

Energy Audit and Optimization of Energy Consumption in the Electronics Manufacturing Industry based on ISO 50001:2018

Abudhiya Harits Ulhaq Hadyan¹, Chairul Gagarin Irianto², Syah Alam³
^{1,2,3}Electrical Engineering Departement, Universitas Trisakti, Jl. Kyai Tapa no.1, Jakarta, Indonesia

ARTICLE INFO

Article history:

Received : 13/01/2026

Revised : 10/02/2026

Accepted : 30/04/2026

Keywords:

Electronics Manufacturing Industry;
Energy Consumption Intensity
(IKE); Energy Management System;
Energy Saving Opportunities (PHE);
ISO 50001:2018

ABSTRACT

The development of modern science and technology, especially in the field of industry. Currently, It will grow every year in line with the increasing demand for electricity. The increase will be directly proportional to the increasing needs and production targets in the Electronics Industry. Industries that have a land area of 25.552,76m². In 2022 the total energy consumption of PT XYZ amounted to 8,133.08 MWh with an average of 677.75 MWh per month and is expected to increase by 2% in 2023. This research will focus on computer loads as the most widely used loads in the Electronics Manufacturing Industry. PT XYZ management motivated to optimize and improve the efficiency of energy use with increasing energy demand. Therefore, this research method will determine the value of Energy Consumption Intensity (IKE) and determine Energy Saving Opportunities (PHE) based on ISO 50001: 2018 and using Power Server Application to facilitate assessments, decisions, and quick actions of relevant parties in saving electrical energy in order to minimize waste of electrical energy in accordance with the principles of energy management.. The savings generated by this application reach 77,839 kWh/m² per year and potential electricity cost savings of around Rp 170,780,234.63 per year.



This work is licensed under a Creative Commons Attribution 4.0 International License

Corresponding Author:

Syah Alam

Electrical Engineering Department, Universitas Trisakti, Jl. Kyai Tapa no. 1, Jakarta, Indonesia

Email: syah.alam@trisakti.ac.id

1. INTRODUCTION

The development of modern science and technology, especially in the industrial sector, continues to experience significant growth every year. A variety of new discoveries can provide competitive advantages and alternatives for increasing productivity. Along with this technological advancement, the need for electrical energy also increases. This increase is directly correlated with the increasing demand and production targets of the electronics industry. This includes, for example, the addition of DC power supplies, lighting, inspection machines, and air conditioners. The growing demand for energy resources and industrial products worldwide creates serious challenges for the sustainable development in many sectors [1].

High energy consumption is often caused by the use of inappropriate equipment and poor energy management, therefore an energy audit must be conducted to address the problem [2]. To achieve continuous improvement in energy performance, companies need to implement a systematic approach that includes the preparation and implementation of standards and structured energy management processes. As a comprehensive global framework, the ISO 50001 standard is an Energy Management

System published on June 15, 2011. ISO 5001 provides technical and strategic guidelines for companies in optimizing energy use.

An energy audit is a systematic procedure designed to evaluate energy flows within an industry, identify potential savings, and formulate strategies to improve energy efficiency without sacrificing productivity [3]. The ISO 50001:2018 Energy Management System framework can be implemented with several regulations that serve as references related to energy management, one of which is the Regulation of the Minister of Energy and Mineral Resources No. 13 of 2012 concerning Energy Management Savings, which also regulates a standard value for Energy Consumption Intensity (IKE).

Energy Consumption Intensity (IKE) is an indicator used to measure the amount of electrical energy used by a company in a building. By knowing the value of Energy Consumption Intensity (IKE), strategic steps can be taken to save and optimize energy performance [4]. Energy Saving Opportunities (PHE) are the potential for reducing energy consumption that can be identified through analysis of Energy Consumption Intensity (IKE). By comparing the IKE value with applicable standards, the potential savings that can be achieved can be identified. It should be noted that efforts to save energy should not only focus on reducing energy consumption alone, but must also consider aspects of comfort and productivity in the workplace [5].

