Energy Continuity of the Electricity at Surabaya Mall Using Continues Power Flow Methods

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Abstract: Power flow analysis aims at ensuring the state of an electrical system is in a stable and normal condition while operating. Besides, it can also determine the condition of power flow in the electrical system, including voltage, active power, and reactive power on each interconnected bus line. Research conducted on the electricity system at Pakuwon Mall Surabaya employing the forward-backward sweep method obtained an active power value of 0.393 kW and a reactive power of 0.164 kVAR. After adding the Continuous Power Flow method and the P-V curve, the lowest bus voltage value gained 0.9521 pu with a lambda value of 4.1. If an additional load is planned for the development of the system in the future, bus 14 will be recommended as it can retain load at the lowest voltage point.

1 INTRODUCTION

Using the Newton-Raphson technique to simulate the ETAP software, this research generates an apparent power of 832 kVA, a reactive power of 480 kVAR, and a total active power of 680 kW under stable working circumstances. In the meantime, 32.458 kW of active power loss findings were acquired, whereas 14,154 kVAR of reactive power were obtained. Voltage collapse has a percentage value of 7% on Bus 7, which has the greatest percentage value(E. A. Z & Z. Mughni, 2020).

According to the findings of this study for load flow, the greatest reactive power value on bus 157 was 19280 MVAR and the active power value was 26083 MW. The combined active power generated is 11103 kW, while the generated reactive power is 2042 kVAR. The voltage then drops by 2.6% on bus 60, which had an initial value of 150 kV, and by 4.65% on buses 61 and 62, which had an initial voltage of 20 kV (K. Timur et al., 2018).

A power flow analysis will be conducted as part of this study, "Analysis of the Power Flow of the Electric Power System at Pakuwon Mall Surabaya," to make sure that the electrical system at Pakuwon Mall Surabaya is still in a stable condition for both systems that are currently operating and those that will occur in the future. and, of course, in compliance with the restrictions outlined in the SPLN 1: 1995 regulations, utilizing Matlab software and the Continuous Power Flow (CPF) technique.

2 METHODOLOGY

The study of power flow (K. Timur et al., 2018) is the calculation of voltage, current, active power, and reactive power that exists at points on the electrical network under normal operating conditions, both those that are currently operating and those that will occur in the future.

With this power flow study, the voltages owned by each bus in a system can be seen, as can the magnitude or phase angle of the voltage, active power, and reactive power supplied in each channel in a system.

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2.1 Forward Backward Sweep Analysis

Power flow studies (A. Indrajaya et al., 2018; Dian Budhi Santoso, 2018; E. A. Z & Z. Mughni, 2020; Guton Albaroka & Gatot Widodo, 2017; I Made Agus Mahardiananta et al., 2020; K. Timur et al., 2018; M. Aziz, 2020; R. W. Novialifiah et al., 2014) are usually used to obtain a value for the voltage from each bus, knowing the magnitude of the current and power values flowing in a system. And, of course, to make analysis and monitoring of electrical network systems such as transmission and distribution networks easier. In the rules for completing the forward sweep, starting at the main point source where the value of the voltage is known, the impedance and current flowing in each channel are known, ignoring other sources (Tambunan et al., 2016), while for the backward sweep, the voltages from all points in the literation are used. The first is assumed to be equal to the voltage at the main source, and the injection current will be zero in the first liter if there are several sources in the network. The load current is found by equating (Tambunan et al., 2016).

2.2 Creating K-Matrix

Before applying the forward-backward sweep method (Dian Budhi Santoso, 2018), it requires a slight change in the calculation that aims to facilitate the formation of equations and the process when performing iteration calculations, namely by forming the BIBC (Bus Injection to Branch Current) matrix. The BIBC (Bus Injection to Branch Current) matrix is a matrix that relates the current to the channel in the distribution system (Dian Budhi Santoso, 2018) An equation is obtained in the formation of the BIBC matrix by utilizing Kirchhoff's law, where the branch current (I) is connected to the bus or channel (B). As a result, the equation corresponding to the single line diagram in this study is as follows:

$$B_1 = I_2 + I_3 + I_4 + I_5 + I_6 + I_7 + I_8 + I_9 + I_{10} + I_{11} + I_{12} + I_{13} \quad (1)$$

$$B_2 = I_3 + I_6 + I_9 + I_{12} \quad (2)$$

$$B_3 = I_4 + I_5 \quad (3)$$

$$B_4 = I_4 \quad (4)$$

$$B_5 = I_5 \quad (5)$$

$$B_6 = I_7 + I_8 \quad (6)$$

$$B_7 = I_7 \quad (7)$$

$$B_8 = I_8 \quad (8)$$

$$B_9 = I_{10} + I_{11} \quad (9)$$

$$B_{10} = I_{10} \quad (10)$$

$$B_{11} = I_{11} \quad (11)$$

$$B_9 = I_{10} + I_{11} \quad (12)$$

$$B_{10} = I_{10} \quad (13)$$

$$B_{11} = I_{11} \quad (14)$$

$$B_{12} = I_{13} + I_{14} \quad (15)$$

$$B_{13} = I_{13} \quad (16)$$

$$B_{14} = I_{14} \quad (17)$$

After getting the above equation, proceed to form the BIBC matrix, as follows:

