INTERCONNECTION COMBINED FEASIBILITY AND SYSTEM IMPACT STUDY REPORT

GENERATOR INTERCONNECTION REQUEST
GI-2017-15

10.6 MW Waste Heat Recovery Generating Facility
Interconnecting at
Tap on Vasquez – Gilcrest 115kV Line

XCEL ENERGY – Public Service Company of Colorado (PSCo)
December 4, 2018

Executive Summary

The GI-2017-15 is a 10.6 MW generator interconnection request ("GIR") that will be located in Weld County, Colorado. GI-2017-15 is a waste heat recovery Generating Facility which will include one (1) 12.47 kV, 15 MVA, 3-phase generator and one (1) 12.47/115 kV, 15 MVA generator step-up (GSU) transformer. The Interconnection Customer has designated the midpoint on the Vasquez to Gilcrest 115kV line-section owned and operated by Public Service Company of Colorado ("PSCo") as the Point of Interconnection (POI). The GI-2017-15 Generating Facility will interconnect to the POI via a ~3.5 miles long 115kV transmission line.

The Commercial Operation Date (COD) requested by the Interconnection Customer is April 30, 2022.

As requested by the Interconnection Customer, this GIR was studied for both Network Resource Interconnection Service ("NRIS")[1] and Energy Resource Interconnection Service ("ERIS")[2].

The GI-2017-15 interconnection request was studied in queue order and, based on engineering judgment, it was determined that no higher-queued interconnection requests have an impact on the results of this study.

The main purpose of this Combined Feasibility/System Impact Study was to evaluate the system impact of the new 10.6 MW of generation injected at the POI by this proposed project. This consisted of identifying and cost estimating the transmission improvements required (interconnection facilities and network upgrades), if any, in the PSCo transmission system and the affected systems to deliver the new generation output to PSCo native load.

The steady-state analysis results demonstrated that no thermal or voltage violations are attributable to GI-2017-15. The short circuit study results showed that no circuit breakers in the PSCo system are over-dutied due to the proposed GI-2017-15 interconnection.

The dynamic simulation results after the addition of GI-2017-15 demonstrated that all generating units are stable (remain in synchronism) and display positive damping and the maximum transient voltage dips are within acceptable performance criteria.

However, it is the responsibility of the Interconnection Customer to ensure that its generating facility is capable of meeting the voltage ride-through and frequency ride-through (VRT and FRT) performance specified in the NERC Reliability Standard PRC-024.

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[1] **Network Resource Interconnection Service (NRIS)** allows Interconnection Customer's Large Generating Facility to be designated as a Network Resource, up to the Large Generating Facility's full output, on the same basis as existing Network Resources interconnected to Transmission Provider's Transmission System, and to be studied as a Network Resource on the assumption that such a designation will occur. (*section 3.2.2 of Attachment N in Xcel Energy OATT*)

[2] **Energy Resource Interconnection Service (ERIS)** allows Interconnection Customer to connect the Large Generating Facility to the Transmission System and be eligible to deliver the Large Generating Facility's output using the existing firm or non-firm capacity of the Transmission System on an "as available" basis. Energy Resource Interconnection Service does not in and of itself convey any right to deliver electricity to any specific customer or Point of Delivery. (See *section 3.2.1 of Attachment N in Xcel Energy OATT*)

Since no adverse system impacts needing mitigation were identified in any of the above analyses, there are no network upgrades required for the delivery of 10.6 MW output from GI-2017-15.

The total estimated cost of the recommended system improvements to interconnect the project is approximately $9.082 million and includes:

- $ 0.697 million for Transmission Provider's Interconnection Facilities (Table 2)
- $ 8.385 million for Network Upgrades for Interconnection for ERIS (Table 3)
- $ 0.000 million for Additional Network Upgrades for NRIS (Table 4)

The total estimated cost of the transmission system improvements required for GI-2017-15 to qualify for:

- **ERIS is $9.082 Million (Tables 2 and 3); and**
- **NRIS is $9.082 Million (Tables 2, 3 and 4)**

For GI-2017-15 interconnection:

ERIS (after required transmission system improvements) = 10.6 MW
(output delivery assumes the use of existing firm or non-firm capacity of the PSCo Transmission System on an as-available basis).

NRIS (after required transmission system improvements) = 10.6 MW

Note: NRIS or ERIS, in and of itself, does not convey transmission service.

Introduction

The GI-2017-15 is a 10.6 MW generator interconnection request ("GIR") that will be located in Weld County, Colorado. GI-2017-15 is a waste heat recovery Generating Facility which will include one (1) 12.47 kV, 15 MVA, 3-phase generator and one (1) 12.47/115 kV, 15 MVA generator step-up (GSU) transformer.

The Interconnection Customer has designated the midpoint on the Vasquez to Gilcrest 115kV line-section owned and operated by Public Service Company of Colorado ("PSCo") as the Point of Interconnection (POI). The GI-2017-15 Generating Facility will interconnect to the POI via a ~3.5 miles Customer owned 115 kV transmission line. It is assumed the new 115 kV line will be constructed with 336 kcmil ASCR "Linnet" conductor on a single-circuit, wooden H-frame tower.

The Commercial Operation Date (COD) requested by the Interconnection Customer isApril 30, 2022.

As requested by the Interconnection Customer, this GIR was studied for both Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS).

The GI-2017-15 interconnection request was studied in queue order and, based on engineering judgment, it was determined that no higher-queued interconnection requests have an impact on the results of this study.

Study Scope and Analysis Criteria

The scope of this study includes steady state (power flow) analysis, transient stability analysis, short circuit analysis and scoping level cost estimates. The power flow analysis identifies thermal and voltage violations in the PSCo system and the affected party's system due to the GIR output. Short circuit analysis determines the maximum available fault current at the POI and determines if any breakers at the POI and/or in the neighboring substations exceed their breaker duty ratings and need to be replaced.

