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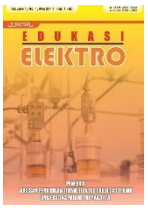

Identification of Energy Saving Potential Through Energy Audit at PT. ABC

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Abstract—Increasing energy efficiency is one of the most important functions for reducing energy costs as well as production costs. One way to reduce the use of electrical energy consumption is by saving energy. This study aims to determine how much energy savings at PT ABC through an energy audit. An energy audit is carried out with two main activities, namely identifying the profile of patterns of electricity use and analysis of power quality. The results of the analysis are then expected to be the basis for knowing the potential for energy savings and energy conservation in the industry. The method used in this study begins with field observations, measurements of electrical systems, and measurements of production machines and production support equipment. Based on some data, both primary data and secondary data, an analysis is carried out through calculations to determine potential energy-saving opportunities. The main energy source used at PT. ABC is from PLN with 1 subscription to a 3-phase system with an installed power of 197 kVA. Energy use or consumption for a year is 804,279.97 kWh. Opportunities for energy savings through energy audits that have been carried out are expected to have an impact on the company, namely energy cost savings of IDR 137,344,162 per year.

Keywords: energy saving, electrical energy, energy audit, specific energy consumption

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1 Introduction

Energy is an indispensable factor for sustainable development and economic growth. Provision of electricity, based on statistics from the Ministry of Energy and Mineral Resources, at the end of 2021 amounted to 289,470.57 GWh consisting of PLN's electricity production of 182,973.884 GWh and purchases of 106,496.69 GWh, with PLN's electricity sales of 257,634.25 GWh. Sales for the industrial sector amounted to 80,904.46 GWh, the household sector amounted to 115,369.70 GWh, the commercial or business sector amounted to 44,027.40 GWh and the public or general sector amounted to 44,440.87 GWh and the public or general sector amounted to 18,931.93 GWh. Based on the data above, the two most dominant sectors are the industrial sector and the household sector. According to [1], from 2013 to 2018 electricity consumption per capita increased significantly.

While at the same time, the ability to provide electricity by the state through PT. PLN (Persero) is still limited, there are even indications that this capacity is starting to decline. One of the reasons for the

decline in the ability to supply is that most of the power plants owned by PT PLN (Persero) use fossil fuels, namely oil or coal, as their energy source, while the availability of fossil fuels is dwindling.

The government regulates energy use nationally through [2], including the obligation for every energy user (including industry) to carry out an energy conservation program). Based on, [3] related to Government Regulation of the Republic of Indonesia Number 70 of 2009, energy conservation is a systematic, planned, and integrated effort to preserve domestic energy resources and increase the efficiency of their utilization. Besides that, according to [4], entrepreneurs are responsible for: implementing energy conservation at every stage of business implementation; and use energy-efficient technology; and/or producing energy-efficient products and/or services.

According to [5], one of the efforts to conserve energy is to conduct an energy audit. Energy audit activities are carried out through several stages, namely: initial audit, detailed audit, analysis of energy-saving opportunities, and energy-saving proposals. Power quality is a general requirement that describes the characteristics of supply parameters such as current, voltage, and frequency, as well as describes the negative effects of electrical disturbances such as frequency deviation, source voltage variations, transient voltages, harmonics, and so on [6]. Power quality and economic factors are interrelated. The economic factor really depends on the selection of the equipment to be operated in the factory and the supply of the factory equipment which is the electrical load. By knowing the profile of the quality of electric power by conducting energy measurements and audits, potential energy use anomalies will be obtained and energy conservation opportunities can be determined [7].

The increasing intensity of electrical energy in the manufacturing sector is influenced by several things, based on among others; (1) Intensive heat energy requirements (heating and cooling) by multiple manufacturers, (2) Managing the introduction of new digital technologies and increasing real-time availability of data including access to redundant data, (3) Extensive use of motor drive systems and (4) Affordability of energy supply, including managing peak demand and power factor costs [8].

Several studies on energy audits have been carried out from [9] to [14]. Research [9] explains that a high level of energy efficiency is not necessarily followed by high power quality as well. In this case, the researcher gave an overview of installing energy-saving CFL (compact fluorescent lamps) lamps. Problems arising from the installation of CFL lamps will affect power quality because harmonics will arise from nonlinear loads in the form of electronic circuits from the CFL lamps.

