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Study of Energy Intensity and Energy Conservation Opportunities in Pharmaceutical Industry

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***Abstract* - In this study the authors conducted an evaluation of energy management with the aim of identifying energy consumption used for production process activities in the pharmaceutical industry. Based on data on energy use in the productivity process, the Energy Intensity (EI) value ranges from 0.020-0.695 GJ/kg. From these IE values, in each productivity process the average IE value can be used as a reference as an energy conservation limit value of 0.125 GJ/kg. From the description of the pattern of total energy consumption, it can be seen that the use of electrical energy tends to be greater, namely around 66.37% compared to the consumption of CNG and diesel which only consume 31.80% and 1.83%. The total energy use for electricity is an average of 1,105.56 MWh/month, CNG fuel is 1,895.54 MMBTU/month and diesel is 3.04 liters/month. In terms of equipment systems, the largest electricity consumption is borne by the HVAC system which consumes around 55.56% of the total electrical energy. From the description of the distribution of electrical energy use, it can be said that the HVAC system is SEU (Significant Energy Use). Based on actual conditions, it shows that the actual COP value obtained is 2.49-2.98 with a design deviation of around 1.24%-27.74% and an EER value of 1.18-1.41 kW/TR with a design deviation value of around 1.17%-38.22%. COP and EER values can still be increased so that performance is more optimal.**

Keywords: Energy, Energy Intensity, Electricity, CNG, Diesel Fuel, SEU.

I. INTRODUCTION

The energy source used in the pharmaceutical industry that is being researched is electricity and diesel fuel. But since 2019, the use of diesel fuel for boilers has been replaced by CNG. In 2017, the amount of energy used to produce 760,053 kg of products amounted to 51,014 GJ. In 2018, its energy consumption increased to 64,679 GJ with a production output of 857,948 kg. In 2019, energy consumption increased again to 69,188 GJ with a production output of 672,749 kg. The results of the calculation of Specific Energy Consumption (SEC) always increase from 0.06712 GJ/kg in 2017 to 0.07539 GJ/kg in 2018 and finally 0.10284 GJ/kg in 2019 (Arif, 2020).

Even though the total energy consumption in 2019 of 69,188 GJ (equivalent to 1,653 TOE) does not meet the mandatory requirements for energy conservation, an increase in Specific Energy Consumption has become an urgency to immediately carry out energy conservation efforts. The aim is to identify the profile of energy use, production and SEC as well as analyze the efficiency value of energy use on equipment that has significant energy use in detail so that opportunities to increase energy performance are obtained.

In this study the authors will conduct an energy audit which is a method of evaluating and analyzing energy use in the production process so that it is known in detail the optimization of energy use based on existing standards/techniques and can determine energy saving opportunities in the equipment used. In addition to technical analysis, this study also discusses the techno-economic potential of energy efficiency that can be implemented.

II. METHODOLOGY

The type of research used in this research is quantitative research. A quantitative approach is used to analyze a phenomenon systematically based on secondary data and primary research data using statistical techniques and processing. Secondary data collection is based on historical data on energy use and production in the industry in the past and specification data on equipment that uses energy significantly. While primary data collection is done by measuring electrical and thermal parameters to obtain facts in the field so that accurate and real information is obtained.

This quantitative study aims to identify features of energy use, production, and analysis of SEC and SEU, boiler efficiency, HVAC and potential large energy savings that can be made. In addition, this study also aims to conduct a techno-economic analysis of the efficiency potential that can be carried out.

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2.1 Data Types and Sources

The type of data used is in the form of primary data and secondary data. Primary data is obtained by involving researchers directly through surveys, observations, and measurements. While secondary data is data taken from the results of sweat or existing reports.

1) Secondary data used in this study include:

- Consumption of electricity, CNG and diesel for the period 2019- 2021.
- Production results per type of product for the period 2019-2021.
- Specifications for large capacity electrical machines, boilers, compressors and HVAC.
- CNG fuel test results (calorie value and fuel composition).
- Parameter monitoring results on boiler and HVAC.
- Basic rates of electricity, CNG and diesel fuel.

