And., Intl.,J., Appl Sci., Eng., Tech, Vol 01, No 01, July 2021
e-ISSN: 2797-0442

POWER FLOW AND SHORT CIRCUIT ANALYSIS OF DISTRIBUTION SYSTEM WITH 300 KW DISTRIBUTED GENERATION CONNECTED

Muhardika[1*] dan Syahroni[1]

[1]Electrical Engineering Postgraduate Program, Engineering Faculty, Universitas Andalas
[*]Corresponding author, e-mail: muhardika17@gmail.com

Abstract— Power flow analysis aims to determine the capacity of a generator to serve loads, to know the value of power losses in the electrical system, and to carry out a planning and development of the electric power system. Power flow analysis is carried out in order to find out the characteristics of the electric power system to be built or to be developed as desired. In this study, power flow analysis and short circuit analysis were carried out in the electrical system of Andalas University with 2 conditions, namely, when the conditions were normal or when the Distributed Generation was not added and when the conditions were added, the Distributed Generation (DG) Photovoltaic 300 kW. The results of this study indicate the largest system losses when normal conditions are on bus 1 to bus 2 amounting to 20.21 kW and 6.13 kVar, and when conditions add DG on bus 17 to bus 18 are 230.8 kW and 142.7 kVar. The results of the short circuit analysis of the two conditions are on bus 1 when the condition is experiencing the addition of DG with an increase in average current, namely 1 soil phase of 0.86 kA, 2 phases of 0.175 kA, 2 soil phases of 0.09609 kA, and 3 phases of 0.085273 kA from when the conditions were normal.

Keywords : Power Flow Analysis, Short Circuit Analysis, Photovoltaic, Wind Turbine

This article *is licensed under the CC–BY-SA license.*

1. Introduction

The electric power system is the process of distributing electrical energy starting from power plants to consumers. The electric power system consists of 4 parts, namely power generation, transmission, distribution, and consumers or loads. A power plant is a device used to produce electrical energy by converting a certain energy so that it can become electrical energy [1]. Energy sources consist of 2 types, namely renewable and non-renewable energy sources. Energy sources that cannot be renewed are energy sources that require a long time to obtain them from fossils and can cause natural energy resources to run out quickly and damage the environment. Some examples of non-renewable energy sources are coal, oil and natural gas. Meanwhile, renewable energy sources are energy sources that can be used continuously for a long time and will never run out. Some examples of renewable energy sources are water, wind, and sun.

In the electrical system, the use of Distributed Generation (DG) can minimize environmental damage due to the use of non-renewable energy. DG is the use of a small generating unit with a power of less than 10 MW, which is connected to a transmission or distribution system. The energy sources used are wind, water and solar energy sources [2]. After minimizing damage from the environment, planning and operation of the electric power system can be carried out using power flow analysis. Analysis of the flow of power in the electric power system aims to determine the capacity of the generation to serve the load, to know the value of losses in the electrical system, and to be able to plan and develop the electric power system. [1],[3].

The calculation of the power flow analysis in this study used computer software ETAP (Electric Transient and Analysis Program) is a software that can simplify calculations in simulating an electric power system before it is realized in real conditions. The software can do some analysis such as power

Received: March 21, 2021, Revised: April 12, 2021, Accepted: May 1, 2021
https://doi.org/10.25077/aijaset.v1i1.3

flow, short circuit analysis, arc flash analysis, coordination of protection, transient stability analysis, motor starting, etc [4].
This research aims to:

1. Analyze the comparison of power flow under normal conditions and after the addition of DG, Photovoltaic (PV) 300 kW.
2. Analyze system losses in normal conditions and after the addition of DG, Phovotoltaic (PV) 300 kW.
3. Analyze short circuit faults in the electric power system under normal conditions and after the addition of DG, Photovoltaic (PV) 300 kW.