PSCo adheres to applicable NERC Reliability Standards & Western Electricity Coordinating Council (WECC) Reliability Criteria, as well as its internal transmission planning criteria for studies. The steady state analysis criteria are as follows:

P0 - System Intact conditions:
Thermal Loading: <=100% of the normal facility rating
Voltage range: 0.95 to 1.05 per unit

P1-P2 – Single Contingencies:
Thermal Loading: <=100% Normal facility rating
Voltage range: 0.90 to 1.10 per unit
Voltage deviation: <=5% of pre-contingency voltage

P3-P7– Multiple Contingencies:
Thermal Loading: <=100% Emergency facility rating
Voltage range: 0.90 to 1.10 per unit
Voltage deviation: <=5% of pre-contingency voltage

For PSCo facilities, thermal violations attributable to the GI-2017-15 interconnection included any facilities without a pre-existing thermal violation but resulted in a thermal loading >100% post GI-2017-15 interconnection and contributed to a 2% increase in the facility loading compared to the benchmark case loading. Pre-existing thermal violations in the benchmark case are attributable to the GI-2017-15 interconnection if the planned PSCo upgrade is insufficient to mitigate the (increased) thermal violation in the study case. In such case, only the additional facility rating increase (beyond the PSCo planned uprate) will be attributed to the GI-2017-15 interconnection.

The study area is the electrical system consisting of PSCo's transmission system and the affected party's transmission system that is impacted or that will impact interconnection of GI-2017-15. The study area for GI-2017-15 includes WECC designated zones 121, 700, 703, 704, 705, 709, 710, 712, 752 and 757.

Transient stability criteria require that all generating machines remain in synchronism and all power swings should be well damped following a contingency event. Also, transient voltage performance should meet the following WECC Disturbance-Performance criteria:

- Following fault clearing, the voltage shall recover to 80% of the pre-contingency voltage within 20 seconds for all contingencies
- For all contingencies, following fault clearing and voltage recovery above 80%, voltage at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds.
- For contingencies without a fault, voltage dips at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds

Power Flow and Transient Stability Analyses

The 2022 Heavy Summer WECC approved PSSE case was used to create the benchmark case for power flow studies. This benchmark case was used to analyze the impacts when adding GI-2017-15 to the transmission system by tapping the existing 115kV line between Vasquez and Gilcrest Substation.

The proposed project was modeled as a single generation unit representing the 10.6 MW waste heat recovery generator. The generator was assumed to have a maximum output of 10.6 MW (15 MVA) with a reactive capability between -8 MVAr and 5 MVAr, assuming a +0.8/-0.9 power factor. The generator was modeled with a terminal voltage of 12.47kV, stepped up to 115kV via a 15 MVA bank, and connected to the 115kV transmission system. For modeling purposes, the generator was set to control the interconnecting bus voltage on the 115kV system to 1.00 per-unit.

The 10.6 MW output of the GI is assumed to be delivered to PSCo native load, so existing PSCo generation is used as its sink. The generation sink was set to Comanche Unit 2 (area swing).

Automated single contingency power flow studies were completed on the benchmark and GI-2017-15 study case models, switching out single elements (lines, transformers and generation units) one at a time in the study area. In addition, some select multiple contingency outages were simulated for this area of the system. The results from the contingency analyses for benchmark and study cases were compared to identify thermal or voltage limit violations attributable to the addition of GI-2017-15.

Transient stability analysis was performed using General Electric's PSLF ver.21.0_02 program. A study case was created by modeling GI-2017-15 in the WECC approved 2023HS2 case. The Customer did not provide a dynamic model for GI-2017-15 so the dynamic model of a typical 15 MVA synchronous machine was used for this study. All wind and solar generating facilities in the study case were left unchanged at 21% and 65% of nameplate. Three phase faults using typical clearing times were simulated for selected single contingencies at the POI and one bus away. Bus voltage, bus frequency, and generator angle were recorded and analyzed. Also, any generators that went out of synchronism were recorded. PSLF's DYTOOLS EPCL program was used to simulate the disturbances.

Voltage Regulation and Reactive Power Capability

Interconnection Customer is required to interconnect its Large Generating Facility with Public Service of Colorado's (PSCo) Transmission System in accordance with the *Xcel Energy Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW* (available at: http://www.transmission.xcelenergy.com/staticfiles/microsites/Transmission/Files/PDF/Interconnection/Interconnections-POL-TransmissionInterconnectionGuidelineGreat20MW.pdf).
In addition, wind generating plant interconnections must also fulfill the performance requirements specified in FERC Order 661-A. Accordingly, the following voltage regulation and reactive power capability requirements at the POI are applicable to this interconnection request:

- To ensure reliable operation, all Generating Facilities interconnected to the PSCo transmission system are expected to adhere to the *Rocky Mountain Area Voltage Coordination Guidelines (RMAVCG)*. Accordingly, since the POI for this interconnection request is located within Southeast Colorado - Region 4 defined in the *RMAVCG*; the applicable ideal transmission system voltage profile range is 1.02 – 1.03 per unit at regulated buses and 1.0 – 1.03 per unit at non-regulated buses.
- Xcel Energy's OATT (Attachment N effective 10/14/2016) requires all non-synchronous Generator Interconnection (GI) Customers to provide dynamic reactive power within the power factor range of 0.95 leading to 0.95 lagging at the high side of the generator substation. Furthermore, Xcel Energy requires every Generating Facility to have dynamic voltage control capability to assist in maintaining the POI voltage schedule specified by the Transmission Operator as long as the Generating Facility does not have to operate outside its 0.95 lag – 0.95 lead dynamic power factor range capability.
- It is the responsibility of the Interconnection Customer to determine the type (switched shunt capacitors and/or switched shunt reactors, etc.), the size (MVAR), and the locations (12.47kV or 115kV bus) of any additional static reactive power compensation needed within the generating plant in order to have adequate reactive capability to meet the +/- 0.95 power factor and the 1.02 – 1.03 per unit voltage range standards at the POI. Further, for wind generating plants to meet the LVRT (Low Voltage Ride Through) performance requirements specified in FERC Order 661-A, an appropriately sized and located dynamic reactive power device (DVAR, SVC, etc.) may also need to be installed within the generating plant. Finally, it is the responsibility of the Interconnection Customer to compensate their generation tie-line to ensure minimal reactive power flow under no load conditions.