2) The primary data used in this study include:

- Electrical power for blower motors, condensers, and HVAC compressors.
- AHU HVAC input and output temperatures.
- AHU HVAC airspeed supply.
- Cross-sectional area of air supplying AHU HVAC.

2.2 Data analysis technique

The data analysis technique to be used in this study is as follows:

1) Secondary data related to energy consumption and production for 2019-2021 will use Microsoft Excel to obtain SEC values and graphs.
2) Secondary data related to boiler and HVAC equipment specifications are processed using Microsoft Excel and the results are used to analyze equipment efficiency based on manufacturing design.
3) Primary data related to voltage, current, and Power Factor of blower motors, condenser fans, and HVAC compressor motor drives will be processed using Microsoft Excel and the results will be used to analyze the efficiency of motor electricity use with a mathematical agreement based on standard ICE and to save electricity that can be done.
4) Primary data related to HVAC input and output temperature values will be used for results and the results are used to analyze HVAC efficiency and energy savings that can be made.
5) Secondary data related to energy consumption for the period 2019-2021 is used to determine the average amount of energy used each year so that energy costs can be determined.

III. RESULTS AND DISCUSSIONS

This research on energy management in the pharmaceutical industry is an activity to identify where and how much energy is used for the products that are produced and provide some potential energy performance improvements that might be obtained in energy user facilities. The main objective of this research is to determine the best way to optimize energy use per unit of output and reduce operational costs (energy costs).

From an energy distribution point of view, the use of electrical energy is intended for all activities in the Company, while the use of CNG and diesel fuel is only for boiler and generator engine operations. Based on the results of tracing the use of energy sources, an overview of the energy reference system is obtained as follows.

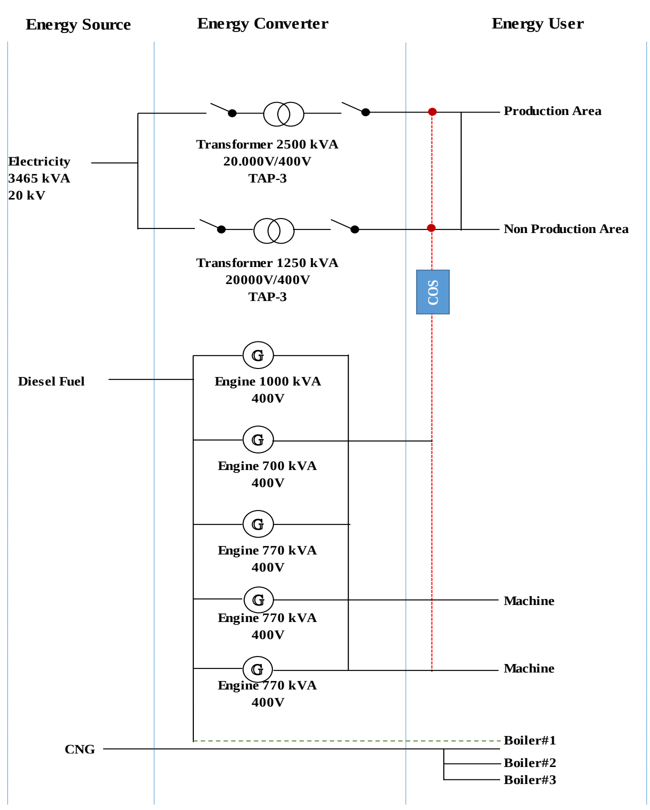

Figure 1: Energy reference system

From the description of the energy reference system, specific patterns of energy use can be identified. An overview of energy use patterns can be seen from historical data as well as from direct measurement data. Based on data on energy use (electricity, CNG & diesel) obtained from January 2019-December 2021, an overview of energy use patterns is as follows.

