Comparative Computations on Supplied and Lost Energy utilizing Numerical Integrations

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Abstract

A low voltage system is the closest line to consumers. There is lost power or energy, either technical or non-technical losses. This research presented the electrical measurements, supplied and lost power and energy computations, modelling, and simulation. The measurements used a power analyser so that some electrical parameters could be measured and recorded simultaneously. The energy computations used the trapezoidal and Simpson's composite rules based on power. While the modellings were made by using parabolic regressions due to the data patterns followed parabolic trends. Finally, the simulation results were redrawn based on the software. The losses were based on the distribution transformer and low voltage lines. The energy computation and power patterns of modelling were based on the numerical method, and the simulation was based on the measurements. The results showed that the highest supplied power was at 1:45 p.m. The high category of the supplied energy was on Tuesday, Wednesday, Thursday, and Monday.

Meanwhile, the medium category was on Friday, and finally, the low category was on Saturday and Sunday. Both supplied and lost power modellings convex up. This case indicated that around midday's, the consumed and lost powers were the highest. Thus, the quadratic constants are negative values. The highest consumed and lost energy were on Tuesday, as 1445.0 and 30.4 kWh (composite trapezoidal rule) and 1441.1 and 30.3 kWh (composite Simpson's rule), respectively. While the lowest consumed and lost energy were 594.1 and 23.3 kWh (composite trapezoidal rule) and 592.6 and 23.2 kWh (composite Simpson's rule), respectively, on Sunday. The power and energy losses ranged from 1.74 % to 3.66 % and 2.08 % to 3.92 %, respectively. The deviations between the composite trapezoidal and Simpson's rule methods for both supplied and loss energy were 0.27 % and 0.30 %, respectively.

Keywords: Composite trapezoidal, energy, losses, modelling, Simpson's

Received: 24 February 2020

To cite this article:
WALUYO, SAWITRI, K., HAMLAR, F., "Comparative computations on supplied and lost energy utilizing numerical integrations," in *Electrotehnica, Electronica, Automatica (EEA)*, 2020, vol. 68, no. 2, pp. 32-40, ISSN 1582-5175.

1. Introduction

The electric powers are active (P), apparent (S), and reactive (Q) powers, which are absorbed by loads [1]. A process of state estimation is influenced by the practically limited measurement highly [2]. The electric power pricing is not easily predicted due to some factors [3]. A vital energy efficiency policy concept is integrating energy supply, known as Demand Side Management (DSM), such as renewable energy and demand elements [4]. The electricity production scenario could be drawn up to the new energy strategy, including renewable energy [5]. The energy policy goals depend upon technology investment [6]. For example, a smart meter installation for energy saving would not reach full potential yet [7]. The procedure for estimating a photovoltaic system is permitted to associate the energy aspects connected to specific features [8]. The electrical grid, as source energy, could also supply electric drive vehicles and backup for renewable electricity [9], [10].

Meanwhile, the power was concerning velocity, acceleration, and roadway grade [11].

Nevertheless, energy efficiency is usually a matter of concern in residential and commercial buildings [12], and the amount of energy was lost due to technical and non-technical losses [13]-[15]. The technical loss is intrinsic and cannot be reduced beyond a certain level of optimism and, depending on the situation and purpose, and should be taken to be reduced by several location distributions, generated to consume energy closeness or improved line quality [16]-[20]. However, it is impossible to prevent the losses completely [21].

On the one hand, electrical energy is vital to provide a need or service for consumers. On the other hand, the electric power loss reduces the supply of power. The losses are crucial problems and not yet be fully resolved. Generally, the power loss would rise due to power consumption, equipment aging, and not proper installation. Based on the above idea, the authors intended to raise the topic to conduct research on the lost power and energy is an example of distribution line, especially the technical loss which was caused by internal conditions, such as the amount of load current, resistivity, type, length, and cross-section area of conductors. Recently, a new comparative computation method of energy based on the power, namely composite trapezoidal and Simpson's rules, has been introduced.

One of the research objectives was to obtain the patterns of supplied power daily, in one week. Based on the parameters of measurements and the computations, the power losses of the supplied energy, and energy losses were obtained. The modelling of daily power pattern was also proposed. In addition, the power and energy losses based on the simulation were also obtained and compared for analysis.

