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Oppurtunities Efficiency Study of Electric Energy Consumption in PT. SAI Apparel Semarang

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Abstract: *National energy stability has a very important role in support of the national development sustainable. However, the problem is often the rate of energy availability not balanced with the rate of energy needs, therefore it is necessary to do the efficiency of energy consumption on the user side. The industrial sector becomes the largest energy consumer in Indonesia. In this study author will conduct analysis energy efficiency potential by raising a case of study on one of the garment industry in semarang, namely PT. SAI Apparel. The energy efficiency will be based on production and energy consumption data during 2016, and evaluate the measurement of the electrical power quality. Based on the results of data analysis obtained from PT. SAI Apparel, it is known that electric power quality values for current imbalance parameters, voltage imbalance, and power factor have values that are not in accordance with the standard and risk increase the loss of power. Based on the analysis of electrical power quality of PT. SAI Apparel is known some quantity of power quality of PT. SAI Apparel has values that are not in accordance with the standards and risk increase the loss of power. Seeing these conditions obtained three energy saving recommendations that can be implemented at PT. SAI Apparel, that is.RST phase load balancing to reduce voltage and current imbalance, replacement of TL lamp by using LED lamp will produce energy saving 449.687kWh/year, replacement sewing machine induction motor with servo motor will produce energy saving 616.223kWh/ year, and improvement of the power factor will produce energy savings 5.774, 5kWh/year.*

Keywords: *energy conservation; energy efficiency.*

1. Introduction

Energy stability has very important contributions in supporting sustainable national development. However, the most problem of energy use is the rate of energy availability which is not balanced with the rate of energy needs. Therefore, in order to maintain national energy stability besides to actively undertaking development and diversification on the energy supply side, energy conservation efforts on the utilization side should be done to reduce the rate of energy use.

Energy efficiency or efficient energy aims to reduce the amount of energy needed to produce a product or service. Government in Government Regulation No. 70 of 2009 has managed that users of energy sources and energy users using the energy and / or energy sources of more than 6,000 TOE (Tonne Oil Equivalent) within a year are required to conserve energy through energy management, besides energy users and / or energy sources below 6,000 TOE (Tonne Oil Equivalent) per year are required for using the energy economically and efficiently.

On this research study, the authors take case studies on one of garment industry at Semarang city, namely PT. SAI Apparel. Total energy consumption at PT.SAI Apparel during 2016 reached 4,815 TOE (Tonne of Oil Equivalent). Because the energy consumption during 2016 is less than 6,000 TOE (Ton of Oil Equivalent), PT. SAI Apparel has no obligation to conserve energy through energy management, but PT. SAI Apparel still has an obligation to consume energy economically and efficiently. Also From the data sampling of Automatic Meter Reading owned by PT. SAI Apparel, during the month of July recorded every day there is a power factor value below 0.85. Also form the data bill of electricity costs PT. PLN (Persero), PT. SAI Apparel was exposed to a kVARH penalty in November 2016 until January 2017[3]. There are still opportunities of energy waste that is not realized by the company, therefore in this study the authors will identify electrical energy efficiency opportunities that can be implemented in PT. SAI Apparel.

1.1. Research Methods

This final project is carried out in several research stages. Figure 1 shows the research flow diagram.

1.2. Overview of the Research Object

PT. SAI Apparel is a garment company established since 1998. Addressed on St. Brigadier General Sudiarto km. 11 Semarang, Central Java, Indonesia. On its production activities, PT. SAI Apparel uses three types of energy sources: 2,770 kVA of electrical energy as energy source for production machinery, coal energy as boiler fuel to produce steam, and the last is solar energy as genset fuel when power outages. Production process conducted at PT. SAI Apparel is shown in Figure 2.