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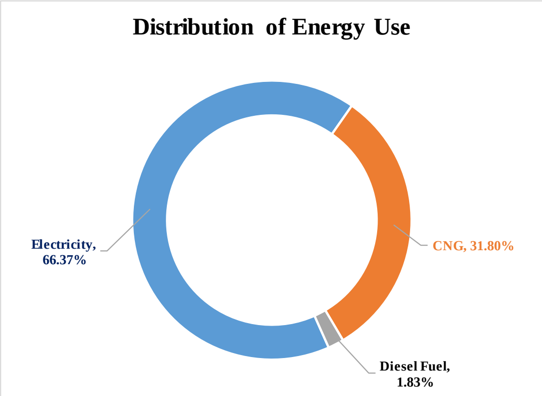

Figure 2: Distribution of energy use

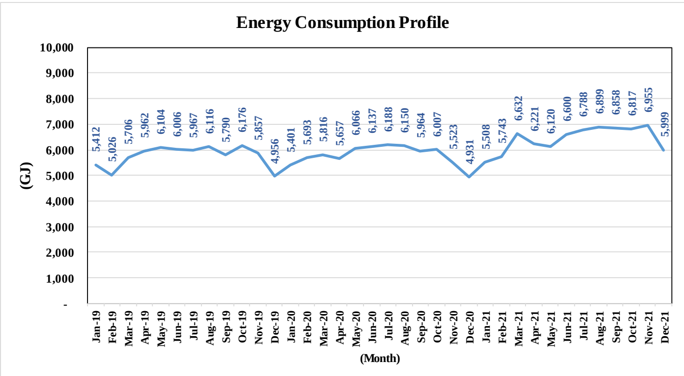

Figure 3: Total energy consumption profile

From the description of the pattern of total energy consumption, it can be seen that the use of electrical energy tends to be greater, namely around 66.37% compared to the consumption of CNG and diesel fuel which only consume 31.80% and 1.83%.

Based on data on total energy use, the average consumption of electrical energy is 1,105.56 MWh/month, while the average consumption of CNG and diesel is 1,895.54 MMBTU and 3.04 liters/month. The use of CNG is specifically for boiler operations while the use of diesel fuel is for generator engine operations and sometimes used for boiler # 1 operations because the type of fuel is dual fuel.

The largest total energy use occurred in November 2021, namely 6,955 GJ, while the lowest energy use occurred in December 2020, namely 4,931 GJ.

When viewed from the total electricity consumption, it can be seen that the largest electricity consumption is borne by the HVAC system floors 1 & 2 in the non-penicillin betalactan production area, which is 10.64% of the Company's total electricity consumption. In terms of equipment systems, the largest electricity consumption is borne by the HVAC system which consumes around 55.56% of the total electrical energy. From the description of the distribution of the use of electrical energy, it can be said that the HVAC system is SEU (Significant Energy Use) which is the main focus in energy conservation activities so that the Company can optimize the use of electrical energy.

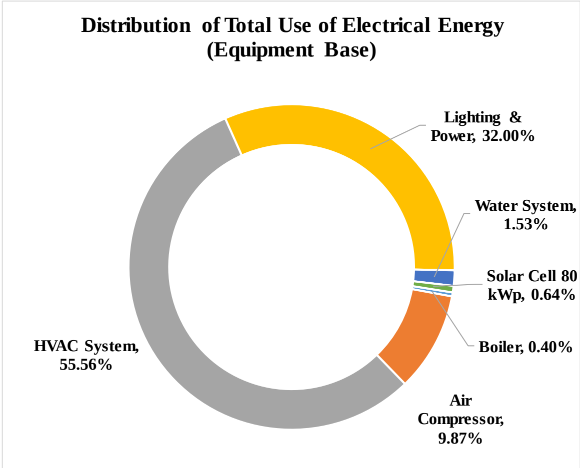

Figure 4: Distribution of total electrical energy

Based on energy consumption data for production process activities, from these data it can be seen the value of the company's actual energy intensity. From the actual energy intensity value, it is also possible to determine the average energy intensity value and the target energy intensity that must be achieved based on the parameters of energy use for activities. From the energy use data obtained from January 2019-December 2021, the following picture of energy intensity is obtained.

