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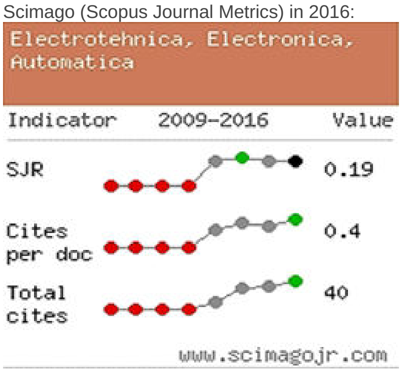

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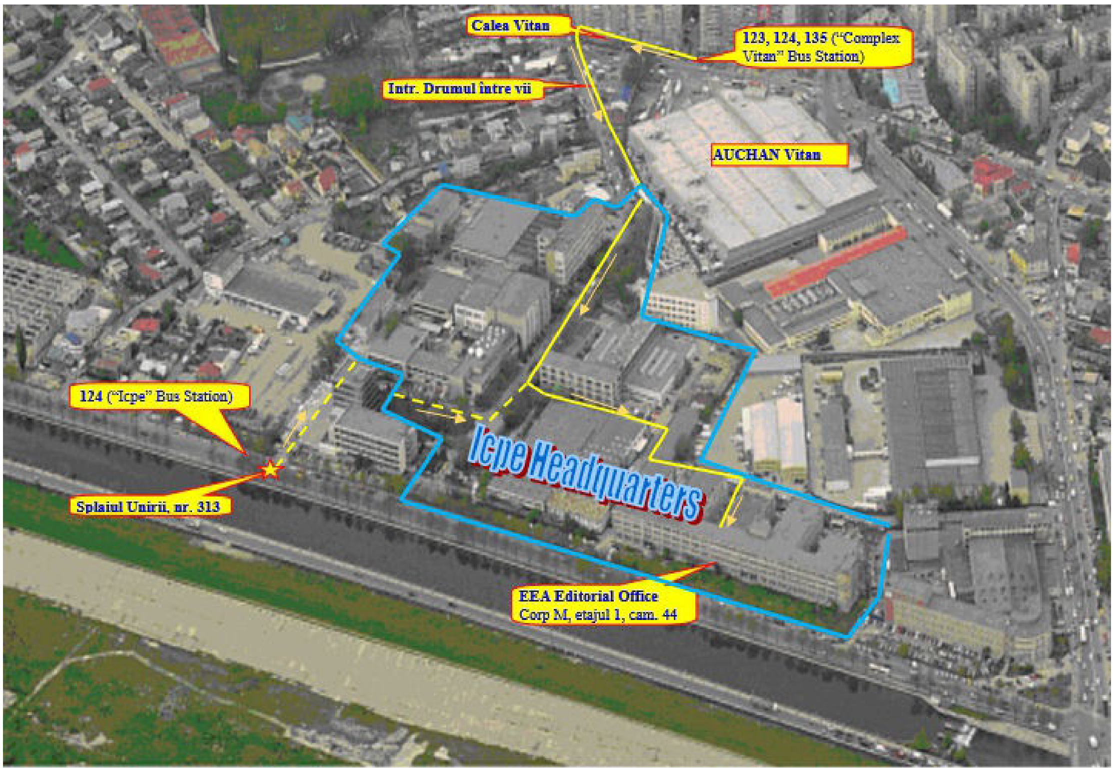

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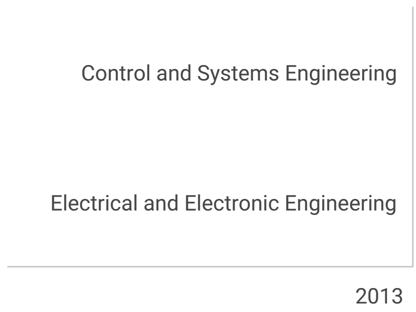

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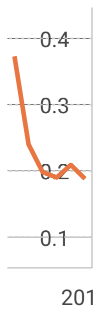

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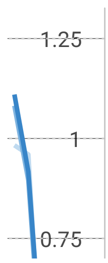

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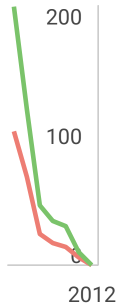

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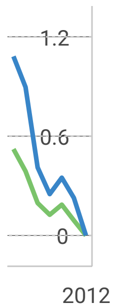

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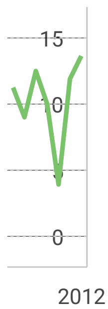

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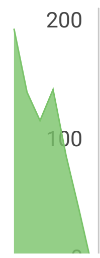

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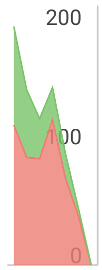

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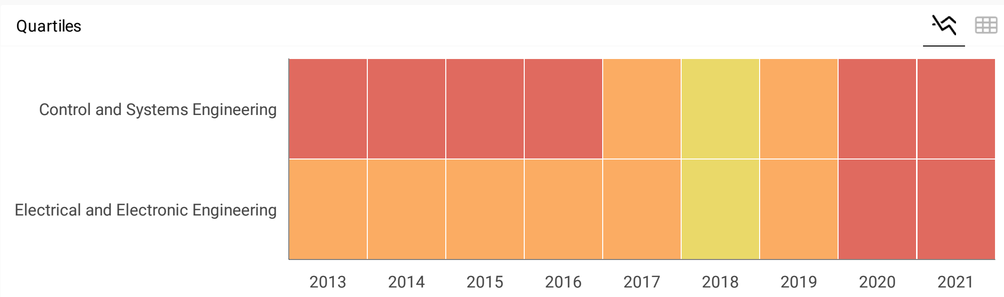

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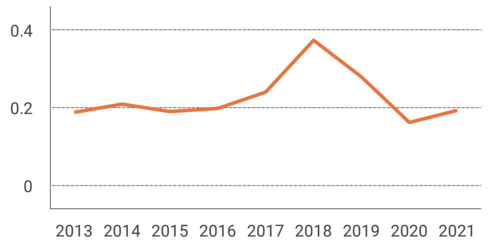

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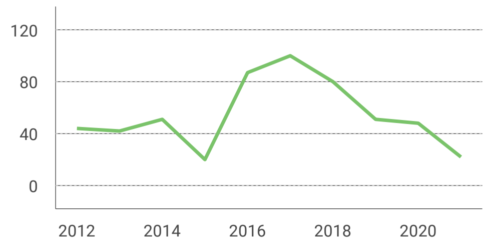

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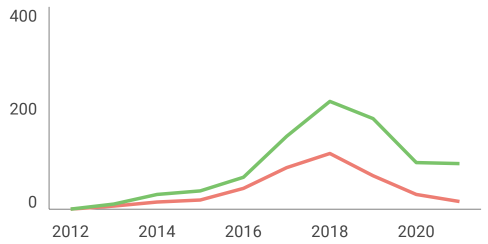

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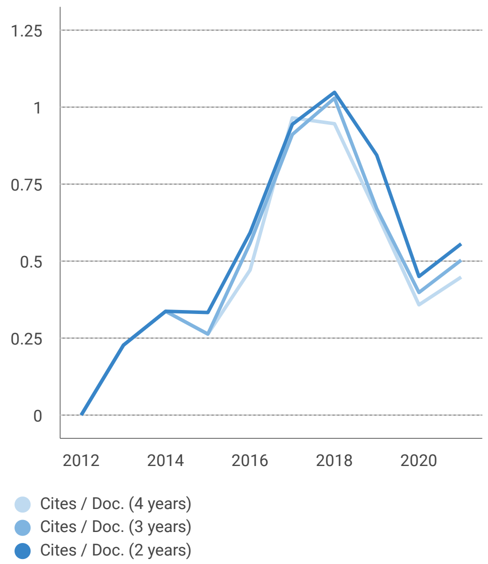

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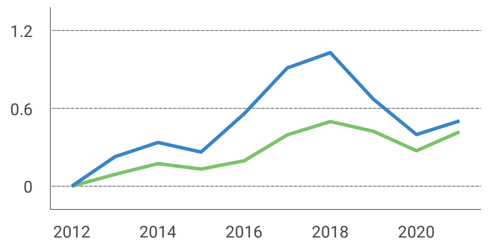

