84.1 Standards.
>
> All other applicable national and Idaho Power standards and prudent utility practices were used to determine the acceptability of the configurations considered.

> The stable operation of the system requires an adequate supply of volt-amperes reactive (VAr) to maintain a stable voltage profile under both steady-state and dynamic system conditions. An inadequate supply of VArs will result in voltage decay or even collapse under the worst conditions.

Equipment/line/path ratings used will be those that are in use at the time of the study or that are represented by IPC upgrade projects that are either currently under construction or whose budgets have been approved for construction soon. All other potential future ratings are outside the scope of this study. Future transmission changes may, however, affect current facility ratings used in the study.

A-3.0 Electrical System Protection Guidance

IPCo requires electrical system protection per Requirements for Generation Interconnections found on the Idaho Power Web site,

https://docs.idahopower.com/pdfs/BusinessToBusiness/FacConnReq.pdf

APPENDIX B – GI #530 Upgrades Needed by GI #551

Table B1 is a summary of the Network Upgrades identified by the Contingent Facility GI #530 that would be needed by GI #551 if GI #530 does not go forward.

GI #530 Network Upgrades Needed by GI #551	
Network Upgrades:	**Cost**
[redacted] **–** [redacted] **230kV Line** Rebuild [redacted] of 230kV line with 1590 MCM ACSR "Lapwing" Conductor	$30,470,000
[redacted] **–** [redacted] **230kV Line Loop in-and-out of** [redacted] **Station** Build [redacted] 230kV Double Circuit Line with 1272 MCM ACSR "Bittern" Conductor	$1,040,000
[redacted] **230kV Station** Add two 230kV Line Terminals	$1,775,000
Reconfigure [redacted] **230kV Line Terminals** Avoid simultaneous loss of lines to [redacted] and [redacted]	$1,240,000
Subtotal	**$34,525,000**
Contingencies (~20%)	$6,905,000
Subtotal	**$41,430,000**
Overheads (~8.5%)	$3,521,550
Network Upgrades – Total Estimated Cost	**$44,951,550**

Table B1: GI #530 Network Upgrades Needed by GI #551

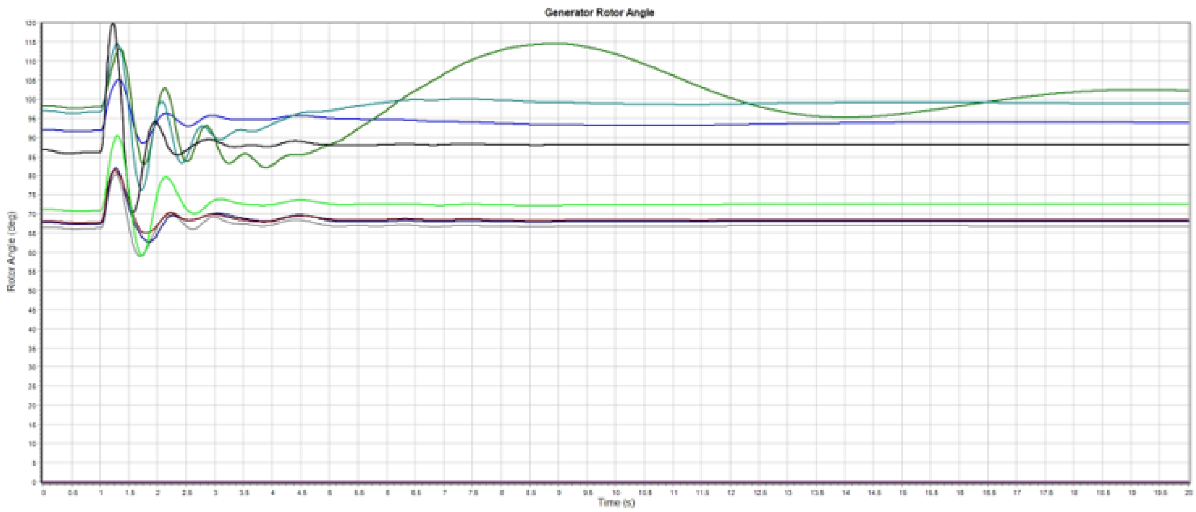
Table B2 is a summary of the Direct Assign Upgrades identified by the Contingent Facility GI #530 that would be needed by GI #551 if GI #530 does not go forward.