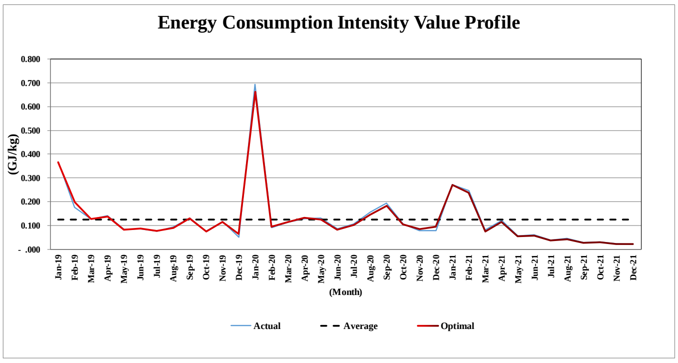

Figure 5: Energy consumption intensity value

From the description of the Energy Consumption Intensity value, it can be seen that the energy intensity value tends to fluctuate between 0.022 and 0.695 GJ/kg. If seen from the value of the average energy intensity, it can be seen that the value is 0.125 GJ/kg. From this value, an energy intensity target can be determined based on the value of the product produced each month. When viewed from the energy consumption of the production process every month, it can be seen that the average productivity tends to be "inefficient". It

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is known from the monthly energy intensity value which tends to be greater than the optimal energy intensity value.

Operational costs are a factor in the Company's productivity costs, where apart from administrative costs, energy costs must also be taken into account in the company's daily operations. The components of energy costs charged for productivity activities are electricity, CNG and diesel costs. Based on energy consumption data, an overview of energy costs can be obtained. From the value of energy consumption, the value of the Cost of Energy [COE] can be seen.

In addition to the energy intensity value that can be seen based on production activities, because the resulting production varies, then to determine the optimal energy planning value, multiple linear regression methods can also be used. In order to calculate the optimal amount of energy, the actual energy consumption and production of the various products produced must be determined first. Based on the data obtained, the following describes the energy value and actual production.

Based on the data obtained, it produces the following information:

	X11	X10	X9	X8	X7	X6	X5	X4	X3	X2	X1	C
	0.043606534	2.97144307	-0.0019209	-0.190561214	-0.0107242	0.12297618	0.056921	-0.01071522	0.096618	0.02336162	-0.024324	5755.26
Standar Error	0.145552781	1.79738645	0.019050973	0.577875875	0.01400371	0.190749629	0.354291	0.017856968	0.144221	0.00725035	0.012574	127.335
r^2	0.635273111	380.433533	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
F	3.800241953	24	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	6050085.528	3473512.15	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

From these results, the performance equation can be determined to be:

$$Y = 5755{,}26 - 0{,}0024\ X_1 + 0{,}0234\ X_2 + 0{,}0966\ X_3 - 0{,}0107\ X_4 + 0{,}0569\ X_5 + 0{,}1230\ X_6 - 0{,}0107\ X_7 - 0{,}1906\ X_8 - 0{,}0019\ X_9 + 2{,}9714\ X_{10} + 0{,}0436\ X_{11}$$

Where:

Y = Energy consumption (GJ)
X_1 = Production of Tablets (kg)
X_2 = Production of Coated Tablets (kg)
X_3 = Capsule Production (kg)
X_4 = Liquid Injection Production (liters)
X_5 = Powder Injection Production (kg)
X_6 = Ointment Production (kg)
X_7 = Liquid Syrup Production (liters)
X_8 = Production of Dry Syrup (kg)
X_9 = Liquid Sachet Production (liters)
X_{10} = Sachet Powder Production (kg)
X_{11} = Other Production (liters)

From the regression analysis, the R2 value was 0.635. Therefore, the above equation can be used as an energy indicator equation that refers to the baseline year January 2019-December 2021. Based on energy performance values for various types of products, energy performance is still included in the efficient criteria.

Regarding energy, system operating costs are a factor in productivity costs, where apart from costs, energy costs also need to be taken into account in the company's daily operations.

The energy cost components charged for production process activities are electricity, CNG and diesel fuel costs. Based on energy consumption data, an overview of energy costs can be obtained. From the energy consumption value, the Cost of Energy (COE) value can be identified. The following is the value of energy costs for production process operations.