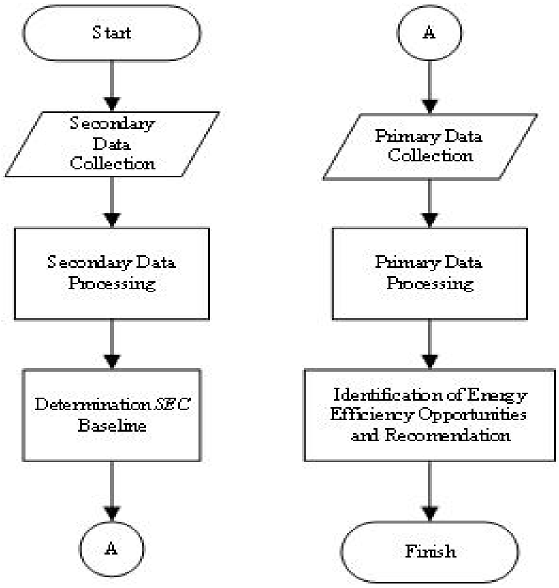

Fig1. *Flowchart of Research study*

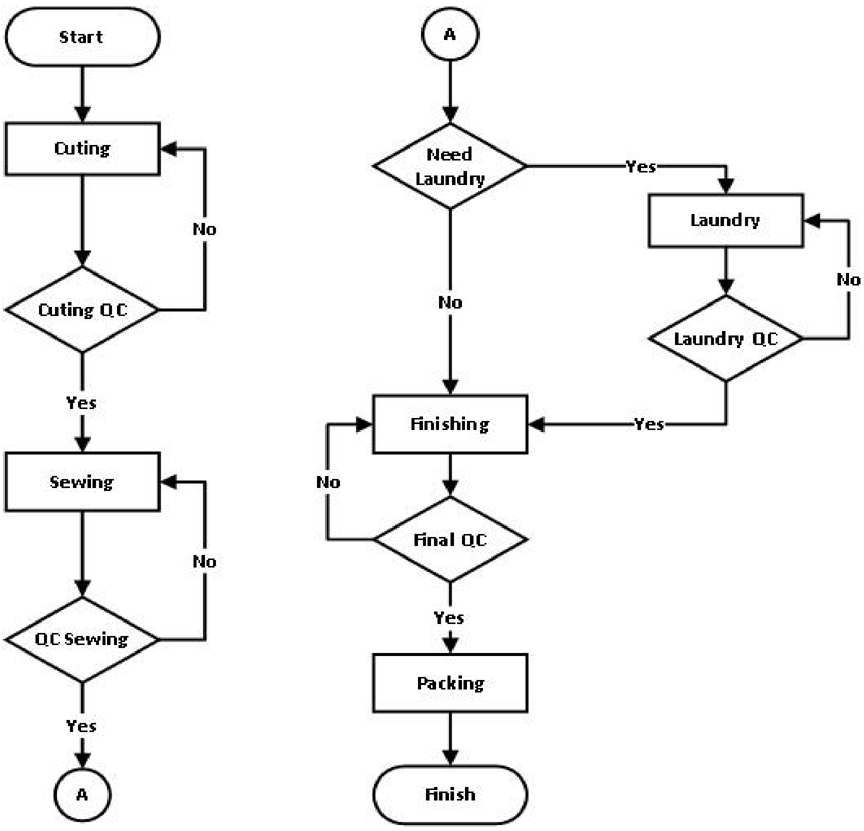

Fig2. *Flowchart of Production Activity*

1.3. Research Data

Research data consist of secondary data and primary data. Secondary data include historical data of energy consumption, production amount during 2016, and data Automatic Meter Reading on PT. SAI Apparel. In addition to secondary data, there are also primary data in the measurement data form of electrical power quality at PT. SAI Apparel. Power distribution in PT. SAI Apparel uses four distribution transformers. Primary data was collected on all 4 substations. Primary data taken are as follows:

- Current and voltage data of each phase
- Total harmonic distortion of current and voltage.
- Power factor
- Load for each substation

1.4. Measuring Instruments

In collecting data, the author use Power Quality Analyzer to record data on the LVMDP and MDP. Measurement at MDP and load is done by using Clamp Hi Tester. In the measurement conditions cannot use both devices, current and voltage measurements are made using Clamp Meter (Current Measurement) and Digital Multi meter shown at Fig 3. And Fig 4.