Costa, et.al [10] provide an overview of Energy Conservation Measures (ECM), which can be recommended for industrial facilities. The audit conducted in this study was carried out over four days, based on functional activities including: (a) Building and utility data analysis (b) Survey (c) Study of energy use, and (d) Evaluation of energy saving measures.

Research conducted by N Y Dahlan [11] conducted an energy audit on the Menara Seri Region Building and the Kastam Building and recommended solutions to optimize the energy efficiency and environmental aspects of the building. Research [12] aims to find and recommend the best energy saving measures for different types of industries. The results of this study state that in different industries, the same energy input will produce the same benefits, so this is less applicable when compared to the economic indices between different industries.

Linbao Liu et al in their research entitled "Energy consumption and potential of energy-saving of China based on Industry classifications" [13] researched and prepared an energy consumption index to analyze energy consumption. The model is then applied in the Ansteel industry, which is one of China's largest iron and steel industries. Before the optimization model was used, the exhaust gas at the blast furnace had high emissions, after the optimization model was applied, gas emissions were almost non-existent, and the efficiency of gas utilization had increased.

In a paper entitled "How to Reduce Energy Consumption by Energy Audits and Energy Management: The Case of Jilin Province in China" by Jian Zhang et al [14] a study was carried out to conduct an in-depth study of how to deal with the problems that arise during an energy audit and energy management activity in Jilin province. In the study, several problems emerged, including: (a) The

companies being audited did not understand the audit objectives, so they were not willing to cooperate. (b) Collecting data in the energy audit process is very difficult, and some of the data reported by the company is false data. (c) The personnel preparing the energy audit report are unprofessional. (d) Poor quality energy audit reports.

Based on the Government Regulation of the Republic of Indonesia Number 70 of 2009 concerning Energy Conservation [5], energy conservation is a systematic, planned, and integrated effort to preserve domestic energy resources and increase the efficiency of their utilization. The main tool for energy conservation activities is an energy audit. An energy audit is a process of evaluating energy use and identifying energy saving opportunities as well as recommendations for increasing the efficiency of energy users and users of energy sources in the context of energy conservation [15]. An energy audit is a search of energy resources from entry to end user to look for leaks and make recommendations that will improve the energy utilization system of a facility.

PT. ABC is a company located in the Special Region of Yogyakarta, PT is a refrigerated food and beverage distribution company and a leading importer of frozen, chilled, dairy, and dry food and beverage products. Over time, the best brands have been entrusted to develop their products. The production system at PT. ABC uses a make-to-stock model, which is making products to be marketed later or in other terms, companies that produce on a market basis (by stock), namely companies that produce continuously as long as there is market demand.

The energy source used at PT. ABC is electrical energy that comes from PT. PLN. The power source contract for electricity from PLN is 197 kVA at low voltage. Energy consumption at PT. ABC is mostly used to supply main equipment consisting of coolers, fans, other production machine tools and production room lighting, while the rest are used to supply utility equipment such as office expenses. The PT.ABC Electrical Diagram is shown in Figure 1 below.