Table 1: Company Operational Cost (Energy Base)

Enterprise Operating Costs (Energy Base)		
Information	**Value**	**Unit**
Electrical energy	1,104,803	kWh/month
CNG consumption	1,896	MMBBTU/month
Diesel fuel consumption	3.17	Liters/month
Cost:		
Electrical energy	1,100	Rp./kWh
	1,215,283,361	Rp./month
CNG	9.45	US$/MMBTU
	14,500	Rp./US$
	259,735,858	Rp./month
Diesel fuel	12,000	Rp./Liters
	38,079	Rp./month
Total cost	**1,475,057,298**	**Rp./month**
Production	85,533	kg/month
Production Cost Intensity	**17,246**	**Rp./kg Product**

From the description of the value of energy costs, it can be seen that the Company's operational costs in production activities average Rp. 1,475,057,298,-/month with a productivity cost intensity of Rp. 17,246,-/kg. Based on energy costs, the Company can determine energy conservation targets so that it can reduce energy costs in daily activities.

Charging energy directly or indirectly can cause emissions. Emission Factor is a representation of a value that relates the amount of pollutant released into the atmosphere from an activity related to the source of the pollutant. This factor is usually expressed as the weight of the pollutant divided by the unit weight, volume, distance, or duration of the activity emitting the pollutant (eg, kilograms of particulate matter emitted per mega gram of coal burned). In some cases, these factors are simply an average of all available data of acceptable quality.

Based on energy use data, CO_2 emission values based on energy consumption are obtained as follows.

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Table 2: Energy Consumption in CO_2 Emission Units

Energy Consumption in CO_2 Emission Units			
Energy	**Energy consumption**	**CO_2 Emission**	**Keterangan**
Electrical energy	1,104,803 kWh/month	800,982.22 $kgCO_2$/month	Based on the CO2 emission factor for the Java Sumatra Bali Region (Indonesia) = 0.725 kgCO2/kWh
CNG	1,896 MMBBTU/month 2,000 GJ/month	112,194.22 $kgCO_2$/month	1 MJ CNG =0,0561 $kgCO_2$
Diesel fuel	3.17 Liters/month	6.98 $kgCO_2$/month	1 liters diesel fuel = 2,2 $kgCO_2$
Total Emissions resulting from energy consumption		**913,183.41 $kgCO_2$/month** **913.18 tCO_2/month**	

Factors that affect emissions can be absorbed into driving force and technological response. Driving force is a factor that encourages increased economic activity and consumer convenience, all of which will increase demand for energy needs; while technological responses offer opportunities to reduce emissions per unit of energy (carbon intensity) used. In general, carbon intensity is influenced by three components:

- End-use energy intensity
- Type of fuel
- Emissions per unit of electrical energy produced

The driving factor is influenced by population growth, building area, private vehicle ownership, mileage, etc. Emission reduction policies must pay attention to the driving factors and existing technological factors. Emission reduction policies can be directed at:

- More efficient use of energy
- The use of fuel types with low carbon content
- Increased use of renewable energy or low-emission energy conversion
- Reduction in activity, for example reducing the number of lights used in the workspace.

By carrying out energy conservation activities, energy use can be reduced directly without having to reduce the value of its productivity so that it can also directly reduce CO_2 emissions obtained from energy sources consumed.

In producing steam in the boiler system several energy sources are needed such as electricity and fuel. Electrical energy in this boiler system is used for several electric motors and fans such as fuel pumps, FD fans, and feed water pumps, while the fuel used to produce steam is CNG or diesel fuel.

Boiler load regulation (load balancing) is part of the energy management program. In general, the technical experience of boiler operation shows that the boiler has the highest efficiency at a load of 65-85% of the design capacity.

Current boiler loading

- Steam load factor in the range of 80-90%
- Manual 6 barg burner On-Off pressure setting system according to production needs
- The boiler will work according to the steam consumption in the production process, while the steam consumption process depends on the rate of the production process

From the operational data, it can be seen the performance of the boiler with the direct method. Based on these data, boiler performance can be calculated directly. The following is the boiler efficiency value based on operating conditions using the direct method.

Table 3: Boilers efficiency (direct method)

Parameter	Value	Information
P	6 bar	Boiler working pressure
h_g	2,764 kJ/kg	Steam enthalpy @boiler pressure
Cp	4.2 kJ/kg ^oC	Water heat capacity
T_{fw}	30 ^oC	Average feed water temperature
GHV gas	1,033 Btu/scf	CNG Gross Calorific Value
	9,241 kcal/m^3	
	38,505 kJ/m^3	
m_s	833 kg/jam	
m_g	186 Nm^3/jam	CNG consumption
Efficiency Boilers	**30.7 %**	**Based on GHV**

The average efficiency of boilers is currently very low, which is around 30.7%. This value illustrates that the boiler system is not optimal. Apart from the efficiency value, the performance of the boiler system can also be seen from the value of the cost of steam where this value provides information on how much steam production costs. Based on operating conditions, the value of cost steam is obtained as follows.