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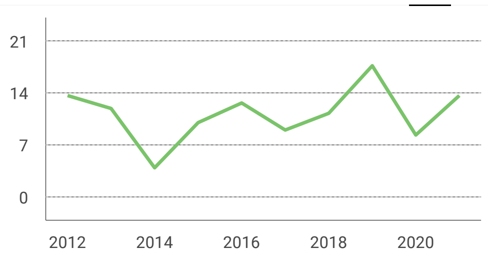

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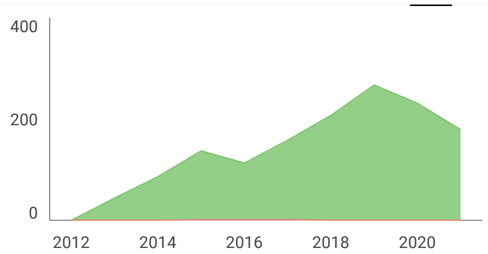

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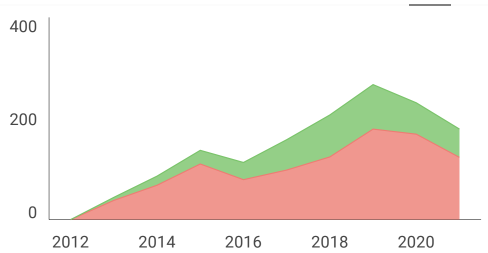

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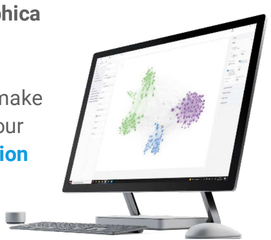

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WALUYO, Jauzie ARIEF, SYAHRIAL

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Keywords: *geothermal, load flow, loss, power, voltage*

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Investigation of Load Flows on Geothermal Power Generation Alone Usage

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Abstract

Power flow is one of parameters to get information and analysis of electric power system, concerns to operating problems and reliability. In this research, the electric power system of geothermal generation has three generating units. The electrical energy is generated to supply for the substation and self-consumption which consists of electric motors mostly. The study was to investigate the operation effect on the first unit to the power flow on the self-consumption loads with the condition of three different scenarios. By the computations of power flow, the bus bar voltages on the three scenarios were in the normal condition, as 98% of nominal voltage. The self-consumption powers of unit 2 and unit 3 were 2.56%, and that unit 1 was 3.4% of per unit generated power. The increases of total loss on the first, second and third scenarios 3 were 395 kW, 405 kW and 406.4 kW respectively.

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1. Introduction

An electrical power system that includes the source of plant until the loads is taking an important role in electrical energy distribution. Its effect on conductor inductance will cause a decrease in the voltage, so that it is necessary to evaluate the load flow. The load or power flow study is the backbone of power system analysis, design and important tool, which is necessary for planning, operation, optimal power flow, economic scheduling and power exchange among utilities. The principal information was voltage magnitude and phase angle, and real and reactive powers. It is also important for planning future expansion and stability analysis [1-13]. It was also necessary to investigate the load flow study related to a geothermal power generation.

The geothermal power generation, in this research, has three generator units, the first unit of 30 MW, and both unit 2 and unit 3 of 55 MW. The generated electrical energy supplied the own use which consisted of electric motors and distributed to the substation, connected to the grid system. Based on the information, the unit 1 experienced problems that caused by lack of energy supply to the load own use and the power distribution through 150 kV interconnection system. Therefore, the objective of study was to determine the effect of operation for unit 1 to the power flow to the user loads with the condition of three scenarios. Furthermore, it was obtained the voltage magnitudes on the load buses for own usage, the condition of buses voltages whether within normal limits, the losses flowing on its own network usage for the three scenarios of operation on the unit 1, the active and reactive powers, and the direction of power flow on the network. Thus, it could be known the effectiveness of system.

2. Materials and Methods

Figure 1 shows the flow chart of the stages those were carried out systematically from the beginning to the end of the research.

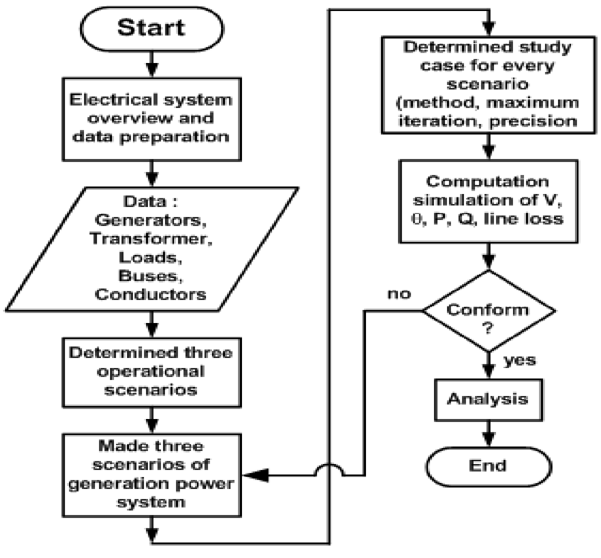


Figure 1. Flowchart of research

The first step was the overview of power system and data collection, namely electrical equipment, the buses, the conductors and load data. Once the data were met, the next step was to determine the three scenarios of operation of the unit 1 that has been set. The computation simulating processes were performed after making representations of power systems and determine the study case by settlement method using fast decoupled for the three scenarios.

After the simulation under the condition of field, the next step might be to analyse the effect of restarting of unit 1 to the power flow in the alone usage loads.

Some formulae which were used as the main methods in this research as bellow [14-17].

$$S_i = P_i + jQ_i = V_i \, x \, I_i \tag{1}$$

By using Kirchoff's current law formula, it was obtained the current at bus i.

$$I_i = V_i \sum_{i=0}^{n} y_{ij} + V_j \sum_{j=0}^{n} y_{ij} \quad j \neq i \tag{2}$$

The active and reactive powers at bus **i** are as below.

$$P_i = \sum_{j=1}^{n} |Y_{ij}||V_i||V_j| \cos(\theta_{ij} + \delta_i - \delta_j) \tag{3}$$

$$Q_i = -\sum_{j=1}^{n} |Y_{ij}||V_i||V_j| \cos(\theta_{ij} + \delta_i - \delta_j) \tag{4}$$

There would be computed the mismatch, where the value showed the difference of power that computed when iterating on a bus with a large yield of previous computation. Thus, the values of power mismatch were computed when reducing the iterations of power calculation results. It is written as equations (5) and (6).

$$\Delta P_i = P_i^{sch} - P_i \tag{5}$$

$$\Delta Q_i = Q_i^{sch} - Q_i \tag{6}$$

where ΔP_i and ΔQ_i were the active and reactive power mismatches on bus i, $\mathbf{P_i^{sch}}$ and $\mathbf{Q_i^{sch}}$ were active and reactive computed powers on bus i and $\mathbf{P_i}$ and $\mathbf{Q_i}$ were active and reactive power computations on bus i respectively.

By using the fast-decoupled power flow, changes in active power (ΔP) were less sensitive to the changes in the voltage magnitudes and the most sensitive to the changes in the phase angle (Δδ), mainly relied on the large changes in the voltages. Therefore, the elements of J_2 and J_3 were set as Jacobian matrix to zero as equation (7) below.

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_1 & 0 \\ 0 & J_4 \end{bmatrix} = \begin{bmatrix} \Delta\delta \\ \Delta|V| \end{bmatrix} \tag{7}$$

So that it was obtained the equations (8) and (9).

$$\frac{\Delta P}{V} = -B' \Delta\delta \tag{8}$$

$$\frac{\Delta Q}{V} = -B'' \Delta V \tag{9}$$

The voltage magnitude and phase angle were modified as equations (10) and (11)

$$\Delta|V| = -[B'']^{-1} \frac{\Delta Q}{|V|} \tag{10}$$

$$\Delta\delta = -[B']^{-1} \frac{\Delta P}{|V|} \tag{11}$$

Besides above method, the research was also conducted by using the simulation [18-19]. The data, which were used in this study, were the single line diagram showing the overall generating units, system configuration, 150 kV, 20 kV, 11.8 kV, 6.3 kV and 0.38 kV networks.

