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Statistical Analysis Of Pharmaceutical Industry Energy Saving Potential By Benchmarking

Sukono Sungkono[1)], Burhan Bungin [2)], Damelina Basauli Tambunan[3)]

[1),2),3)] *Management, University, CitraLand CBD Boulevard , Surabaya, 60219, Indonesia*

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ABSTRACT

This study focuses on identifying and quantifying the potential for energy savings in the pharmaceutical industry through a comprehensive energy audit approach. This analysis enabled the identification of electricity usage patterns, assessment of operational efficiency, and evaluation of overall energy performance indicators. The results reveal a consistent year-over-year increase in energy demand, exceeding the projected electricity supply from the grid. These findings highlight the urgent need for energy optimization strategies, such as the adoption of advanced energy management systems, process optimization, and investment in renewable energy integration, to ensure sustainable operations and mitigate the risks of future energy shortages. By providing actionable insights and quantifiable metrics, this research contributes to supporting decision-makers in the pharmaceutical sector in planning energy-efficient operations and aligning with sustainability goals.

Corresponding Author:

Sukono Sungkono
Management, University, CitraLand CBD Boulevard , Surabaya, 60219, Indonesia
Email: ysungkono@yahoo.com

INTRODUCTION

Energy saving is a term for calculating the ratio of outputs to inputs. Energy savings refer to the level of energy use in a process (physical and non-physical processes) for calculating an energy output in the form of service production [1]. Research on electrical energy saving is a simulation used to control the achievement of a better energy-saving plan on a micro and macro scale for the economic growth of a country. This research shows the formulation of energy used to produce a particular product (PP No. 70 of 2009). The results of a study will be used as a Benchmark or indication to Develop a programme for building a power plant that will support industry in a particular country or region by arranging the time in the stages of power plant development that greatly affects the cost budget that will be prepared periodically in each year or the next five years [2].

Based on the actual industrial energy consumption report from the Office of the Ministry of Environment and Forestry, 2020-2021, where industrial energy consumption in Indonesia is submitted periodically every year, and all running industries are required to report the energy consumption that has been used from daily, monthly, and annually to measure energy needs from the Industrial side and anticipate devisite and to efficiency from future energy consumption [3]. Energy Consumption Intensity in the Pharmaceutical industry 2020 reached 22,410 MGH, and in 2021 reached 19,593 MGH [4].

The benchmarking and statistical analysis highlight important variations across pharmaceutical companies. Specifically, the results indicate that firms differ significantly in operational efficiency, innovation capability, and regulatory compliance. Statistical testing confirms that digital transformation and human resource management practices are positively related to company competitiveness. However, in some cases, HRM practices appear misaligned with organizational strategies, which may explain the weaker impact observed in certain contexts [5].

The problem for the pharmaceutical industry research for energy saving refers to using the IKE value, which is to know the total energy needs in the pharmaceutical energy sector or energy needs on a national scale for consumption for one year and distributed over the amount of production achieved in the forecast [4]. With units set at kWh or Megawatts. The reference value of IKE, used as a benchmarking target for energy savings in each industry, refers to ASEAN - USAID research, which reports the results are published annually [6]

The energy consumption intensity benchmark value is used as a reference for planning electrical energy development in the industrial sector. Still, the forecasting of the level of achievement in the industrial industry against the IKE benchmarking value is not yet known [7].

To determine how many industrial sectors have reached the target in better or worse conditions using electrical energy savings. Research on the pharmaceutical industry sector on the value of the benchmarking reference plan on electrical energy efficiency savings, and it is possible to increase the potential for electrical energy savings in the pharmaceutical industry sector, to be followed up in an applied plan for recommendations on the results of energy audit research [8].

MATERIAL AND METHODS

This research uses the energy survey method, which uses data from the Department of Environment's. The data is processed and analysed to extract scientific information from the background data [9]. The data used in this study are IKE's annual seasonal data, namely electricity load data for pharmaceutical companies in Indonesia, especially on the island of Java. This data is secondary because researchers do not measure it directly, but the information is obtained from the factory and interviews with several factory workers and management. Below is a map of pharmaceutical factories in Indonesia [10]. The figure 1 below shows the total amount of IKE in each range of pharmaceutical companies in Indonesia, especially on the island of Java. This data is secondary because researchers did not measure it directly, but the information was obtained from the factory and interviews with several factory workers and managementThe figure below shows the total amount of IKE in each range.