Fig3. *Clamp Hi Tester Hioki*

Fig4. *Power Quality Analyzer*

To ensure safety, during the data retrieval authors always use Personal Protective Equipment.

1.5. Data Collecting Procedure

Data collection is done in several places, with the following procedure:

1) LVMDP: collecting data is done for one hour using PQA meter. The data collected with PQA meter are voltage and current data of each phase, THD values of current and voltage. Besides that, measurements were made using a Hi-Tester Clamp for five minutes with a duration of twelve hour cycle measurements and the data captured for every hour. The data collected is load data. Besides that, measurement of power factor values is taken on LVMDP digital at cosphi meter panel.

2) MDP: The data retrieval is done for one hour using PQA meter because current on some LVMDP exceeds the ability of measuring instrument (1000A). The data taken is the data voltage and current of each phase, THD values of current and voltage. Besides that, measurements were made using a hi-tester clamp for five minutes with a duration of twelve hour measurements and a pause of data capture every hour. The data taken is load data.

3) SDP: Load measurement is done by using Clamp Hi Tester. Besides to the load measurements on several SDP, sampling voltage data is collected.

4) *Load:* Load-side measurements using Hi-Tester Clamp Gauge to determine actual load power consumption.

1.6. Data Analysis

The data obtained then analyzed in this study. Energy consumption data and total production of PT. SAI Apparel during 2016 is used to find energy distributions, load profile, and specific energy consumption of PT. SAI Apparel during 2016. Primary data obtained from measurements were processed to look for:

- Significant Energy Uses (SEU).
- Loading factor and transformer efficiency.
- Imbalance of current and voltage.
- Current and voltage THD’s value.
- Power factor of each substation
- Drop voltage.

1.7. Identification of Energy-Saving Oppurtunities and Energy Efficiency Recommendations

The results of data processing are analyzed based on the value of the applicable efficiency standards. All equipment connected to the distribution system must have the standards which regulated from SNI (Standard National Indonesia). For standard equipment’s not yet regulated in SNI, may refer to international standards such as ANSI, IEEE, NEC, NEMA, and IEC or refer to the standard set by PLN (SPLN) [3].

Data that exceeds the standard value, or indicated will lead to wastage which then analyzes to obtain the value of waste energy production. After the waste value of power generated, give a recommendation to eliminate the cause of energy wastage is accompanied by calculation of energy savings. Electrical energy utilization equipment is also analyzed based on the amount of power consumption, and compared with substitution equipment’s that have the same function but higher efficiency of energy consumption.

After the cause of energy waste is known, the author will provide recommendations on energy efficiency based on the problems and potential energy efficiency of existing electricity.

2. Result And Analysis

2.1. Energy Distributions of PT. SAI Apparel

Based on the data obtained, can be written on TABLE I for energy distributions of PT. SAI Apparel during 2016.

Table1. *Energy Distributions of PT. SAI Apparel 2016*

Energy Sources	Units (TOE)	Precentage
Electricity	650	13,5%
Coal	4.004	83,15%
Solar	161	3,35%
Total	4.815	100%

Based on Table 1, the total energy consumption used by PT. SAI Apparel during 2016 is 4,815 TOE. The largest energy source used is coal energy, which is 4.004 TOE (83.15%), electrical energy is 650 TOE (13.5%), and the smallest is solar energy, which is 161 TOE (3.35%).