2. Materials and Methods

The main stages of research were the data collection of the used distribution transformer, low voltage loading measurements, supplied power and energy, lost power and energy, relative deviations, and simulation as a comparison. It was needed to perform the data processing to obtain the supplied powers and power losses on each phase of the distribution transformer. On the low voltage side of the transformer, the apparent power in single-phase is as

$$S_{LV} = I_{LV} \times V_{LV} \quad (1)$$

Meanwhile, the nominal transformer iron (or core) and copper loss data were obtained from the technical data of the transformer brand and the Electric State Company standard. The actual nominal iron and copper losses were for the three-phase transformer. The single-phase core loss was proposed as

$$P_{Fe-1ph} = \frac{P_{Fe-3ph}}{3} \quad (2)$$

This core loss was considered to be the same due to the constant voltage assumption. The nominal transformer current was:

$$I_n = \frac{K_T}{\sqrt{3}V_{LL}} \quad (3)$$

The copper resistance for single-phase was:

$$R_{Cu} = \frac{P_{Cu-1ph}}{(I_n)^2} \quad (4)$$

The actual transformer loss was computed per-phase on each loading, and the copper loss depended upon the load current. The copper loss per-phase was:

$$P_{Cu-1ph} = I_L^2 . R_{Cu} \quad (5)$$

Therefore, the transformer total loss per-phase was as:

$$P_{Tr} = P_{Fe-1ph} + P_{Cu-1ph} \quad (6)$$

The data of cable conductors were obtained from the basic design. The loss of line was computed for each segment, which was between one point to another, and computed on each phase. In the tennis court, the loss was revealed by the equation of

$$P_{ten} = I_L^2 R \quad (7)$$

where

$$R = r.l \quad (8)$$

In the building, the loss was indicated by the equation of

$$P_{build} = I_L^2 R \quad (9)$$

The total losses represented the losses on both the distribution line and the transformer, as equation (10).

$$P_{tot} = P_{Tr} + P_{ten} + P_{build} \quad (10)$$

The above computation methods were for a single-phase only. For three-phase quantity, summation from each phase should be made.

The measurements were conducted using a power analyser. These measurements would be carried out under normal operating conditions in the building panel. The circuit diagram to perform the measurements is shown in Figure 1.

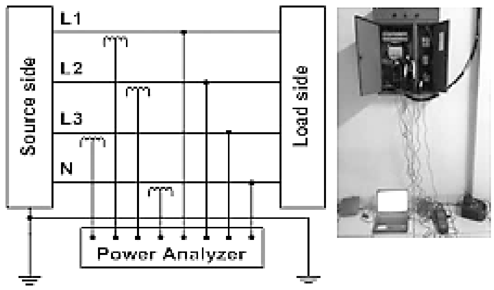

Figure 1. Electric parameter measurements using a power analyser

These measurements were conducted for the voltages and currents in the three-phase system and power factors simultaneously.

While the inserted picture of Figure 1 shows the real condition of the measurement in the panel. The tools mainly consisted of a computer (laptop) and a power analyser, including the clamps. In this case, the data loggings were conducted in fifteen minutes and in one week, as the representation of weekly electrical loading.

Furthermore, the electric energy is the summation of power. On the other hand, there are some numerical integration methods, such as the composite trapezoidal and Simpson's rules [22]. The former is as equation (11).

$$\int_a^b f(x)dx = \frac{h}{2}[f(a) + 2f_1 + 2f_2 + 2f_3 + \ldots\ldots + 2f_{M-1} + f(b)] \quad (11)$$

While the latter is as equation (12).

$$\int_a^b f(x)dx = \frac{h}{3}[f(a) + 4f_1 + 2f_2 + 4f_3 + \ldots\ldots + 2f_{M-2} + 4f_{M-1} + f(b)] \quad (12)$$

Based on these equations, the cumulative energy and comparative results could be revealed and analysed. Besides the measurements and computations, the simulation was conducted. Based on the simulation, the results could be compared to the measurement and computation ones.

Furthermore, power consumption and losses could be made as modelling.

Based on the data of both quantities, generally, they were assumed to approach to be parabolic trending. Therefore, they were approximated by the least-square parabola. The parabolic function could be stated as equation (13) [22].

$$y = f(x) = Ax^2 + Bx + C \tag{13}$$

The coefficients of **A**, **B**, and **C** could be obtained by the equations (14) as below.

$$\left.\begin{aligned}
\left(\sum_{k=1}^{N} x_k^4\right)A + \left(\sum_{k=1}^{N} x_k^3\right)B + \left(\sum_{k=1}^{N} x_k^2\right)C &= \sum_{k=1}^{N} y_k x_k^2 \\
\left(\sum_{k=1}^{N} x_k^3\right)A + \left(\sum_{k=1}^{N} x_k^2\right)B + \left(\sum_{k=1}^{N} x_k\right)C &= \sum_{k=1}^{N} y_k x_k \\
\left(\sum_{k=1}^{N} x_k^2\right)A + \left(\sum_{k=1}^{N} x_k\right)B + NC &= \sum_{k=1}^{N} y_k
\end{aligned}\right\} \tag{14}$$

These equations were used as the empirical modelling approaches on the trends of power consumption and losses to the time in twenty-four hours.

3. Results

The used network, as a sample in this power and loss computations, was the distribution transformer, the low voltage line in the tennis court, and in the building, which consisted of the lecture rooms and the laboratories. A single line diagram of the low voltage network sample was the object of research. In this sample, the line consisted of a distribution transformer and the cable from the distribution transformer to the building through the tennis court. The loads were in the building as the lecture room lightings and laboratory equipment, including electric motors, computers, and electronic devices.