Referring to Deny Satyagraha's research which discusses the implementation of ISO 50001:2018 in the tire manufacturing industry, it examines efforts to optimize energy use at Plant X, a tire production facility owned by PT. Ban Indonesia which faces the challenge of inefficient energy consumption. The method used in analyzing the data is in the form of requirements referring to the ISO 50001:2018 standard and the calculation of energy consumption intensity (IKE) and specific consumption (KS). Plant X has a high level of energy consumption but low efficiency due to unutilized power and over-supply. This encourages the need for an energy audit to identify opportunities for savings and optimization [6].

In this study, PT. XYZ is a manufacturing industry that produces electronic products and will use a quantitative method based on the ISO 50001:2018 framework in companies that consume fossil energy from PLN sources. The industry has a land area of 25,552.76 m². In 2022, the amount of energy consumption of PT. XYZ is 8,133.08 MWh with an average of 677.75 MWh per month, and is estimated to increase by 2% in 2023. PT. PLN as the main source of electricity provides electrical energy with a power contract of 3,465 kVA at a 20 kVA substation. Therefore, analysis and optimization of electrical energy use are needed for the implementation of energy management based on the ISO 5001:2018 system.

Some companies, as part of their environmental policies and commitments, set goals to reduce energy consumption. However, due to various factors (lack of indicators, a methodology that does not adapt to the production method, among others), the stated objective is not achieved. Despite its benefits, energy efficiency can encounter barriers in various areas, including behavioural, financial, economic, political, regulatory, awareness, information, and organizational [7]. PT XYZ management is motivated to optimize and improve energy efficiency with increasing energy needs. To do these two things, an energy audit and management are needed [8].

2. RESEARCH METHOD

2.1. Energy Audit

An energy audit is the first step in implementing energy management. Identifying potential energy waste in energy-using systems, planning, analyzing, evaluating, and suggesting actions to improve energy efficiency are all part of an energy audit.

Research methodology in energy management involves a systematic approach to understanding, analyzing, and managing energy use in an organization. Figure 1 below show energy audit research flowchart.

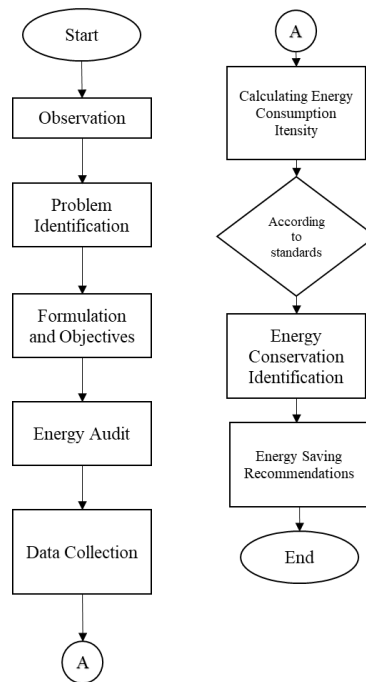


Figure 1. Energy audit research flowchart

This research applied a systematic methodology to evaluate energy use and propose improvements based on the principles of the ISO 50001:2018 Energy Management System Standard. The study began with field observation to understand the company’s operational conditions and identify existing energy-related issues. The main problem identified was the absence of an ISO 50001:2018–based Energy Management System, which potentially causes inefficient energy use and higher electricity costs. Based on this problem, the research objectives were formulated to design a more efficient energy management approach. An energy audit was then conducted in an electronics manufacturing industry located in Karawang, covering a total building area of 25,552.76 m². Data were collected using documentation tools such as Microsoft Word and Microsoft Excel, supported by relevant literature as references for analysis. The collected data were used to calculate energy consumption intensity based on building area according to applicable regulatory standards. Furthermore, the audit results were analyzed to identify potential energy conservation opportunities in each room or operational area. Finally, recommendations were proposed to improve energy efficiency and support the implementation of an effective energy management system.