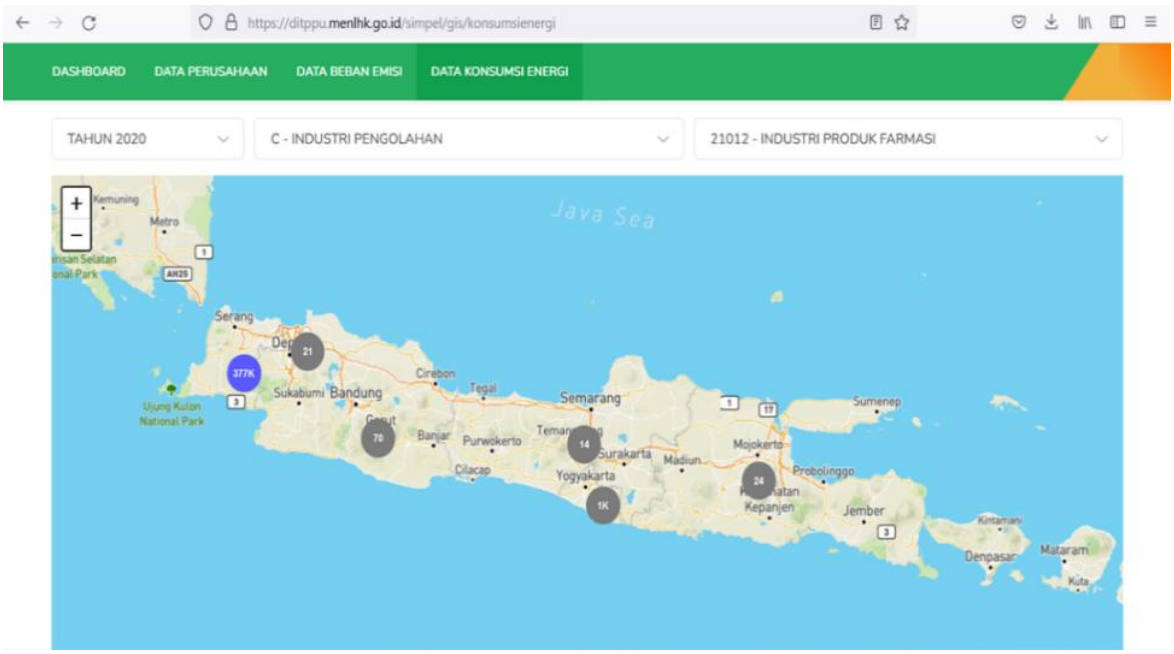

Figure 1. Indonesia Pharmaceutical Industry Map

1. Literature Study
   This research begins with a library research system, namely learning through magazines with similar case studies and the internet and books that can be used as references for learning [11].
2. Data Collection
   Data collection is essential in research, the goal is to get research material. In this study, data was obtained from pharmaceutical factories from the website of the Ministry of Environment, so that this research observation involves researchers directly in conducting experiments, collecting data and making conclusions, that shown in table 1.

Table 1. Secondary data on pharmaceutical industry consumption in Indonesia industry in 2021 & 2020

No.	Area Province	2021				2020			
		Electricity GWH	Crude Oil	Gas M3	Coal Ton	Electricity GWH	Crude Oil	Gas M3	**Coal Ton**
1	DKI Jakarta	24	588,000	642,000	-	21	206,000	304,000	-
2	Banten	-	1,000	200	-	-	280	377,000	-
3	Jawa Barat Garut	71	6,222,000	200,000	-	70	5,052,000	584,000	-
4	Jawa Tengah Temangung	21	1,231,000	200,000	8,000	14	811,000	27,000	**7,000**
5	Yogyakarta	0.81	-	249,000	-	1	-	300,000	-
6	Jawa Timur Jombang	23	60,000	300,000	-	24	28,000	300,000	-
	TOTAL	**140**	**8,102,000**	**1,591,200**	**8,000**	**130**	**6,097,280**	**1,892,000**	**7,000**

3. Data analysis
   The survey results and data collection of electricity loads were then analytically applied to existing data from 53 pharmaceutical companies. Using testing using SPSS to obtain linear regression with the dependent variable Electrical_Consumption, and independent variables annual investment, Man Working Hours, Land Area

RESULT AND DISCUSSION

Measurement Model (Outer Model)

