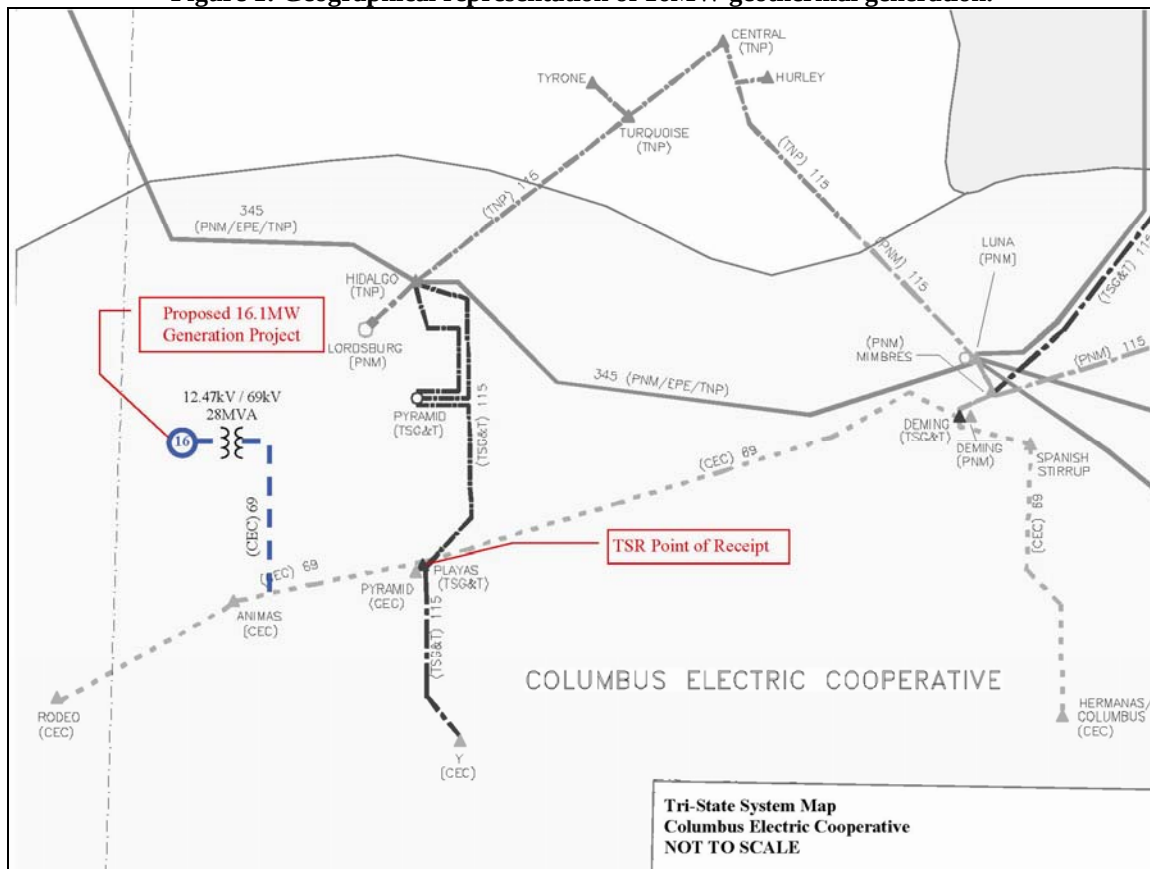


System Impact Study for RaserTech 16.1MW Geothermal Generation

Introduction

Raser Technologies, Inc. in collaboration with Columbus Electric Cooperative (CEC) is proposing to add a total of approximately 16.1 MW of geothermal generation 14 miles north of the 69kV Animas substation in CEC's service territory in southern New Mexico. According to SGS Engineering, the 16.1 MW generation will not come from one source, but from a composite of 60-269kW geothermal units for an estimated output of 16.1 MW operating at 91.8% lagging power factor. Each unit also has a no load reactive requirement of 26kVar. The generator will be connected to Columbus Electric's 69kV system through a 28MVA, 69kV - 12.47kV LTC transformer as shown in Figure 1 below.

Figure 1: Geographical representation of 16MW geothermal generation.



Power Flow Base Case

Steady-state power flow analysis was performed to determine the impact of the generator addition to the 69kV system. The 2012HS WECC Approved base case was utilized to perform the power flow analysis. Tables in Appendix 1 contain parameters used in generating the 69kV power flow model west of the 69kV Playas substation.