The Interconnection Customer is required to demonstrate to the satisfaction of PSCo Transmission Operations prior to the commercial in-service date of the generating plant that it can safely and reliably operate within the required power factor and voltage ranges (noted above).

Power Flow Study Results

The results of the single contingency analysis (P1 and P2) are given in Table 5 in Appendix A. Several pre-existing (without GI-2017-15) thermal violations exist. But since these thermal violations show no (zero) incremental change with the addition of GI-2017-15, none of them can be attributed to GI-2017-15. The single contingency analysis did not show any voltage limit violations due to the addition of the GI-2017-15.

Transient Stability Study Results

The transient stability analysis for GI-2017-15 System Impact Study simulated four (4) disturbances for the study case (with GI-2017-15 modeled).

- ✓ No machines lost synchronism with the system
- ✓ No transient voltage drop violations were observed
- ✓ Machine rotor angles displayed positive damping

The transient stability results are given in Table 6 in Appendix B. Transient stability plots for each of the four disturbances showing surrounding bus voltages, bus frequencies, generator terminal voltages, generator relative angles, generator speeds, and generator power output are also included in Appendix B.

However, it is the responsibility of the Interconnection Customer to ensure that its generating facility is capable of meeting the voltage ride-through and frequency ride-through (VRT and FRT) performance specified in the NERC Reliability Standard PRC-024.

Short Circuit and Breaker Duty Analysis

The calculated fault current levels and Thevenin equivalent impedance values for three phase and single line to ground faults at the POI are given in Table 1 below.
A preliminary breaker duty study did not identify any circuit breakers that became over stressed as a result of adding this generation.

Table 1 – Short Circuit Results at the GI-2017-15 POI station

	Without GI-2017-15	With GI-2017-15
Three Phase Current	10166.7 A	10476.0 A
Single Line to Ground Current	6893.22 A	7578.85 A
Positive Sequence Impedance	1.23383 + j6.41307 ohms	1.17457 + j6.22808 ohms
Negative Sequence Impedance	1.23880 + j6.41498 ohms	1.18875 + j6.26646 ohms
Zero Sequence Impedance	3.60646 + j15.4212 ohms	2.95404 + j13.2437 ohms

Conclusion

For GI-2017-15 interconnection:

ERIS (after required transmission system improvements) = 10.6 MW
(output delivery assumes the use of existing firm or non-firm capacity of the PSCo Transmission System on an as-available basis).

NRIS (after required transmission system improvements) = 10.6 MW

Note: NRIS or ERIS, in and of itself, does not convey transmission service.

Costs Estimates and Assumptions

Transmission Provider has specified and estimated the cost of the equipment, engineering, procurement and construction work needed to interconnect GI-2017-15. The results of the engineering analysis for facilities owned by the Transmission Provider are estimates and are summarized in Tables 2 and Table 3.

Table 2: "Transmission Provider's Interconnection Facilities" includes the nature and estimated cost of the Transmission Provider's Interconnection Facilities and an estimate of the time required to complete the construction and installation of such facilities.

Table 3: "Network Upgrades required for Interconnection (applicable for either ERIS or NRIS)" includes the nature and estimated cost of the Transmission Provider's Network Upgrades necessary to accomplish the interconnection and an estimate of the time required to complete the construction and installation of such facilities.

The total estimated cost of the transmission system improvements required for GI-2017-15 to qualify for NRIS is $9.082 million (Table 2 and Table 3).

- Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by PSCo Engineering.
- Estimates are based on 2018 dollars (appropriate contingency applied).
- Allowance for Funds Used During Construction (AFUDC) has been excluded.
- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- PSCo (or its Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- The estimated time to design, procure and construct the interconnection facilities is approximately 36 months (after authorization to proceed has been obtained).
- Line and substation bus outages will be necessary during the construction period. Outage availability could potentially be problematic and extend requested backfeed date due.
- A CPCN may be required for the Network Upgrades for ERIS. The time to secure the CPCN is included in the 36 months duration estimated for site, design, procure and construct.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- The Customer will be required to design, procure, install, own, operate and maintain a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer Substation. PSCo / Xcel will need indications, readings and data from the LFAGC RTU.
- Power Quality Metering (PQM) will be required on the Customer's 115 kV line terminating into PSCo's proposed new Substation.

The following tables list the transmission system improvements required to accommodate the interconnection of GI-2017-15. The cost responsibilities associated with these transmission system improvements shall be handled as per current FERC guidelines.

Table 2 – Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Vasquez-Gilcrest 115kV Greenfield Substation	Interconnect Customer to tap at the Vasquez-Gilcrest 115kV Greenfield Substation The new equipment includes: • One 115kV motor operated gang switch • Three 115kV arresters • One set (of three) high side metering units • Fiber Optic communications termination • Station controls • 115kV line relaying panel • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing.	$0.612
	Transmission line tap into substation - Funded and estimated by Customer.	$0.055
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction	$0.030
	Total Cost Estimate for Transmission Providers Interconnection Facilities	**$0.697**
Time Frame	**Site, design, procure and construct**	**36 Months**

Table 3: Network Upgrades for Interconnection (ERIS or NRIS)

Element	Description	Cost Est. (Millions)
PSCo's Vasquez-Gilcrest 115kV Greenfield Substation	Build new 115kV 3 position ring bus substation Major equipment includes (3) 115kV SF6 Breakers, (8) 115kV disconnect switches, (2) 115kV motor operated disconnect switches, (6) 115kV CCVTs, (6) 115kV Surge Arresters, (2) 115kV Wave traps, (2) Dead Ends, (1) Electrical Equipment Enclosure. Estimate includes transmission line work, new communications equipment according to Xcel's standards, and remote end relay settings	$7.572
	Siting and Land Rights support for substation land acquisition and construction.	$0.350
PSCo's Fort Lupton Substation	Replace one (1) 115kV Circuit Breaker	$0.463
	Total Cost Estimate for Network Upgrades for Interconnection (ERIS)	**$8.385**
Time Frame	**Site, design, procure and construct**	**36 Months**

Table 4 – Additional Network Upgrades for NRIS

Element	Description	Cost Est. (Millions)
	None Identified	**$0.000**
	Total Cost Estimate for Network Upgrades for Delivery (NRIS)	**$0.000**
Time Frame	**Site, design, procure and construct**	**N/A**
	Total Project Estimate	**$9.082**

Transmission improvements identified in Table 2 and Table 3 are illustrated in the conceptual one-line diagram in Figure 2 below which show the electrical connection of the Interconnection Customer's Generating Facility to the Transmission Provider's Transmission System.