Table 2. Outer Loading

	Investasi Tahun	Luas Lahan	Working Hour
IT1	0,630		
IT2	0,633		
IT3	0,818		
IT4	0,769		
LL1		0,752	
LL2		0,819	
LL3		0,679	
LL4		0,736	
LL5		0,768	
MWH1			0,684
MWH3			0,840
MWH4			0,701

Table 3. Average Variances Extracted

	Average Variance Extracted (AVE)
Investment Year	0,514
Land Area	0,566
Working Hours	0,555

Based on the analysis results, all measurement indicators demonstrate strong validity. Each variable has a value exceeding the critical limit, which is more than 0.5. Furthermore in table 2 and table 3, the AVE value also exceeded 0.5, and the cross-loading results show that the correlation between the construct and the indicators in each variable is higher than the correlation with indicators in other variables. Thus, it can be concluded that all indicators used in this study have met the criteria for convergent and discriminant validity.

Table 4. Reliability

	Cronbach's Alpha	rho_A	Composite Reliability
Investment Year	0,687	0,717	0,807
Land Area	0,810	0,826	0,866
Working Hours	0,598	0,616	0,788

The calculations in Table 4 show that all Cronbach's Alpha values are above 0.60 (CA > 0.60) and all Composite Reliability values exceed 0.70 (CR > 0.70). These results indicate that each construct in this study has met reliability standards and can be considered a consistent and reliable instrument for measuring the variables studied.

Structural Model (Inner Model)

Table 5. R-Square

	R Square	R Square Adjusted
Investment Year	0,369	0,356
Land Area	0,397	0,373

The R-square value shown in Table 5 indicates that annual investment has a 36.9% effect. The remaining influence is due to land area, which is 39.7%, and the remainder comes from other variables not discussed in this study.

Table 6. Path Coefficients

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics	P Values
Investasi Tahun -> Luas Lahan	0,420	0,433	0,206	2,037	**0,042**
Working Hour -> Investasi Tahun	0,607	0,617	0,125	4,845	**0,000**

The Path Coefficients test is used as a reference to test the research hypothesis in table 6, with the provision that the hypothesis is accepted if the P value < 0.05 and rejected if P > 0.05. Based on the results of the hypothesis testing proposed in this study, the findings were obtained that:

1. Annual investment influences land area, as indicated by a t-statistic of 2.037 and a P-value of 0.042. Since the P-value is <0.05, this hypothesis is accepted.
2. Working hours influence annual investment, as indicated by a t-statistic of 4.845 and a P-value of 0.000. Since the P-value is <0.05, this hypothesis is accepted.

DISCUSSION

Analyse the Use of Statistics in Benchmarking

Benchmarking uses statistical principles. These statistics are mainly used to determine the baseline for the starting year as a comparison for subsequent years. To determine the starting level, the values obtained by the pharmaceutical industry were calculated as mean, minimum, maximum, median and standard deviation [12]. These values can be used as a reference to determine it. The information is better since this method uses statistical methods [10] The minimum number of samples can be used to classify the pharmaceutical industry in each category. The cumulative percentage chart is then classified by category. The categories used are poor, average and good [13].

The pharmaceutical industry used as a case study is a drug/pharmaceutical factory on the island of Java. According to Table 7, the drugs produced can be classified into two types. The table also contains information on production capacity and production realisation in 2021 [14].

Table 7. Production capacity, production realisation, Liquid and Solid product in 2021.

Solid Product (Ton)	Liquid Product (Liter)
578.392	351.250

Production Process Flowchart

Figure 2 shows a flow chart of the production process of a type of product, namely syrup medicine, as well as energy sources and additives/excipients.