Assumptions

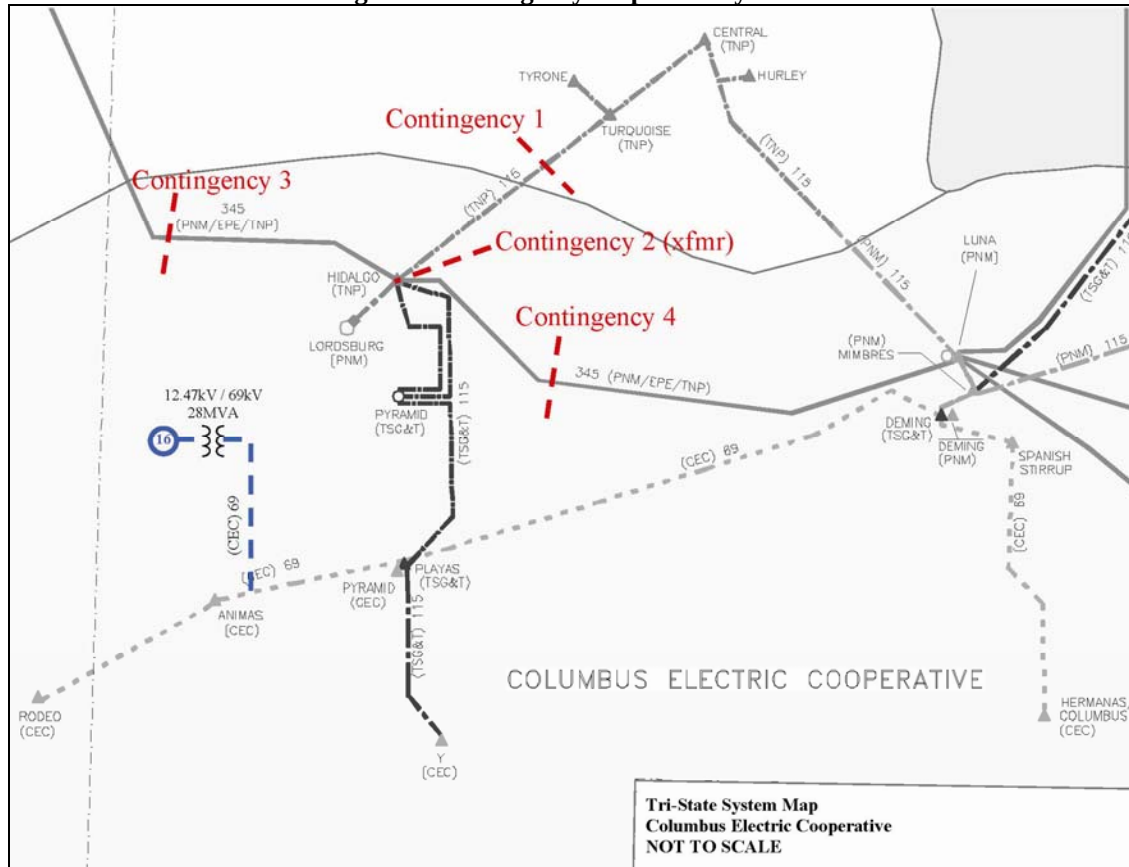
Assumptions made in the power flow analysis include line ratings and line impedances based on different tower structures than specified due to the limitation of the data files in the PSS/E TMLC program. The station service at the generation bus was assumed to have a 500kW load at 0.95 lagging power factor as that was not specified by the member.

Contingency Analysis

Four contingencies were taken in the power flow analysis as recommended by Public Service of New Mexico (PNM).

- Contingency 1: Hidalgo – Turquoise 115kV Line
- Contingency 2: Hidalgo 345kV/115kV transformer (one transformer unit)
- Contingency 3: Hidalgo – Greenlee 345kV line
- Contingency 4: Hidalgo – Luna 345kV line

Figure 2: Contingency Map in Study Area.



Results

According to the results shown in per unit voltages in Table 1 below, the voltages at the 69kV buses are lower without the 16.1 MW generator addition. Additionally, the voltages at the 69kV buses are even lower by about 0.01pu with the Rasertech generator operating at no load. However, with the generator operating at full load, the 69kV system is operating near unity.

Contingency 1 shows an overload on the Lordsburg 115kV/69kV transformer. However, the generator addition did not cause this overload. The transformer overloads in the approved base case when the Hidalgo-Turquoise 115kV line outage is taken.

Another observation from this analysis shows that the worst contingency is the Hidalgo-Turquoise 115kV line outage. The worst voltage during that contingency is recorded at the Lightning Dock generator bus at 0.983pu which is above our contingency criteria of 0.90pu. During System Normal, the worst voltages occur on the 69kV system when the generator is running at no load with only

station service being served. The Rodeo bus is most impacted as that bus is at the end of the radial line.

Dynamic studies were not performed as a part of this analysis. Dynamic stability impacts are expected to be minimal with the proposed (60) individual generating units. In addition, no-load reactive requirements of the combined (60) generating units would be significant if many were on-line not generating at one time. However, if only a few of these units are in this state at any one time, no additional reactive support should be required.

The generator running at full load improves the voltages in the Columbus 69kV service area and has little impact on the surrounding 115kV system.

Table 1: Bus Voltages in each scenario.