Table 1 lists the three scenarios set out in analysing the geothermal power generation system.

Table 1. Research scenarios of geothermal power generation

Scenario	Description	Burbar origin	Closed CBs	Opened CBs
1	Before Unit 1 enter to network	-	-	-
2	T8 contribution to Unit 1	Station SB.A	52T8, 52ST8	-
			52T2, 52T3	
			52U1C, 52S1C	
3	After Unit 1 enter to network	-	52T1	52T8, 52ST8
				52U1C, 52S1C

The desired goals could be achieved in the operation of unit 1. The explanation of three scenarios are as follows.

The first scenario was the condition of geothermal power generation system operated normally without the unit 1. The diesel generators were connected to the bus STT.SW.BOARD A ESSNTL. The circumstances were not synchronized.

Figure 2 (*infra*) is the representation of simulating diagram of the first scenario.

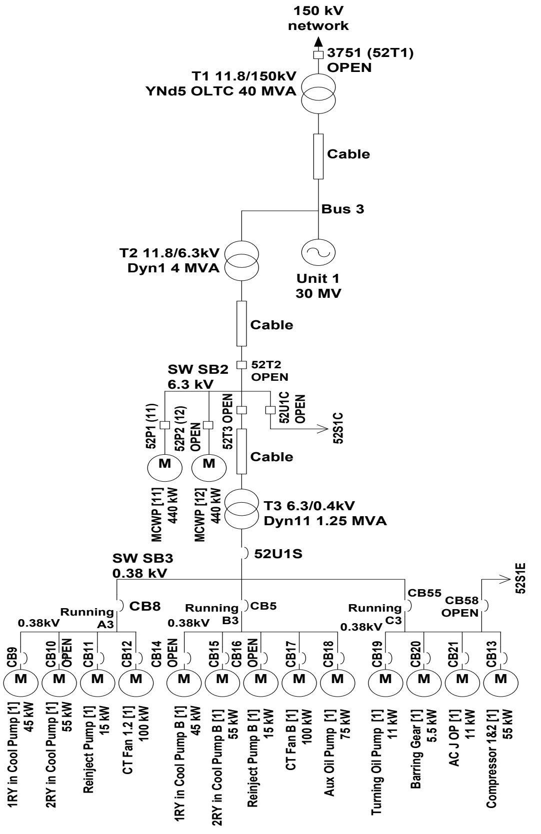


Figure 2. Representation condition of unit 1 for the first scenario

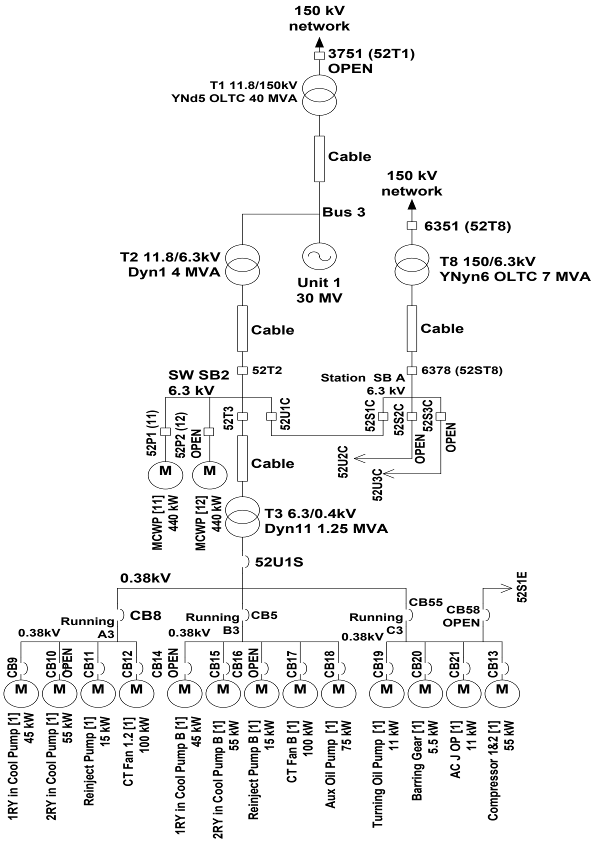


Figure 3. Representation condition of unit 1 for the second scenario

The second scenario was the star-up unit 1, where the providing process of voltage was obtained from the bus station STATION SB. A 6.3 kV via the transformer (T8) of the 150 kV network, with the closed circuit breakers were 52ST8, 52ST2, 52ST3, 52U1C and 52S1C.

Figure 3 (*supra*) shows the simulating diagram for the second scenario.

The third scenario was after the star-up unit 1, where the generator unit 1 performed parallel system of 150 kV network through the step-up transformer (T1), with the 11.8 kV closed circuit breaker was 52T1, and the opened circuit breakers were 52ST8, 52U1C, and 52S1C.

Figure 4 shows the representation of simulation condition for the third scenario.

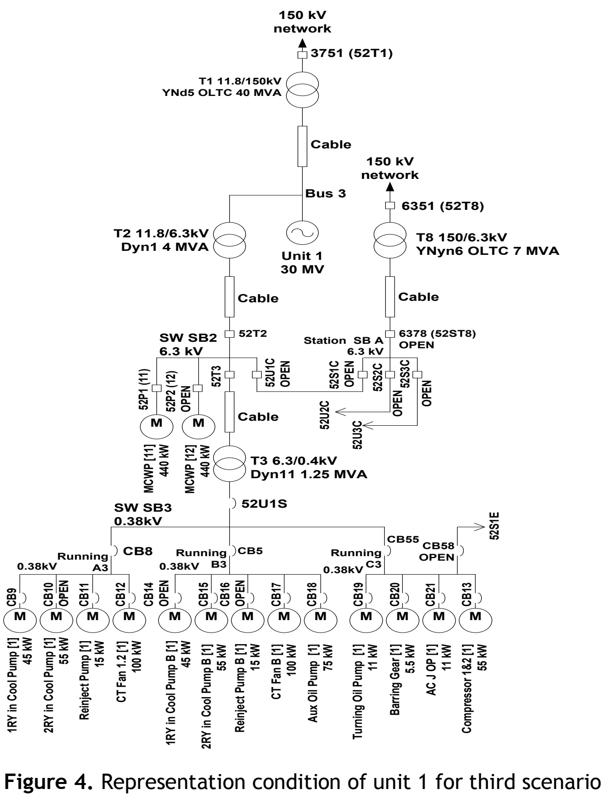


Figure 4. Representation condition of unit 1 for third scenario

3. Results and Discussion

Figure 5 shows the results of simulation were obtained by using the fast decoupled, with the factor of 5 times and the accuracy of 0.0001, for the first scenario.

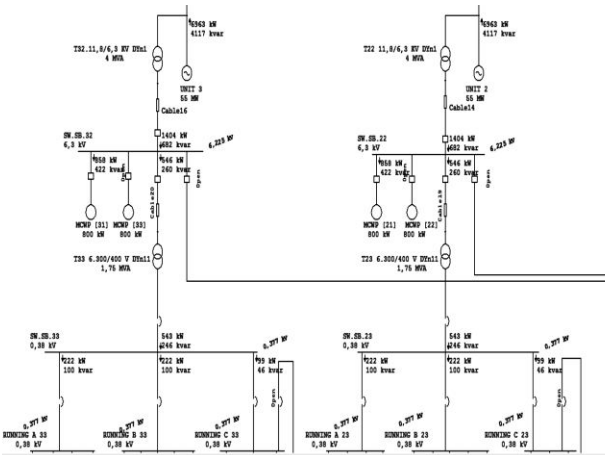


Figure 5. Simulation of power flow in the first scenario

The unit 2 and unit 3 had the same capacity of the equipment, so that the power flow from a bus to another bus and the bus voltage would be the same.