Table 4: Cost of steam

Parameter	Value	Unit	Information
CNG cost	13,000	Rp./m^3	Secondary data
steam (mass base)	1,000	kg	tons of steam
Q	2,637,500	kJ	The heat required per tonne of steam
m_g	223.3	m^3	Gas required per tonne of steam
Gas to steam ratio	223.3	m^3/ton	m3 of gas/tonne of steam
Steam to gas ratio	4.5	kg/m^3	kg steam/m3 gas
Cost of Steam	**2,902,761**	**Rp./tonne of steam**	
	2,903	**Rp./kg of steam**	

Based on the performance recovery data of the boiler system, the result is that the efficiency of the boiler only reaches 30.7% with the price of hot steam Rp. 2,903,-/kg then this provides information that there is a boiler component that is damaged and has an impact on the failure of the steam generation production process.

Activity factors that cause low boiler efficiency values and high steam production costs include heating and activating

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boiler activities. The influence of the damage that occurs to the boiler component is found in the boiler pipe which is the component with the highest proportion of damage. Boiler pipes affect the down time of the production process which is caused by frequent damage in the form of pipe leaks caused by scale deposits that appear on the boiler pipes, causing imperfect heat absorption and resulting in excess heat and pipe leaks. Pipes that experience leaks include generator tubes (evaporator tubes) which function to cool water or speed up the drying process.

The high proportion of damage and total down time indicates the need to replace the boiler unit so that steam generation productivity can operate optimally.

The pharmaceutical industry is required to produce drugs that are of good quality, safe and have appropriate effects. So that the manufacturing process must also be controlled by air conditioning in the room. So that it can provide comfort, work uniformity, and security in all processes. Air control is required to meet the room conditions required by CPOB.

In the production room, the air conditioning system is the main component that uses the most energy, which is around 55.56% of the total electricity consumption. This enormous use makes air conditioning systems a major focus in energy conservation activities.

In conditioning the air in the work/production space using various systems, namely the AHU system with a cooling engine in the form of an air cooled chiller type, ducting split type AC and central AC with different capacities according to the needs of the room.

Based on the distribution of electrical energy use in the HVAC system, it is known that the largest electricity consumption is borne by the HVAC system in building H area, which in its activities carries out the production process of TTSK, TSK and ISS. In the following, the distribution of electrical energy consumption in the HVAC system is presented.

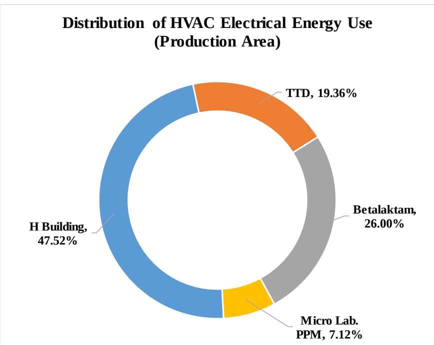

Figure 6: Distribution of electrical energy consumption for HVAC systems

Based on the description of the use of electrical energy in the HVAC system, it can be seen that the largest electricity consumption is borne by building H, which in its activities is the TSK and ISS production area. The electricity consumption in the H building area is 47.52% of the total electricity consumption for the HVAC system.

In this study, the authors reviewed the HVAC system in the production area of building H, where from the overview the distribution of electrical energy in the HVAC system is the biggest load on the HVAC system.

The efficiency level of the HVAC system, which is characterized by the ability to absorb heat from the building compared to the electricity consumed, is a standard number for the efficiency of a building's cooling system according to SNI 6390:2020:

- Air Cooled Chiller type reciprocating with a capacity of < 150 TR of 1.256 kW/TR and COP 2.8.
- Air Cooled Chiller type screw with a capacity of > 150 TR of 1.172 kW/TR and COP 3.
- Water Cooled Chiller type screw with a capacity of > 150 TR of 0.799 kW/TR and COP 4.4.