BUS VOLTAGES								
BUS NUMBER	BUS NAME	SYSTEM NORMAL- No Raser Generator addition	SYSTEM NORMAL @ No Load w/ SS	SYSTEM NORMAL @ Full Load	CONTINGENCY			
					1	2	3	4
12113	RAZER	0.991	0.981	1.000	0.995	0.998	0.998	0.999
12114	ANIMAS	0.988	0.978	0.997	0.992	0.995	0.995	0.996
12117	RODEO	0.984	0.974	0.992	0.987	0.991	0.991	0.991
12115	RAZERGEN	-	0.978	0.990	0.985	0.989	0.989	0.989
12116	LIGHTNDCK	-	0.998	0.998	0.983	0.987	0.987	0.987
12060	PLAYAS	1.009	1.004	1.009	1.004	1.007	1.008	1.008
12061	PLAYAS	1.020	1.017	1.012	1.013	1.010	1.016	1.011
12093	PYRAMID	1.027	1.026	1.024	1.025	1.022	1.028	1.023
13007	HIDALGO	1.023	1.023	1.021	1.023	1.019	1.029	1.020

Recommendations

There are no impacts to Tri-State Generation and Transmission Association's Playas 115kV/69kV transmission system from Playas to Hidalgo. Furthermore, there are no apparent impacts to PNM's system study area caused by the Raser Generation project. There are no significant impacts to the integrated 115kV system. Tri-State Generation and Transmission Association recommends approval of the Raser TSR request.

Appendix 1

Power Flow Model Parameters

BUSES										
Bus Number	Bus Name	Base kV	Area Number/Name	Zone Number/Name	Owner Number/Name	Code	G-Shunt (MW)	B-Shunt (MVAR)	Voltage (pu)	Angle (deg)
12060	PLAYAS	69	10 NEW MEXICO	123 ZONESO	127 TSGT	1	0	0	0.9984	14.78
12113	RAZER	69	10 NEW MEXICO	123 ZONESO	127 TSGT	1	0	0	0.9768	17.67
12114	ANIMAS	69	10 NEW MEXICO	123 ZONESO	127 TSGT	1	0	0	0.9738	17.54
12115	RAZERGEN	69	10 NEW MEXICO	123 ZONESO	127 TSGT	1	0	0	0.9575	20.14
12116	LIGHTNDCK	12.47	10 NEW MEXICO	123 ZONESO	127 TSGT	-2	0	0	0.9431	25.17
12117	RODEO	69	10 NEW MEXICO	123 ZONESO	127 TSGT	1	0	0	0.9692	17.31

BRANCHES											
From Bus Number	From Bus Name	To Bus Number	To Bus Name	Id	Line R (pu)	Line X (pu)	Charging (pu)	In-Service	Metered	Length	Conductor
12060	PLAYAS 69.000	12113	RAZER 69.000	1	0.203089	0.242726	0.003775	1	1	14	3/0
12113	RAZER 69.000	12114	ANIMAS 69.000	1	0.033061	0.039514	0.000615	1	1	2.25	3/0
12113	RAZER 69.000	12115	RAZERGEN 69.000	1	0.06244	0.21881	0.00366	1	1	13.7	477
12114	ANIMAS 69.000	12117	RODEO 69.000	1	0.1339	0.19594	0.003	1	0	11.2	4/0

From Bus Number	From Bus Name	To Bus Number	To Bus Name	Rate A (MVA)	Rate B (MVA)	Rate C (MVA)	Line G From (pu)	Line B From (pu)	Line G To (pu)	Line B To (pu)	Owner 1	Fraction
12060	PLAYAS 69.000	12113	RAZER 69.000	29	29	29	0	0	0	0	127	1
12113	RAZER 69.000	12114	ANIMAS 69.000	29	29	29	0	0	0	0	127	1
12113	RAZER 69.000	12115	RAZERGEN 69.000	76.5	76.5	76.5	0	0	0	0	127	1
12114	ANIMAS 69.000	12117	RODEO 69.000	350	350	350	0	0	0	0	127	1

LOADS												
Bus Number	Bus Name	Id	Area Number/Name	Zone Number/Name	Owner Number/Name	In-Service	Pload (MW)	Qload (MVAR)	IPload (MW)	IQload (MVAR)	YPload (MW)	YQload (MVAR)
12114	ANIMAS 69.000	TS	10 NEW MEXICO	123 ZONESO	127 TSGT	1	4.36	1.433	0	0	0	0
12116	LIGHTNDCK 12.470	SS	10 NEW MEXICO	123 ZONESO	127 TSGT	1	0.5	0.16	0	0	0	0
12117	RODEO 69.000	TS	10 NEW MEXICO	123 ZONESO	127 TSGT	1	2.38	0.78	0	0	0	0

MACHINES												
Bus Number	Bus Name	Id	In- Service	Pgen (MW)	Pmax (MW)	Pmin (MW)	Qgen (MVAR)	Qmax (MVAR)	Qmin (MVAR)	Mbase (MVA)	R Source (pu)	X Source (pu)
12116	LIGHTNDCK 12.470	S1		16.14	16.1	0	-6.9	-6.9	-6.973	100	0	0.2

Bus Number	Bus Name	RTran (pu)	XTran (pu)	Gentap (pu)	Owner 1	Fraction 1
12116	LIGHTNDCK 12.470	0	0	1	127	1

PLANTS										
Bus Number	Bus Name	PGen	QGen	QMax	QMin	VSched (pu)	Remote Bus Number	Remote Bus Name	Voltage (pu)	RMPCT
12116	LIGHTNDCK 12.470	16.14		-6.9 -6.9	-7	1	0		1	100