The figure shows the power flow from each unit 2 and unit 3 as 6963 kW and 4117 kVAR. On other hand, the powers for alone usage were 1404 kW and 682 kVAR for each from unit 2 and unit 3.

The voltages reduced to 6.225 kV from 6.3 kV based on the voltages, on both buses.

The simulation results of geothermal power generation system for the first scenario, as power flow representation, is listed in Table 2.

Table 2. Results of power flow in the scenario 1

Line		Power flow		Current	Power
From bus	To bus	MW	MVAR	(A)	factor (%)
UNIT 3	SW.SB 32	1.404	0.682	144.8	89.9
SW.SB.32	MCWP[31]	0.858	0.422	144.8	89.9
	SW.SB.33	0.543	0.246	56.1	90.2
SW.SB.33	RUNNING A 33	0.222	0.100	372.2	91.1
	RUNNING B 33	0.222	0.100	372.8	91.3
	RUNNING C 33	0.099	0.046	167.0	90.6
UNIT 2	SW.SB.22	1.404	0.682	144.8	89.9
SW.SB.22	MCWP [21]	0.858	0.422	144.8	89.9
	SW.SB.23	0.543	0.246	56.1	90.2
SW.SB.23	RUNNING A 23	0.222	0.100	372.2	91.1
	RUNNING B 23	0.222	0.100	372.8	91.3
	RUNNING C 23	0.099	0.046	167.0	90.6
BUS B	SUB STATION 7	7.318	5.323	261.3	80.9
SUB STATION 7	PSH	1.910	1.432	73.8	80.0
	DRWT	1.324	0.986	49.5	80.0
	SMRG	3.335	2.501	125.5	80.0
	STATION SB.B	0.422	0.204	13.6	89.9
STATION SB.B	ST.SB ESSNTL B	0.211	0.102	21.6	90.0
ST.SB ESSNTL B	MTR ESSNTL B	0.205	0.101	357.6	90.3
	ST.SB ESSNTL A[1]	0.175	0.078	293.7	91.3
	ST.SB ESSNTL A[2]	0.041	0.021	71.0	89.0
ST.SB ESSNTL A[2]	ST.SB ESSNTL A[3]	0.035	0.017	59.3	89.6
ST.SB ESSNTL A[1]	MTR ESSNTL A[1]	0.175	0.078	293.7	91.3
ST.SB ESSNTL A[2]	MTR ESSNTL A[2]	0.007	0.004	59.3	89.6
ST.SB ESSNTL A[3]	MTR ESSNTL A[3]	0.035	0.017	59.3	89.6

It is shown that the highest power flow was from BUS B to SUB STATION 7, as 7.318 MW and 5.323 MVAR. While, the lowest power flow was from ST.SB ESSNTL A[2] to MTR ESSNTL A[2], as 0.007 MW and 0.004 MVAR. The highest currents were SW.SB.33 to RUNNING B.33 and SW.SB.33, both as 372.8 A.

Table 3 summarizes the simulation results of busbar voltage conditions, found that in the first scenario, the bus condition was in normal limits.

Table 3. Voltage condition in the first scenario

Bus ID	Rating (kV)	Operation (kV)	(%)	Condition
UNIT 3	11.8	11.8	100	Normal
SW.SB.32	6.3	6.2	98.80	Normal
SW.SB.33	0.380	0.377	99.32	Normal
RUNNING A 33	0.380	0.377	99.32	Normal
RUNNING B 33	0.380	0.377	99.32	Normal
RUNNING C 33	0.380	0.377	99.32	Normal
UNIT 2	11.8	11.8	100	Normal
SW.SB.22	6.3	6.2	98.80	Normal
SW.SB.23	0.380	0.377	99.32	Normal
RUNNING A 23	0.380	0.377	99.32	Normal
RUNNING B 23	0.380	0.377	99.32	Normal
RUNNING C 23	0.380	0.377	99.32	Normal
SUBSTATION 7	20	19.995	99.98	Normal
STATION SB.B	6.3	6.2	99.58	Normal
ST.SB ESSNTL B	0.380	0.376	99.05	Normal
ST.SB ESSNTL A [1]	0.380	0.376	99.05	Normal
ST.SB ESSNTL A [2]	0.380	0.376	99.05	Normal
ST.SB ESSNTL A [3]	0.380	0.376	99.05	Normal

The table indicates that the highest percentages, of course, were on unit 3 and unit 2 as 100 %. Otherwise, the lowest ones were SW.SB.32 and SW.SB.22 as 98.8 %.

Table 4 summarized the simulation results for the losses in each line caused by the transformers and cable conductors.

Table 4. Line power losses on the first scenario

Lines		ID	From to Bus Flow		To-from Bus Flow		Losses		Voltage
From Bus	To Bus		MW	MVAR	MW	MVAR	kW	kVAR	drop (%)
UNIT 3	BUS A	T31 11.8/150 kV	-5.553	-3.321	5.555	3.397	1.7	76.3	0.63
UNIT 2	BUS B	T21 11.8/150 kV	-5.553	-3.321	5.555	3.397	1.7	76.3	0.63
UNIT 2	BUS B	Cable 12	5.556	3.399	-5.550	-3.397	1.1	1.6	0.03
UNIT 2	SW.SB.22	T22 11.8/6.3 kV	1.407	0.718	-1.404	-0.682	3.1	35.6	1.18
BUS B	SUB STATION 7	T7 150/20 kV	7.351	5.926	-7.321	-5.325	30.1	601.5	0.66
UNIT 3	BUS A	Cable 13	5.556	3.399	-5.555	-3.397	1.1	1.6	0.03
UNIT 3	SW. SB. 32	T32 11.8/6.3 kV	1.407	0.718	-1.404	-0.682	3.1	35.6	1.18
BUS B	SUB STATION 7	Cable 5	7.320	5.325	-7.318	-5.323	2.3	1.4	0.03
SUB STATION 7	STATION SB. B	T4 20/6.3 kV	0.422	0.207	-0.422	-0.204	0.4	3.4	0.39
UNIT 2	SW. SB. 22	Cable 14	1.404	0.682	-1.404	-0.682	0.2	0.1	0.01
UNIT 3	SW. SB. 32	Cable 16	1.404	0.682	-1.404	-0.682	0.2	0.1	0.01
SW. SB. 22	SW. SB. 23	Cable 19	-0.545	-0.260	0.546	0.260	1.3	0.0	0.20
SW. SB. 22	SW. SB. 23	T23 6.300/400 V	0.545	0.260	-0.543	-0.246	2.0	14.2	0.72
SW. SB. 32	SW. SB.33	Cable 20	-0.545	-0.260	0.546	0.260	1.3	0.0	0.20
SW. SB. 32	SW. SB. 33	T33 6.300/400 V	0.545	0.260	-0.543	-0.246	2.0	14.2	0.72
STATION SB. B	ST. SB ESSNTL B	Cable 21	-0.209	-0.102	0.209	0.102	0.1	0.0	0.04
STATION SB. B	ST. SB ESSNTL B	T6 6.300/400 V	0.211	0.102	-0.211	-0.100	-0.3	2.0	0.49

Lines		ID	From to Bus Flow		To-from Bus Flow		Losses		Voltage
From Bus	To Bus		MW	MVAR	MW	MVAR	kW	kVAR	drop (%)
STATION SB. B	ST. SB ESSNTL B	Cable 22	-0.209	-0.102	0.209	0.102	0.1	0.0	0.04
STATION SB. B	ST. SB ESSNTL B	T5 6.300/400 V	0.211	0.102	-0.211	-0.100	0.3	2.0	0.39
SUB STATION 7	SMRG	Line 9	-3.335	-2.501	3.479	2.599	143.7	98.1	4.12
SUB STATION 7	DRWT	Line 10	-1.314	-0.986	1.372	1.007	58.1	21.0	4.23
SUB STATION 7	PSH	Line 11	-1.909	-1.432	2.045	1.51	135.4	77.8	6.61
SW.SB.22	MCWP [21]	Cable 25	-	-	-	-	3.0	0.7	0.31
SW.SB.32	MCWP [31]	Cable 23	-	-	-	-	3.0	0.7	0.31
Total Losses							395.0	1064.2	

The total line losses in the first scenario were 395 kW of active power and 1064 kVAR of reactive power. It was indicated that the highest losses were from SUBSTATION 7 to SMRG (line 9) as 143.7 kW and 98.1 kVAR. Otherwise, the lowest one was STATION SB.B to ST.SB.ESSNTCB (cable 22) as 0.1 kW and practically zero of reactive power.