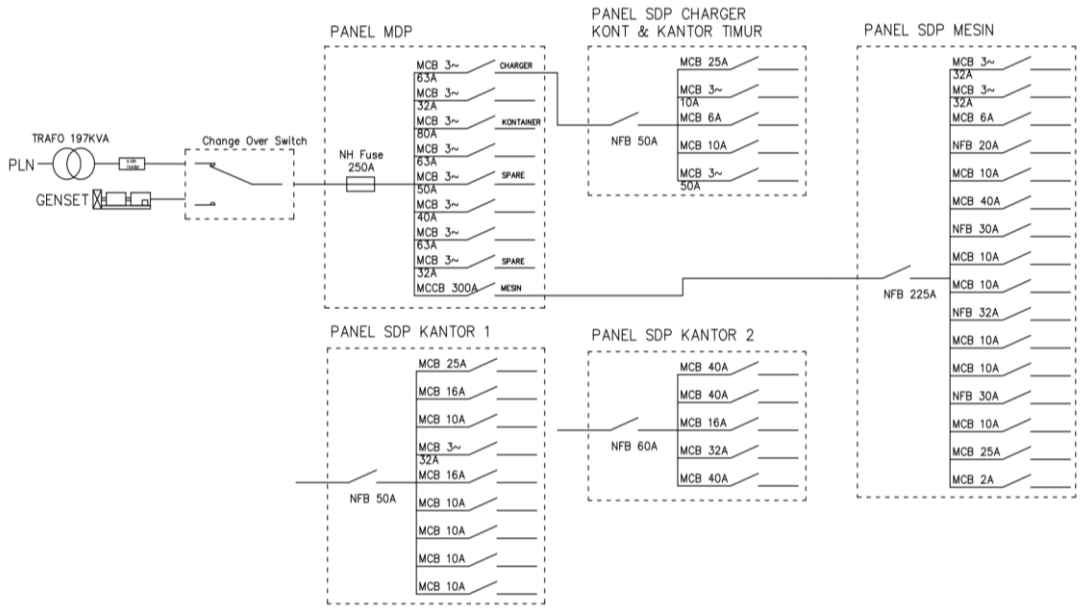

Fig. 1. PT. ABC electrical diagram

2 Methods

Energy conservation is a systematic, planned, and integrated effort to preserve domestic energy resources and increase the efficiency of their utilization. Meanwhile, an energy audit is a concrete action effort that aims to reduce energy consumption by calculating the amount of electrical energy consumption, identifying energy-saving opportunities, and providing recommendations so that further use of electrical energy can be carried out more effectively and efficiently. Energy conservation in energy utilization, users of energy sources and energy users who use energy sources and/or energy greater than or equal to 6,000 (six thousand) tons of oil equivalent (TOE) per year are required to carry out energy conservation through energy management [4].

The methodology for implementing activities is carried out through several stages including preparation and coordination stages, stages of audit implementation, stages of data analysis, stages of recommendation, and feasibility study stages. The research method is shown in Figure 3 below.

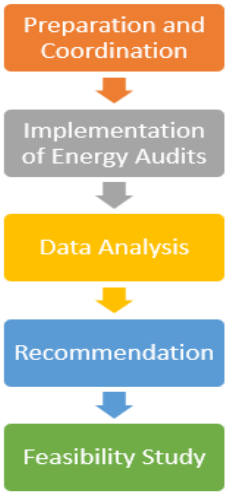

Fig. 2. Research methods

When carrying out an energy audit consists of two main activities, the first stage of this activity includes the overall data collection on the level of use and type of energy used by PT. ABC. The data to be retrieved includes the energy sources used, the load connected, the level of suitability of the load with the needs, the level of suitability of the connection capacity with the connected load, the number of bills each month, production data (kg) and data on good and defective products in one production process. The second stage of activity in the research is to process the data based on what has been obtained.

To find out the pattern of loading when activities are operating, observations are made by recording the consumption of electrical energy in several departments or sections that consume the most electricity. The determination of the department for which electricity usage will be recorded is carried out jointly by the researcher and company management (in this case the Head of General Affairs and Households). The results of recording electricity usage in the MDP panel in each building include current, voltage, active power, reactive power, apparent power, power factor, current THD and voltage THD.

After conducting an audit, the next step is to perform data analysis. data obtained during audits or data collection in the industry are analyzed and processed according to standards on electric power systems. The results of the analysis serve as a basis for providing recommendations. The results of the recommendations are used as improvements in utilizing energy.

3 Result and Discussion

3.1. Source and Loading Distribution

PT. ABC has 1 electricity subscription with a total subscription of 197 kVA. From the results of the measurements that have been made, the comparison between the capacity of the subscribed power and the consumption of electrical energy at PT. ABC can be seen in Figure 3.

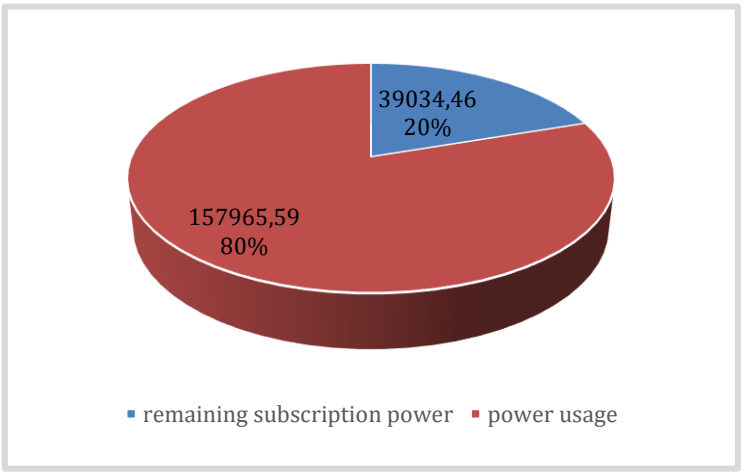

Fig. 3. Comparison of installed power with consumed power (electrical energy consumption) of 197 kVA Panel