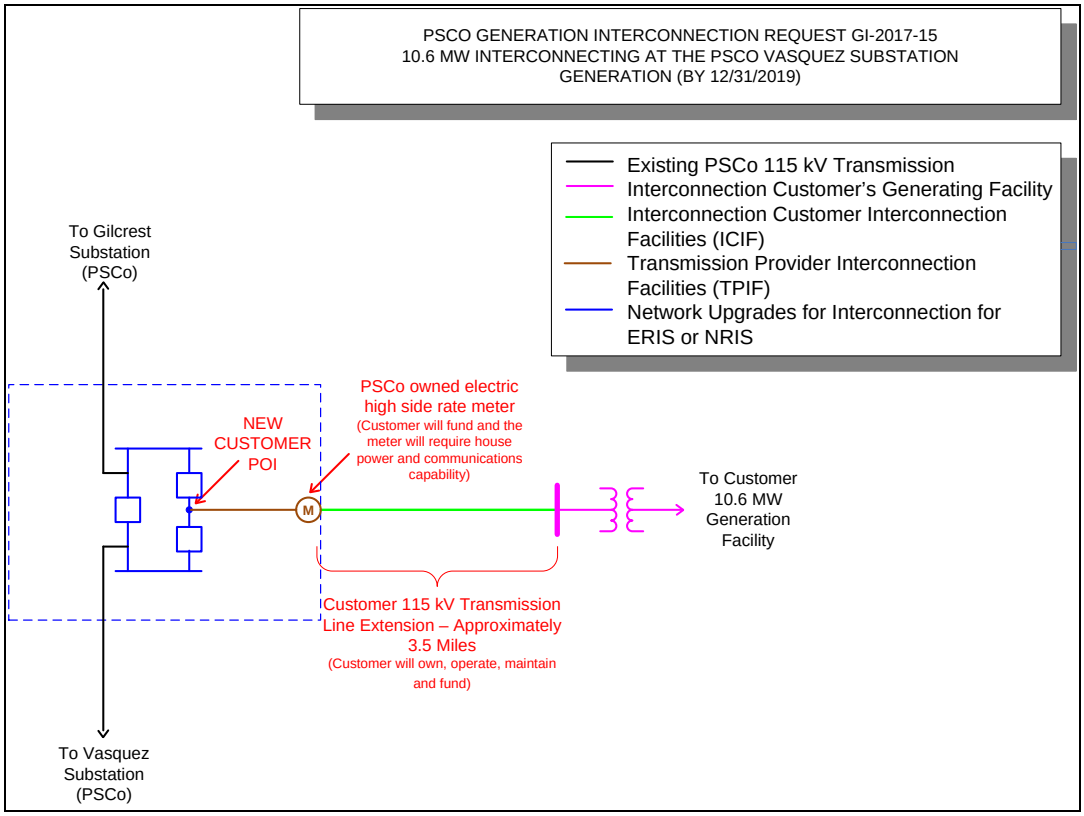


Figure 2: Conceptual One-Line Diagram of GI-2017-15 POI

The preliminary one-line diagram in Figure 3 below identifies the electrical switching configuration of the interconnection equipment, including, without limitation: the transformer, switchgear, meters, and other station equipment.

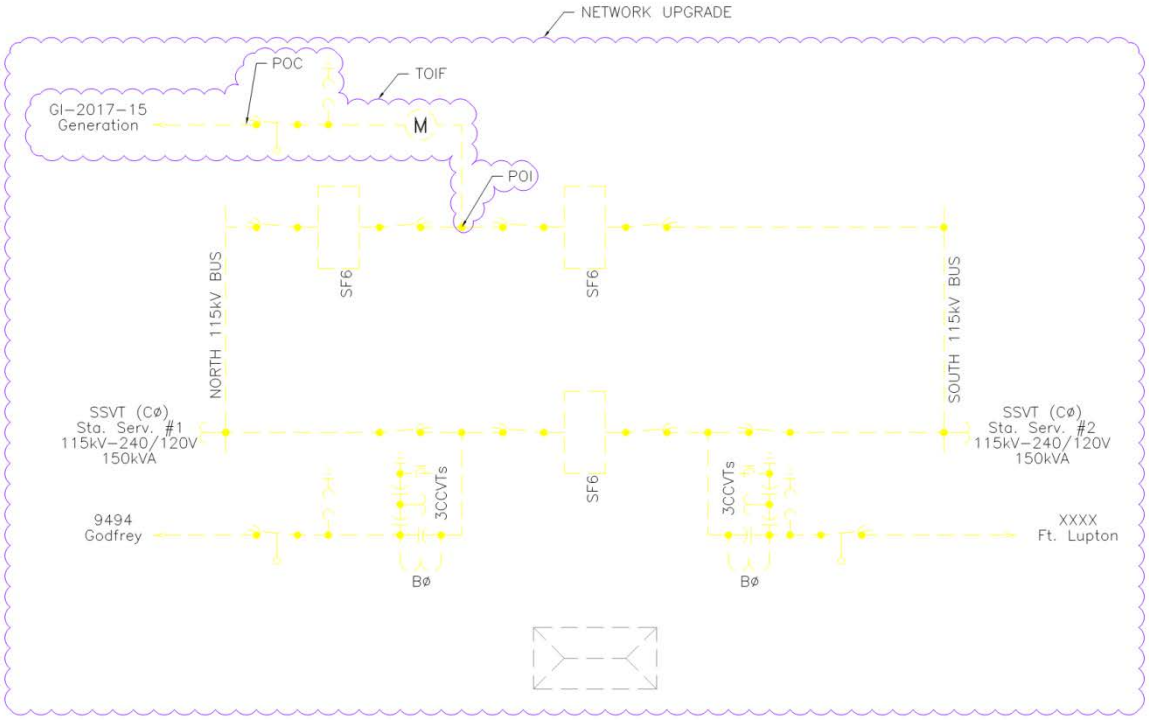


Figure 3 –GI-2017-15 Interconnection at the POI tap on Godfrey–Gilcrest–Vasquez–FtLupton 115 kV line (L9494)

Appendix - A

A. Power Flow Analysis Results

1. No new thermal violations occurred with GI-2017-15.
2. Thermal overloads are calculated using the normal rating of the facility.
3. Below is a summary of pre-existing thermal violations.