2-WINDING TRANSFORMERS

From Bus Number	From Bus Name	To Bus Number	To Bus Name	Id	Name	In- Service	Metered	Winding 1 Side	Controlled Bus	Controlled Side	Tap Positions	Control Mode
12115	RAZERGEN 69.000	12116	LIGHTNDCK 12.470	1	LGHTNDCK	1	0	0	12116	1	33	Voltage

From Bus Number	From Bus Name	To Bus Number	To Bus Name	Auto Adjust	Winding I/O Code	Impedance I/O Code	Admittance I/O Code	Specified R (pu or watts)	Specified X (pu)	Rate A (MVA)	Rate B (MVA)	Rate C (MVA)
12115	RAZERGEN 69.000	12116	LIGHTNDCK 12.470	1	Winding volt. (kV)	Zpu (system base)	Y pu (system base)	0.05	0.5	28	28	28

From Bus Number	From Bus Name	To Bus Number	To Bus Name	Mag. Admitt. (pu or watts)	Mag. Admitt. (pu)	Owner 1	Fraction 1	Winding MVA Base	Wnd 1 Ratio (pu or kV)	Wnd 1 Nominal kV	Wnd 1 Angle (degrees)	Wnd 2 Ratio (pu or kV)
12115	RAZERGEN 69.000	12116	LIGHTNDCK 12.470	0	0	127	1	100	12.595	12.47	0	67

From Bus Number	From Bus Name	To Bus Number	To Bus Name	Wnd 2 Nominal kV	Rmax (pu kV or deg)	Rmin (pu kV or deg)	Vmax (pu, kV MW, or MVAR)	Vmin (pu, kV MW, or MVAR)	Load Drop Comp R(pu)	Load Drop Comp X(pu)	Impedance Table
12115	RAZERGEN 69.000	12116	LIGHTNDCK 12.470	67	13.717	11.223	1.1	0.9	0	0	0

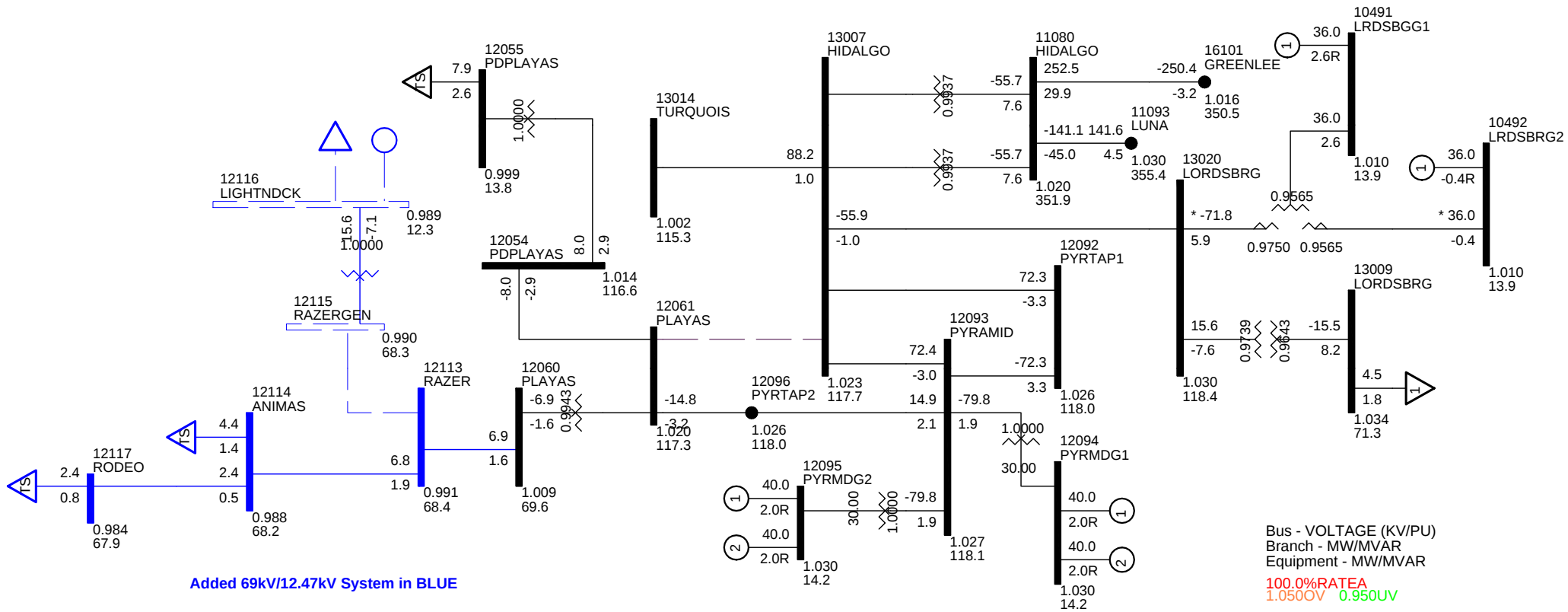
Appendix 2

Powerflow Results – System Normal & Contingency Results

WESTERN ELECTRICITY COORDINATING COUNCIL
2012 HS2A APPROVED BASE CASE
Columbus Electric Coop - 69kV system MON, JUN 16 2008 15:59

16.1MW Geothermal Plant Addition
between Animas - Playas 69kV line
Columbus Electric Coop.