2.2. Energy Management System ISO5001 : 2018

A systematic and comprehensive method for using energy effectively, efficiently, and rationally without sacrificing the quantity or quality of a building's primary activities is known as energy management. Monitoring, assessing, and regulating a system's energy consumption to achieve maximum energy efficiency is the primary goal of energy management. Energy efficiency plays a crucial role in a clean energy transition of the industrial sector [9]. The implementation of energy management is crucial given the recent rise in energy costs [10]. The following are some programs that can be applied in management:

1. Increase energy efficiency through audits energy
2. Collect and analyze energy usage data At the moment
3. Save energy
4. Prepare the energy sources needed in the energy budget

2.3. Electrical Energy Consumption Intensity (IKE)

The regulation issued by the Government regarding Energy Consumption Intensity (IKE) is contained in the Minister of Energy and Mineral Resources Regulation Number 13 of 2012. This regulation aims to serve as a basis for planning, monitoring, and evaluation. The ECI value is an

indicator for measuring energy efficiency in a room. ECI parameters can be categorized into four categories, namely very efficient, efficient, fairly efficient, and wasteful, as shown in Table 2 below [11].

Table 1. Category of IKE parameters

Class	Room with AC	Room Non AC
	(Kwh/m2/month)	(Kwh/m2/month)
Very Efficient	< 8.5	< 3.4
Efficient	8.5 - 14	3.4 – 5.6
Quite Efficient	14 – 18.5	5.6 – 7.4
Inefficient	>18.5	>7.4

Energy Consumption Intensity (IKE) to calculate Electrical Energy Consumption Intensity (IKE) is the ratio of electrical energy consumption over a certain period of time to the amount of time required. IKE is usually calculated over a period of one year using building area units. This formula can also be used to write it, in equation (1) [12]:

$$IKE = \frac{kWh}{m^2} \tag{1}$$

Information:

IKE = Energy Consumption Intensity. (kWh /m²).

kWh = Consumption energy (kWh).

m²= unit of area (m²)

2.4. Energy Saving Opportunities (PHE)

Particularly, energy saving is considered the most economical energy source since it can provide, at a cheap cost, a great reduction in CO2 emissions and save investments on infrastructures and new energy sources [13]. This implies that the potential or opportunity increases as the price of energy intensity achieved relative to the target energy intensity. The target achieved must be in accordance with the standard. Thus, the Energy Consumption Intensity analysis produces potential energy savings, which are then compared with the current applicable standard using SNI. The following calculation offers savings opportunities if the IKE value is higher than the general IKE, in equation (2) [14].

$$PHE: \frac{\Delta IKE \times \text{total area} \times \text{tarif listrik}}{12 \text{ bulan /tahun}} \tag{2}$$

Information :

PHE = Energy Saving Opportunity (kWh)

ΔIKE = IKE value obtained – IKE value obtained targeted

kWh = Consumption energy (kWh).

PHE value is a parameter in carrying out opportunity programs. To optimize energy savings and increase electrical efficiency, we have carried out various stages of energy audits, from the most basic to in-depth analysis [15].

2.5. Power Server Application

PT. XYZ is a manufacturing industry electronics with use automation system in the process . The automation system uses computer (PC) with Power around 300W. The number of PCs used in industry manufacturing the is 447.

It used the high load on computers, the high number of operating hours, and the fluctuating energy consumption, energy-saving processes are necessary. One opportunity is the development of power server applications .

Power Server application is designed to conserve energy when the computer is idle *during* employee breaks. The total idle time per day is 60 minutes. It works by automatically putting the computer to sleep when not in use, maximizing the potential of idle time. The following is a screenshot of the Power Server application, as shown in Figure 2.