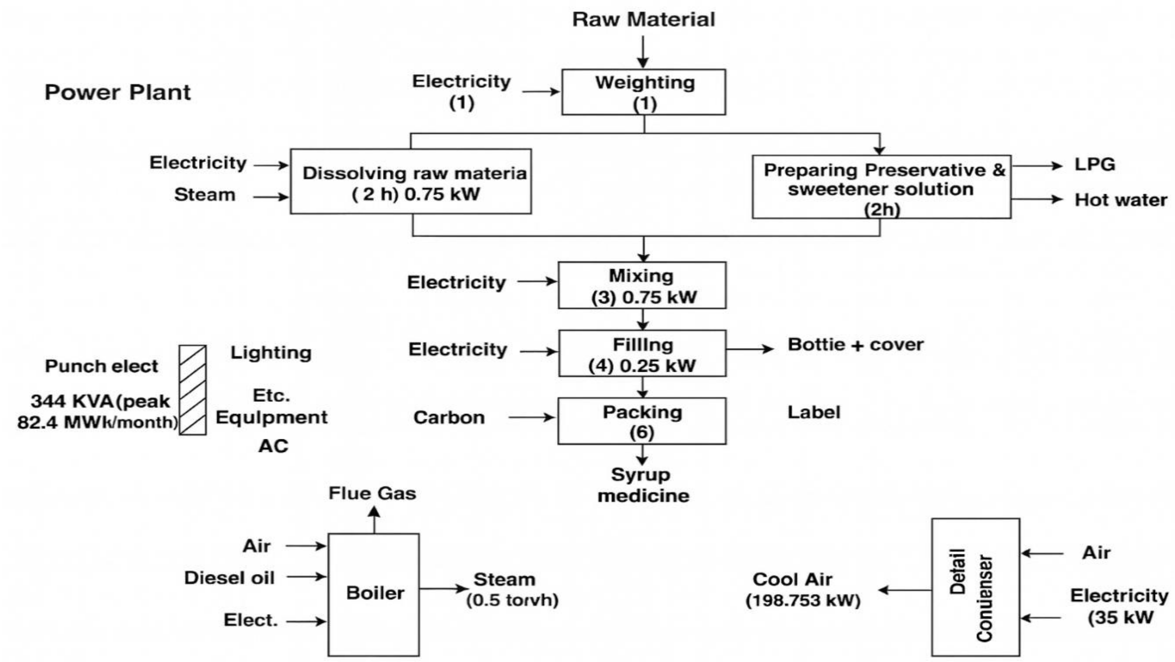

Figure 2 Flowchart of liquid and solid drug manufacturing processes and their energy sources

The mass and energy balance of each part of the production process cannot be described because most processes are not continuous. But it is impossible not to tell them. The amount of input, output, and waste materials can be determined by carefully observing each process that occurs on a particular machine. Similarly, for energy, the amount of energy/electricity required can be determined by knowing the duration of continuous machine usage or by directly measuring the current flowing during machine operation. These results are beneficial when determining the efficiency of the production process regarding equipment reliability, worker productivity and the amount of energy consumed.

Electricity supply and demand

Electrical energy is required to operate various production machines. However, work can continue in this industry despite a power outage. Manual production processes can be carried out as a product, liquid filling, or other methods. Looking at the most critical production costs in 2020, the production costs of the energy cost component (electricity, diesel, gas, coal) amounted to about 166 million kWh of the total production costs. The PLN grid supplied 137,322 kWh of electricity for production purposes. Except for production machinery, this power is mainly used for air-conditioning machinery(16). A diesel power generator with an output of 1.92 million kWh is used as a backup generator. It can only be used as a backup power source during a power interruption in the PLN network.

Electricity consumption and the cost paid per kWh consumed over two years (24 months) are shown in figure 3. It shows

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that annual consumption is relatively flat at an average of $1.93 billion per month [15]. The average price per kWh of electricity consumed was IDR 1,444 per kWh compared to industry prices in 2020. This value is relatively low compared to the average industry electricity cost for the same installed capacity and tariff group. For comparison, figure 3 and figure 4 show electricity consumption data and electricity consumption data per kilowatt hour paid by the pharmaceutical industry and two other companies that have the same installed capacity as the pharmaceutical industry and the same type of use, but with lower installed load capacity, This comparative information is also available in graphical Figures 3 and figure 4 show that the electricity price paid per kWh increases as monthly consumption decreases. In fact, in addition to tariffs based on electricity consumption, the price of which varies every month according to the amount consumed, consumers must also pay the installed electricity tariff, which is fixed every month. The higher the installed capacity, the higher the tariff. If the electricity installation is oversized, the price per kWh will also be higher. This is expected in this pharmaceutical industry [16].