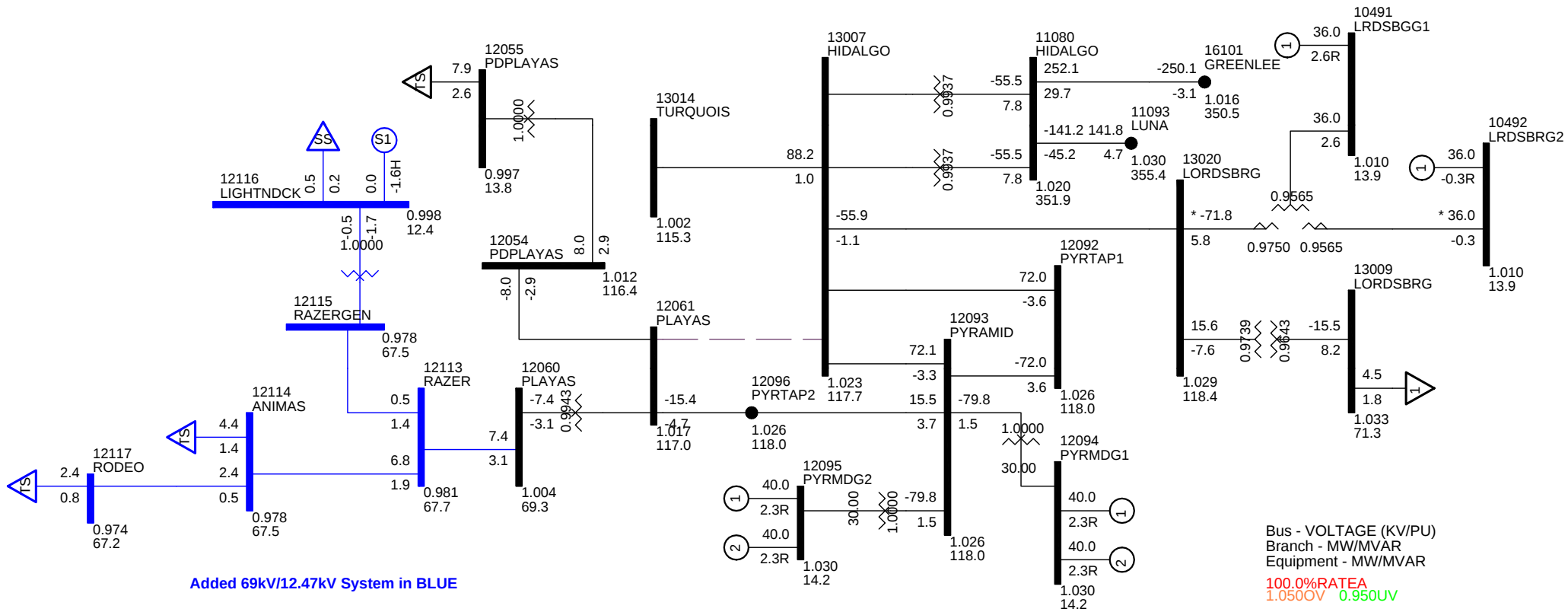
Lordsburg / Pyramid Units at Full Output
No Generator Addition at Razer



WESTERN ELECTRICITY COORDINATING COUNCIL
2012 HS2A APPROVED BASE CASE
Columbus Electric Coop - 69kV system MON, JUN 16 2008 14:57

16.1MW Geothermal Plant Addition
between Animas - Playas 69kV line
Columbus Electric Coop.

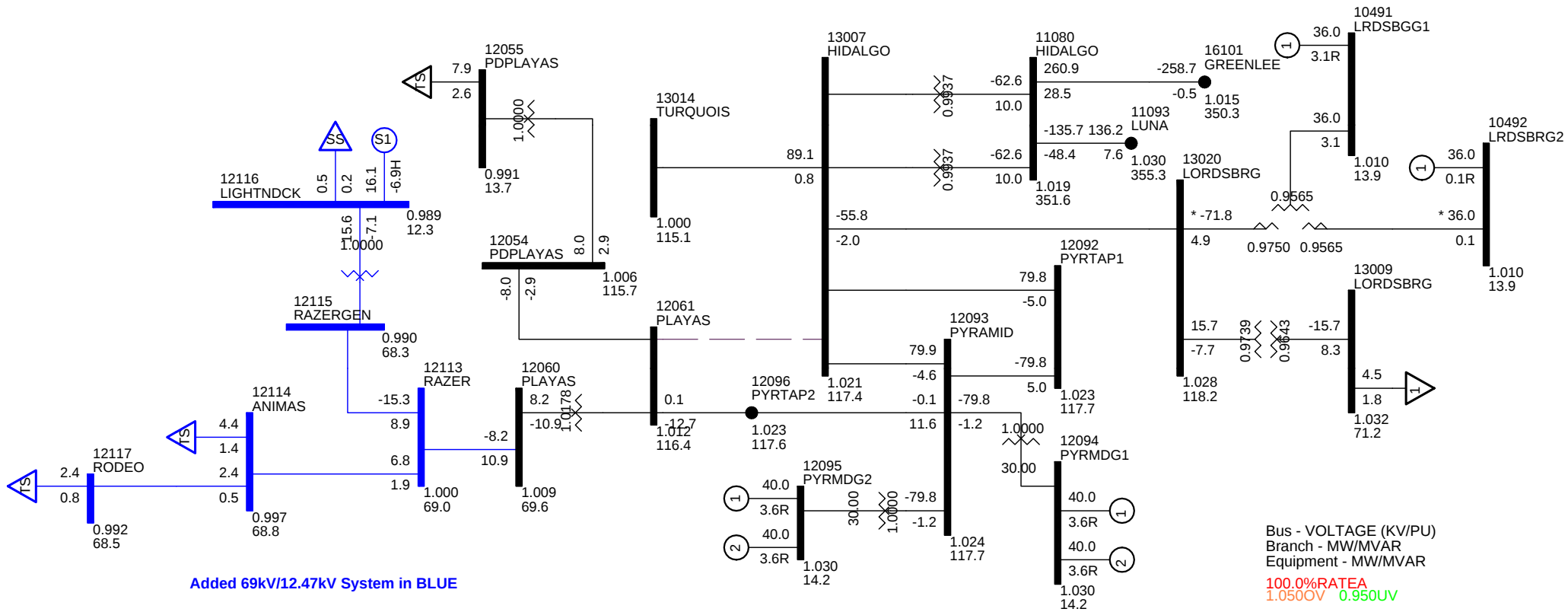
Lordsburg / Pyramid Units at Full Output
System Normal - Generator Running at No Load