The nominal distribution transformer data were required to compute the power losses, which were 400 kVA, 930 W, 4600 W, and 0.8 lagging for the transformer capacity, core loss, copper loss, and power factor, respectively. The load data were the amount of usage of electricity, which was yielded from the output measurements.

Figure 2 shows the computation charts on the daily consumption powers.

It is indicated that Tuesday and Wednesday occupied the highest supplied powers and instantly followed by the power consumption on Monday and Thursday.

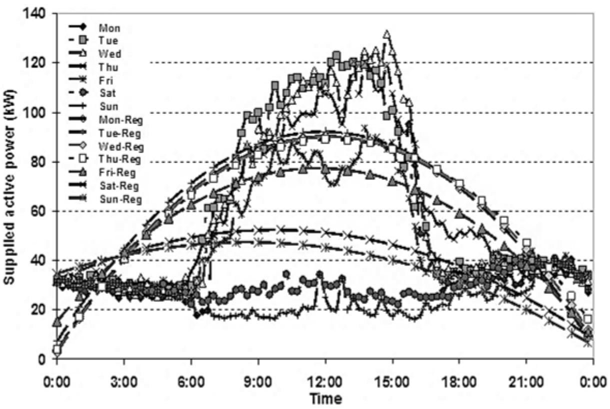

Figure 2. Computation and modelling charts of supplied power

Furthermore, it was followed by moderate consumption on Friday. In far apart, finally, the power consumptions were on Saturday and Sunday, as the lowest ones respectively.

Figure 2 also shows the modelling of the supplied powers, which tended to be parabolic equations. The curves on Monday, Tuesday, Wednesday, and Thursday were close together, which occupied the highest supplied powers. Nevertheless, among the four days above, the supplied power on Tuesday was the highest one. This case occurred due to the use of an organized lab that consumed high power, especially for electric motors. Nevertheless, the lectures were minimized.

The medium supplied power was on Friday. This occurrence was probably caused by more time for praying so that it would be lower supplied power. Finally, the low supplied powers were on Saturday and Sunday. The supplied power on Saturday was slightly higher than that on Sunday. This case was probably caused by a few lectures held on that day, without administrative activity, while on Sunday, there was not any lecture at all.

Table 1. Supplied power modelling equation coefficients

Day	A	B	C
Mon.	-0.596	14.382	3.577
Tue.	-0.599	14.258	7.286
Wed.	-0.586	14.315	2.775
Thu.	-0.559	13.794	3.959
Fri.	-0.455	10.620	15.386
Sat.	-0.218	4.245	31.752
Sun.	-0.175	2.991	34.693

Based on the equation (13), **A**, **B**, and **C** coefficients were obtained as listed in Table 1, in kilowatt (kW). The coefficient of **A** represented the curve curvature level. The values were negatives, which meant the curves were upward. The higher the magnitude value of **A**, the sharper the curvatures. Meanwhile, **B** values represented the slope of the curves—the higher the **B** values, the greater the curve slopes. Finally, the **C** values represented the constant as much as the shift curves or the value additions from the zero point.

Figure 3 shows the computations of power loss based on the measurements.

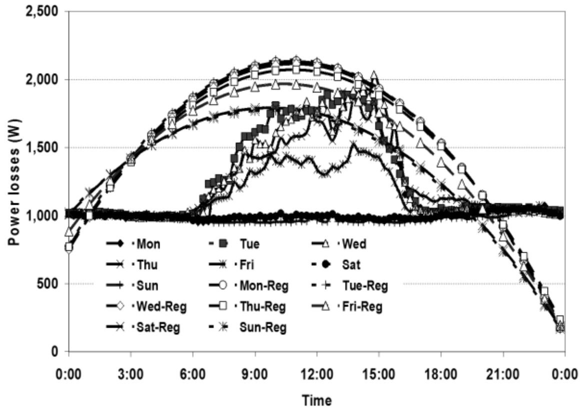

Figure 3. Computation and modelling charts of lost power

These curve patterns were similar to the supplied power ones. However, the magnitudes were extremely different, generally, much lower than the supplied powers.

Figure 3 also shows the modelling of power losses, as followed by the parabolic equations, similar to the modelling of supplied powers. However, the curves on Monday, Tuesday, Wednesday, and Thursday were close together, which occupied as the highest supplied powers. Nevertheless, among the four days above, the supplied power on Tuesday was the highest. This case was mainly caused by the similarity to the supplied power.

The medium power loss was on Friday. This occurrence was probably caused by a lower supplied power due to the use of part-time for praying. Therefore, during part-time, there would be no activity, either lecture or lab. Finally, the low power losses were on Saturday and Sunday. The power losses on Saturday was slightly higher than that on Sunday. This case was probably caused by a few lectures held on that day, while on Sunday, there was not any lecture at all.

Based on the equation (13), **A**, **B**, and **C** coefficients were obtained as listed in Table 2. The coefficient of **A** represented the same as the supplied power modelling ones. However, the values and the unit were extremely different, and the latter was in watt (W).