2. Experimental Section/Methods

This research was conducted in 6 stages:

1. Simulating the power system
2. Enter the data values used, such as generator, line, transformer, and load data.
3. Calculating the power flow value using the Newton Raphson method.
4. Calculating the losses or power losses in the electric power system.
5. Calculating the value of short circuit fault currents, namely 1-phase ground, 2-phase, 2-phase, and 3-phase faults in an electric power system.
6. After all the calculations are done, an evaluation of the calculation will be carried out.

Power flow analysis can be calculated using 3 calculation methods [5]:

1. Gauss-Seidel Method
   The Gauss-Seidel method is a method that uses a repetition process by assigning an approximate value to an unknown bus voltage and by calculating a new value for each bus voltage from the estimated value on the other bus. A new set of voltage values obtained on each bus will be used to calculate the circuit at other bus voltages. Each calculation of a new set of voltages is called an iteration. The iteration or repetition process is carried out until the change in value on each bus is less than the specified minimum value.
2. Newton Raphson Method
   The Newton Raphson method is a method that uses quadratic convergence, and can be used for more complex situations. This method requires less iteration to achieve convergence.
3. Fast Decoupled Method
   Fast Decoupled method is a popular choice for real time grid management. However, this can be less accurate because of the assumptions used to get the calculation fast.

Short circuit fault analysis is the study of the specifications of the short circuit fault current flowing in an electric power system. The cause of short circuit failure can occur due to interference originating from within the system or originating from outside the system. One of the causes of interference originating from within the system is the quality of the equipment that is not good, such as generator coils, transformers, and other electrical equipment, and poor network installation. As for the causes originating from outside the system, namely the occurrence of strong winds that cause friction between the trees and the electricity network, and the occurrence of heavy rain accompanied by lightning strikes [6],[7]. Short circuit fault consists of symmetrical and asymmetrical faults. Symmetrical fault is a short circuit that occurs in 3 phases. While asymmetrical fault is a short circuit that occurs in 1 ground phase, 2 phases, and 2 soil phases.

3. Result and Discussion

A. Network Specifications

The following is the network specifications at the Pauh Limo Substation with a voltage of 20 kV which is the electrical system at Andalas University, namely:

There are 9 transformers in the Pauh Limo electrical system, the transformer capacity can be seen in Table 1.

Table 1. Transformer Capacity

Transformer	Capacity (kVA)
Public Health	315
Engineering	630
Animal Sci	630
ISIP	630
Agriculture	1000
MIPA	1000
PKM	250
Hospital	2000
Medical	630

There are 9 loads at the Pauh Limo substation with the type of load, namely Lumped Load, the load capacity can be seen in Table 2.

Table 2. Load Capacity

No Bus	Load	kW	kVar
10	Public Health	195.9	121.1
8	Engineering	117.1	72.7
14	Animal Sci	154.4	95.4
12	ISIP	137.8	85.6
18	Agriculture	230.5	142.5
20	MIPA	264.8	164
16	PKM	131	81.5
4	Hospital	398.3	49.7
6	Medical	257.2	118.7
	Total	1887	931.2

There are 10 cables used in the Pauh Limo electrical system using XLPE CU type cables with sizes 50 mm^2, voltage 33 kV and frequency 50 Hz, the length of the cable can be seen in Table 3.

Table 3. Length of the Cable

Cable Name	Length (km)
Cable1	4
Cable2	2
Cable3	3
Cable4	1.2
Cable5	4
Cable6	2.3
Cable7	3.2
Cable8	2.1
Cable9	4.5
Cable10	3.2

AIJASET – Vol. 01, No. 01, July 2021. 33-40
https://doi.org/10.25077/aijaset.v1i1.3

B. Power Flow Analysis Results for Each Bus Voltage

The electrical system in this study consists of 2 conditions, namely in normal conditions or not adding generators and conditions after adding DG. The DG added to the electrical system is a 300 kW Photovoltaic. The single line diagram of the system in normal conditions is shown in Figure 1, and the system with which the generator is added is shown in Figure 2.