The figure shows that the refrigeration system consumes maximum electricity to produce the ability to generate heat of 1 ton of refrigeration or 12,000 Btu/hour or 3024 kcal/hour.

Meanwhile, the air distribution system can use a system such as an AHU with chilled water or refrigerant or also use a fan coil system to circulate cold air to the rooms served by the AC system. The choice of cooling system and air distribution is determined by many factors, especially the conditions and location of the placement of the air conditioning system in the building and the price owned by the building owner. In addition, what is very important is the AC system which is designed according to its capacity with the heat load that must be overcome.

From the measurement results of loading conditions (electrical and thermal) on the HVAC system, it can describe the performance of the AC system from each installed AC equipment.

The actual condition parameters of the HVAC equipment can determine the value of system performance. The performance value of HVAC equipment can be seen from the COP value and its performance. If the actual COP value of the AC equipment is <2 or shows a working value of less than 60%, then the AC equipment needs to be repaired or inspected.

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The concept of COP or performance coefficient is the same as efficiency which states the ratio between the amount of the desired result and the cost. The COP value is directly proportional to the refrigeration effect and inversely proportional to the compression work.

Based on these data it is known that the performance values of the HVAC system are as follows.

Table 5: Chiller system performance

Parameter		Green Chiller#3	Green Chiller#4	Green Chiller#1	Green Chiller#2	Chiller#5	Chiller#6
		TTSK Area 1st & 2nd Floor		ISS Area 3rd Floor			
Design:							
Chiller							
Type		Air Cooled	Air Cooled	Air Cooled	Air Cooled	Water Cooled	Air Cooled
Year		Dec-20	Dec-20	Nov. 2017	Nov. 2017	Nov. 2017	Jan. 2017
Refrigerant		R290	R290	R290	R290	R134a	R134a
Drive type		Reciprocating	Reciprocating	Reciprocating	Reciprocating	Screw	Screw
Cooling Capacity	(kWth)	120.38	120.38	231.9	231.9	528	598.4
	(TR)	34.19	34.19	66	66	150	170
Power Consumption	(kW)	33.5	33.5	65.2	65.2	175	200
COP		**3.59**	**3.59**	**3.56**	**3.56**	**3.02**	**2.99**
SEC		**0.9798**	**0.9798**	**0.9879**	**0.9879**	**1.1667**	**1.1765**
B. Cold Water Pump							
Pompa							
Year		2020	2020	2017	2017	2011	2017
Capacity	(m^3/jam)	42	42	42	42	192.4	102
Rotation	(rpm)	1500	1500	3000	3000	1500	3000
Head	(m)	30	30	45	45	123	50
Electric Motor							
Year		2020	2020	2017	2017	2011	2017
Class		F	F	F	F	F	F
Voltage	(Volt)	380	380	380	380	380	380
Current	(Ampere)	15.6	15.6	21.4	21.4	20.9	36
Power	(kW)	7.5	7.5	11	11	11	18
Power Factor		0.84	0.84	0.84	0.84	0.85	0.86
Actual:							
Compressor Load	(kW)	30.7	30.7	61	61	175	190
Chilled Water	T_{in} (°C)	13.1	13.1	12	12	12	12
	T_{out} (°C)	8.8	8.8	8.5	8.5	9	8
	P_{in} (Bar)	3,6	3,6	3	3	2.5	2.5
	P_{out} (Bar)	1,6	1,6	3.5	3.5	3	3
	Flowrate (m^3/h)	16	16	40	40	150	102
	Flowrate (m^3/s)	0.004	0.004	0.011	0.011	0.042	0.028
Chilled Water Pump	P (Bar)	5	5	3	3	3	3
	Power (kW)	6,5	6,5	11	11	11	18
Reference:							
Water							
Density	(kg/m^3)	997	997	997	997	997	997
Cp	(kJ/kg.°C)	4.184	4.184	4.184	4.184	4.184	4.184
Analysis:							
Cooling Capacity	**(kW_{th})**	**79.72**	**79.72**	**162.22**	**162.22**	**521.43**	**472.76**
	(TR)	**22.67**	**22.67**	**46.13**	**46.13**	**148.27**	**134.43**
COP		**2.60**	**2.60**	**2.66**	**2.66**	**2.98**	**2.49**
SEC	**(kW/TR)**	**1.3543**	**1.3543**	**1.3224**	**1.3224**	**1.1803**	**1.4134**

From the description of the performance value of the HVAC equipment, it can be seen that most of the chiller equipment has good performance or it can be said that the COP value is > 2.5.