Table 2. Coefficients of lost power modelling

Day	A	B	C
Mon.	-11.69	252.82	765.24
Tue.	-11.73	252.77	781.96
Wed.	-11.54	250.75	751.41
Thu.	-11.04	239.62	770.70
Fri.	-9.98	207.98	883.47
Sat.	-8.22	160.40	1009.39
Sun.	-8.07	155.79	1022.19

Figure 4 shows the bar charts for the supplied energy based on the power measurements using the composite trapezoidal and Simpson's rules.

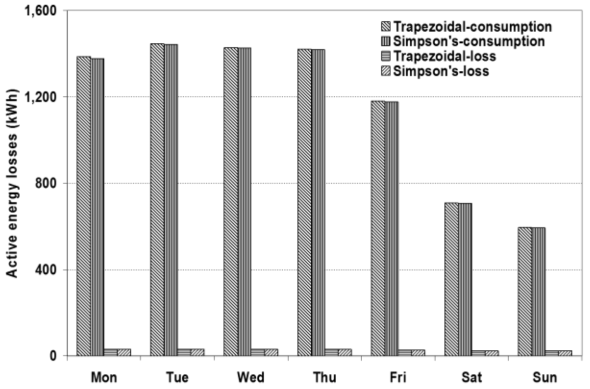

Figure 4. Supplied and lost electrical energy

The high supplied energy occurred on Tuesday, Wednesday, Thursday, and Monday. The medium supplied energy was on Friday. Finally, the low supplied energy was on Saturday and Sunday. The order of supplied energy, for the composite trapezoidal rule, from the highest, were on Tuesday, Wednesday, Thursday, Monday, Friday, Saturday, and Sunday as 17.7%, 17.5 %, 17.4 %, 17.0 %, 14.5 %, 8.7 %, and 7.3 % respectively. Meanwhile, the order for the composite Simpson's rule was the same as the composite trapezoidal rule, but different in the magnitudes, like 17.7 %, 17.5 %, 17.4 %, 16.9 %, 14.5 %, 8.7 %, and 7.3 % respectively. Besides, the average deviation between the composite Simpson's and trapezoidal rules on the supplied energy was 0.27 %. Thus, this value was significantly low.

The figure also shows the bar charts of the electrical energy losses based on the power losses using the composite trapezoidal and Simpson's rules. Similar to the supplied energy, the high energy losses occurred on Tuesday, Wednesday, Thursday, and Monday. Meanwhile, the medium lost energy was on Friday, and the low energy losses were on Saturday and Sunday. Nevertheless, the patterns were not exactly the same, due to the core loss of the distribution transformer that was assumed to be constant. The order of supplied energy, for the composite trapezoidal rule, from the highest, were on Tuesday, Monday, Wednesday, Thursday, Friday, Saturday, and Sunday as 15.65 %, 15.51 %, 15.50 %, 15.18 %, 13.99 %, 12.20 %, and 11.97% respectively. The order for the composite Simpson's rule was a little bit different from the composite trapezoidal rule, as 15.65 %, 15.50 %, 15.50 %, 15.19 %, 13.99 %, 12.20 % and 11.97 % for the same days respectively. Meanwhile, the average deviation between the composite Simpson's and trapezoidal rules on the lost energy was 0.30 %. This value was significantly low.

Figure 5 shows the charts on the energy losses, both in magnitude (kWh) and in the percentage (%), and both utilizing the composite trapezoidal and Simpson's rules, as the function of the supplied energy. The deviations between both rules, as previously mentioned, were minimal so that it could be stated as fairly coincidence.

For this case, for composite Simpson's rule, it was ranged from 23.2 kWh to 30.3 kWh or from 3.91 % to 2.10 % as the supplied active energy rose from 592.6 kWh to 1441.1 kWh.

Meanwhile, for the composite trapezoidal rule, it was ranged from 23.3 kWh to 30.4 kWh or from 3.92 % to 2.10 % as the supplied active energy rose from 594.1 kWh to 1445.0 kWh. It is shown that the magnitudes of losses would increase considerably, and the percentages of losses would reduce slightly, as the supplied energy increased.

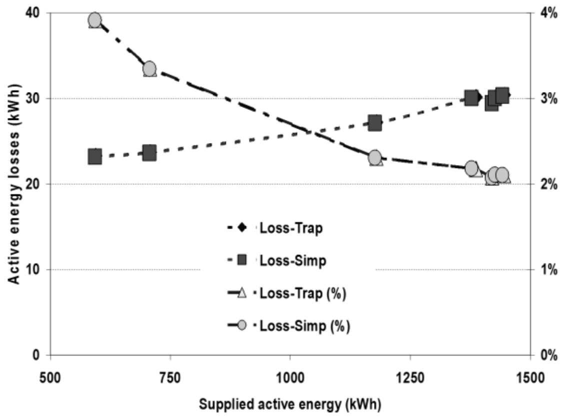

Figure 5. Energy losses versus supplied energy

Figure 6 shows the results of the simulation. Based on the computation results, the full load was obtained, occurring at 1:45 p.m., as 693 kW. While using the simulation, it occurred at 1:45 p.m., as 720 kW. Thus, the used load in the simulation was not precisely the same as the load condition in the field. This case was reasonable, the load condition in the field was in the real condition, and the simulation was in the ideal condition. There were two types of load, dynamic and static loads in the simulation. The use of dynamic and static loads was assumed by 50% each. Nevertheless, for the real condition, the use of static and dynamic loads varied according to customer load characteristics.