2.2. Significant Energy Consumptions (Sec)

Electrical energy used by PT. SAI Apparel during the production process consists of electrical energy from PLN sources, and from diesel generators (genset). Therefore, the diesel consumption used by the genset must be converted into kWh which generated by genset. Genset will generate power as big as load requirement from system; from AMR data known that the apparent power average of PT. SAI Apparel during office hours is 1.946kVA with power factor is 0.87. The calculation of the electrical energy forecasts generated by genset uses the following calculations (1) [4].

$$Q = k \, x \, S_{AVG} \, x \, t \tag{1}$$

Given:

$k = 0,21$

$S_{AVG} = 1.946$ kVA

$T = 1$ hour

and then calculate Q value,

$Q = 0,21 \, x \, 1,946 \, x \, 1$

$Q = 409$ liter/hour

Furthermore, if diesel consumption known for every hour, by dividing the consumption of diesel per month with diesel consumption per hour will be obtained the genset operation time per month. The example data of January 2016 calculations uses the following equations (2).

$$t_{january} = Q_{january}/Q \tag{2}$$

and then calculate $t_{january}$ value,

$t_{januari} = 15.157/409$

$t_{januari} = 37,09$ hours

The electrical energy generated by the genset is obtained by multiplying the average power (Watt) generated by the genset with genset operating time. Calculating the electrical energy uses the following equations (3).

$$kWh = P_{avg} \, x \, t_{january} \tag{3}$$

and then calculate kWh value,

kWh = 1.692 x 37,09

kWh = 62.754 kWh

After the value of kWh is generated by genset is known, that can be obtained the total electric energy every month. By dividing the total electric energy consumption by the amount of production every month, and then the data obtained on TABLE II as follows.

Table2. *SEC PT. SAI APPAREL 2016*

Month	**Electrical Energy Total (kWH)**	**Production Capacity (Potong)**	**SEC (kWh/Piece)**
January	638.994	1.487.395	0,43
February	722.895	1.600.737	0,45
March	664.148	1.400.419	0,47

April	605.165	1.256.763	0,48
May	759.372	1.208.248	0,63
June	760.548	1.186.215	0,64
July	709.720	662.145	1,07
August	522.257	1.108.317	0,47
September	663.580	1.020.903	0,65
October	682.828	1.061.814	0,64
November	737.276	1.393.442	0,53
December	842.979	1.387.159	0,61

Based on the data analysis of Table II, it is known that specific energy consumption of PT. SAI Apparel during 2016 ranges from 0.43 to 1.07 kWh / piece, with an average value is 0.59 kWh / piece.

2.3. Load Profile of PT.SAI Apparel

Based on AMR data in May 2017, it is known that the maximum apparent power consumption is 2,534kVA. For maximum apparent power consumption has an average value is 2.413kVA. PT. SAI Apparel subscribes 2,770kVA electricity to PLN, when viewed from the maximum apparent power consumption there is still has 236kVA power reserve (9%).

2.4. Significant Energy Uses (Seu)

Total electrical energy consumption of PT. SAI Apparel during 2016 is 8,309,763kWh. With actual power measurement at load we get percentage of load energy consumption based on SEU and non SEU load classification as shown in TABLE III as follows.

Table3. *Significant Energy uses (Seu) of PT. SAI APPAREL*

Load	**Energy Consumption (kWh)**	**Percentage**
Air Conditioning	531.700	6%
Air Compresor	817.414	10%
Lighting	1.005.309	12%
Motor	4.302.841	52%
Total SEU	**6.657.264**	**80%**
Total Non SEU	**1.652.498**	**20%**

The SEU load is dominated by motor load, which is 80%, followed by 12% lighting load, 10% air compressor load and 6% cooling load of total electrical energy consumption during 2016. In addition to SEU load, there is a non-SEU load of 20% total electrical energy consumption in 2016.

2.5. Efficiency and Transformer Loading Factor

Efficiency on the transformer is influenced by the value of iron loss and winding loss. Loss of winding on the transformer is influenced by the large current flowing load, while the iron loss is fixed value. Here is an example of the calculation of the efficiency of transformer substation 1 at 08.00 a.m. Known that the transformer capacity is 1.600kVA; 2,200 Watt iron loss; and 19.000 Watt winding loss.