GI #530 Direct Assign Upgrades Needed by GI #551	
Direct Assign Upgrades:	**Cost**
Reconfigure [redacted] 230kV Line Terminals Raise 230kV lines to new [redacted] 230kV terminal location	$420,000
Subtotal	**$420,000**
Contingencies (~20%)	$84,000
Subtotal	**$504,000**
Overheads (~8.5%)	$42,840
Direct Assign Upgrades – Total Estimated Cost	**$546,840**

Table B2: GI #530 Direct Assign Upgrades Needed by GI #551

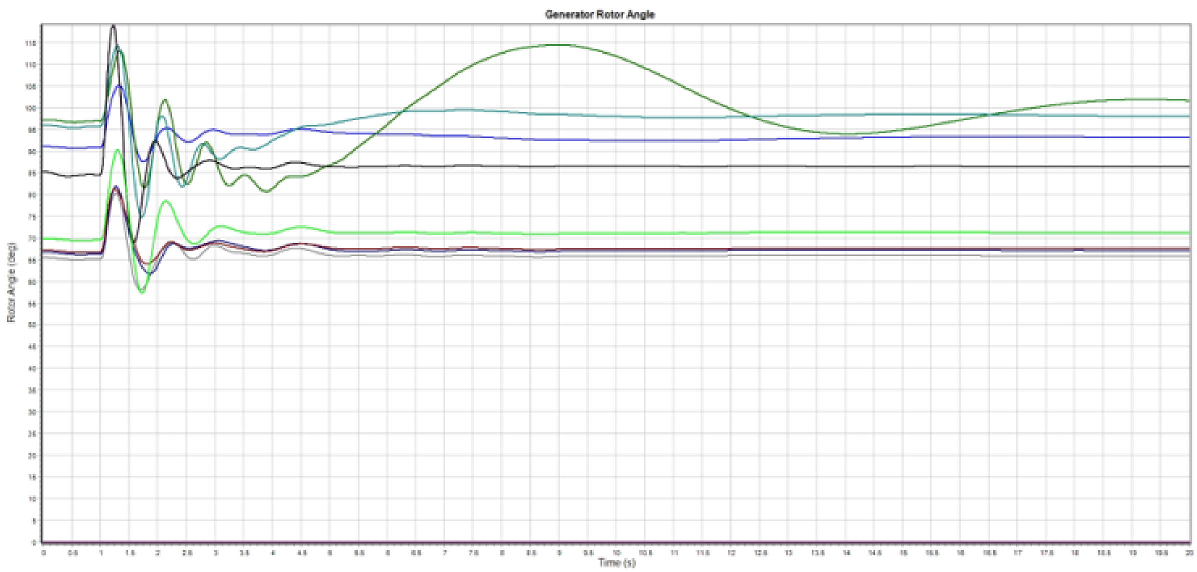
APPENDIX C – Transient Stability Plots

C-1.0 5.0 Cycle [redacted] – [redacted] 230kV Line 3-phase fault



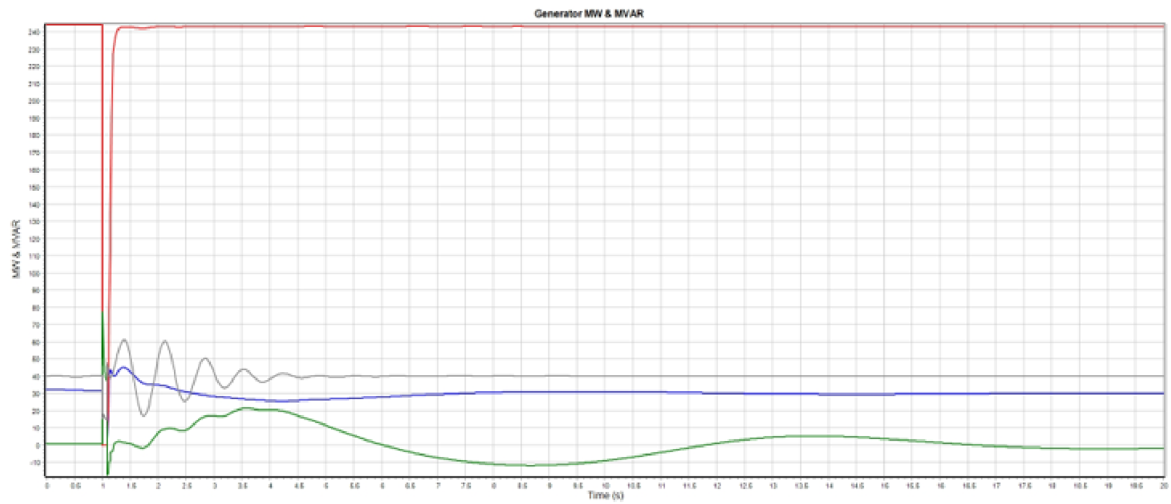
[redacted]