Based on the computation, the average transformer power loss was obtained as 7.52 kW. Meanwhile, based on the simulation, it was obtained as 7.4 kW. Therefore, the difference between the computation and simulation results was 0.12 kW. This was, as one factor, caused by the transformer condition that was not exactly the same as the used transformer in the simulation. At the time of transformer measuring, it has been influenced by the increase of temperature or environment, while the used transformer in the simulation was in an ideal condition.

Figure 7 shows the comparative charts of the nominal supplied powers between the computation and simulation results. Both patterns were similar. There was a small deviation as 30.4 kW or 8.66 % in the average on both results. This value was considerably small.

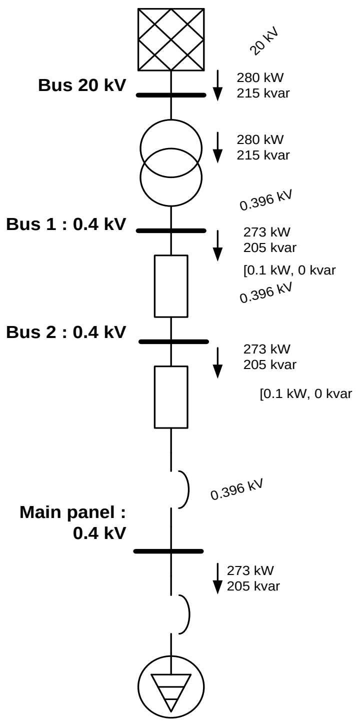

Figure 6. A simulation result

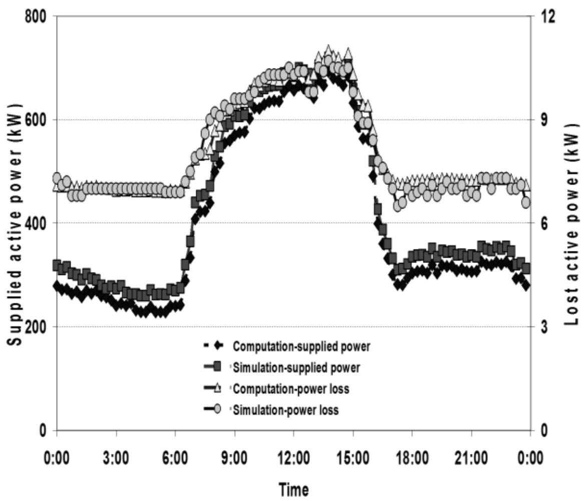

Figure 7. Nominal supplied and lost powers

The figure also shows the charts of nominal power losses using computation and simulation. The average of the deviation losses between both computation and simulation results was 0.198 kW or 2.41 %.

While the average losses of the computation and simulation in one day were 8.18 kW and 8.07 kW, therefore, the difference of the average losses was 0.11 kW. The used line condition in the field was not exactly the same as the used cable condition in the simulation.

The parameters that influenced the conductor included the length, cross-sectional area, and the resistance according to the conductor material. The used conductor in the field was estimated to have been used some years so that the quality of the cable, including the insulation, decreased, causing the increasing power loss. Otherwise, the simulation cable data was in an ideal condition, while the line cable was adjusted to the facility in the library.

Figure 8 shows the nominal supplied energy bar charts based on the computation and the simulation and based on the composite trapezoidal and Simpson's rules. The comparison of the nominal supplied energy between the computation and the simulation was 93.06% and 93.07 %, respectively. While, the comparisons between the composite Simpson's and composite trapezoidal rules were 99.71 % and 99.73 %, respectively. The average deviation between both rules was 0.28 %, which was very small.

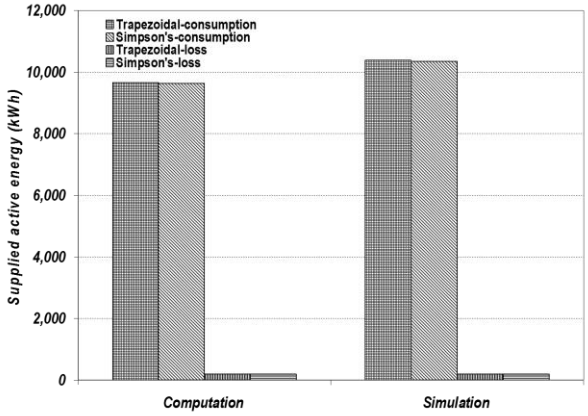

Figure 8. Nominal supplied and lost energy

The figure also shows the lost nominal energy bar charts, in which the comparison between the computation and the simulation results were 101.32 % and 101.34 % for the composite trapezoidal and Simpson's rules, respectively. Meanwhile, the average composite Simpson's to trapezoidal rule comparison was 99.69 %, so that the average deviation was 0.31 %.