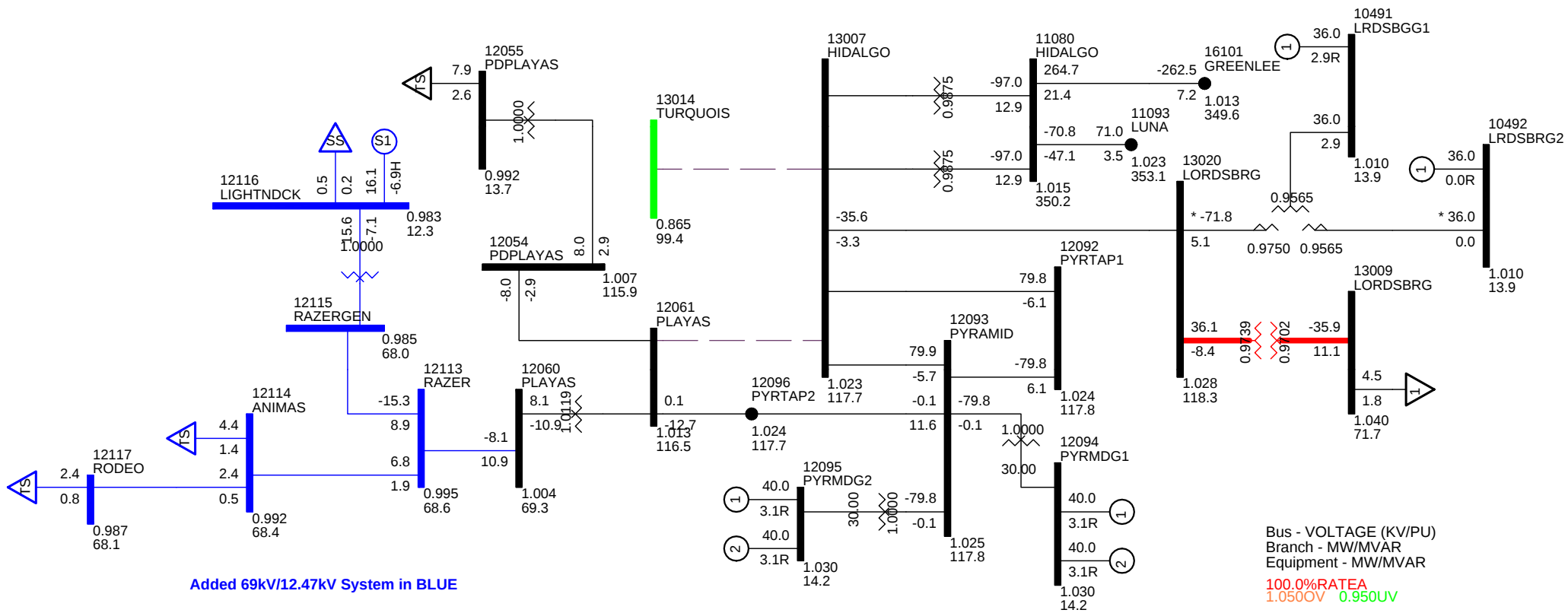
WESTERN ELECTRICITY COORDINATING COUNCIL
2012 HS2A APPROVED BASE CASE
Columbus Electric Coop - 69kV system MON, JUN 16 2008 15:04

16.1MW Geothermal Plant Addition
between Animas - Playas 69kV line
Columbus Electric Coop.