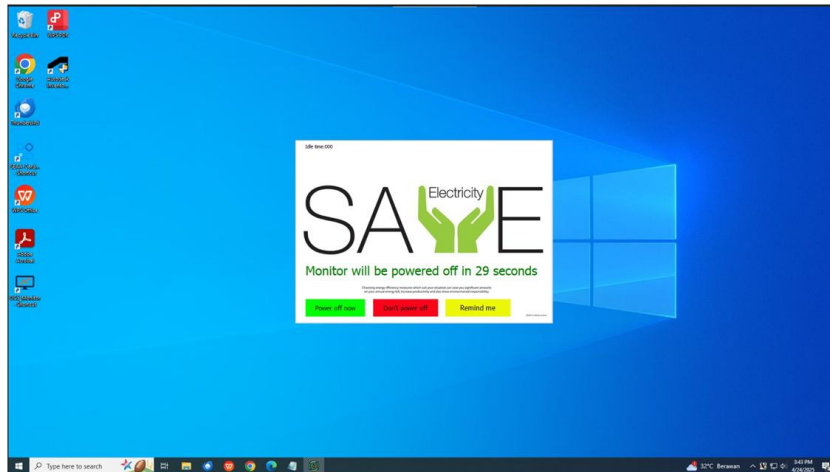


Figure 2. Power server application

The PHE calculation from the savings value using the Power Server application can be obtained from the PHE equation (2.3):

$$\text{PHE computer} = Kc1 - Kc2 \tag{3}$$

$Kc1$ = (Total power consumption in running mode)

$Kc2$ = (Total power consumption in running mode - idle power + Total power in sleep mode power mode)

3. RESULTS AND DISCUSSION

The Following is energy audit results from use PT. XYZ's load before implementing the energy audit method in table 3 .

Table 2. Energy audit

No	Rooms Name	Lenght (mm)	Widht (mm)	Area (m2)	Power Consumption (Kwh)	IKE Before	Type	Category
1	Pantry	5650	5600	31.64	5.690	3.956	AC	Very Efficient
2	Laboraturium 1	5740	5600	32.144	0.904	0.619	Non-AC	Very Efficient
3	Meeting Room 1	3775	5850	22.0838	15.297	15.239	AC	Quite Efficient
4	Meeting Room 2	3400	5850	19.89	15.306	16.930	AC	Quite Efficient
5	Customer Service Room	8750	8046	70.4025	76.141	23.793	AC	Inefficient
6	Laboraturium 2	8750	3350	29.3125	0.824	0.619	Non-AC	Very Efficient
7	Rest Room 1	8750	19200	168	20.460	2.679	AC	Very Efficient
8	Bank	4025	2180	8.7745	14.467	36.272	AC	Inefficient
9	Main Office	15250	53500	815.875	565.208	15.241	AC	Quite Efficient
No	Rooms Name	Lenght	Widht	Area	Power	IKE	Type	Category

		(mm)	(mm)	(m2)	Consumption (Kwh)	Before		
10	Clinic	8750	4300	37.625	16.574	9.691	AC	Efficient
11	Coating Room	8750	5814.94	50.8807	8.226	3.557	AC	Very Efficient
12	RnD Room 1	8750	5501.32	48.1366	10.522	4.809	Non-AC	Very Efficient
13	RnD Room 2	15250	6350	96.8375	36.114	8.205	AC	Very Efficient
14	Quality Control Room 1	8750	11850	103.688	133.584	28.343	AC	Inefficient
15	Part Storage Room 1	8416	8678	73.034	13.224	3.983	AC	Very Efficient
16	Workshop Room 1	13450	17200	231.34	27.026	2.570	Non-AC	Very Efficient
17	Workshop Room 2	13450	11600	156.02	10.836	1.528	Non-AC	Very Efficient
18	Part Storage Room 2	8416	23500	197.776	200.592	22.313	AC	Inefficient
19	Logistic Room 1	17450	10647	185.79	17.633	2.088	Non-AC	Very Efficient
20	Logistic Room 2	17450	6954	121.347	27.774	5.035	AC	Very Efficient
21	Logistic Room 3	8416	5703	47.9964	13.938	6.389	Non-AC	Very Efficient
22	Logistic Room 4	8416	5647	47.5252	1.337	0.619	Non-AC	Very Efficient
23	Driver Room	5812	6150	35.7438	1.005	0.619	Non-AC	Very Efficient
24	Production 1	75250	92796	6982.9	6451.496	20.326	AC	Inefficient
26	General Storage	75250	35500	2671.38	75.132	0.619	Non-AC	Very Efficient
27	Measurement Room	6700	6700	44.89	1.263	0.619	Non-AC	Very Efficient
28	Quality Control Room 2	26925	6700	180.398	152.874	18.643	AC	Inefficient
29	Part Storage Room 3	44750	119500	5347.63	2705.604	11.131	AC	Efficient
30	Meeting Room VIP 1	5250	3900	20.475	28.992	31.151	AC	Inefficient
31	Meeting Room VIP 2	5250	4550	23.8875	11.054	10.181	AC	Efficient
32	Lobby	13750	20350	235.45	64.404	6.018	AC	Very Efficient
33	Musholla	8500	3050	25.925	36.229	30.744	AC	Inefficient
34	Meeting Room VIP 3	7150	10097	72.1936	24.288	7.401	AC	Very Efficient
35	Part Storage Room 4	7150	20350	145.503	27.648	4.180	AC	Very Efficient
36	Production 2	119500	44150	5234.89	5667.686	23.819	AC	Inefficient
38	General Storage 2	5700	11700	66.69	1.876	0.619	Non-AC	Very Efficient
39	Production Storage 2	5700	11700	66.69	1.876	0.619	Non-AC	Very Efficient
40	Building Storage	5700	11700	66.69	1.876	0.619	Non-AC	Very Efficient
41	IT	14600	8750	127.75	147.047	25.323	AC	Inefficient
42	Meeting Room 3	6150	6900	42.435	33.072	17.146	AC	Quite Efficient