The corrected supplied power charts of the simulation were based on the computation, typical measurements on Friday. Nevertheless, the computation and simulation were very closed, where the average deviation was 3.39 kW or 8.66 %. It also indicated that the corrected lost power charts of simulation based on the computation. The computation and simulation were also very close, in which the average deviation was 2.46 W or 0.24 %.

The corrected supplied energy was based on the computation and the simulation and based on the composite trapezoidal and Simpson's rules. The comparison of the corrected supplied energy between computation and the simulation was 94.07 % and 94.08%, respectively. While the comparisons between the composite Simpson's and composite trapezoidal rules were 99.73 % and 99.71 % respectively, the average deviation between both rules was 0.28 %.

The corrected lost energy was also based on the computation and the simulation and based on the composite trapezoidal and Simpson's rules. The comparisons on the corrected losses between the computation and the simulation were 101.2 % and 101.2%, respectively. While, the comparisons between the composite Simpson's and trapezoidal rules were 99.65 % and 99.65 %, respectively. Therefore, the average deviation between both rules was 0.35%.

The patterns of the supplied reactive power were similar to the active power. The high categories of supplied were on Monday, Tuesday, Wednesday, and Thursday. Meanwhile, the medium one was Friday, and finally, the low categories were on Saturday and Sunday. The first category was the full working days, whereas the electric power, including reactive power, was very high for supporting the work due to the supplied power. The second category, as a medium category, i.e., on Friday, was lower supplied reactive power rather than the first category.

Nevertheless, the rate of decline was relatively low compared to the active power. The last category occurred due to the low supplied power. Nevertheless, the reactive supplied power on Saturday was slightly higher rather than that on Sunday. This happens because, on Saturday, there were only a few lectures, while on Sunday there were no lectures at all.

Figure 9 shows the bar charts of supplied reactive energy each day. On the high category of the supplied energy, the order from the highest category was on Tuesday, Monday, Wednesday, and Thursday as 18.1 %, 17.1 %, 16.8 %, and 16.7 % of total reactive supplied energy in one week respectively. In contrast, the medium category, i.e., on Friday, occupied 15.0 % of total supplied reactive energy in one week. Finally, the last low category was 9.2 %, and 7.1 % of the total supplied reactive energy in one week, for Saturday and Sunday, respectively. Like the previous statement, the supplied reactive energy on Saturday was slightly higher than that on Sunday. This occurs because, on Saturday, there were few lectures, while on Sunday, there were no lectures at all. The above percentages were the same pattern for both composite trapezoidal and Simpson's rules. While the average of the composite Simpson's to trapezoidal rule ratio was 99.67 %. Therefore, the average deviation between composite Simpson's to trapezoidal rules was 0.33 %, which was regarded as very low.

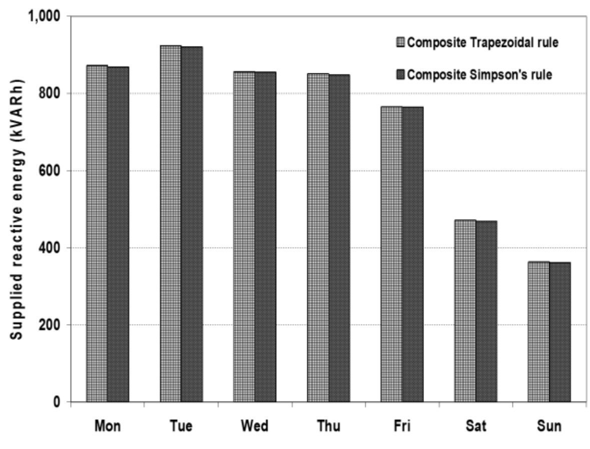

Figure 9. Supplied reactive energy

4. Discussion

As shown in Figure 2, the range of average power in the nights was 29.9 up to 35.0 kW, on Thursday and Sunday, respectively, with the weekly average was 32.6 kW. While the range on the daylights was 86.2 up to 20.3 kW, on Tuesday and Sunday respectively, with the weekly average was 64.5 kW. In the percentage, the range of average power in the nights was 26.6 % up to 59.6 % kW, on Sunday and Monday, and the weekly average was 37.2 %. Nevertheless, the percentage range on daylights was 40.4 % up to 73.4 %, on Friday and Monday, respectively, and the average was 62.8 %. Generally, the daylight consumed powers were higher than those that the nights. This case indicated that the daylight activity was higher than that of the night for the class lecture, laboratory, and administration. In the nights, the electric power was usually for lighting and some research with low power consumption. Nevertheless, two days, Saturday and Sunday, had daylight power lower than that of the nights. The daylight activity was low due to some and not any lecture.