Figure 6 shows the simulation results of geothermal power generation system for the second scenario.

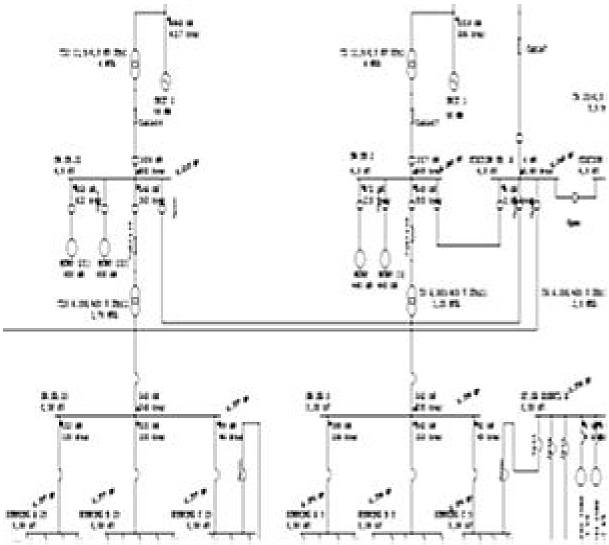


Figure 6. Simulation of power flow in the second scenario

The figure shows that the unit 1 supplied the power of 1019 kW and 586 kVAR and the unit 2 supplied the power of 6963 kW and 4117 kVAR.

However, the unit 1 supplied to own usage as 1017 kW and 569 kVAR and the unit 2 supplied to own usage as 1404 kW and 682 kVAR only.

On other hand, the bus voltage which was the power from the unit 1 was 6.246 kV and the bus voltage which was the power from the unit 2 was 6.227 kV, reduced from the rating bus voltage of 6.3 kV.

Based on the simulation results of the obtained power flow values, it could be summarized in Table 5.

Table 5. Results of power flow in the second scenario

Lines		Power flow		Current (A)	Power factor (%)
From bus	To bus	MW	MVAR		
UNIT 3	SW.SB.22	1.404	0.682	144.8	89.9
SW.SB.22	MCWP [21]	0.858	0.422	144.8	89.9
	SW.SB.33	0.543	0.246	56.1	90.2
SW.SB.33	RUNNING A 33	0.222	0.100	372.2	91.1
	RUNNING B 33	0.222	0.100	372.8	91.3
	RUNNING C 33	0.099	0.046	167.0	90.6
UNIT 2	SW.SB.22	1.404	0.682	144.8	89.9
SW.SB.22	MCWP [21]	0.858	0.422	144.8	89.9
	SW.SB.23	0.543	0.246	56.1	90.2
SW.SB.23	RUNNING A 23	0.222	0.100	372.2	91.1
	RUNNING B 23	0.222	0.100	372.8	91.3
	RUNNING C 23	0.099	0.046	167.0	90.6

Lines		Power flow		Current (A)	Power factor (%)
From bus	To bus	MW	MVAR		
UNIT 1	SW.SB 2	1.017	0.569	107.7	87.3
SW.SB 2	MCWP	0.472	0.215	107.7	87.3
	SW.SB.3	0.548	0.355	60.4	83.9
SW.SB.3	RUNNING A 3	0.188	0.136	357.1	81
	RUNNING B 3	0.262	0.150	465.3	86.8
	RUNNING C 3	0.092	0.049	161.1	88.1
BUS A	STATION SB.A	0.004	0.001	0.4	98.7
STATION SB.A	SW.SB 2	0.004	0.001	0.4	98.7
BUS B SUB	STATION 7	7.318	5.323	261.3	80.9
SUB STATION 7	PSH	1.910	1.432	73.8	80.0
	DRWT	1.314	0.986	49.5	80.0
	SMRG	3.335	2.501	125.5	80.0
	STATION SB.B	0.422	0.204	13.6	89.9
STATION SB.B	ST.SB ESSNTL B	0.211	0.102	21.6	90.0
ST.SB ESSNTL B	MTR ESSNTL B	0.205	0.101	357.6	90.3
	ST.SB ESSNTL A [1]	0.175	0.078	293.7	91.3
	ST.SB ESSNTL A [2]	0.041	0.021	71.0	89.0
ST.SB ESSNTL A [2]	ST.SB ESSNTL A [3]	0.035	0.017	59.3	89.6
ST.SB ESSNTL A [1]	MTR ESSNTL A [1]	0.175	0.078	293.7	91.3
ST.SB ESSNTL A [2]	MTR ESSNTL A [2]	0.007	0.004	59.3	89.6
ST.SB ESSNTL A [3]	MTR ESSNTL A [3]	0.035	0.017	59.3	89.6

With the bus additions, namely SW.SB.A and unit 1, on the second scenario, it was obtained the bus voltage condition in the normal limits, as listed in Table 6.

Table 6. Condition voltage in the second scenario

Bus ID	Rating (kV)	Operation (kV)	Operation (%)	Condition
UNIT 3	11.8	11.8	100	Normal
SW. SB. 32	6.3	6.2	98.80	Normal
SW. SB. 33	0.380	0.377	99.32	Normal
RUNNING A 33	0.380	0.377	99.32	Normal
RUNNING B 33	0.380	0.377	99.32	Normal
RUNNING C 33	0.380	0.377	99.32	Normal
UNIT 2	11.8	11.8	100	Normal
SW. SB. 22	6.3	6.2	98.80	Normal
SW. SB. 23	0.380	0.377	99.32	Normal
RUNNING A 23	0.380	0.377	99.32	Normal
RUNNING B 23	0.380	0.377	99.32	Normal
RUNNING C 23	0.380	0.377	99.32	Normal
UNIT 1	11.8	11.8	100	Normal
SW. SB 2	6.3	6.2	99.13	Normal
SW. SB 3	0.380	0.374	98.54	Normal
RUNNING A 3	0.380	0.374	98.54	Normal
RUNNING B 3	0.380	0.374	98.54	Normal
RUNNING C 3	0.380	0.374	98.54	Normal
STATION SB. A	6.3	6.2	99.13	Normal
SUB STATION 7	20	19.995	99.98	Normal
STATION SB. B	6.3	6.2	99.58	Normal
ST. SB ESSNTL B	0.380	0.376	99.05	Normal
ST. SB ESSNTL A [1]	0.380	0.376	99.05	Normal
ST. SB ESSNTL A [2]	0.380	0.376	99.05	Normal
ST. SB ESSNTL A [3]	0.380	0.376	99.05	Normal

This bus addition would increase the line losses as 406.2 kW for active power and 1102.2 kVAR for reactive power, as shown in Table 7.