No	Rooms Name	Lenght (mm)	Widht (mm)	Area (m2)	Power Consumption (Kwh)	IKE Before	Type	Category
43	Meeting Room 4	8750	6900	60.375	33.206	12.100	AC	Efficient
44	Production Storage 1	17500	23500	411.25	11.340	0.607	Non-AC	Very Efficient
45	Hall	17450	35650	622.093	4.423	0.156	AC	Very Efficient
46	Meeting Room 5	6599	2750	18.1473	8.646	10.482	AC	Efficient
47	Meeting Room 6	6599	2750	18.1473	8.646	10.482	AC	Efficient
48	Meeting Room 7	6599	2750	18.1473	8.646	10.482	AC	Efficient
49	Meeting Room 8	6599	2698	17.8041	8.646	10.684	AC	Efficient
50	Meeting Room 9	8448	5500	46.464	8.356	3.956	AC	Very Efficient
51	Meeting Room 10	6599	5500	36.2945	4.480	2.716	AC	Very Efficient
52	Meeting Room 11	5350	11400	60.99	50.430	18.191	AC	Quite Efficient
53	Director Room	5350	5600	29.96	24.030	17.646	AC	Quite Efficient
54	Secretary Room	5350	3050	16.3175	7.146	9.635	AC	Efficient
55	Training Room 1	8900	10400	92.56	0.868	0.206	AC	Very Efficient
56	Training Room 2	8900	13100	116.59	1.093	0.206	AC	Very Efficient

Result of energy audit data collection and analysis show that there are 10 rooms with IKE value that is still categorized as wasteful so that required the existence of a savings program energy in the room.

Table 3. Sample of audit computer in CS room using power server application

No	Dept	Room Name	Type	Brand	OS Version	Power (W)	Time (h)	Power Consumption (Wh)	Power Sleep Mode (W)	Sleep Mode Time (h)	Power Sleep Mode (wh)	Power Idle Mode (wh)
1	CS	Ruang Customer Service	Laptop	Dell Latitude 3480	win 10	42	4	168	-	-	-	-
2	CS	Ruang Customer Service	Laptop	Dell Inspiron 3459	win 10	65	4	260	-	-	-	-
3	CS	Ruang Customer Service	Laptop	Dell Inspiron 3459	win 10	65	4	260	-	-	-	-
4	CS	Ruang Customer Service	Laptop	Lenovo Thinkpad E14	win 10	45	4	180	-	-	-	-
5	CS	Ruang Customer Service	Computer	Dell OptiPlex 3010	win 10	250	9	2250	1.77	1	1.77	250
6	CS	Ruang Customer Service	Computer	Dell OptiPlex 3070	win 11	200	9	1800	1.62	1	1.62	200
7	CS	Ruang Customer Service	Computer	Dell OptiPlex 3060	win 11	200	9	1800	1.14	1	1.14	200
8	CS	Ruang Customer Service	Computer	Dell OptiPlex 3080	win 11	200	9	1800	1.62	1	1.62	200
9	CS	Ruang Customer Service	Computer	Dell OptiPlex 3060	win 11	200	9	1800	1.14	1	1.14	200