Table4. *Data Measurement of Substation 1*

Power (Watt)	**Current (A)**	**Voltage (V)**	**Cos ϴ**
611.352	1.108	362	0,88

Calculate full load current,

$$I_{FullLoad} = \frac{S}{\sqrt{3} \times V}$$

$$I_{FullLoad} = \frac{1.600}{1{,}73 \times 362}$$

$$I_{FullLoad} = 2.522A$$

Actual winding losses[5],

$$P_{cu}^{'} = (I_{Load} / I_{FullLoad})^2 \times P_{cu} \quad (4)$$

$$= (1.108/2.552) \times 19.000$$
$$= 3.582 Watt$$

And then calculate transformer efficiency as follows,

$$\eta = (P_O / (P_O + P_{\sum})) \times 100\% \quad (5)$$

$$= \frac{611.352}{611.352 + 3.582 + 2.200} \times 100\%$$
$$= 99{,}06\%$$

In the same way, we can get the efficiency of all transformers owned by PT. SAI Apparel. Only substation 1 transformer has load factor more than 50%. When loaded above 50%, transformer substation 1 has power factor of 98.99% and 99.00%. For all transformers when loaded above 25% has an efficiency value above 98%. The value of this efficiency is in conformity with the SPLN standard D3.002-1; 2007 and SPLN 50 1997.

2.6. Imbalance Voltage

Here is a calculation example for imbalance voltage of MDP Hall A at 12.55 in Table 5.

Table5. *Voltage Data of Mdp Hall A At 12.55*

Time	Voltage (V)			
	R-N	S-N	T-N	Average
12.55.00	214,3	217,4	218,3	216,67

$$\%V_{imbalance} = \frac{Maximum\_Deviation}{Average\_Voltage} \times 100\% \quad (6)$$

$$= \frac{2{,}37}{216{,}67} \times 100\%$$
$$= 1{,}09\%$$

In the same way, we can get the value of average imbalance voltage in MDP Hall A, B, and C, respectively is 1.08, 1.05, and 1.04. This value exceeds the NEMA MG 1 standard, which is 1% [8]. This condition results in three phase motors cannot work optimally, besides the voltage imbalance has a tendency to cause current imbalance .

2.7. Imbalance Current

Here is a calculation example for imbalance voltage of MDP Hall A at 12:55 in Table 6.

Table6. *Voltage Data of Mdp Hall A At 12.55*

Time	Current (A)			
	R	S	T	Average
12.55.00	456,9	430,7	401,4	429,67

$$\%I_{imbalance} = \frac{Maximum\_Deviation}{Average\_Current} \times 100\% \quad (7)$$

$$= \frac{28{,}27}{429{,}67} \times 100\%$$
$$= 6{,}58\%$$

In the same way, we can get the value of average imbalance current in MDP Hall B and C, respectively is 12.23% and 14.21%. This value exceeds the NEMA MG 1 standard, which is 10% [8]. This condition results the existence current in neutral and creates an I2R power loss along the neutral wire.

2.8. Power Factor

PT. SAI Apparel was recorded several times with kVARH penalties, in November 2016 to January 2017. This condition identifies that the average power factor value of PT. SAI Apparel in the month is below 0.85. Based on AMR data observations from 10 to 16 July 2016, it is known that the average power factor value of PT. SAI Apparel is 0.84. This value is slightly below the kVARH limit of 0.85 [9]. If the average power factor value for one month below 0.85 will be subject to a kVARH penalty.

In the observation of power factor on each substation known that the power factor average of each substation as follows in TABLE VII.

Table7. *The Average of Power Factor Substation*

Substation			
1	**2**	**3**	**4**
0,85	0,86	0,83	0,98

Based on Table 7, it is known that the lowest power factor value is found in substation 3, there is 0.83. The average power factor substation 1 and 2 is 0.85. The best power factor is in substation 4, which is 0.98. This condition is caused by the condition of capacitor bank that function only on substation 4. Low value of power factor in substation will increase risk of PT. SAI Apparel is exposed to a kVARH penalty, and increases the loss value of power due to the large of current flowing in the conductor.