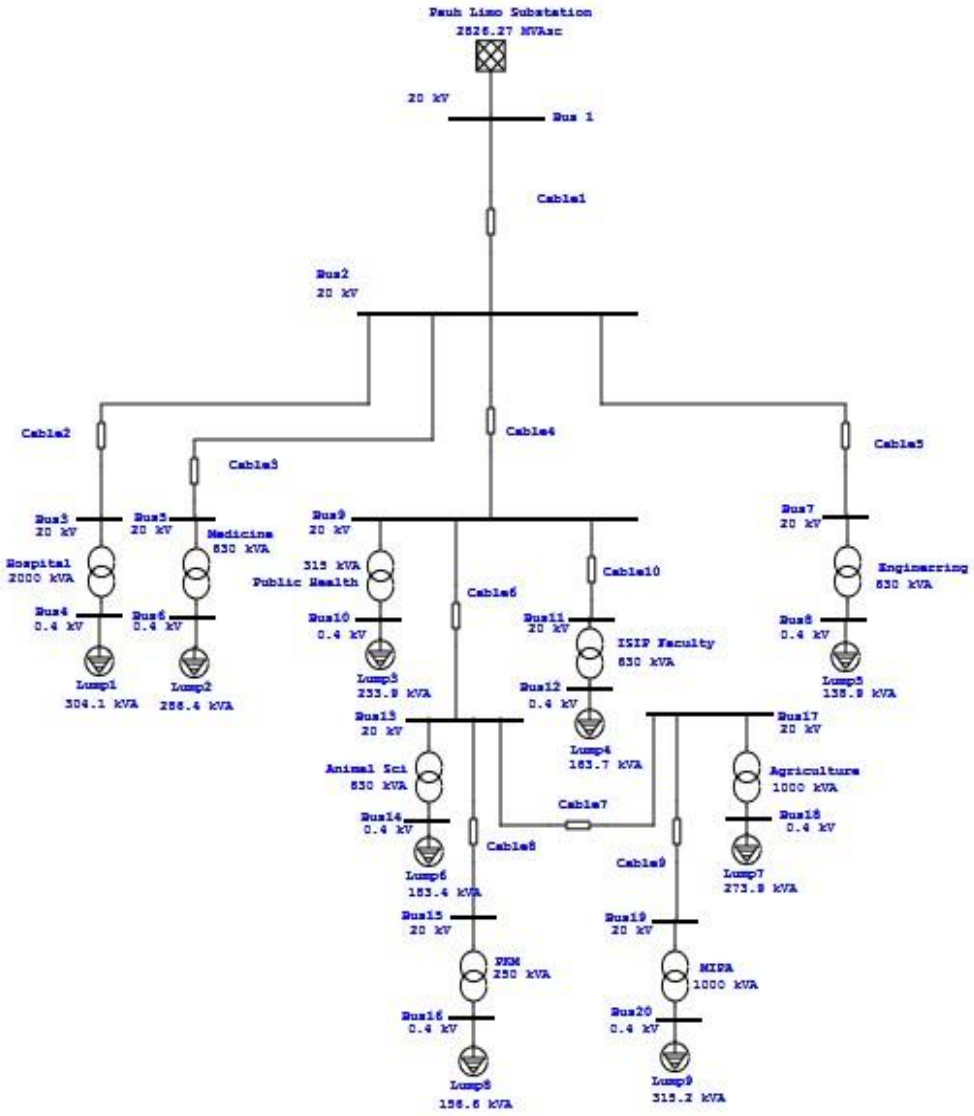


Figure 1. Single Line Diagram of the System When Conditions Are Normal

The results of the SLD above can be seen the value of each bus in the electrical system which can be seen in Table 4.From these results, it can be seen that the largest voltage value is on bus 1 of 20 kV, and the smallest voltage value is on bus 17 of 19,664 kV. After knowing the results of the flow of power from the electrical system during normal conditions, the DG is added to the bus with the smallest voltage value, namely on bus 17, which is seen in Figure 2. The addition of generators consists of a type of new renewable energy generation, namely Photovoltaic 300 kW. The results of the voltage value of each bus when adding DG can be seen in Table 4.