3.2. Energy Costs

The cost of electrical energy in 2017-2019 has fluctuated up and down. The following graph presents monthly energy costs based on data collected from the object of the audit and data from PLN. graphic images of energy consumption are shown in Figures 4, 5, and 6.

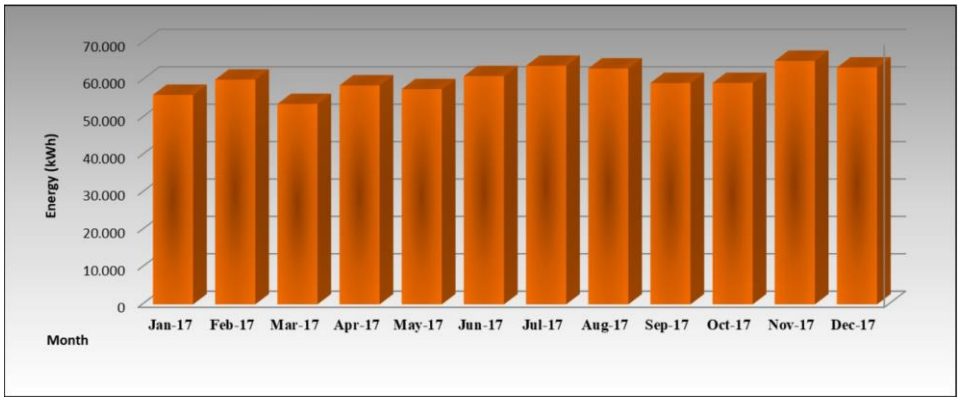

Fig. 4. Graph of 197 kVA MDP electrical energy consumption in 2017

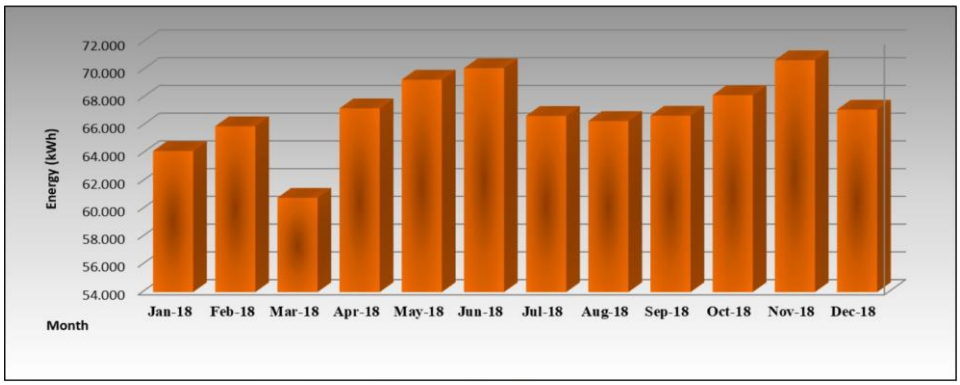

Fig. 5. Graph of 197 kVA MDP electrical energy consumption in 2018

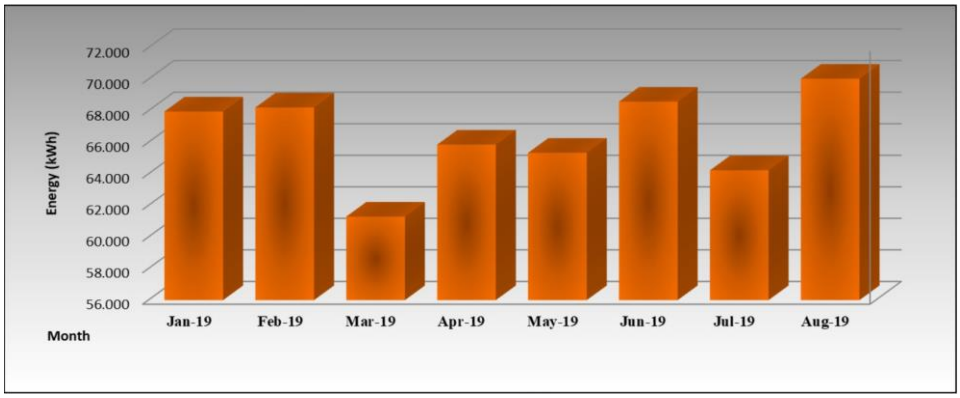

Fig. 6. Graph of 197 kVA MDP electrical energy consumption in 2019

3.3. Analysis of Electric Power Quality

Related to the quality of electric power at PT. ABC needs to be measured, especially on the MDP side. Figure 7 shows measurement activities in the MDP panel.

Fig. 7. Measurements on PT ABC's electrical panels

The measurement results on the MDP panel include current, voltage, active power, reactive power, apparent power, power factor, current THD, and voltage THD at PT. ABC is shown in Table 1.

Table 1. PT. ABC MDP panel measurement results

No.	Parameter	Phase R	Phase S	Phase T	Neutral
1.	Current of average load condition (ampere)	191.63	158.62	183.1	158.62
2.	Current of maximum load condition (ampere)	254.59	214.36	244.36	214.36
3.	Voltage (V), Volt	224.28	225.15	224.96	-
4.	Active Power (P), Watt	33246.8	26731.56	29927.85	-
5.	Apparent Power (S), VA	42967.18	35708.66	41186.73	-
6.	Reactive Power (Q), Var	27103.21	23568.49	28247.58	-
7.	Power factor (PF)	0.77	0.75	0.73	-
8.	Frequency (Hz)	49.99			
9.	Current Harmonics (%)	3.84	3.23	3.15	-
10.	Voltage Harmonics (%)	2.94	2.87	2.73	-

3.4. Electrical System Analysis