Table 5 – Single Contingency Analysis Results

Summary of Thermal Violations from Single Contingency Analysis									
				Facility Loading Without GI-2017-15		Facility Loading With GI-2017-15			
Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	Flow MVA	Flow % of Rating	Flow MVA	Flow % of Rating	% Change	NERC Contingency
Allison - Soda Lake 115 kV	Line	PSCo	153/174	159	103.7	159	103.7	0	Bancroft - Kendrick 115 kV
Arap_B - Engle3TP 115 kV	Line	PSCo	159/175	169	107.2	169	107.2	0	Waterton - Martn1TP 115 kV
Bancroft - Kendrick 115kV	Line	PSCo	156/172	159	102.5	159	102.5	0	Allison - Sodalake 115 kV
Bo_Term - Valmont 115 kV (2)	Line	PSCo	120/149	153	125.8	153	125.8	0	Bo-Term - Valmont 115 kV
Califor - Cherokee_S 115 kV	Line	PSCo	137/151	148	106.5	148	106.5	0	Cherokee_S - Mapleto1 115 kV
Coorsrec - Ft Lupton 115 kV	Line	PSCo	120/146	146	121.2	146	121.4	0.165	Lafayett - Valmont 115 kV
East - Chmbers 115 kV	Line	PSCo	120/145	148	120.3	148	120.5	0.166	Fitzsmns - Chmbers 115 kV
Lafayett - Valmont 115 kV	Line	PSCo	120/146	137	114.9	137	114.9	0	Coorsrec - Ftlupton 115 kV
Pawnee 22 - 230 kV (U1)	Xfrmr	PSCo	364/364	491	134.9	491	134.9	0	Pawnee 230/22 kV xfrmr (U2)
Pawnee 22 - 230 kV (U2)	Xfrmr	PSCo	364/364	491	134.9	491	134.9	0	Pawnee 230/22 kV xfrmr (U1)
Waterton - Martn1TP 115 kV	Line	PSCo	138/152	168	120.9	168	121	0.083	ARAP_B - ENGLE3TP 115 kV
Heart MT 69 - 2.4 kV	Xfrmr	WAPA LM	6	6.06	101.1	6.06	101.1	0	BRUSH_SS - BCK_PS_S 115 kV
Thermopl 115 - 34.5 kV	Xfrmr	WAPA LM	25	26	102	16	102	0	BRUSH_SS - BCK_PS_S 115 kV