Lordsburg / Pyramid Units at Full Output
System Normal - Generator Running at Full Load at 91.8% lagging power factor

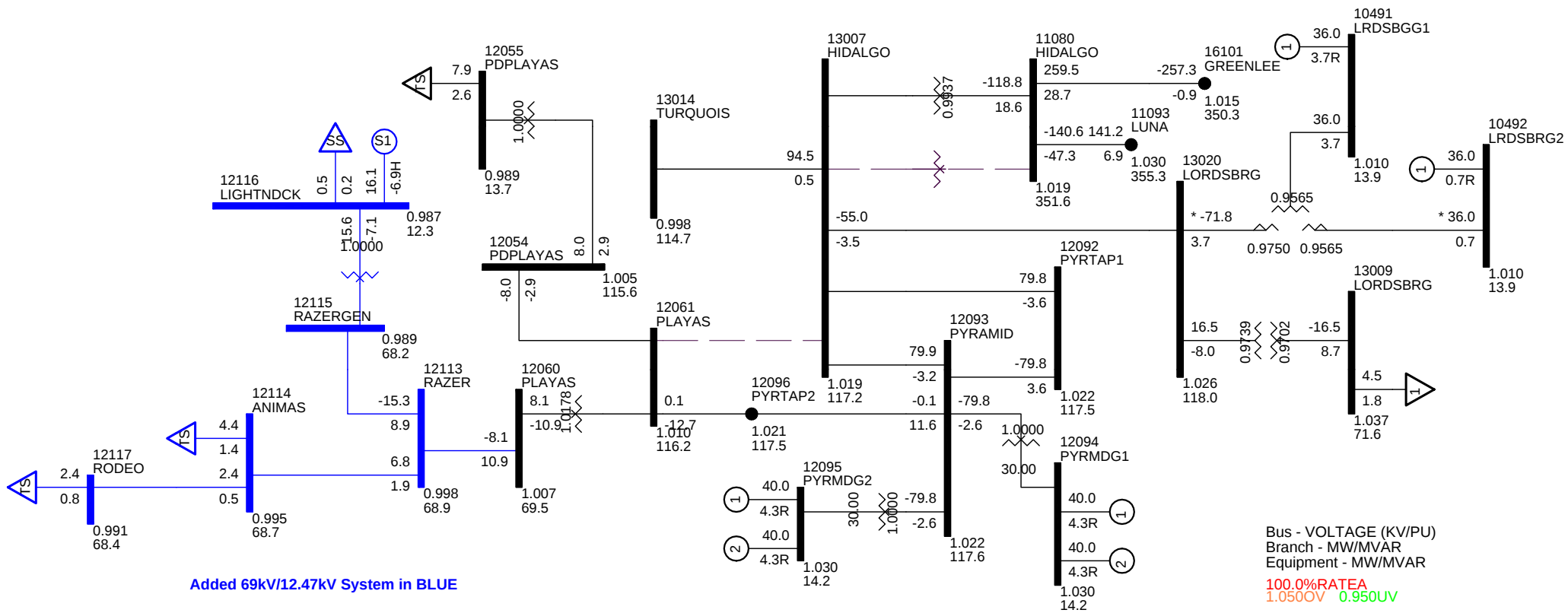


Lordsburg / Pyramid Units at Full Output
Scenario 1: Hidalgo - Turquoise 115kV Line Outage



16.1MW Geothermal Plant Addition
between Animas - Playas 69kV line
Columbus Electric Coop.

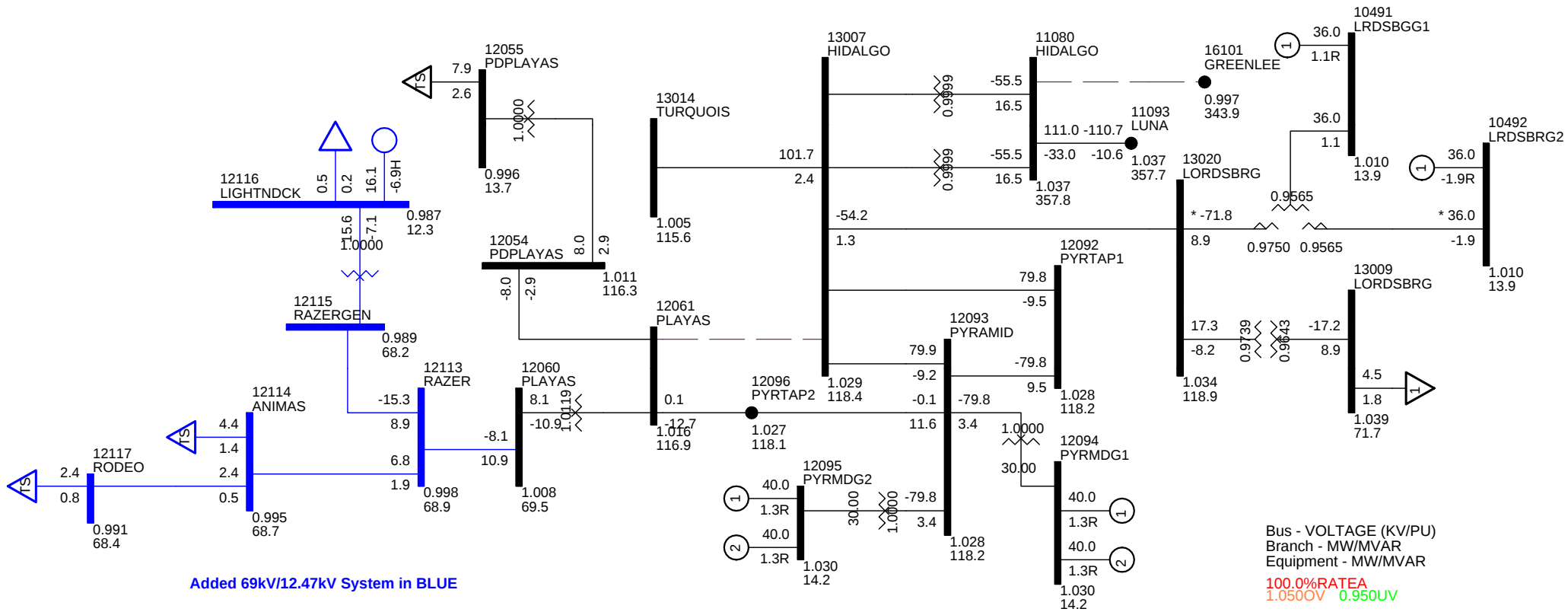
Lordsburg / Pyramid Units at Full Output
Scenario 2: Hidalgo 345kV/115kV transformer outage (one unit)