The definition of power quality is the statistical designation of a system that can work at 99.98 percent. Power quality and economic factors are interrelated. The economic factor really depends on the selection of the equipment to be operated and the supply to the equipment that is the electrical load. With good power quality, the economic factor can be reduced to a minimum. The amount of electricity that is considered and at the same time determines whether or not the quality of electric power at PT. ABC, among others, voltage, current, active power, apparent power, reactive power, frequency, harmonics, power factor.

The results of measuring several important parameters on the MDP panel were obtained by measuring and recording data using a power quality analyzer. Based on the measurements and records that have been made, the following is an analysis of the parameters related to the quality of the electric power.

a. Phase Voltage

The measured voltage value on the MDP panel of PT. ABC which is measured graphically is shown in Figure 8.

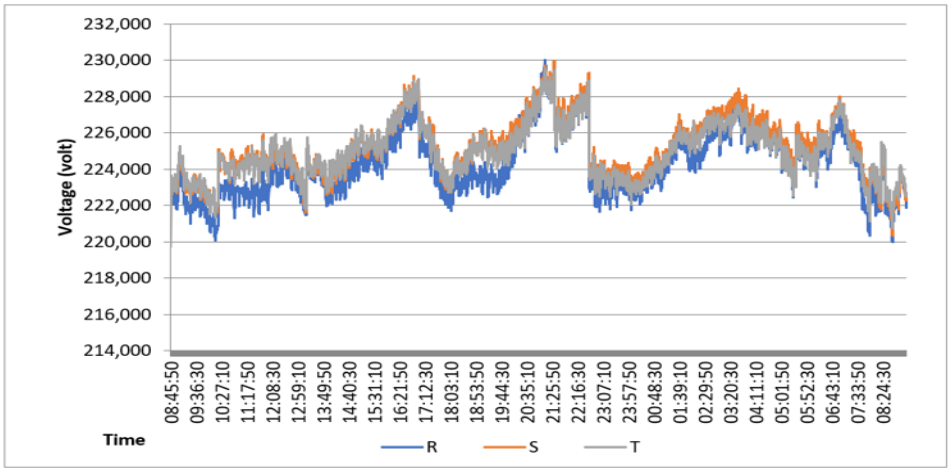

Fig. 8. Phase voltage profile on MDP panel PT. ABC

The value of the phase voltage on each phase is different which causes an unbalanced voltage value to appear. Based on the calculation results, the average unbalance voltage value on the MDP panel of PT. ABC: equal to 0.16%. The unbalance voltage value has not exceeded the standard limit set by NEMA, which is 1%. The unbalanced voltage causes losses (power loss) and also results in a reduction in the service life of the 3-phase equipment connected to the system. This agrees with [16] which explains that the voltage imbalance has an impact on the performance of transformers and equipment that uses.

b. Phase Current

The phase current value is based on the measurement results at the MDP panel of PT. ABC which is measured graphically is shown in Figure 9.