$$\begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \\ B_6 \\ B_7 \\ B_8 \\ B_9 \\ B_{10} \\ B_{11} \\ B_{12} \\ B_{13} \end{bmatrix} = \begin{bmatrix} 1\,1\,1\,1\,1\,1\,1\,1\,1\,1\,1\,1\,1 \\ 0\,1\,0\,0\,1\,0\,0\,1\,0\,0\,1\,0\,0 \\ 0\,0\,1\,1\,0\,0\,0\,0\,0\,0\,0\,0\,0 \\ 0\,0\,1\,0\,0\,0\,0\,0\,0\,0\,0\,0\,0 \\ 0\,0\,0\,1\,0\,0\,0\,0\,0\,0\,0\,0\,0 \\ 0\,0\,0\,0\,0\,1\,1\,0\,0\,0\,0\,0\,0 \\ 0\,0\,0\,0\,0\,1\,0\,0\,0\,0\,0\,0\,0 \\ 0\,0\,0\,0\,0\,0\,1\,0\,0\,0\,0\,0\,0 \\ 0\,0\,0\,0\,0\,0\,0\,0\,1\,1\,0\,0\,0 \\ 0\,0\,0\,0\,0\,0\,0\,0\,1\,0\,0\,0\,0 \\ 0\,0\,0\,0\,0\,0\,0\,0\,0\,1\,0\,0\,0 \\ 0\,0\,0\,0\,0\,0\,0\,0\,0\,0\,0\,1\,1 \\ 0\,0\,0\,0\,0\,0\,0\,0\,0\,0\,0\,0\,1 \end{bmatrix} = \begin{bmatrix} I_2 \\ I_3 \\ I_4 \\ I_5 \\ I_6 \\ I_7 \\ I_8 \\ I_9 \\ I_{10} \\ I_{11} \\ I_{12} \\ I_{13} \\ I_{14} \end{bmatrix} \quad (18)$$

The BIBC matrix can also be simplified into the following form (Dian Budhi Santoso, 2018):

$$[B] = [BIBC][I] \quad (19)$$

Wherein:
B = Bus
BIBC = Matrix between Injecting current & bus
I = current (Ampere)

From equation 19 above we can find for the matrix BCBV (*Branch Current to Bus Voltage*) and find the drop voltage with following form:

$$[\Delta V] = [BCBV][B] \quad (20)$$

$$[\Delta V] = [BCBV][BIBC][I] \quad (21)$$

$$[\Delta V] = [DLF][I] \quad (22)$$

2.3 Continuous Power Flow (CPF)

Continuous Power Flow usually applies the concept of the Newton-Raphson method (Yaqin, 2015) to determine the results of the calculation of the power flow of an electrical system, where the research data to be used is processed in such a way that the processed data can form a P and V curve with the addition of a continuous load (continuous). The power supplied can be represented by the magnitude of the current in the i^{th} bus replacement circuit from the *n*-bus system, so that the following equation is formed:

$$P_i = \sum_{K=1}^{N} V_i \mid V_k \mid (G_{ik} \cos\theta_{ik} + B_{ik} \sin\theta_{ik}) \quad (23)$$
$$Q_i = \sum_{K=1}^{N} V_i \mid V_k \mid (G_{ik} \sin\theta_{ik} + B_{ik} \cos\theta_{ik}) \quad (24)$$

where symbols *G* and *D* indicate the generation and load required on each connected bus. To simulate load changes, the load parameter λ is entered into the power parameters P_{Di} and Q_{Di}. as can be seen in the following equation:

$$P_{Di} = P_{Di0} + \lambda\,(P_{\triangle base})$$
$$Q_{Di} = Q_{Di0} + \lambda\,(Q_{\triangle base}) \quad (25)$$

P_{Di0} and $Q_{Di0}$are the initial load requirements on the i^{th} bus, where $(P_{\triangle base})$ and $(Q_{\triangle base})$ get the selected amount of power to scale properly. To replace the new power requirement as in equations 20 to 21, a new equation is obtained, which can be seen below:

$$F(\theta, V, \lambda) = 0 \quad (26)$$

where θ represents the voltage angle vector and *V* represents the vector of the bus magnitude voltages. The basic solution for $\lambda = 0$ will be found through the power flow, which will then be carried out by a further simulation process according to the parameters that have been determined.

3 SIMULATION RESULT

In this section, we will see a simulation of the use of Continuous Power Flow usually applies the concept of the Newton-Raphson method to determine the results of the calculation of the power flow of an electrical system from pakuwon mall with 14-Bus as shown to the table 2 and system data as shown in the table 1.