Generator Rotor Angles with GI #551



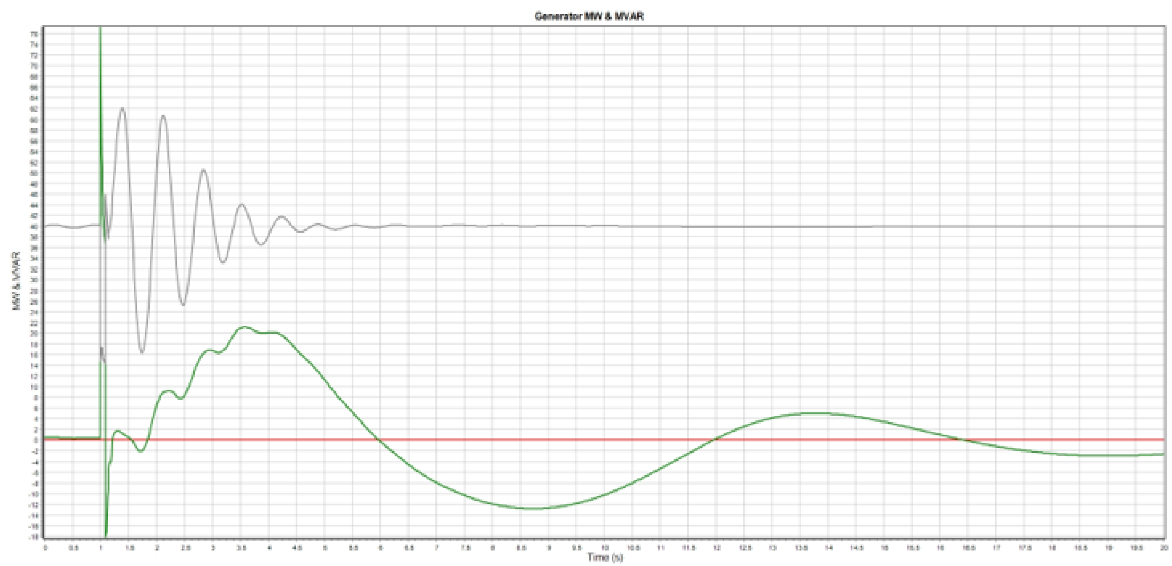
[redacted]

Generator Rotor Angles without GI #551



[redacted]