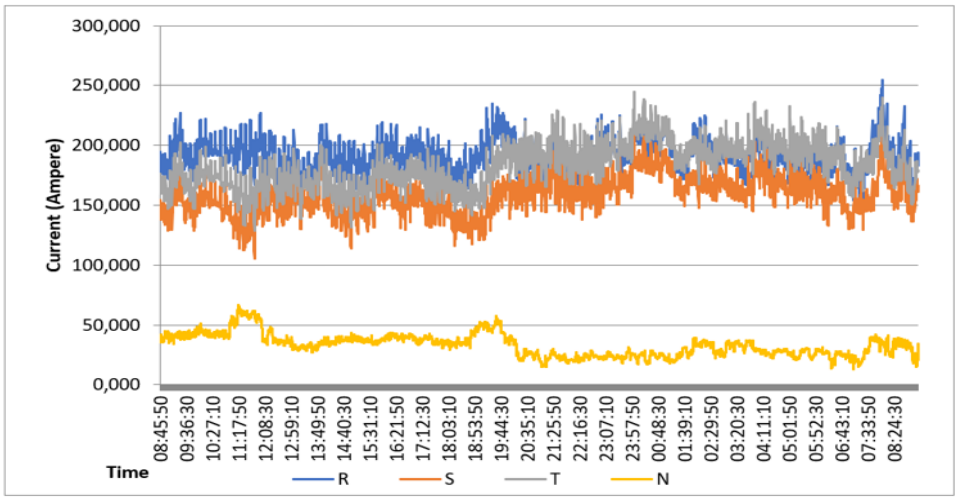

Fig. 9. Phase current profile on MDP panel PT. ABC

The current value shows that at peak load conditions, there is a difference in the current in each phase of 7.79%. Based on the value above, it means that the loading conditions that occur at PT. ABC is still within the safe limit range. The standard unbalanced load current as determined by NEMA is 10%. Based on these conditions, the current flowing in the neutral wire of 214.36 amperes (at maximum conditions) needs to be corrected in order to minimize the current flowing in the neutral wire.

c. Active Power

The value of active power (watts) for each phase is based on the measurement results on the MDP panel of PT. ABC measured graphically is shown in Figure 10.

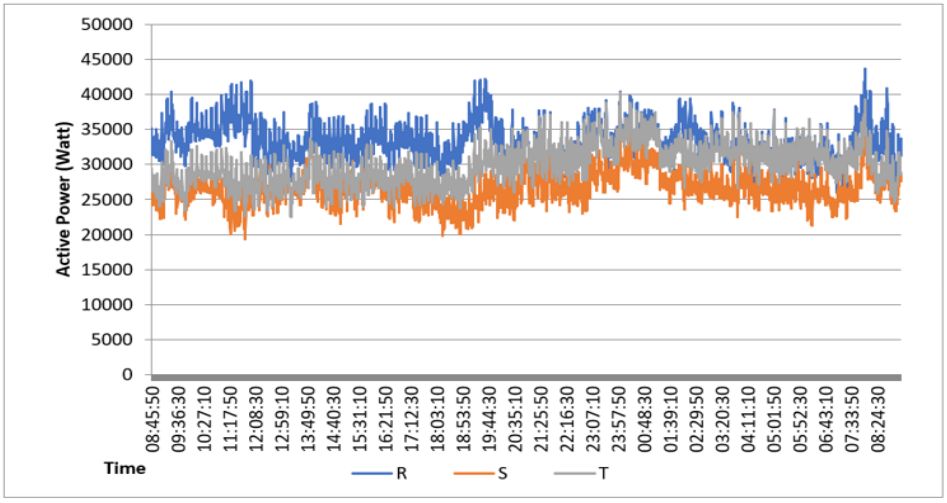

Fig. 10. Active power profile on MDP panel PT. ABC

The active power value shows that under average load conditions (production process conditions), there is a difference in the real power consumption in each phase of 10.94%. This condition results in the emergence of currents in the neutral wire which causes losses in the transformer. This agrees with [17] which explains that the neutral current in the wire has an impact on the efficiency of the transformer

d. Power Factor

The value of the power factor in each phase is based on the measurement results at the MDP panel of PT. ABC which is measured graphically is shown in Figure 11.