WESTERN ELECTRICITY COORDINATING COUNCIL
2012 HS2A APPROVED BASE CASE
Columbus Electric Coop - 69kV system MON, JUN 16 2008 16:22

16.1MW Geothermal Plant Addition
between Animas - Playas 69kV line
Columbus Electric Coop.

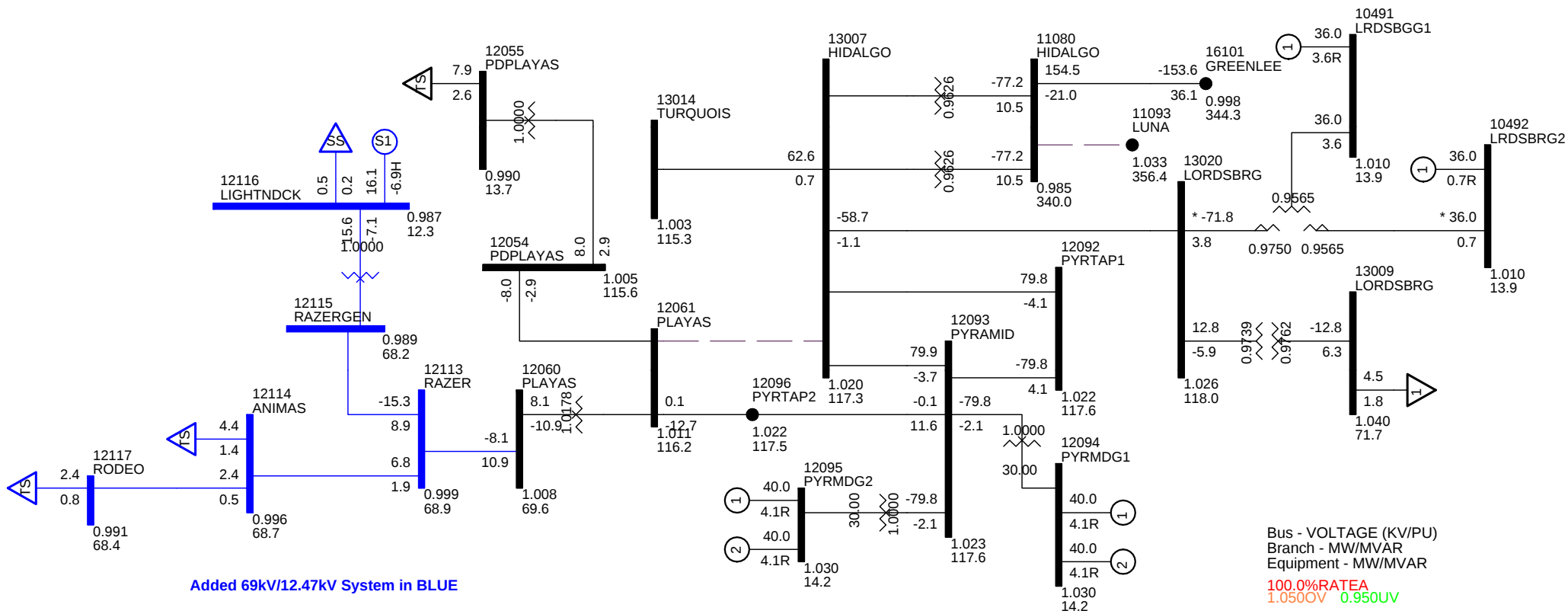
Lordsburg / Pyramid Units at Full Output
Scenario 3: Hidalgo - Luna 345kV Line Outage



WESTERN ELECTRICITY COORDINATING COUNCIL
2012 HS2A APPROVED BASE CASE
Columbus Electric Coop - 69kV system MON, JUN 16 2008 15:54

16.1MW Geothermal Plant Addition
between Animas - Playas 69kV line
Columbus Electric Coop.

Lordsburg / Pyramid Units at Full Output
Scenario 4: Hidalgo - Luna 345kV Line Outage



16.1MW Geothermal Plant Addition
between Animas - Playas 69kV line
Columbus Electric Coop.

[illegible]