Power flow analysis is carried out by utilizing the forward-backward method (Dian Budhi Santoso, 2018), which can be used to obtain accuracy in finding a specific voltage value in the distribution network system at Pakuwon Mall Surabaya.

The following are the results of calculations using the Continuous Power Flow method.

The following in Figure 1 below shows the voltage graph data on each bus:

Table 1: Pakuwon Mall 14-Bus system data.

Bus		Impedance		L (m)	P (Kw)	Q (kVar)
From	To	R (Ω)	X (Ω)			
1	2	0,0329	0,0316	179	2,249	0,855
2	3	0,0653	0,0353	243	0,514	0,181
2	6	0,0653	0,0353	272	0,376	0,137
2	9	0,0653	0,0353	73	0,478	0,181
2	12	0,0653	0,0353	56	0,790	0,357
3	4	0,0823	0,0363	20	0,249	0,081
3	5	0,0823	0,0363	23	0,262	0,082
6	7	0,0823	0,0363	25	0,177	0,055
6	8	0,0823	0,0363	28	0,198	0,072
9	10	0,0823	0,0363	27	0,326	0,112
9	11	0,0823	0,0363	29	0,150	0,049
12	13	0,0823	0,0363	30	0,393	0,164
12	14	0,0823	0,0363	33	0,393	0,164

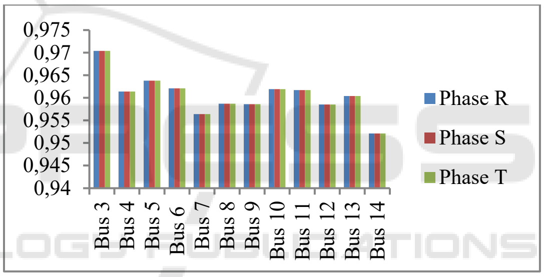

Figure 1: Voltage Graph Data On Each Bus.

The most suitable bus for expand or development system from pakuwon mall is bus number 14 because from The results of running the P-V curve data program on bus 14 are that the bus voltage value is 0.9521 pu. with Lamda reaching the maximum point of 4.1, we can see to the Figure 2 below.

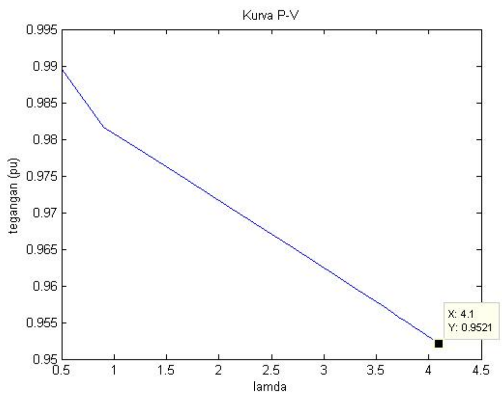

Figure 2: P-V Curve From Bus 14.

Table 2: Simulation Result using CPF method.

Bus Number	Voltage		Current (Ampere)	Bus Number	Voltage		Current (Ampere)
	Vm (P,U)	Degree			Vm (P,U)	Degree	
3	0,9704	0,03	47,2	9	0,9586	0,03	812,5
3	0,9704	-119,97	47,2	9	0,9586	-119,97	812,5
3	0,9794	120,03	47,2	9	0,9586	120,03	812,5
4	0,9614	0,02	34,7	10	0,9619	0,03	923
4	0,9614	-119,98	34,7	10	0,9619	-119,97	923
4	0,9614	120,02	34,7	10	0,9619	120,03	923
5	0,9638	0,03	44,3	11	0,9617	0,03	1527
5	0,9638	-119,97	44,3	11	0,9617	-119,97	1527
5	0,9638	120,03	44,3	11	0,9617	120,03	1527
6	0,9621	0,04	75,1	12	0,9585	0,03	689,1
6	0,9621	-119,96	75,1	12	0,9585	-119,97	689,1
6	0,9621	120,04	75,1	12	0,9585	120,03	689,1
7	0,9564	0,03	1151	13	0,9604	0,05	1878
7	0,9564	-119,97	1151	13	0,9604	-119,95	1878
7	0,9564	120,03	1151	13	0,9604	120,05	1878
8	0,9587	0,03	1209	14	0,9521	0,05	1878
8	0,9587	-119,97	1209	14	0,9521	-119,95	1878
8	0,9587	120,03	1209	14	0,9521	120,05	1878

4 CONCLUSIONS

Based on the results of the analysis and simulation in this thesis research, it can be concluded:

1. From the simulation results carried out on buses 3 to 14 using the Continuous Power Flow (CPF) method, it can be seen that bus 14 has an active power flow of 0.393 kW and a reactive power of 0.164 kVAR, with the lowest bus voltage of 0.9521 p.u and a lamda value of 4.1 compared to other buses.
2. Therefore, bus 14 is the recommended bus when planning for additional load for future development of the system because it can withstand the load with the lowest stress point.

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