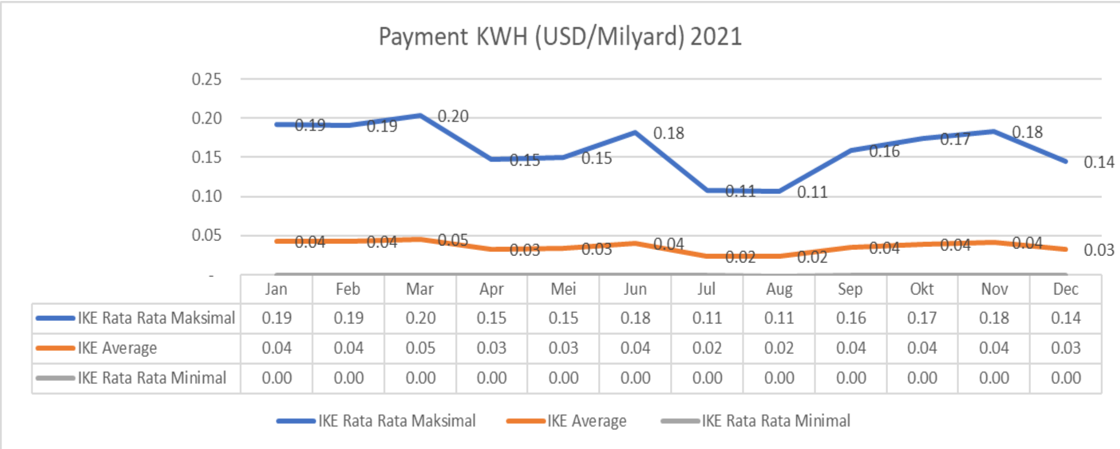

Figure 3. Comparison of average electricity usage per month and price per kWh for installed power

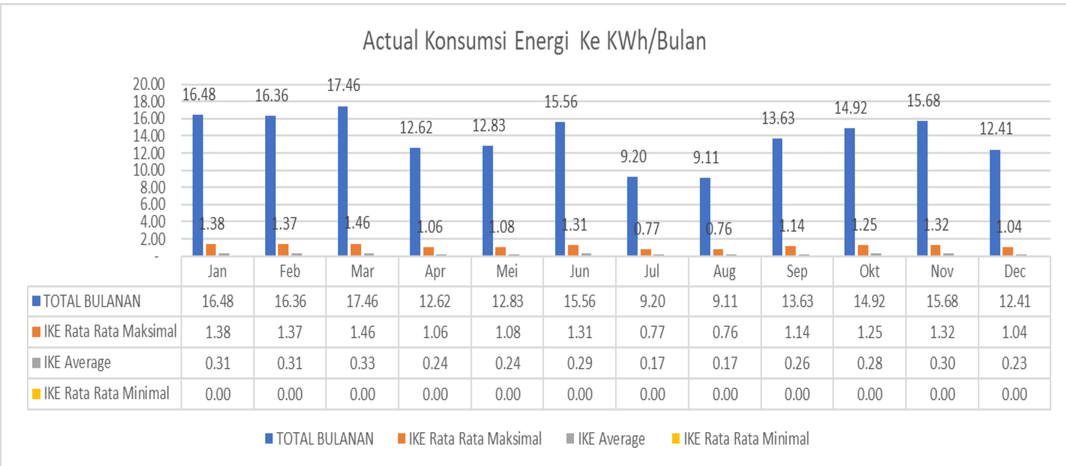

Figure 4. Comparison of electricity usage per month

Alternative technologies to improve energy efficiency

The alternative technologies presented here can be critical considerations when all companies in the pharmaceutical industry plan to introduce new backup production systems. However, economic considerations for these options cannot yet be made, as the investment and operating costs of these two systems (CHP systems and conventional power systems) still need to be fully elucidated [17].

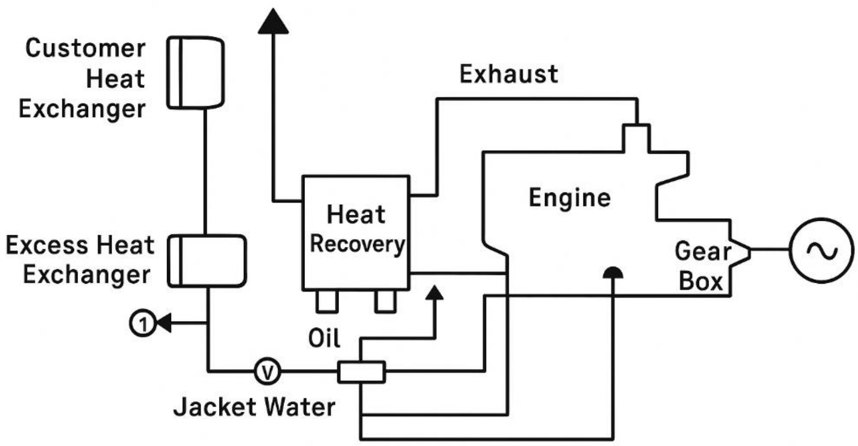

Figure 5. Cogeneration piston engine with its heat recovery system

Overview of investment costs and O&M costs (EPA) based on production capacity and age of the equipment used to support the production process can be shown in figure 5.