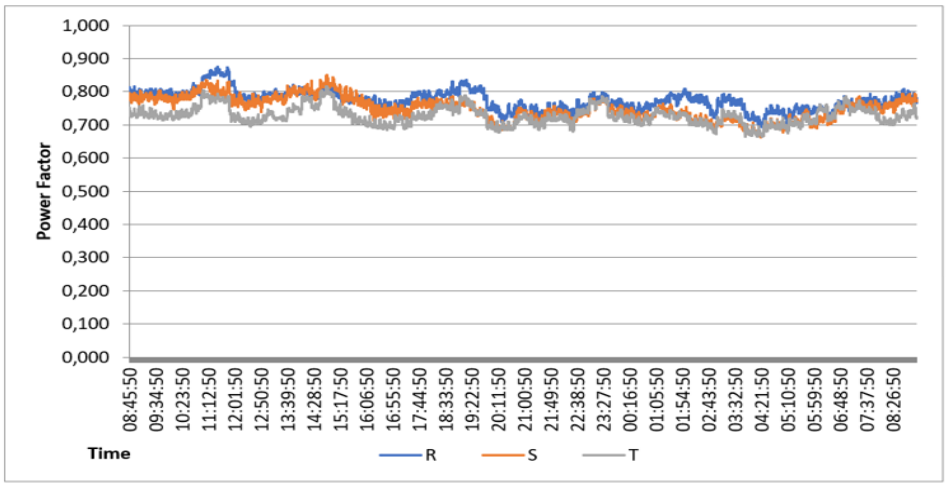

Fig. 11. Power factor profile on MDP panel PT.ABC

The power factor value shows that in general under production conditions the power factor value of each phase on the MDP panel of PT. ABC is not in accordance with the standards set by PLN, which is greater than or equal to 0.85. A low power factor value will result in very large reactive power consumption resulting in an increase in overall losses.

3.5. Energy Saving Opportunities

From the results of field observations, data collection and analysis carried out as well as calculations of energy use for PT. ABC, there are energy saving or conservation opportunities that can be done as shown in Table 2 below.

Table 2. Energy saving potential recommendations

TOTAL ENERGY CONSUMPTION (kWh)				**804279.97**			
TOTAL ENERGY CONSUMPTION COST (Rp)				**1180103916**			
No.	**Energy Saving Recommendations**	**Saving Energy**			**Saving Money**	**Implementation Costs (IDR)**	**Simple Payback Periode (year)**
		kWh/year	**%**	**Rp/year**	**%**		
A. HUMAN RESOURCES							
1.	Comprehensive load management through the establishment of an organization responsible for managing energy use	48256.80	6.00	70806235	6.00	0	0.00
B. SYSTEM							
1.	Decreasing operating temperature of the space conditioner (deducted by two degrees from the normal operating temperature)	1375.03	0.17	2017550	0.17	0	0.00
2.	Replacing refrigerant R22 with hydrocarbons in Split AC units	2750.05	0.34	4035100	0.34	2800000	0.69
3.	Neutral current reduction	41222.72	5.13	60485277	5.13	0	0.00
TOTAL		93604.60	11.64	137344162	11.64	2800000	0.02

4 Conclusions

The main energy source used at PT. ABC is from PLN with 1 subscription to a 3-phase electricity system with an installed power of 197 kVA. Energy use or consumption for a year is 804,279.97 kWh. Based on the results of the measurements that have been carried out, there is an indication that the current flow in the neutral wire is quite high, namely 37.69 amperes, where this value will have an impact on energy losses on the neutral line and losses on the transformer. Potential energy saving opportunities are expected to have an impact on industrial objects, namely PT. ABC with energy cost savings of IDR. 137,344,162 per year or 11.64% of energy costs per year. The condition when there are neutral current can be avoided by re-installing or dividing the electrical load so that the ratio of current usage for each phase is the same which aims to reduce the current in the neutral wire. Another thing that needs to be done is to re-draw the electrical system at PT ABC. Re-drawing the electrical system is very important, especially when adding loads or pulling cables for other electrical loads.

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