No	Dept	Room Name	Type	Brand	OS Version	Power (W)	Time (h)	Power Consumption (Wh)	Power Sleep Mode (W)	Sleep Mode Time (h)	Power Sleep Mode (wh)	Power Idle Mode (wh)
10	CS	Ruang Customer Service	Computer	Dell OptiPlex 3080	win 11	200	9	1800	1.62	1	1.62	200
11	CS	Ruang Customer Service	Computer	Dell Optiplex 3010	win 10	250	9	2250	1.77	1	1.77	250
12	CS	Ruang Customer Service	Computer	Dell Optiplex 790	win 11	240	9	2160	2.27	1	2.27	240
13	CS	Ruang Customer Service	Computer	Dell OptiPlex 3060	win 11	200	9	1800	1.14	1	1.14	200
14	CS	Ruang Customer Service	Computer	HP 280 G1 MT	win 10	280	9	2520	1.43	1	1.43	280
15	CS	Ruang Customer Service	Laptop	Dell Latitude 3400	win 10	42	4	168	-	-	-	-
16	CS	Ruang Customer Service	Laptop	Lenovo Thinkpad x13	win 10	45	4	180	-	-	-	-
17	CS	Ruang Customer Service	Laptop	Lenovo Thinkpad E14	win 10	45	4	180	-	-	-	-
Total						2569		21376	15.52		15.52	2220

Electricity savings on computer loads using the Power Server application in equation (3) resulted in CS Room savings.

$$Kc1 = 21.376 \text{ Kwh}$$

$$Kc2 = (21.376 - 2.220 + 0.01552) \text{ Kwh}$$

$$\text{PHE computer} = 21.376 - 19.171 = 2.205 \text{ Kwh}$$

The electricity savings in the CS room is 2,205 Kwh per day, so the total savings per month is 48.51Kwh as 1 month as 22 work day. The IKE is :

$$\text{IKE} = 48.51 \text{ Kwh} / 70.4025 \text{ m}^2 = 0.689$$

The following are the results of energy consumption savings generated by the power server application in table 4.

Table 4. Energy consumption savings

No	Rooms Name	Area (m ²)	Power Consumption (Kwh)	IKE Before	IKE After	Δ IKE
1	Customer Service	70.4025	76.141	23.793	23.104	0.689
2	Laboraturium 2	29.3125	0.824	0.619	0.484	0.135
3	Bank	8.7745	14.467	36.272	35.276	0.996
4	Main Office	815.875	565.208	15.241	14.815	0.426
5	Clinic	37.625	16.574	9.691	9.441	0.250
6	RnD 1	48.13655	10.522	4.809	4.355	0.454
7	RnD 2	96.8375	36.114	8.205	7.925	0.280
8	Quality Control 1	103.6875	133.584	28.343	27.852	0.491
9	Part Storage 1	73.034048	13.224	3.983	3.789	0.195
10	Workshop 1	231.34	27.026	2.570	2.357	0.213
11	Workshop 2	156.02	10.836	1.528	1.430	0.098
12	Part Storage 2	197.776	200.592	22.313	22.156	0.157

No	Rooms Name	Area (m ²)	Power Consumption (Kwh)	IKE Before	IKE After	Δ IKE
13	Logistic 1	185.79015	17.633	2.088	1.928	0.160
14	Logistic 2	121.3473	27.774	5.035	4.803	0.232
15	Logistic 3	47.996448	13.938	6.389	5.760	0.628
16	Production 1	6982.899	6451.496	20.326	20.147	0.179
17	Quality Control 2	180.3975	152.874	18.643	18.389	0.254
18	Part Storage 3	5347.625	2705.604	11.131	11.111	0.020
19	Part Storage 4	145.5025	27.648	4.180	4.039	0.141
20	Production 2	5234.885	5667.686	23.819	23.705	0.114
21	IT	127.75	147.047	25.323	24.948	0.375
Total		20,243.01	16316.814	274.302	267.815	6.487