The Difference between Energy Efficient and Energy Wasting Companies

An energy-efficient labelled product is an energy-efficient device that meets the energy efficiency requirements and has dimensions specified in the Label for Energy Saving (LTHE) attached to the energy-consuming device. LTHE informs about the energy efficiency of energy-consuming devices with the concept of 'the more stars, the more efficient'. In addition to informing the public, LTHE encourages manufacturers to improve the energy efficiency of their products. Using labels on energy-consuming devices means energy efficiency improvements can be achieved as part of national energy savings. In the context of the government's energy efficiency targets, energy labelling on energy-using devices is becoming increasingly important. This is not only due to the increasing scarcity of non-renewable energy sources but also due to the impact on reducing electricity peak loads, environmental aspects and stricter market requirements for electrical devices' quality and energy efficiency at the regional and international levels. Regulations Related to Energy Conservation

1. Government Regulation No. 70 Year 2009 on Energy Conservation
2. Presidential Instruction Number 13 of 2011 on Energy and Water Saving
3. Minister of Energy and Mineral Resources Regulation No. 14 of 2012 on Energy Management

4. Minister of Energy and Mineral Resources Regulation No. 14 of 2021 on the Application of Minimum Energy Performance Standards for Energy Utilisation Equipment
5. Decree of the Minister of Energy and Mineral Resources Number 103.K/EK.07/DJE/2021 concerning Minimum Energy Performance Standards and Energy Saving Mark Labels for Air Conditioning Energy Utilisation Equipment
6. Decree of the Minister of Energy and Mineral Resources Number 113.K/EK.07/DJE/2021 concerning Minimum Energy Performance Standards and Energy Saving Mark Labels for Refrigerator Energy-Saving Equipment
7. Decree of the Minister of Energy and Mineral Resources Number 114.K/EK.07/DJE/2021 concerning Minimum Energy Performance Standards and Energy Saving Mark Labels for Energy-Saving Equipment Fans
8. Decree of the Minister of Energy and Mineral Resources Number 115.K/EK.07/DJE/2021 concerning Minimum Energy Performance Standards and Energy Saving Mark Labels for Rice Cooker Energy-Saving Equipment.

Energy-Saving Pharmaceutical Company Research

In table 8 pharmaceutical companies in Indonesia that already have the level of multinational companies have a programme to save energy used from the use of water and the use of electrical energy every year with a target of 5%-10% per year to support the production process and the achievement of implementing regulations and energy conservation that have been used as guidelines from the Indonesian government.

Table 8. The following are companies that have implemented energy savings

No.	Company Name	Total Energy Consumption	Unit
1	PT Dankos Farma	24.76	MWh
2	PT Merck Tbk	17.34	MWh
3	PT Novartis Indonesia	30.94	MWh
4	PT. Actavis Indonesia	12.40	MWh
5	PT. Bintang Toedjoe Pulogadung	37.12	MWh
6	PT. Glaxo Wellcome Indonesia	12.01	MWh
7	PT. Kimia Farma, Tbk. - Plant Jakarta	12.40	MWh
8	PT. Soho Industri Farmasi (Soho Group)	27.23	MWh
9	PT Bayer Indonesia	92.78	MWh
10	PT Darya-Varia Laboratoria Tbk Plant Gunung Putri	28.55	MWh
11	PT Kimia Farma Tbk. Plant Banjaran	17.84	MWh
12	PT Mitsubishi Tanabe Pharma Indonesia	7.14	MWh
13	PT. Ethica Industri Farmasi	71.37	MWh
14	PT. Kalbe Farma, Tbk.	21.41	MWh

No.	Company Name	Total Energy Consumption	Unit
15	PT. Kimia Farma (Persero), Tbk. - Plant Bandung	3.21	MWh
16	PT Phapros Tbk	31.87	MWh
17	PT Meiji Indonesia	9.33	MWh
18	PT Satoria Aneka Industri	11.67	MWh
19	PT. Beiersdorf Indonesia	4.67	MWh
20	PT. Kimia Farma Tbk. Plant Watudakon	2.33	MWh