Table 6: Comparison of COP and EER values

Parameter	Green Chiller#3	Green Chiller#4	Green Chiller#1	Green Chiller#2	Chiller#5	Chiller#6
	TTSK Area 1st & 2nd Floor		ISS Area 3rd Floor			
COP design	3.59	3.59	3.56	3.56	3.02	2.99
COP actual	2.60	2.60	2.66	2.66	2.98	2.49
Deviation	**27.74%**	**27.74%**	**25.23%**	**25.23%**	**1.24%**	**16.84%**

Parameter	Green Chiller#3	Green Chiller#4	Green Chiller#1	Green Chiller#2	Chiller#5	Chiller#6
	TTSK Area 1st & 2nd Floor		ISS Area 3rd Floor			
EER design	0.9798	0.9798	0.9879	0.9879	1.1667	1.1765
EER actual	1.3543	1.3543	1.3224	1.3224	1.1803	1.4134
Deviation	**38.22%**	**38.22%**	**33.87%**	**33.87%**	**1.17%**	**20.14%**

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Based on actual conditions, it shows that the actual COP value obtained is 2.49-2.98 with a design deviation of around 1.24% -27.74% and an EER value of 1.18-1.41 kW/TR with a design deviation value of around 1.17% - 38.22%. COP and EER values can still be increased so that performance is more optimal. The greater the cooling load, the greater the compressor work. The COP value can be optimized by optimizing the cooling effect value. One that can optimize the cooling effect because the inlet and outlet temperature differences are getting bigger, the bigger the inlet and outlet temperature differences, the COP value will be even bigger.

From the description of the performance of the HVAC system, information is obtained that the savings value is obtained through several things, namely:

- Perform cleaning on the air suction surface of the AHU so that more fresh air is breathed
- Improve insulation on AHU cooling water pipes so as to reduce heat loss.
- Replace the temperature and pressure monitoring devices on each air duct and air duct so that their operation can be regulated and monitored properly
- Improve chilled water quality to optimize cooling
- Replace the roof/canopy on the roof of a building where the condenser position is not directly exposed to the sun's heat so as to optimize cooling on the condenser side.
- Mark the direction of cooling water flow (in/out)
- Record energy management (eg per 1 hour)

IV. CONCLUSION

From the results of this research activity it can be concluded that there are opportunities to improve energy performance and provide added value such as achieving a level of work comfort and increasing safety values.

Based on data on energy use in the productivity process, the Energy Consumption Intensity [IKE] value ranges from 0.020-0.695 GJ/kg. From the IKE value, in each productivity process the average IKE value can be used as a reference as the limit value for energy conservation at Phapros Tbk, which is 0.125 GJ/kg.

To optimize energy management, it is necessary to take corrective or maintenance actions for units that already have energy conservation opportunities. For that, the steps that need to be taken are as follows:

1) To support and evaluate the use of electrical energy, an electrical energy monitoring system per area can be installed.
2) Replacement of boiler units due to the high proportion of damage so that steam generation productivity can operate optimally.
3) Redraw the schematic diagram of the boiler & steam distribution system and the HVAC system for optimization in system evaluation.
4) Improving the quality of air cooling by cleaning the air suction surface on the AHU so that more fresh air is breathed
5) Improve insulation on AHU cooling water pipes so as to reduce heat loss.
6) Replacing the temperature and pressure monitoring devices on each air duct and air duct so that their operation can be regulated and monitored properly.
7) Improving the quality of chilled water to optimize cooling by installing a roof/canopy on the roof of a building where the condenser is not directly exposed to the sun's heat so as to optimize cooling on the condenser side.
8) Record energy management (eg per 1 hour) and mark the direction of cooling water flow (in/out).

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