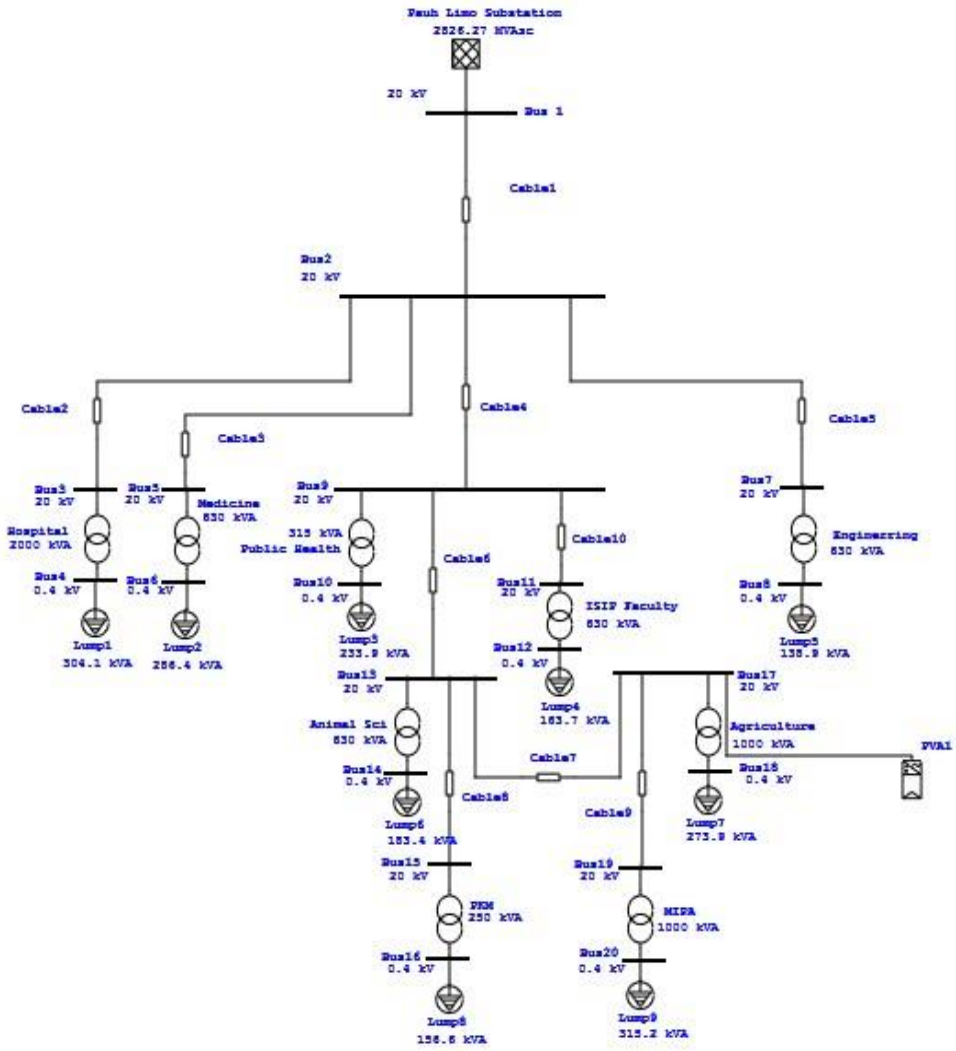


Figure 2. Single Line Diagram System When DG Addition Conditions

Table 4. Voltage of Each Bus

Bus	Voltage (kV) Conditions Normal Condition	Voltage (kV) Conditions for Adding DG	Deviation	Bus	Voltage (kV) Conditions Normal Condition	Voltage (kV) Conditions for Adding DG	Deviation
1	20	20	0	11	19.748	19.782	0.034
2	19.8	19.826	0.026	12	0.3391	0.3918	0.0527
3	19.764	19.81	0.046	13	19.71	19.758	0.048
4	0.3944	0.3949	0.0005	14	0.3898	0.3908	0.001
5	19.778	19.804	0.038	15	19.702	19.75	0.048
6	0.3892	0.3897	0.026	16	0.3846	0.3856	0.001
7	19.7860	19.812	0.026	17	19.664	19.734	0.07
8	0.3924	0.393	0.0006	18	0.3891	0.3905	0.0014
9	19.762	19.794	0.032	19	19.63	19.698	0.068
10	0.3952	0.3848	-0.0104	20	0.3878	0.3892	0.0014

If the value of the voltage for each bus during normal conditions is compared with the value of the voltage for each bus during the condition after adding DG, then the value of the voltage when the condition is experiencing DG addition will be greater than normal conditions. The value of the voltage on each bus will increase by an average of 0.5102 kV.

C. Power Flow Analysis Results for System Losses

The results of the value of power losses in the electric power system during normal conditions can be seen in Table 5, and the value of power losses during the condition after the addition of DG is shown in Table 6.

Table 5. Value of System Losses When Conditions Are Normal

Bus to Bus		System Losses		Bus to Bus		System Losses	
		kW	kVar			kW	kVar
1	2	20.21	6.13	11	12	0.969	1.45
	3	0.222	0.0673		14	1.22	1.83
2	5	0.3	0.0909	13	15	0.0637	0.0193
	9	2.58	0.784		17	1.36	0.412
	7	0.093	0.0282	15	16	2.28	3.43