Table 7. Line power losses on the second scenario

Lines		ID	From-to Bus Flow		To-from Bus Flow		Losses		Voltage
From Bus	To Bus		MW	MVAR	MW	MVAR	kW	kVAR	Drop (%)
SW. SB 2	UNIT 1	T2 11.8/6.3 KV	1.019	0.586	-1.017	-0.569	1.5	17.6	0.85
UNIT 3	BUS A	T31 11.8/150 KV	-5.553	-3.321	5.555	3.397	1.7	76.3	0.63
UNIT 2	BUS B	T21 11.8/150 KV	-5.553	-3.321	5.555	3.397	1.7	76.3	0.63
UNIT 2	BUS B	Cable 12	5.556	3.399	-5.555	-3.397	1.1	1.6	0.03
UNIT 2	SW.SB.22	T22 11.8/6.3	1.407	0.718	-1.404	-0.682	3.1	35.6	1.18
BUS B SUB	STATION 7	T7 150/20 KV	7.351	5.926	-7.321	-5.325	30.1	601.5	0.66
UNIT 3	BUS A	Cable 13	5.556	3.399	-5.555	-3.397	1.1	1.6	0.03
UNIT 3	SW. SB. 32	T32 11.8/6.3	1.407	0.718	-1.404	-0.682	3.1	35.6	1.18
BUS B	SUB STATION 7	Cable 5	7.32	5.325	-7.318	-5.323	2.3	1.4	0.03
SUB STATION 7	STATION SB. B	T4 20/6.3 KV	0.422	0.207	-0.422	-0.204	0.4	3.4	0.39
BUS A	STATION SB. A	Cable 7	0.004	0.001	-0.004	-0.001	0	0	0.21
UNIT 2	SW. SB. 22	Cable 14	1.404	0.682	-1.404	-0.682	0.2	0.1	0.01
UNIT 3	SW. SB. 32	Cable 16	1.404	0.682	-1.404	-0.682	0.2	0.1	0.01
SW. SB 2	UNIT 1	Cable 17	1.017	0.569	-1.017	-0.569	0.1	0.1	0.01
SW. SB 2	SW. SB 3	Cable 18	-0.547	-0.355	0.549	0.355	1.5	0	0.20
SW. SB 2	SW. SB 3	T3 6.300/400 V	0.548	0.355	-0.542	-0.335	5.7	20.1	0.40
SW. SB. 22	SW. SB. 23	Cable 19	-0.545	-0.26	0.546	0.26	1.3	0	0.20
SW. SB. 22	SW. SB. 23	T23 6.300/400 V	0.545	0.26	-0.543	-0.246	2	14.2	0.72
SW. SB. 32	SW. SB.33	Cable 20	-0.545	-0.26	0.546	0.26	1.3	0	0.20
SW. SB. 32	SW. SB. 33	T33 6.300/400 V	0.545	0.26	-0.543	-0.246	2	14.2	0.72
STATION SB. B	ST. SB ESSNTL B	Cable 21	-0.209	-0.102	0.209	0.102	0.1	0.0	0.04
STATION SB. B	ST. SB ESSNTL B	T6 6.300/400 V	0.211	0.102	-0.211	-0.1	0.3	2	0.49
STATION SB. B	ST. SB ESSNTL B	Cable 22	-0.209	-0.102	0.209	0.102	0.1	0	0.04
STATION SB. B	ST. SB ESSNTL B	T5 6.300/400 V	0.211	0.102	-0.211	-0.1	0.3	2	0.49
SUB STATION 7	SMRG	Line 9	-3.335	-2.501	3.479	2.599	143.7	98.1	4.12
SUB STATION 7	DRWT	Line 10	-1.314	-0.986	1.372	1.007	58.1	21	4.23
SUB STATION 7	PSH	Line 11	-1.909	-1.432	2.045	1.51	135.4	77.8	6.61
SW.SB 2	MCWP	Cable 27	-	-	-	-	0.9	0.2	0.17
SW.SB.22	MCWP [21]	Cable 25	-	-	-	-	3.0	0.7	0.31
SW.SB.32	MCWP [31]	Cable 23	-	-	-	-	3.0	0.7	0.31
Total losses							405.2	1102.2	

Figure 7 shows the representation of simulation results in geothermal power generation system for the third scenario, in the absence of power supply through STATION SB A bus at the operation time of unit 1.

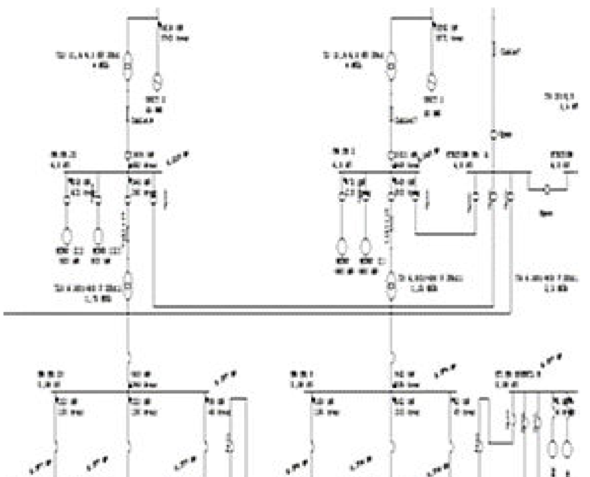


Figure 7. Simulation of power flow in the third scenario

The unit 1 supplied the power of 5592 kW and 3371 kVAR, for both the network and alone usage. Nevertheless, the powers for alone usage were 1021 kW and 569 kVAR, with the voltage reduced to 6.245 kV, from 6.3 kV nominal. While, the unit 2 supplied to the network and alone usage as 6414 kW and 3760 kVAR. Nevertheless, the powers for the alone usage were 1404 kW and 682 kVAR, with the voltage reduced to 6.225 kV from the nominal of 6.3 kV. Based on the simulation results as shown in Figure 8, it could be summarized the obtained value of power flow as listed in Table 8.

Table 8. Results of power flow in the third scenario

Lines		Power flow		Current (A)	Power Factor (%)
From bus	To bus	MW	MVAR		
UNIT 3	SW.SB.32	1.404	0.682	144.8	89.9
SW.SB.32	MCWP [31]	0.858	0.422	144.8	89.9
	SW.SB.33	0.543	0.246	56.1	90.2
SW.SB.33	RUNNING A 33	0.222	0.100	372.2	91.1
	RUNNING B 33	0.222	0.100	372.8	91.3
	RUNNING C 33	0.099	0.046	167.0	90.6
UNIT 2	SW.SB.22	1.404	0.682	144.8	89.9
SW.SB.22	MCWP [21]	0.858	0.422	144.8	89.9
	SW.SB.23	0.543	0.246	56.1	90.2
SW.SB.23	RUNNING A 23	0.222	0.100	372.2	91.1
	RUNNING B 23	0.222	0.100	372.8	91.3
	RUNNING C 23	0.099	0.046	167.0	90.6
UNIT 1	SW.SB 2	1.021	0.569	108.1	87.3
SW.SB 2	MCWP	0.472	0.215	107.7	87.3
	SW.SB.3	0.548	0.355	60.4	83.9
SW.SB.3	RUNNING A 3	0.188	0.136	357.1	81
	RUNNING B 3	0.262	0.150	465.3	86.8
	RUNNING C 3	0.092	0.049	161.1	88.1
BUS B SUB	STATION 7	7.326	5.329	261.4	80.9
SUB STATION 7	PSH	1.912	1.434	73.8	80.0
	DRWT	1.316	0.987	49.5	80.0
	SMRG	3.339	2.504	125.6	80.0
	STATION SB.B	0.422	0.204	13.6	89.9
STATION SB.B	ST.SB ESSNTL B	0.211	0.102	21.6	90.0
ST.SB ESSNTL B	MTR ESSNTL B	0.205	0.101	357.6	90.3
	ST.SB ESSNTL A [1]	0.175	0.078	293.7	91.3
	ST.SB ESSNTL A [2]	0.041	0.021	71.0	89.0
ST.SB ESSNTL A [2]	ST.SB ESSNTL A [3]	0.035	0.017	59.3	89.6
ST.SB ESSNTL A [1]	MTR ESSNTL A [1]	0.175	0.078	293.7	91.3
ST.SB ESSNTL A [2]	MTR ESSNTL A [2]	0.007	0.004	59.3	89.6
ST.SB ESSNTL A [3]	MTR ESSNTL A [3]	0.035	0.017	59.3	89.6

Table 9 summarizes the simulation results of busbar voltage conditions, obtained after the unit 1 re-entered the bus network in the normal limit condition, with the increase of line losses amounting to 406.4 kW for active power and 1128.9 kVAR for reactive power, as listed in

Table 10.