2.9. Drop Voltage

Because the amount of SDP is too high, the value of drop voltage is measured between voltage MDP side with the farthest point of SDP sample, and between the SDP with the farthest load point. Here is an example of the calculation of the voltage shrinkage Hall A at 14.55 in TABLE VIII.

Table8. *Voltage Measurements on MDP and SDP*

Hall	**Phase**	**Measuring Terminal**		
		MDP	**SDP**	**Voltage Drop**
A	R	372	369	0,81%
	S	376	374	0,53%
	T	373	371	0,54%

Drop Voltage of Phase R,

$$\%Drop\_Voltage = \frac{\Delta V}{\Delta t} \times 100\%$$

$$= \frac{372 - 369}{372} \times 100\%$$

$$= 0{,}81\%$$

Drop Voltage of Phase S,

$$\%Drop\_Voltage = \frac{\Delta V}{\Delta t} \times 100\%$$

$$= \frac{376 - 374}{376} \times 100\%$$

$$= 0{,}53\%$$

Drop Voltage of Phase T,

$$\%Drop\_Voltage = \frac{\Delta V}{\Delta t} \times 100\%$$

$$= \frac{373 - 371}{373} \times 100\%$$

$$= 0{,}54\%$$

The average drop voltage value between MDP and SDP substation 1 to 4 is respectively 0.58%, 1.2%; 1.31%; and 2.76%. The average voltage drop value between the SDP and the substation loads 1 to 4 is respectively 0.18%, 0.67%; 0.35%; and 0.89%. The voltage drop value in PT. SAI Apparel is still in accordance with the standard value in PUIL 2000, which is below 5%.

2.10. THD of Voltage and Current

THD voltage values at PT.SAI Apparel based on the results of data collection is shown in TABLE 9.

Table9. *The Average of Thd Voltage at PT. SAI APPAREL*

Measuring Terminal	THD V (%)			Standard (%)
	R-N	S-N	T-N	
MDP Hall A	2,30	2,11	1,97	5
MDP Hall B	2,18	1,98	1,81	5
MDP Hall C	2,06	1,60	1,57	5
MDP Polybag & Karton	2,00	1,56	1,43	5
LVMDP Substation 3	1,34	1,40	1,39	5

Based on Table 9, the THD values across the voltage substation still conforms to SPLN standard values D5.004-1: 2012. The next THD current values will be shown in TABLE X.

Table10. *The Average of Thd Current at PT. SAI APPAREL*

Measuring Terminal	I_{SC}/ I_L	THD I (%)			Standard (%)
		R-N	S-N	T-N	
MDP Hall A	94,11	6,33	6,59	8,14	12
MDP Hall B	83,20	6,40	6,65	8,17	12
MDP Hall C	58,68	5,30	5,17	4,42	12
MDP Polybag & Karton	260,3	9,28	11,2	12,2	15
LVMDP Substation 3	58,70	9,24	8,26	8,85	12
LVMDP Substation 4	56,57	8,10	8,26	9,13	12

Total harmonic distortion voltage value at PT. SAI Apparel has a maximum value is 2.52% and average value is 1.87%. For harmonic distortion, the total current on the whole substation has a maximum value is 12.16% and average value is 7.87%. THD value of voltage and current in PT. SAI Apparel still conforms to SPLN.D5.004-1.2012 standards, the standards are 5% for voltage THD, and 12 to 15% for current THD.

2.11. Energy Efficiency Oppurtunities

Based on data analysis that has been processed has some potential energy savings as follows.

1) Load balancing of each phase to reduce voltage imbalance and current imbalance.
2) Use of energy-saving equipments.
3) Improvement of power factor by addition of capacitor bank capacity on substation 1, 2, and 3.

2.12. Load Balancing in Phases R, S, And T

The load imbalance between the R, S, and T phases results in high current and voltage imbalance in the power system at PT. SAI Apparel. The current imbalance resulted current in the neutral conductor, the magnitude of current calculated as follows with the example of MDP Hall A data at 12:55.