3	4	0.483	2.9	17	18	1.07	3.73
5	6	2.99	4.48		19	0.547	0.167
7	8	0.695	1.04	19	20	1.42	4.96
	10	4.05	6.08				
9	11	0.104	0.0315				
	13	2.43	0.737				

Table 6. System Losses Value When DG Addition Condition

Bus to Bus		System Losses		Bus to Bus		System Losses	
		kW	kVar			kW	kVar
1	2	15.83	4.81	11	12	0.967	1.45
	3	0.221	0.0672		14	1.22	1.83
2	5	0.299	0.0908	13	15	0.0635	0.0193
	9	1.8	0.547		17	0.592	0.18
	7	0.0928	0.0282	15	16	2.28	3.41
3	4	0.483	2.9	17	18	1.06	3.71
5	6	2.98	4.47		19	0.545	0.166
7	8	0.694	1.04	19	20	1.41	4.94
	10	4.04	6.06				
9	11	0.104	0.0314				
	13	1.44	0.437				

From the results shown in the table above, the value of the largest system losses when normal conditions are on bus 1 to bus 2 is 20.21 kW and 6.13 kVar, while when the conditions are added DG the largest value of system losses is on bus 1 to bus 2 at 15.83 kW and 4.81 kVar.

D. Results of short circuit fault analysis from buses with a voltage of 20 kV

In this study, there were 11 buses that experienced circuit problems, both symmetrical and asymmetrical short circuit faults on buses with a voltage of 20 kV. The results of the short circuit during normal conditions are shown in Table 7, and when the conditions of adding DG are in Table 8.

Table 7. Short Circuit Interference Value When Conditions Are Normal

Short Circuit	Type of Short Circuit Interference (kA)			
Bus	Phase 1 Soil	Phase 2	Phase 2 Soil	Phase 3
1	7.391	70.888	72.149	81.589
2	3.160	5.582	5.870	6.241
3	2.439	3.740	3.986	4.208
5	3.618	2.189	3.210	3.618
7	1.983	2.804	3.016	3.173
9	2.692	4.346	4.602	4.843
11	1.592	2.089	2.258	2.326
13	1.916	2.689	2.892	3.027
15	1.735	2.376	2.558	2.657
17	1.599	2.154	2.319	2.393
19	1.196	1.515	1.643	1.688