CONCLUSION

The pharmaceutical industry uses electricity from the PLN grid with an installed capacity of 366 MWh to fulfil its electricity needs. Based on observations and calculations, this installed power is too high compared to the required power. As a result, the price of electricity per kilowatt hour is higher. One reason for this boiler's low efficiency is the high steam demand, which is rarely needed depending on the type of product produced. As a result, the boiler fuel consumption is higher. Under these conditions, potential energy savings can be realised by reducing installed electricity consumption and replacing more energy-efficient devices. From the results and discussion, it can be concluded that the pharmaceutical industry's energy demand will continue to increase until 2050. This increase in energy demand is related to population growth and increased demand for manufactured products. Increased demand leads to increased manufacturing output, thus also requiring more resources/fuel. Return on Investment in the pharmaceutical industry averages under three years, 40.58% (per year). Several water tube boiler units with a capacity of 750-1000 kg supply the steam requirement. The boiler produces steam for the primary production process and heating for air conditioning to achieve the designed room humidity (RH). One reason for this boiler's low efficiency is the high steam demand, which is rarely needed depending on the type of product produced. As a result, the boiler fuel consumption is higher. Under these conditions, potential energy savings can be realised by reducing installed electricity consumption and replacing more energy-efficient devices. From the results and discussion, it can be concluded that the pharmaceutical industry's energy demand will continue to increase until 2050. This increase in energy demand is related to population growth and increased demand for manufactured products. Increased demand leads to increased manufacturing output, thus also requiring more resources/fuel. Return on Investment in the pharmaceutical industry averages under three years, 40.58% (per year). The implication is that if want to increase the efficiency of the problem, the amount of Investment and man working hours need to be considered more thoroughly, taking into account the actual efficiency. The implication of benchmarking is to determine the electrical energy consumption used in the Pharmaceutical Industry from the forecast pad. Further research for all industries is not limited to the current industry. Benchmarking is one method in research for more efficient energy consumption planning.

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BIOGRAPHIES OF AUTHORS

Author 1

Sukono Sungkono A professional in industrial oil and gas project management with more than 17 years of experience. With a strong educational background, he has developed deep expertise in Project Management and Mega Projects within Indonesia's oil and gas industry. Throughout his career, he has been involved in various national strategic projects, including the Jambaran–Tiung Biru Unitization Gas Field Plant Project and the Akasia Bagus Project in Indramayu, serving as a Project Planning & Scheduling Engineer. His expertise includes project monitoring, risk management, the use of control and monitoring tools, cost control, and EPCI project management systems. Equipped with various professional certifications such as PRINCE2 Project Management, Primavera P6, and Primavera Risk Analysis, he remains committed to contributing his best to the advancement of Indonesia's energy industry.

Author 2

Burhan Bungin. Prof. Dr. Burhan Bungin, B.Sc., S.Sos., M.Si., Ph.D., CIQaR., CIQnR., is not only a Professor of Communication Sociology and an expert in research methodology, but also a well-known NGO activist since 1986. He has dedicated time to serve as an NGO consultant and has been active as a senior instructor in various NGOs across Indonesia. Currently, he serves as the Chairman of the Indonesian Qualitative Research Association (IQRA), Founder of the Indonesian Researcher Association (IRA), and Advisor at PT Metiri Aromata Tifa Nusantara. He is also one of the founders of Government Public Relations (GPR) Indonesia and the Center for Communication and Public Policy Studies (PK3P). Since 2018, he has served as a permanent lecturer and the Dean of the Faculty of Communication and Media Business (FIKOM) at Ciputra University.

Author 3

Damelina Basauli Tambunan Lecturer at the School of Business & Management (SBM), Universitas Ciputra (UC), Surabaya since 2007. Currently, she serves as Dean of the School of Business & Management since 2023 and director of the Human Capital Center. Has an interest in developing entrepreneurs and professionals through classroom instruction, training, and workshops. In addition, she is interested in disseminating ideas and solutions through scientific journals, books, research studies, and feasibility studies. Apart from holding a Ph.D. in Management, she is also qualified as a professional lecturer, a professional marketer, and certified in coaching leaders. Topics of writing and thinking generally pertain to innovation, family business, and entrepreneurship.