Generator MW & MVAR with GI #551



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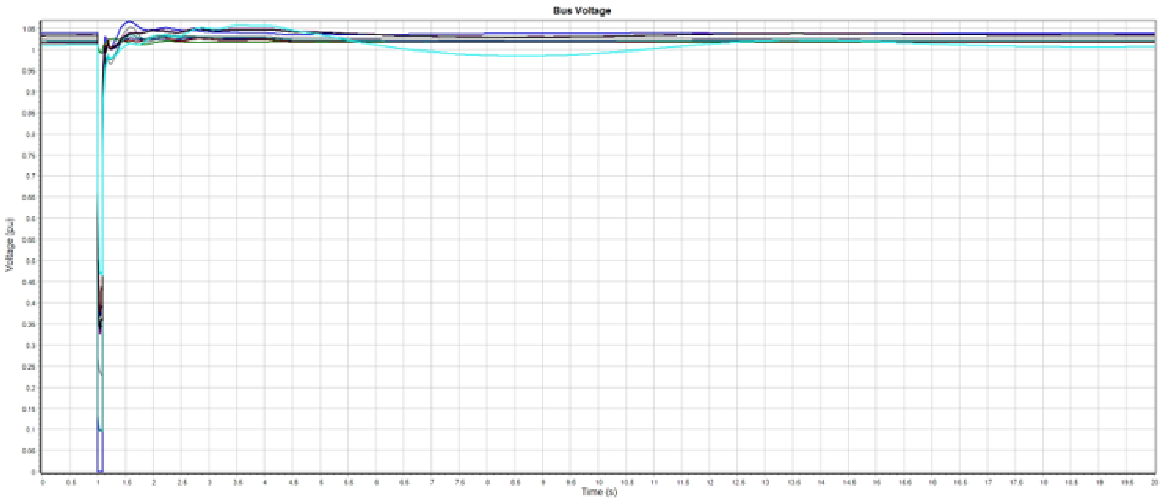
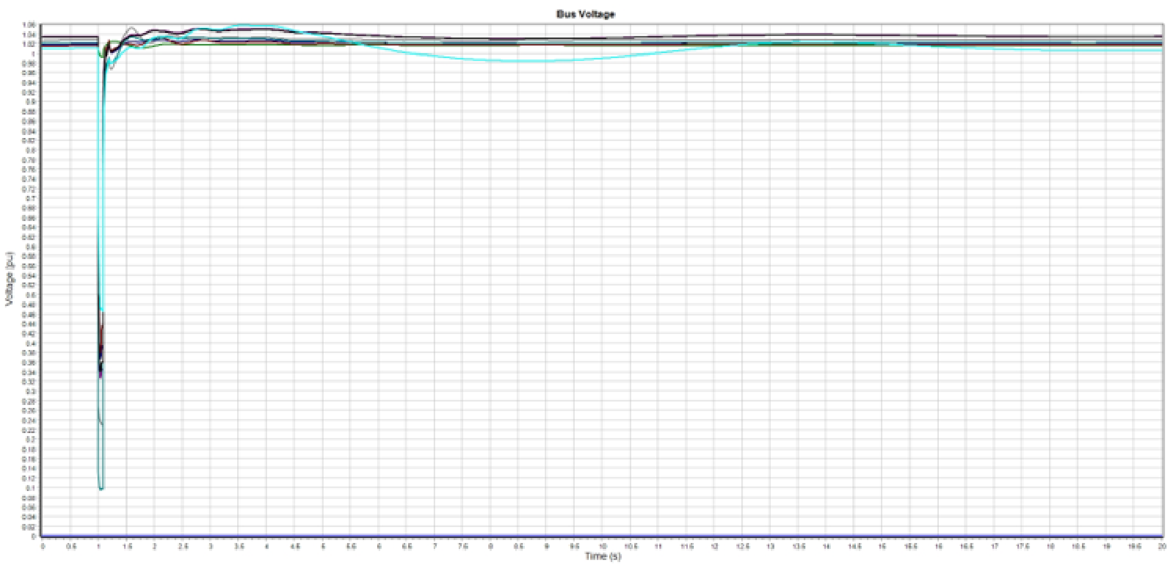
Generator MW & MVAR without GI #551



[redacted]