Table 8. Interference Value Short Circuit When Addition Condition DG

Short Circuit	Type of Short Circuit Interference (kA)			
Bus	Phase 1 Soil	Phase 2	Phase 2 Soil	Phase 3
1	7.391	70.888	72.149	81.587
2	3.158	5.573	5.860	6.229
3	2.438	3.736	3.981	4.202
5	2.188	3.207	3.434	3.614
7	1.982	2.808	3.014	3.170
9	2.689	4.336	4.592	4.831
11	1.915	2.686	2.888	3.022
13	2.091	3.040	3.248	3.378
15	1.733	2.370	2.551	2.650
17	1.596	2.143	2.307	2.381
19	1.194	1.510	1.536	1.637

The results of the short circuit fault current above show that the short circuit fault current value when the addition of DG is greater than the normal condition.
The increase in the value of the short circuit fault current from normal conditions to the condition of adding DG:

1. 1 soil phase during the addition of DG has an average current increase of 0.086 kA from normal conditions.
2. 2 phases when the condition of addition of DG has an average current increase of 0.175 kA from normal conditions.
3. 2 phases of soil during the addition condition with an increase in the average current of 0.09609 kA from normal conditions.
4. 3 phases when the DG addition condition has an average current increase of 0.085273 kA from normal conditions.

4. Conclusion

The power flow analysis and short circuit analysis have been simulated for the electrical system of Andalas University with 2 conditions, with DG connected and without DG. The result for power system without adding DG have achieved that the largest value of system losses in line 1 - 2 i.e. 20.21

kW and 4.81 kVar. The largest short circuit fault current value is on bus 1, namely, 1 ground phase of 7,391 kA, 2 phases of 70,888 kA, 2 ground phases of 72,149 kA, and 3 phases of 81,589 kA. However, the power system is in a condition of addition of DG, Photovoltaic 300 kW. The largest value of system losses is on bus 1 to bus 2, amounting to 15.83 kW and 4.81 kVar. The largest short circuit fault current value is on bus 1, namely, 1 ground phase of 7,391 kA, 2 phases of 70,888 kA, 2 ground phases of 72,149 kA, and 3 phases of 81,587 kA.

References

[1] Syafii, *Komputasi Sistem Tenaga Dengan Pemograman Visual C++*. Padang: Andalas University Press, 2015.

[2] R. Syahputra, I. Robandi, and M. Ashari, "Performance Analysis of Wind Turbine as a Distributed Generation Unit In Distribution System," *Int. J. Comput. Sci. Inf. Technol.*, vol. 6, no. 3, pp. 39–56, 2014.

[3] J. T. Elektro, F. Teknik, U. N. Semarang, and P. Fibers, "Analisis Aliran Daya Sistem Tenaga Listrik pada Bagian Texturizing di PT Asia Pasific Fibers Tbk Kendal menggunakan Software ETAP Power Station 4.0," *J. Tek. Elektro*, vol. 7, no. 1, pp. 7–10, 2015.

[4] L. Multa and R. P. Aridani, *Modul Pelatihan ETAP*. Yogyakarta: Universitas Gadjah Mada, 2013.

[5] L. Powell, *Power System Load Flow Analysis*. New York: McGraw-Hill, 2005.

[6] C. Calnela, Suyitno, and I. Arif R, "Analisis Hubung Singkat Pada Gardu Induk 150/20 kV (Studi Kasus di Gardu Induk Gandul, Cinere)," *J. Electr. Vocat. Educ. Technol.*, vol. 4, no. 2, pp. 53–59, 2019.

[7] Dasman, "Studi Gangguan Hubung Singkat 1 Fasa Ke Tanah Pada SUTT 150 kV (Aplikasi GI Pip – Pauh Limo)," *J. Tek. Elektro ITP*, vol. 5, no. 2, pp. 113–119, 2016.