Table 9. Voltage conditions in the scenario 3

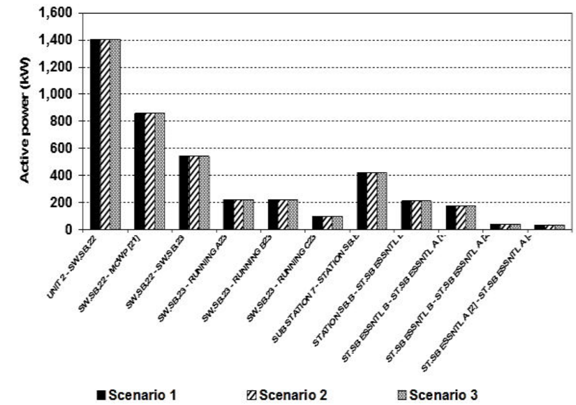
Bus ID	Rating (kV)	Operation (kV)	Operation (%)	Condition
UNIT 3	11.8	11.8	100	Normal
SW. SB. 32	6.3	6.2	98.80	Normal
SW. SB. 33	0.380	0.377	99.32	Normal
RUNNING A 33	0.380	0.377	99.32	Normal
RUNNING B 33	0.380	0.377	99.32	Normal
RUNNING C 33	0.380	0.377	99.32	Normal
UNIT 2	11.8	11.8	100	Normal
SW. SB. 22	6.3	6.2	98.80	Normal
SW. SB. 23	0.380	0.377	99.32	Normal
RUNNING A 23	0.380	0.377	99.32	Normal
RUNNING B 23	0.380	0.377	99.32	Normal
RUNNING C 23	0.380	0.377	99.32	Normal

Bus ID	Rating (kV)	Operation (kV)	Operation (%)	Condition
UNIT 1	11.8	11.8	100	Normal
SW. SB 2	6.3	6.2	99.13	Normal
SW. SB 3	0.380	0.374	98.54	Normal
RUNNING A 3	0.380	0.374	98.54	Normal
RUNNING B 3	0.380	0.374	98.54	Normal
RUNNING C 3	0.380	0.374	98.54	Normal
SUB STATION 7	20	19.995	99.98	Normal
STATION SB. B	6.3	6.2	99.65	Normal
ST. SB ESSNTL B	0.380	0.377	99.12	Normal
ST. SB ESSNTL A [1]	0.380	0.377	99.12	Normal
ST. SB ESSNTL A [2]	0.380	0.377	99.12	Normal
ST. SB ESSNTL A [3]	0.380	0.377	99.12	Normal

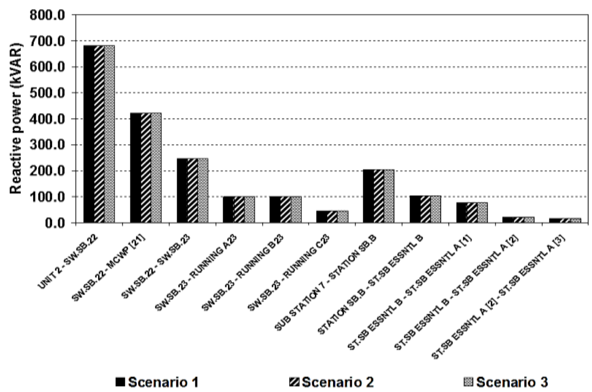
Table 10. Line power losses in the scenario 3

Lines		ID	From-to Bus Flow		To-from Bus Flow		Losses		Voltage Drop (%)
From Bus	To Bus		MW	MVAR	MW	MVAR	kW	kVAR	
UNIT 1	BUS B	Cable 11	4.568	2.783	-4.568	-2.782	0.8	1.1	0.02
SW. SB 2	UNIT 1	T2 11.8/6.3 kV	1.023	0.587	-1.022	-0.569	1.6	17.7	0.86
UNIT 3	BUS A	T31 11.8/150 kV	-5.005	-2.979	5.006	3.041	1.4	61.8	0.56
UNIT 2	BUS B	T21 11.8/150 kV	-5.005	-2.979	5.006	3.041	1.4	61.8	0.56
UNIT 2	BUS B	Cable 12	5.007	3.042	-5.006	-3.041	0.9	1.3	0.02
UNIT 2	SW.SB.22	T22 11.8/6.3	1.407	0.718	-1.404	-0.682	3.1	35.6	1.18
UNIT 1	BUS B	T1 11.8/150 kV	-4.566	-2.726	4.568	2.782	1.3	56.5	0.57
BUS B	SUB STATION 7	T7 150/20 kV	7.358	5.932	-7.328	-5.33	30.1	601.9	0.66
UNIT 3	BUS A	Cable 13	5.007	3.042	-5.006	-3.041	0.9	1.3	0.02
UNIT 3	SW. SB. 32	T32 11.8/6.3	1.407	0.718	-1.404	-0.682	3.1	35.6	1.18
BUS B	SUB STATION 7	Cable 5	7.328	5.33	-7.326	-5.329	2.3	1.4	0.03
SUB STATION 7	STATION SB. B T4	20/6.3 kV	0.422	0.207	-0.422	-0.204	0.4	3.4	0.39
UNIT 2	SW. SB. 22	Cable 14	1.404	0.682	-1.404	-0.682	0.2	0.1	0.01
UNIT 3	SW. SB. 32	Cable 16	1.404	0.682	-1.404	-0.682	0.2	0.1	0.01
SW. SB 2	UNIT 1	Cable 17	1.022	0.569	-1.021	-0.569	0.1	0.1	0.01
SW. SB 2	SW. SB 3	Cable 18	-0.548	-0.355	0.549	0.355	1.5	0.0	0.2
SW. SB 2	SW. SB 3	T3 6.300/400 V	0.548	0.355	-0.542	-0.335	5.7	20.1	0.4
SW. SB. 22	SW. SB. 23	Cable 19	-0.545	-0.26	0.546	0.26	1.3	0.0	0.2
SW. SB. 22	SW. SB. 23	T23 6.300/400 V	0.545	0.26	-0.543	-0.246	2.0	14.2	0.72
SW. SB. 32	SW. SB.33	Cable 20	-0.545	-0.26	0.546	0.26	1.3	0.0	0.2
SW. SB. 32	SW. SB. 33	T33 6.300/400 V	0.545	0.26	-0.543	-0.246	2.0	14.2	0.72
STATION SB. B	ST. SB ESSNTL B	Cable 21	-0.209	-0.102	0.21	0.102	0.1	0.0	0.04
STATION SB. B	ST. SB ESSNTL B	T6 6.300/400 V	0.211	0.102	-0.211	-0.100	0.3	2.0	0.49
STATION SB. B	ST. SB ESSNTL B	Cable 22	-0.209	-0.102	0.21	0.102	0.1	0.0	0.04
STATION SB. B	ST. SB ESSNTL B	T5 6.300/400 V	0.211	0.102	-0.211	-0.1	0.3	2.0	0.49
SUB STATION 7	SMRG	Line 9	-3.339	-2.504	3.483	2.602	143.8	98.2	4.12
SUB STATION 7	DRWT	Line 10	-1.316	-0.987	1.374	1.008	58.1	21.0	4.23
SUB STATION 7	PSH	Line 11	-1.912	- 1.434	2.047	1.512	135.5	77.9	6.62
SW.SB 2	MCWP	Cable 27	-	-	-	-	0.9	0.2	0.17
SW.SB.22	MCWP [21]	Cable 25	-	-	-	-	3.0	0.7	0.31
SW.SB.32	MCWP [31]	Cable 23	-	-	-	-	3.0	0.7	0.31
Total losses							406.4	1128.9	

Figure 8(a) shows the bar charts of bus active power and Figure 8(b) shows the bar charts of bus reactive power in the own usage loads for the three scenarios.



(a) Active power



(b) Reactive power

Figure 8. Bar chart of power flow: (a) active and (b) reactive powers own usage for three scenarios

The power flow to the user loads their selves did not experience any difference for three scenarios, due to the type of used network was the radial type, in which the power flows only in one direction and did not influenced other units. The amount of own used power from the simulation results for the unit 2 and the unit 3 were 2.56% of each unit the generated power of 55 MW.

While, the third scenario of power consumption itself in the unit 1 was 3.4 % of the generated power of 30 MW. Thus, the calculation power flow simulation for internal use of each unit was still normal limit, as 1-4 %.

Figure 9 shows the bar charts of own usage bus voltages.