Appendix - B

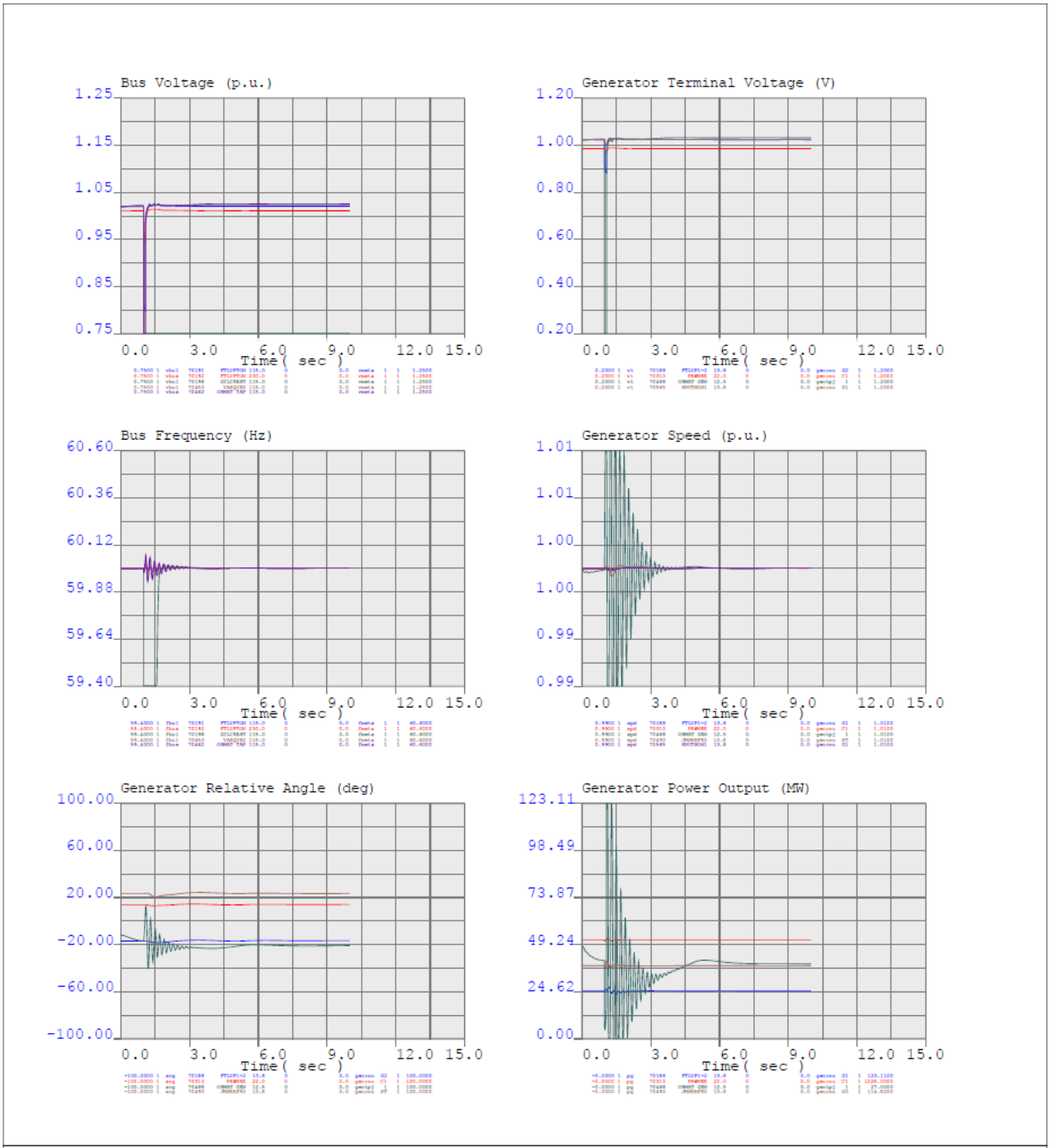
B. Transient Stability Analysis Results

1. No transient instability occurred with GI-2017-15.
2. Transient stability examined faults in the vicinity of the proposed generation.
3. Additional Stability Plots are available upon request.

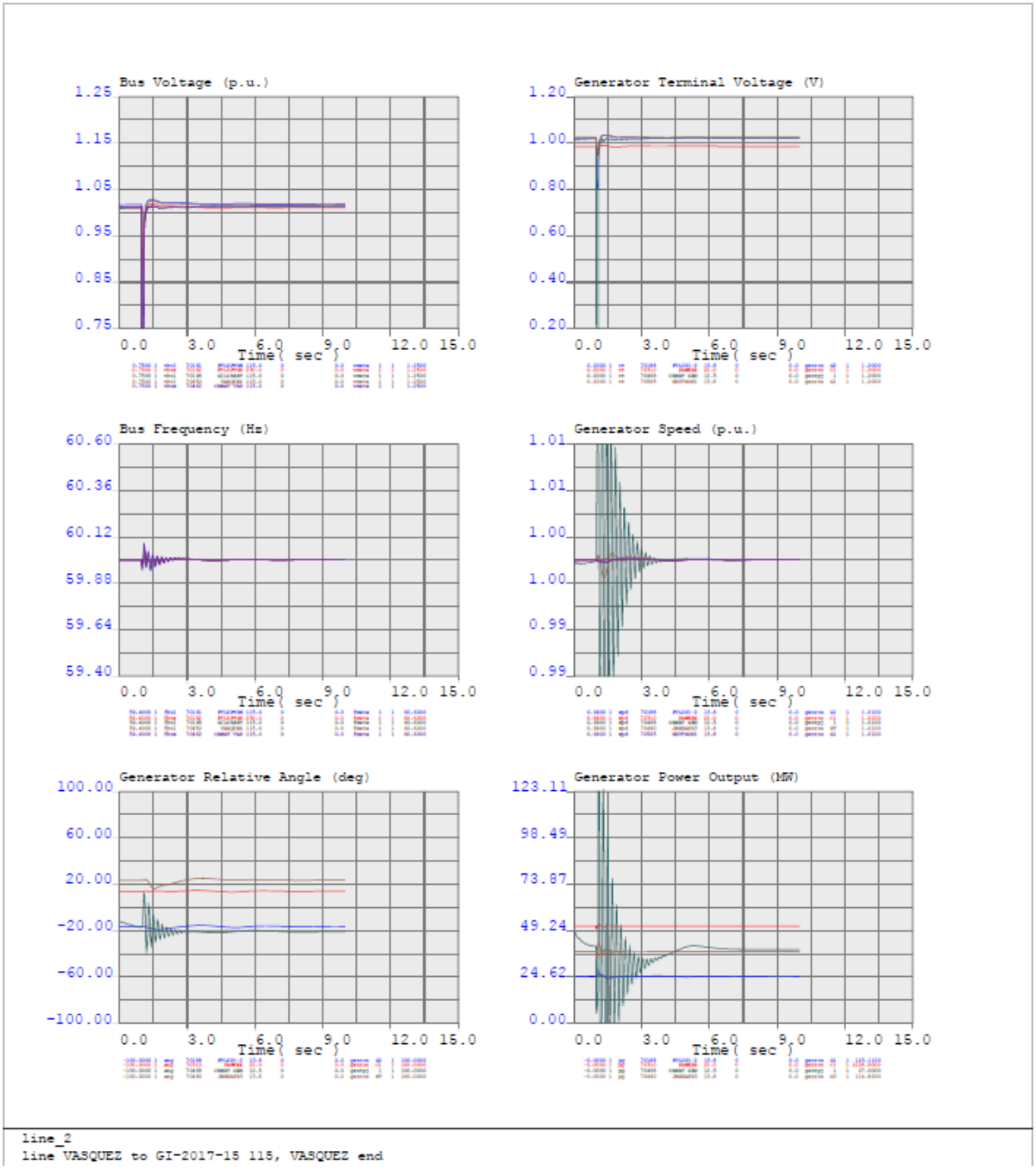
Table 6 - Transient Stability Analysis Results