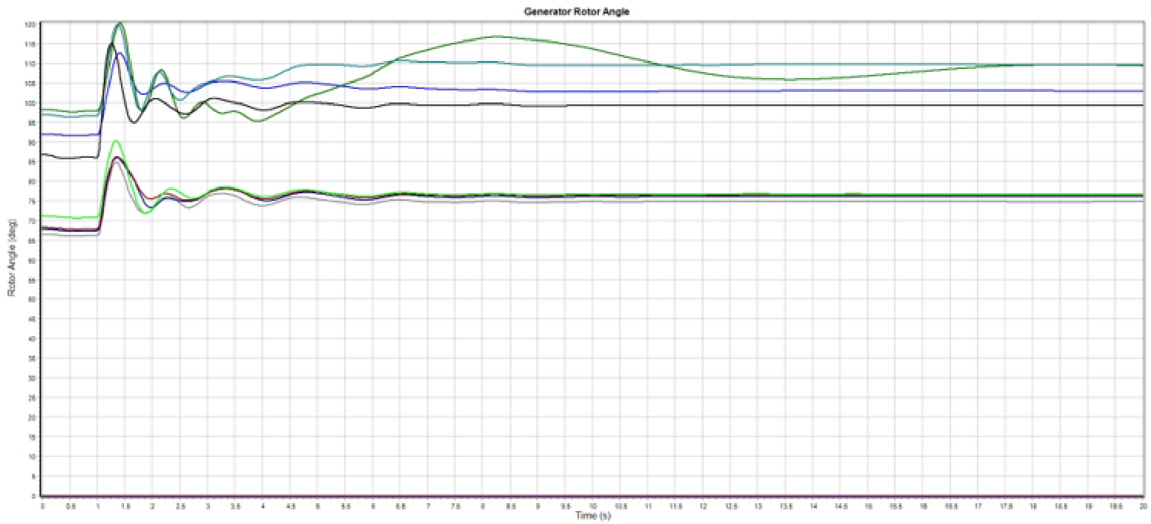
Bus Voltages with GI #551



[redacted]

Bus Voltages without GI #551

C-2.0 5.0 Cycle [redacted] – [redacted] 500kV Line 3-phase fault



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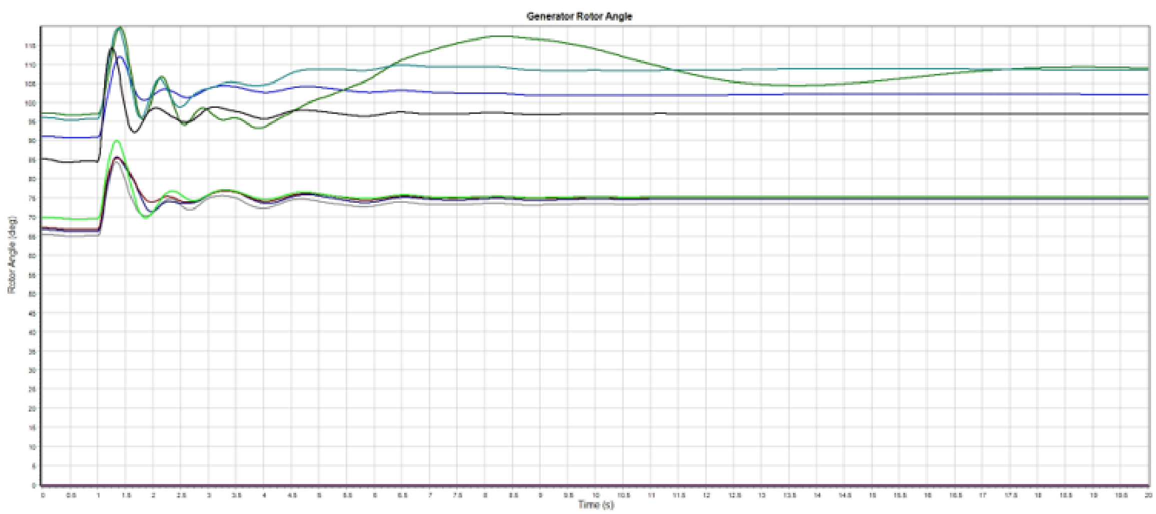
Generator Rotor Angles with GI #551