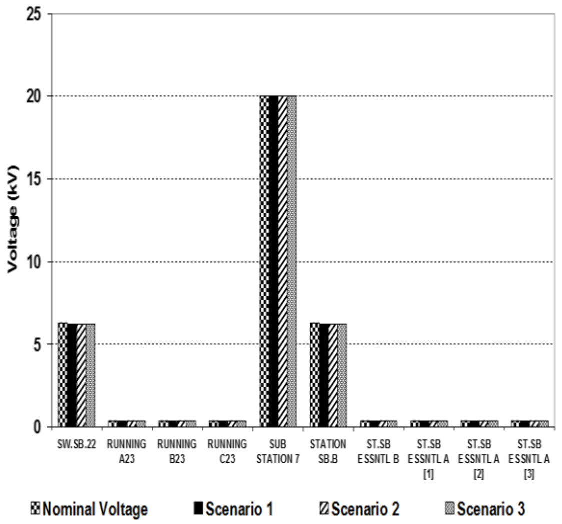


Figure 9. Bar chart of own usage load bus voltages

In general, the busbar voltages were under normal limits, as 98 %, under 5% of allowable voltage tolerance for each scenario.

Figure 10 shows the bar chart of total losses for each line.

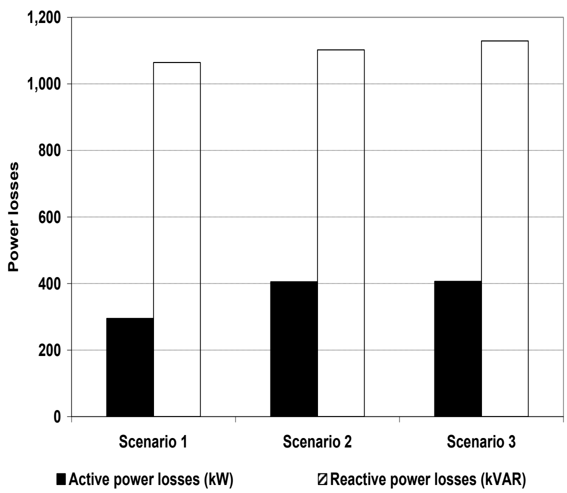


Figure 10. Bar chart of line total losses for three scenarios

The difference of three scenarios was the increase of total line losses. This case was caused by the addition of losses on the installed transformers and conductors on the buses.

On the second scenario, the increasing total losses were caused by the line loss addition, as 1.6 kW and 17.7 kVAR, on SW.SB.2 bus to the bus unit 1, and the losses of line bus SW.SB.2 to the bus SW.SB.3, as much as 7.2 kW and 20 kVAR. While on the scenario 3, the increasing losses were occurred due to the line losses from the bus unit 1 to the bus B, as 2.1 kW and 57.6 kVAR, through the conductor with the size of 400 mm^2 and length 60 m.

4. Conclusions

The network type influenced the calculation results, which caused not occurred difference of power flows on its own usage for the three scenarios. The own use power based on the simulation calculation results for the unit 2 and unit 3 were 2.56%, and the own use power for the unit 1 was 3.4%, based on per unit generated power.

The condition of own usage load bus voltages in the three scenarios was still within normal limits. Based on the results, the simulating condition was 98 % of nominal voltage. There were increases of line losses in the three operating scenarios of the unit 1. In the first scenario, the total losses were 395 kW and 1064.2 kVAR, in the second scenario, the total losses were 405.2 kW and 1102.2 kVAR, and in the third scenario, the total losses were 406.4 kW and 11289.9 kVAR, for active and reactive powers respectively.

5. References

[1] Afolabi, O.A.,. Ali, W.H., Cofie, P., Fuller, J., Obiomon, P., Kolawole, E.S., (2015), Analysis of the Load Flow Problem in Power System Planning Studies, Energy and Power Engineering, 7, Scientific Research Publishing Inc., pp. 509-523.

[2] Dharamjit, Tanti, D.K., (2012), Load Flow Analysis on IEEE 30 bus System, International Journal of Scientific and Research Publications, Vol. 2, Issue 11, ISSN 2250-3153, pp. 1-6, Nov.

[3] Hazarika, D. (2012), A Fast Continuation Load Flow Analysis for an Interconnected Power System, International Journal of Energy Engineering (IJEE), Vol. 2 Issue 4, pp. 126-136, Nov.

[4] Husain, T., Ansari, M.M., (2016), Distribution Load Flow Analysis for Radial and Mesh Distribution System, International Journal of Electrical Engineering and Technology (IJEET), Vol. 7, Issue 3, ISSN(p) 0976-6545, ISSN(e) 0976-6553, pp. 157-168, May-June.

[5] Kailay, A.K., Brar, Y.S., (2015), Identification of Best Load Flow Calculation Method for IEEE-30 BUS System Using Matlab, International Journal of Electrical and Electronics Research, Vol.3, Issue 3, ISSN 2348-6988, pp. 155-161, July-Sept.

[6] Kusekwa, M.A., (2014), Load flow solution of the Tanzanian power network using Newton-Raphson method and Matlab software, International Journal of Energy and Power Engineering, 3(6), ISSN 2326-957X (p); ISSN 2326-960X (e), pp. 277-286, December 05.

[7] Mahdi, N.M., (2013), Power flow analysis of Rafah governorate distribution network using ETAP software, International Journal of Physical Sciences Vol. 1(2), Academe Research Journals ISSN 2331-1827, pp. 19-26, June.

[8] Mander, D.K., Saini, S.K., (2016), Load Flow Analysis: A Review, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, ISSN (p) 2320-3765, ISSN (e) 2278-8875, Vol. 5, Issue 3, pp. 1254-1260, March.

[9] Pandey, V., (2015), Load Flow Analysis of Advance Power Transmission System, International Journal of Advanced Computing and Electronics Technology (IJACET), ISSN(p) 2394-3408, (e) 2394-3416, Vol. 2, Issue-3, pp. 16-19.

[10] Ramakrishnan, H.V., Khaleel, H.K., (2015), Effect of Acceleration Factor in Gauss Seidel Method Onload Flow Studies, International Journal for Research in Emerging Science and Technology, Vol. 2, Issue 5, E-ISSN 2349-7610, pp. 147-154, May.

[11] Rathour, R.S., Yadav, D.L., (2015), Newton Raphson TCSC Model for Power System Stability Improvement, International Journal of Artificial Intelligence and Mechatronics (IJAIM), Vol. 4, Issue 2, ISSN 2320-5121, pp. 35-40.

[12] Salgar, S.A. Mallareddy, C., (2015), Load Flow Analysis for a 220 kV Line – Case Study, International Journal of Innovation in Engineering Research and Technology (IJIERT), ISSN 2394-3696, Vol. 2, Issue 5, Novateur Publications, pp. 1-12, May.

[13] Samuel, I.A., Marian, O.N., Abudulkareem, A., (2014), Investigating The Selection of a Suitable Slack Bus: A Case Study of The Multi-Generating Stations of The Nigerian 330 kV Power System Network, International Journal of Electrical Electronic Engineering Studies Vol. 2, No. 1, pp. 1-12, Sept.

[14] Andersson, G., (2012), Power System Analysis, Lecture 227-0526-00, ITET ETH Z¨urich, EEH-Power Systems Laboratory ETH Z¨urich, , pp. 31-56, September.

[15] Glover, J.D., Sarma, M.S., Overbye, T.J., (2012), Power System Analysis and Design, Thomson, 4ed, pp. 280-342.

[16] Grainger, J. J., Stevenson, W. D. Jr., (1994), Power System Analysis, McGraw-Hill, pp. 329-373,

[17] Saadat, H., (1999), Power System Analysis, McGraw-Hills Companies, pp. 189-256.

[18] Kapahi, R., (2013), Load Flow Analysis of 132 kV substation using ETAP Software, International Journal of Scientific and Engineering Research, Vol. 4, Issue 2, ISSN 2229-5518, Feb.

[19] Operation Technology, 2011, ETAP 11 User Guide, Operation Technology Inc., September.

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