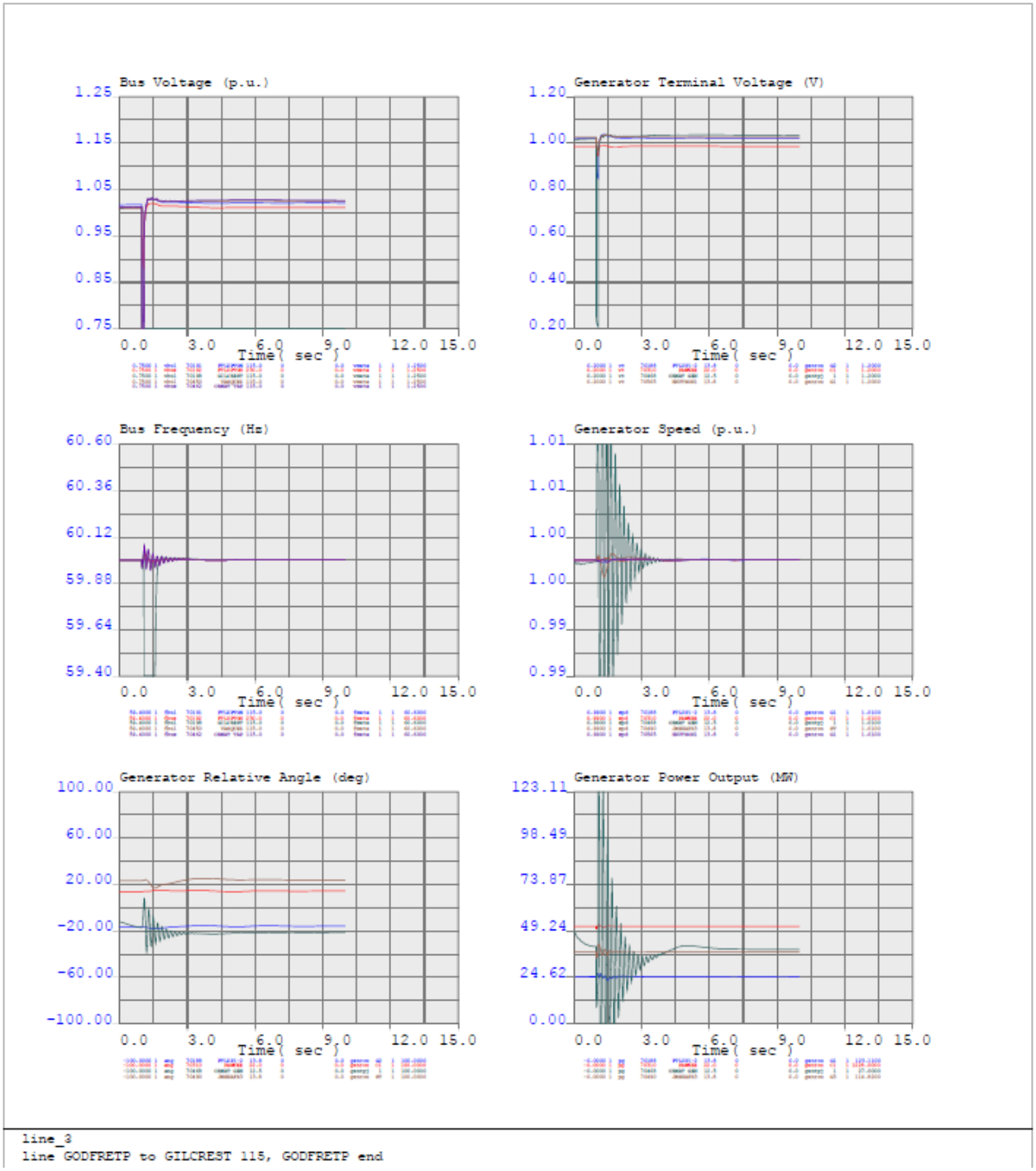
Stability Scenarios						
#	**Fault Location**	**Fault Type**	**Facility Tripped**	**Clearing Time (cycles)**	**Post-Fault Voltage Recovery**	**Angular Stability**
1	Gilcrest 115kV	3ph	Gilcrest – GI-2017-15 115kV	Primary (5.0)	Maximum transient voltage dips within criteria	Stable with positive damping
2	Vasquez 115kV	3ph	Vasquez – GI-2017-15 115kV	Primary (5.0)	Maximum transient voltage dips within criteria	Stable with positive damping
3	Godfrey 115kV	3ph	Godfrey – Gilcrest 115kV	Primary (5.0)	Maximum transient voltage dips within criteria	Stable with positive damping
4	Ft.Lupton 115kV	3ph	Ft.Lupton - Vasquez 115kV	Primary (5.0)	Maximum transient voltage dips within criteria	Stable with positive damping

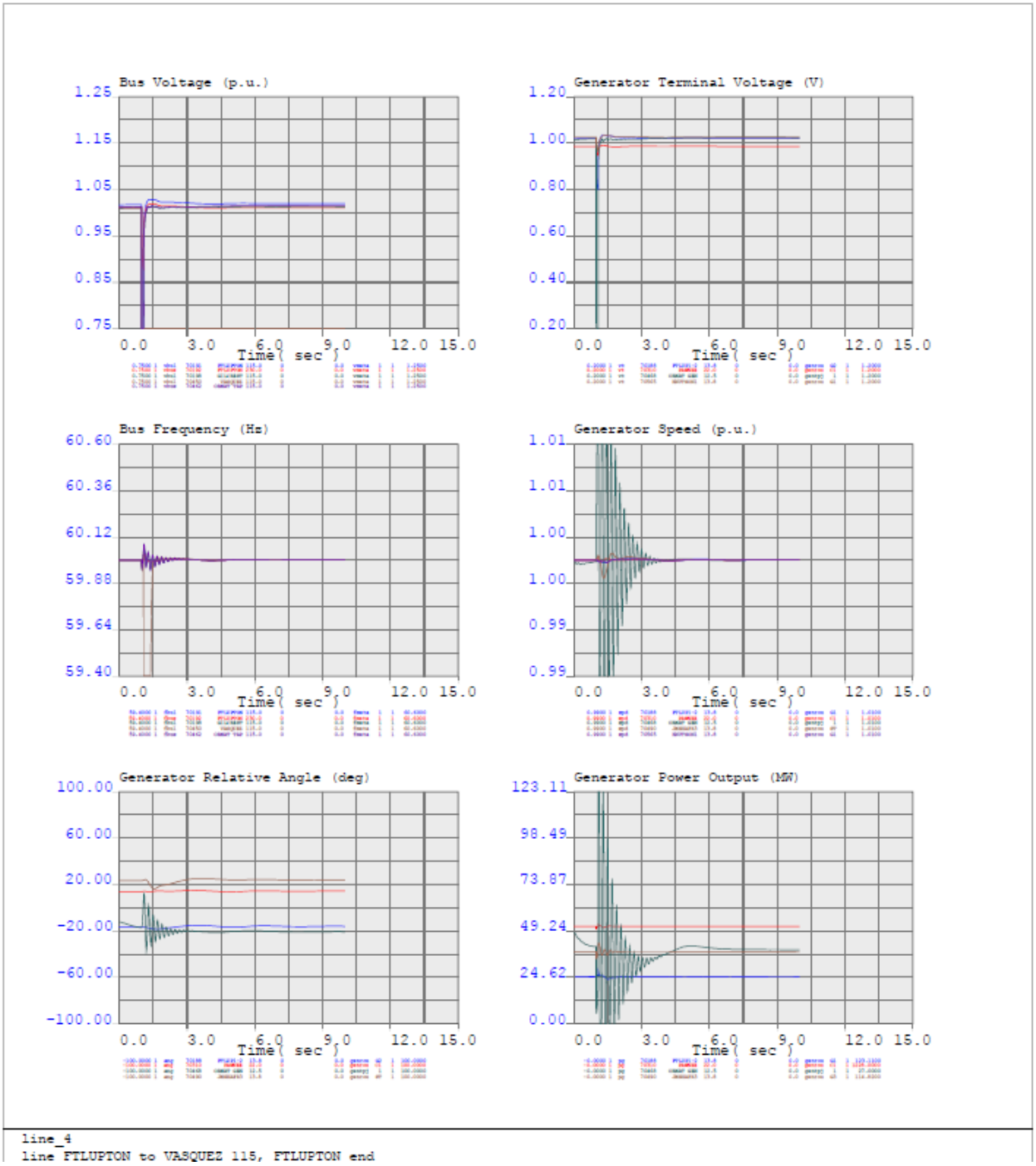
Note: For disturbance #1 and #3, the GodfreyTap was operated normally open. For disturbance #2 and #4, the Godfrey Tap was operated closed.