Given:

Phase Angle of I_R = 30,78
Phase Angle of I_S = 151,32
Phase Angle of I_T = 268,83

$$
\begin{aligned}
I_N &= I_R + I_S + I_T \\
&= 456{,}9\angle 30{,}8 + 430{,}7\angle 151{,}3 + 401{,}4\angle 268{,}8 \\
&= 39{,}7 A
\end{aligned}
$$

Similarly, neutral currents in LVMDP and MDP PT are obtained. SAI Apparel in TABLE XI. This neutral current will increase I^2R power loss along the neutral wire. Neutral currents can be minimized by balancing inter-phase loads.

Table11. *Neutral Current Calculations*

Measuring Terminal	Condition	Current Unbalance	Current Neutral (A)
MDP Hall A	Maximum	14,94%	101,72
	Minimum	3,24%	36,06

	Average	8,87%	64,56
MDP Hall B	Maximum	17,12%	94,65
	Minimum	7,37%	12,12
	Average	12,23%	52,93
MDP Hall C	Maximum	19,63%	207,44
	Minimum	9,73%	133,37
	Average	14,21%	162,94
MDP Polybag & Karton	Maximum	16,81%	37,54
	Minimum	2,92%	12,66
	Average	9,00%	19,63
LVMDP Substation 3	Maximum	8,75%	57,85
	Minimum	4,19%	50,05
	Average	6,84%	55,33
LVMDP Substation 4	Maximum	12,90%	131,87
	Minimum	2,98%	21,52
	Average	7,98%	74,97

2.13. Energy Efficient Equipment Uses

The recommended energy-saving appliances in this research are replacement of induction motor machine with servo motor, and 36 Watt TL Fluorescent lamp replacement with 16 Watt LED lamp.

The actual power measurement results on the sewing machine with the induction motor and servo motor are shown in TABLE XII.

Table12. *Results of Actual Power Measurement of Induction Motor and Servo*

Type	Condition	Power (kW)		Power Factor	
		Induction	Servo	Induction	Servo
SNLS	Burdened	0,391	0,127	0,80	0,56
	Standby	0,090	0,019	0,30	0,46
DNLS	Burdened	0,372	0,109	0,84	0,67
	Standby	0,100	0,013	0,33	0,65
Overlock	Burdened	0,274	0,264	0,84	0,64
	Standby	0,068	0,011	0,45	0,45

Based on the measurement data in Table 12, we can find the total existing energy consumptions for installed motors and energy consumption when all sewing machines use servo motors. Here is the calculation of energy savings given as follows.

$$Energy\_Saving = kWh_{Old} - kWh_{New}$$

$$= 1.001.268 - 385.045$$

$$= 616.223 kWh$$

With the replacement of induction motor machine with motor servo on motor type SNLS, DNLS, and Overlock got the value of electrical energy saving is 616.223kWh / year. In addition to the replacement of motors with a more energy-efficient motor, similar recommendations can be applied to light loads. The measurement data of power consumption on TL 36 Watt and 16 Watt LED is shown in TABLE XIII.

Table13. *Results Measurement Power of Tl and Led Lamp*

Measuring Terminal	Number of Lamp		Cos Θ	Power Measurement (W)
	TL	LED		
Line 2 left side	28	0	0,96	840
Line 1 left side	12	16	0,91	630
Line 2 right side	26	0	0,96	850
Line 1 right side	12	14	0,91	620

Based on the measurement results are given that the average power consumption of one TL is 31.35 Watt and for LED lamp is 16.57 Watt. With the replacement of TL lamps into LED lamps will be obtained energy savings as in the following calculations.

$$Power\_Reduce = P_{Old} - P_{New}$$
$$= 379{,}915 - 200{,}828$$
$$= 179{,}087 kW$$

The resulting energy savings are the result of the multiplication of the power loss generated by the operating day and hours of operation for one year.

$$Energy\_Saving = 179{,}087 \times 279 \times 9$$
$$= 449.687 kWh / Year$$

With more energy-efficient consumption, LED lamps have a measured LUX value equivalent to TL 36Watt lamp. The result of LUX measurement on TL lamp and LED is shown in TABLE XIV.