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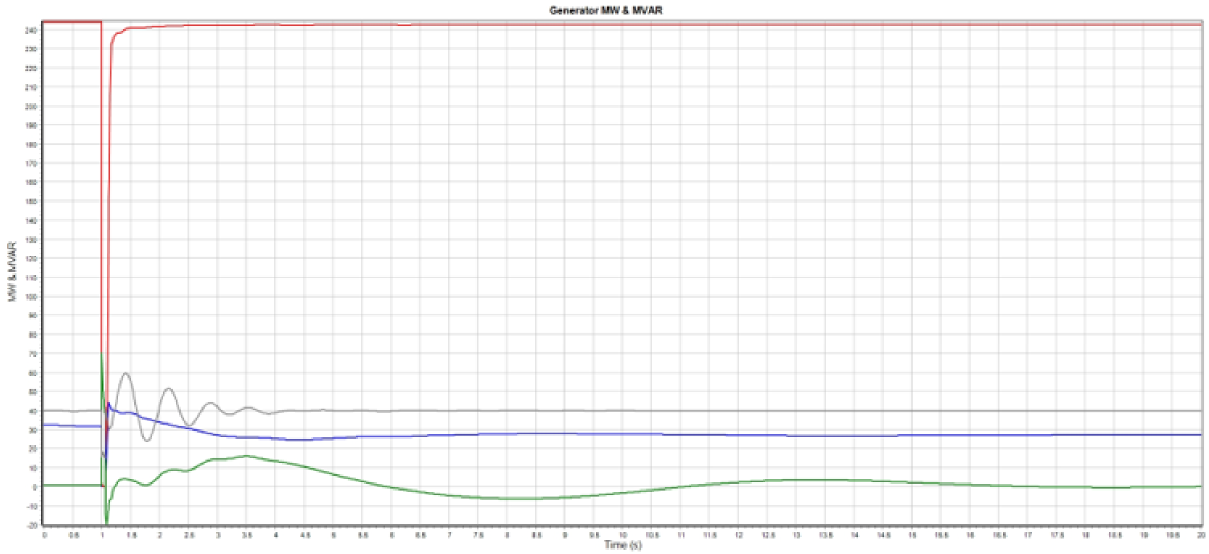
Generator Rotor Angles without GI #551



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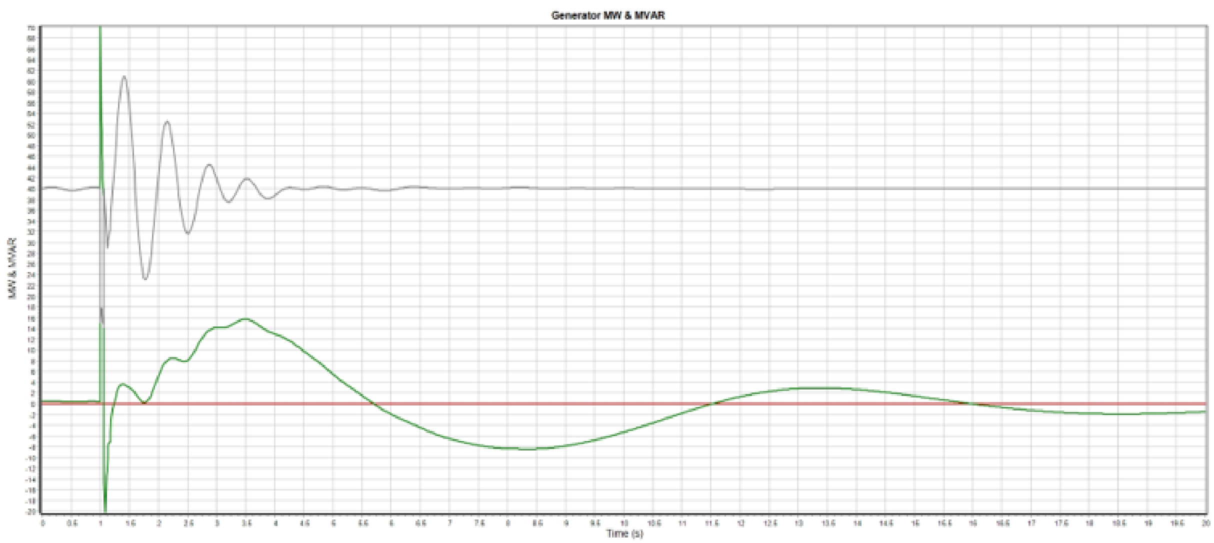
Generator MW & MVAR with GI #551