line_1
line GILCREST to GI-2017-15 115, GILCREST end


Bus Voltage (p.u.)
1.25
1.15
1.05
0.95
0.85
0.75
0.0 3.0 6.0 9.0 12.0 15.0
Time (sec)
Generator Terminal Voltage (V)
1.20
1.00
0.80
0.60
0.40
0.20
0.0 3.0 6.0 9.0 12.0 15.0
Time (sec)
Bus Frequency (Hz)
60.60
60.36
60.12
59.88
59.64
59.40
0.0 3.0 6.0 9.0 12.0 15.0
Time (sec)
Generator Speed (p.u.)
1.01
1.01
1.00
1.00
0.99
0.99
0.0 3.0 6.0 9.0 12.0 15.0
Time (sec)
Generator Relative Angle (deg)
100.00
60.00
20.00
-20.00
-60.00
-100.00
0.0 3.0 6.0 9.0 12.0 15.0
Time (sec)
Generator Power Output (MW)
123.11
98.49
73.87
49.24
24.62
0.00
0.0 3.0 6.0 9.0 12.0 15.0
Time (sec)
line_2
line VASQUEZ to GI-2017-15 115, VASQUEZ end


Bus Voltage (p.u.)
1.25
1.15
1.05
0.95
0.85
0.75
0.0
3.0
6.0
9.0
12.0
15.0
Time (sec)
Generator Terminal Voltage (V)
1.20
1.00
0.80
0.60
0.40
0.20
Bus Frequency (Hz)
60.60
60.36
60.12
59.88
59.64
59.40
Generator Speed (p.u.)
1.01
1.01
1.00
1.00
0.99
0.99
Generator Relative Angle (deg)
100.00
60.00
20.00
-20.00
-60.00
-100.00
Generator Power Output (MW)
123.11
98.49
73.87
49.24
24.62
0.00
line_3
line GODFRETP to GILCREST 115, GODFRETP end


Bus Voltage (p.u.)
1.25
1.15
1.05
0.95
0.85
0.75
0.0 3.0 6.0 9.0 12.0 15.0
Time (sec)
Generator Terminal Voltage (V)
1.20
1.00
0.80
0.60
0.40
0.20
0.0 3.0 6.0 9.0 12.0 15.0
Time (sec)
Bus Frequency (Hz)
60.60
60.36
60.12
59.88
59.64
59.40
0.0 3.0 6.0 9.0 12.0 15.0
Time (sec)
Generator Speed (p.u.)
1.01
1.01
1.00
1.00
0.99
0.99
0.0 3.0 6.0 9.0 12.0 15.0
Time (sec)
Generator Relative Angle (deg)
100.00
60.00
20.00
-20.00
-60.00
-100.00
0.0 3.0 6.0 9.0 12.0 15.0
Time (sec)
Generator Power Output (MW)
123.11
98.49
73.87
49.24
24.62
0.00
0.0 3.0 6.0 9.0 12.0 15.0
Time (sec)
line_4
line FTLUPTON to VASQUEZ 115, FTLUPTON end

Appendix - C

Table 7 – Generation Dispatch in the Study area (MW is Gross Capacity)

PSCo:

BUS	Gen ID	MW (Pgen)	MW (Pmax)
Comanche 1	C1	360	360
Comanche 2	C1	362	365
Comanche 3	C1	780	780
Pawnee	C1	515	536
RMEC 1	G1	147	147
RMEC 2	G2	147	147
RMEC 3	G3	292	292
Spruce 1	G1	132	132
Spruce 2	G2	136	136
JM Shaffer	G1	35.8	35.8
JM Shaffer	G2	35	35
JM Shaffer	ST	50.7	50.7
JM Shaffer	G3	36.1	36.1
JM Shaffer	ST	50	50
JM Shaffer	G4	34.8	34.8
JM Shaffer	G5	33	33
Cedar Creek 1A	W1	46.2	220
Cedar Creek 1B	W1	16.8	80
Cedar Creek 2A	W1	31.5	150
Cedar Creek 2B	W1	10	50
Cedar Creek 2B	W2	10	50
GI-2017-15	W1	10.6	10.6
Missile Site	W1	52.5	250
RushCrk_W1	W1	84	400
RushCrk_W2	W2	42	200
Limon1_W	W1	42.2	201
Limon2_W	W2	42.2	201
Limon3_W	W3	42.2	201