Based on Figure 2, too, there are three categories of curve modelling, namely, high, medium, and low magnitudes. The high magnitude was represented by Monday, Tuesday, Wednesday, and Thursday, the medium magnitude was represented by Friday, and the low magnitude was represented by Saturday and Sunday. These magnitudes represented the power consumption in daylight. The height of the modelling concave to the top was also represented by the negative constants (A) of the quadratic variable in Table 1.

Based on Figure 3, the power loss on Sunday occupied the lowest one, due to the lowest consumed power. The second-lowest loss in the low category was on Friday, whereas the medium category was on Friday. Finally, the high category was on Monday, Tuesday, Wednesday, and Friday.

As Monday until Thursday, the average night power losses were 1012.6 W (40.1 %), 1027.2 W (40.3 %), 1018.9 W (40.4 %), and 1028.8 W (41.6 %) respectively. While the daylight ones were 1510.2 W (59.9 %), 1519.5 W (59.7 %), 1503.1 W (59.6 %) and 1444.5 W (58.4 %) respectively. On average, on the night, the power loss was 1021.9 W/day or 40.6 %, and the average power of the daylight was 1494.3 W/day or 59.4 %. It is clear that on the daylight, the building absorbed higher lost power than that of the night. This case was caused by the higher activity in the daylight than that on the night. On Friday, the night power loss was 1020.2 W (44.70 %), and the daylight lost power was 1262.9 W (55.30 %). It also shows that daylight lost power was higher than that of the night. On this daylight, the lost power was lower than the previous days due to lower activity than those days. Nevertheless, the opposite condition was on Saturday and Sunday. The night lost power was higher than that of the daylight. For Saturday and Sunday, the night lost powers were 1011.8 W (50.7 %) and 1002.1 W (51.1 %), respectively. While the daylight lost powers were 985.3 W (49.3 %) and 959.1 W (48.9 %), respectively. Based also on Figure 3, the modelling of lost power for Monday, Tuesday, Wednesday, and Thursday occupies the highest peak as the representation of the highest lost power. The second highest modelling is the power loss for Friday. Finally, the lowest lost power is Saturday and Sunday. The modellings are appropriate for the real condition. Based on the mathematical quadratic regressions, the modellings also conform. This case is indicated by the quadratic constants, as three categories, namely high, medium, and low. These are -11.69, -11.73, -11.54, and -11.04 for the high category (Monday, Tuesday, Wednesday, and Thursday), -9.98 for the medium category (Friday) and -8.22 and -8.07 for low category (Saturday and Sunday) respectively.

Based on Figure 4, there are also three categories of the consumed energy, namely high (above 1200 kWh), medium (800-1200 kWh), and low (below 800 kWh) per day. The first category is Monday, Tuesday, Wednesday, and Thursday, with the highest consumed energy was Tuesday, the second category is Friday, and the third category is Saturday and Sunday. Likewise, for the losses, the power losses for Monday, Tuesday, Wednesday, and Thursday occupy 30.10 kWh (15.50 %), 30.38 kWh (15.65 %), 30.09 kWh (15.50 %) and 29.47 kWh (15.18 %), as the high category. While the medium category of the lost power was for Friday, as 27.16 kWh (13.99 %), and the low category of the power losses is 23.68 kWh (12.20 %) and 23.24 kWh (11.97 %), for Saturday and Sunday respectively. It is seen that the lost powers were proportional to power consumption.

Based on Figure 5, the lost energy would increase, as the supplied active energy rose. This increase was linear. The average lost energy increments to the supplied active energy were 0.0204 and 0.0182 for the Simpson's and trapezoidal composite rules, respectively. However, in the percentage, the average lost energy decreased to the supplied active energy, as -0.00092 % and -0.00108 % for the Simpson's and trapezoidal composite rules, respectively. Thus, although the lost energy increased as the supplied active energy increased, in the percentage, it decreased.

Based on Figure 6, the power flows and power losses are indicated in each segment of the single line diagram. These values could be displayed in various conditions, depending on the load.

Based on Figure 7, there are comparative values between the computation and simulation, for the supplied active power and lost active power. The differences are called errors. The average absolute errors were 8.07 kW and 0.20 kW for the supplied active power and lost active power, respectively. Nevertheless, it still makes sense.

Based on Figure 8, there are consumed and lost energy in both trapezoidal and Simpson's composite rules. The relative deviations on Simpson's to trapezoidal composite rules were 99.73 %, 99.71 %, 99.70 %, and 99.68 % for the computation of the consumed energy, the simulation of the consumed energy, the computation of the lost energy and the simulation the lost energy respectively. While, the relative deviations on the computations to the simulations were 93.1 %, 93.1 %, 101.3 % and 101.3 % for the trapezoidal and composite rule consumed energy and trapezoidal and composite rule lost energy respectively. Thus, there were small value differences due to the ideal condition in the simulation. Nevertheless, this was still in reasonable condition.