Table14. *Lux Led and Tl Lamp Measurements*

Type of Lights	Mesurement Place	Lamp Distance (m)	Lighting Performa (Lux)
TL 36 Watt	Front Desk	1,5	955
	Beside Desk	1,45	861
LED 16 Watt	Front Desk	1,5	936
	Beside Desk	1,45	892

2.14. Power Factor Improvements

Based on the measurement results, it is known that the power factor value at substation 1, 2, and 3 is about 0.85, therefore it is necessary to improve the power factor to avoid pinalty kVARH and minimize the power loss. Here is an calculating the capacitor bank capacities example for power factor improvement on substation 1.

Given :

PF_1 = 0,88

PF_2 = 0, 98

$P_{sub\ 1}$ = 627.861 Watt

$$Q_C = P\left[\tan(\cos^{-1} PF_1) - \tan(\cos^{-1} PF_2)\right]$$
$$= 627.861[\tan(\cos^{-1} 0{,}88) - \tan(\cos^{-1} 0{,}98)$$
$$= 627.861(\tan 28{,}36 - \tan 11{,}48)$$
$$= 211{,}39 kVAR$$

Similarly, the capacitor capacities of banks required for power factor improvements in substations 2 and 3 are shown in TABLE XV as follows:

Table15. *Calculation Results of Capacitor Capacitiy Needs*

Substation	PF_1	PF_2	P(kW)	Qc (kVAR)
1	0,88	0,98	627,86	211,39
2	0,86	0,98	282,85	110,39
3	0,83	0,98	466,31	218,67

The capacitor bank produces a number of reactive power requirements for the load, then the amount of reactive power that PLN's network transferred to the customer will be reduced. This condition results in current flowing values from the PLN connecting point to LVMDP where the capacitor installation of the bank will be reduced, thus the cunductor loss I2R along the channel will also decrease. Here is the reduction of power loss and energy-savings generated by power factor improvements.

$$Reduce\_Power\_Loss = Old\_Power\_Loss - New\_Power\_Loss$$
$$= 22.646{,}67 - 20.346{,}99$$
$$= 2.299{,}68 Watt$$

The resulting energy savings are obtained by multiplying the reduction of power loss, by day of operation, and daily operating hours for one year.

$$Energy\_Savings = 2.299{,}68 \times 279 \times 9$$

$$= 5.774{,}5 kWh / year$$

3. Conclusion

Based on the data analysis in this research and we can take some conclusions, that is during year 2016 PT. SAI Apparel uses energy distribution is 4,815 with coal energy (83.15%), electricity (13.5%), and diesel (3.35%). Power consumption of PT. SAI Apparel during 2016 is 8,309,763 kWh consumed by SEU and non SEU loads. SEU loads consist of motor loads (52%), lighting (12%), compressors (10%) and air conditioning (6%). Non-SEU loads consist of office equipment, and household is not related to the production process, which is 20%. Significant Energy Consumption of PT. SAI Apparel during 2016 is in the range of 0.43-1.07kWh / piece, with an average value of 0.59kWh / piece. The average value of SEC 0.59kWh / pieces is then used as a baseline for SEC evaluation in subsequent years.

There are several values of electrical power quality that are below the standard values, i.e voltage imbalance and current imbalance. This condition can be minimized by balancing the load on each phase. The power factor values of substations 1, 2, and 3 also range from 0.85, with power factor improvements resulting in energy savings is 5,774.5 kWh / year. In addition to the quality of electrical power, there is the potential for saving electricity energy by the use of energy-saving equipment. Replacement of energy-saving equipment is replacing the induction motor sewing machine using servo motors, resulting in energy savings of 616.223 kWh / year. Replacing a 36 Watt TL lamp using a 16 Watt LED lamp produces an energy savings of 449,687 kWh / year.

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