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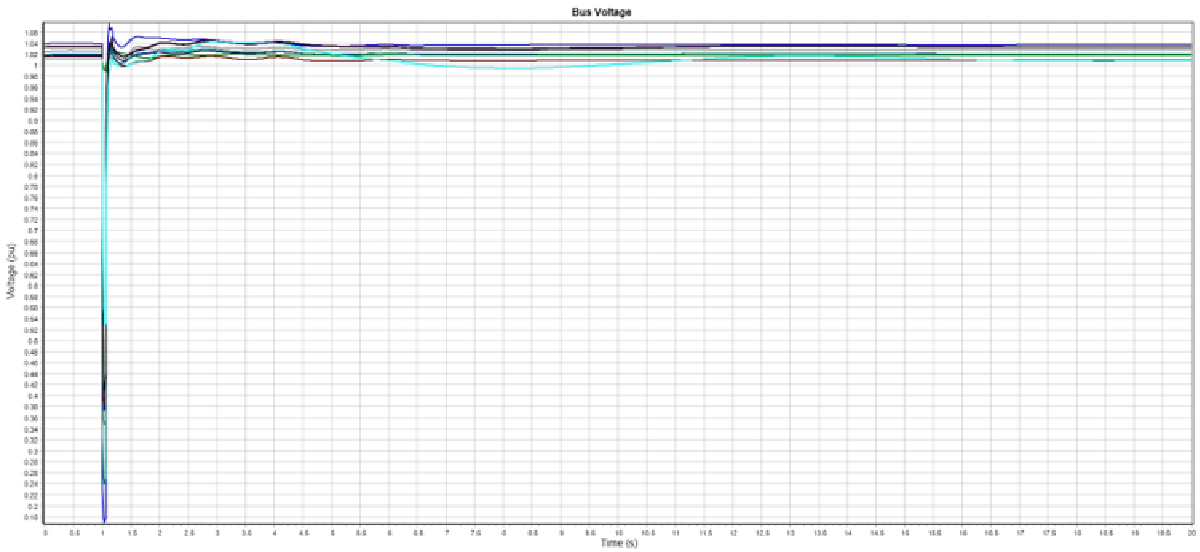
Generator MW & MVAR without GI #551



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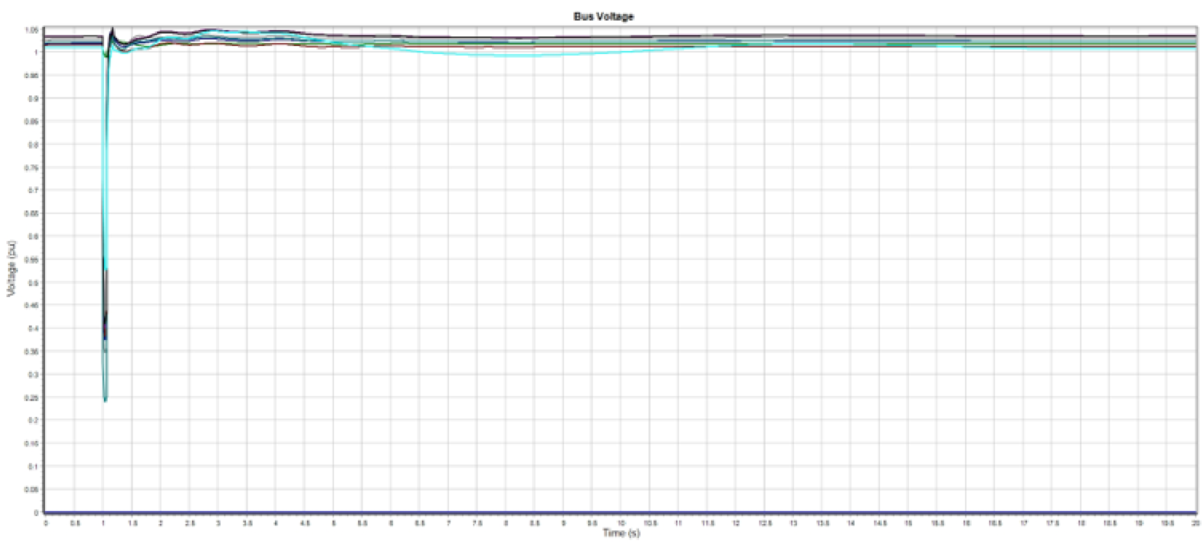
Bus Voltages with GI #551



[redacted]

Bus Voltages without GI #551

Revision History

Date	Revision	Initials	Summary of Changes
09/02/2020	0	SWL	Initial Draft Report
09/18/2020	1	SWL	Specified which Network Upgrades are needed from GI #530
10/21/2020	2	SWL	Added [redacted] Reconfiguration to Appendix B