The corrected simulation power based on the computations, as the previous statement, the deviations for the average supplied and lost active powers were 3.39 kW (8.66 %) and 2.46 W (0.24 %). These values were also still in reasonable condition.

There were comparisons between the computation and the simulation, and the trapezoidal and Simpson's composite rules. On the one hand, for the supplied active energy, Simpson's composite rule compared to the trapezoidal composite rule is 99.73 % and 99.71 % for the computation and simulation, respectively. While, for the computation to the simulation comparisons, they are 94.07 % and 94.08 %, for the trapezoidal and Simpson's composite rules respectively. On the other hand, it is for the lost active power. They are 99.65 % and 99.65 % and 101.21 % and 101.22 % for the same condition, respectively. Thus, the deviations are not so significant.

The patterns of supplied reactive power were similar to the active power. Nevertheless, the comparisons between the night and the daylight were 23.7 kVAr (32.7%) and 48.8 kVAr (67.3 %), 25.8 kVAr (33.5 %) and 51.2 kVAr (66.5 %), 22.6 kVAr (31.8 %) and 48.6 kVAr (68.2 %), 24.0 kVAr (33.7 %) and 47.2 kVAr (66.3 %), 23.4 kVAr (36.6 %) and 40.5 kVAr (63.4 %), 21.6 kVAr (54.7 %) and 18.0 kVAr (45.3 %), and 20.0 kVAr (65.2 %) and 10.7 kVAr (34.8 %) for Monday until Sunday, respectively. The percentages of the daylight supplied reactive power were higher than those that the nights, except for Saturday and Sunday. This case indicated that, for the previous days, the daylight activity was higher than that of the nights. It was vice versa for the two last days.

Based on Figure 9, it is revealed the supplied reactive energy, where the high category was on Monday, Tuesday, Wednesday, and Thursday. The absorbed energy was higher than 800 kVArh. In this category, the highest absorbed energy was on Tuesday. This case was caused by electric motor practices in the electric power laboratory. While, the medium category was on Friday, as lower than 600 kVArh and higher than 400 kVArh. Finally, the low category of the absorbed energy was Saturday and Sunday, where they were lower than 600 kVArh and 400 kVArh, respectively. While, the deviation between the Simpson's to trapezoidal composite rules had 0.577 % and 0.139 % for the maximum and minimum values, or the average of 0.33 %. Thus, these values were very low and did not significantly influence the real condition.

As suggestions, for reducing the cumulative power on Monday until Thursday, in the future, it is necessary to shift the consumed power to Friday and Saturday, such as lectures and laboratory practices. Besides that, it is necessary to consider increasing the current carrying capacity of the power cables, whether replaced by the bigger cable sizes or added the cable lines in parallel. Nevertheless, it should get permission from the foundation.

5. Conclusions

Generally, the charts of supplied power tended to be typical upward parabolic curves, while in the average, the highest value occurred at 1:45 p.m. The charts could be divided into three categories, namely high, medium, and low supplied power. The days that included the high supplied power were Monday, Tuesday, Wednesday, and Thursday. Among the high supplied power days, Tuesday was the day when the equipment in the building consumed the highest power due to lab work in the laboratories. Meanwhile, the medium category was Friday, due to the use of some time for praying. Finally, the days that included low supplied power were Saturday and Sunday. The supplied power on Saturday was slightly higher than that on Sunday. This case was caused, on Saturday, by a few lectures and not any administrative activity. While on Sunday, there was not any activity at all, including lectures, lab, or administrative activity.

The power loss charts were similar to the pattern of supplied power, because most losses, like copper or ohmic losses, either on the transformer or the lines, directly depending on the supplied power or loading. Only the iron loss of the transformer was independent directly to the loading. Nevertheless, of course, the power losses were much smaller than the supplied power, which ranged from 1.74 % to 3.66 %.

The daily supplied energy patterns were different from each other. The daily supplied energy was similar to the daily peak supplied power. The highest supplied energy was on Tuesday, due to the use of laboratories and some lectures, and the lowest one was on Sunday, due to no activities in the building. The lost energy ranged from 2.08% to 3.92%. The magnitude lost energy would rise considerably, and the percentage lost energy would reduce slightly as the supplied energy increased. The deviation of computation between composite trapezoidal and Simpson's rules was 0.30 % and 0.27 % for lost and supplied energy, respectively. On the other hand, for the supplied energy, the deviations between simulation and computation were 6.94 % and 6.93 % for the composite trapezoidal and Simpson's rules, respectively. Meanwhile, the deviations of the lost energy between simulation and computation were -1.32% and -1.34 % for the composite trapezoidal and Simpson's rules, respectively. Although not so precisely the same, the patterns of supplied reactive power and energy were similar to the active power ones. Nevertheless, the magnitudes were much lower than the active power.

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Acknowledgment

The authors would like to express the most profound appreciation to the Electric State Company (PLN), which has supplied the data.

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