Table 5. Total Energy consumption savings

Area (m ²)	Electric Rate (Rp)	Δ IKE year (kWh /m ²)	PHE (Rp)
20,243.01	1300.6	77.839	170,780,234.63

The Δ IKE year calculate is :

$$\Delta \text{IKE year} = 6.487 \times 12 \text{ months} = 77.839 \text{ kWh /m}^2$$

The PHE year calculate is :

$$\text{PHE} = (20,243.01 \times 1300.6 \times 77.839) / 12 = \text{Rp. } 170,780,234.63$$

Overall, this table shows that with a reduction in energy consumption of 77,839 kWh/m² per year in an area of 20,243.01 m², potential electricity cost savings of around Rp 170,780,234.63 per year can be achieved.

4. CONCLUSION

The Result of energy audit and optimization data collection and analysis show could saving energy that there are 21 rooms from 56 rooms with IKE value that is still categorized as that required the existence of a savings program energy in the room.

Computer load is one of the most widely used energy sources at PT. XYZ, with 447 PCs in use, necessitating an audit of the computer load usage. The Power server application is an application developed by PT. XYZ to save energy in computer use. The savings generated by this application reach 77,839 kWh/m² per year and potential electricity cost savings of around Rp 170,780,234.63 per year.

REFERENCES

- [1] P. Zlateva, A. Terziev, N. Kolev, M. Ivanov, M. Murzova, and M. Vasilev, "Methods for Enhancing Energy and Resource Efficiency in Sunflower Oil Production : A Case Study from Bulgaria," *MDPI*, vol. 6, no. 195, pp. 1–20, 2025.
- [2] D. Almanda and B. Kusuma, "Audit energi listrik pabrik," *Resist. (Elektronika Kendali Telekomun. Tenaga List. Komputer)*, vol. 1, no. 1, p. 25, 2018, doi: 10.24853/resistor.1.1.25-34.
- [3] W. Gunawan, "Mengurangi konsumsi energi dengan audit dan manajemen energi pada ruang kendali," *J. Ind. Serv.*, vol. 4, no. 1, 2018, doi: 10.36055/jiss.v4i1.4099.
- [4] P. T. Helena Hutabarat and M. Fitra Zambak, "Penghematan konsumsi energi melalui analisa ike di kampus 2 efarina pematangsiantar," *Jesce*, vol. 5, no. 1, p. 2021, 2021, [Online]. Available: <http://ojs.uma.ac.id/index.php/jesce>
- [5] W. Gunawan, T. Zakaria, and M. A. Ridlo, "Audit energi listrik pt. niaga nusa abadi dengan

- menggunakan metode intensitas konsumsi energi (ike) dan peluang hemat energi (phe),” *J. Intent (Jurnal Ind. dan Teknol. Terpadu)*, vol. 7, no. 1, pp. 41–49, 2024, doi: 10.47080/intent.v7i1.3533.
- [6] D. Satyagraha, S. Abduh, and I. Kasim, “Manajemen energi di industri: optimasi sisi utiliti pada industri ban,” *Jetri J. Ilm. Tek. Elektro*, vol. 17, no. 2, pp. 191–204, 2020, doi: 10.25105/jetri.v17i2.5362.
- [7] L. Vargas-gurrola, Q. Aguilar-virgen, and S. Balderas-lópez, “PDCA-Based Methodology for the Evaluation of Energy Efficiency in the Industrial Sector,” *MDPI*, vol. 15, no. 12530, pp. 1–17, 2025.
- [8] M. . Catur Trimunandar’, Dr. Ir Dian Retno Sawitri, M.T, Herwin Suprijono, ST, “Audit energi untuk efisiensi listrik di gedung b universitas dian nuswantoro semarang,” *Techno.Com*, pp. 1–7, 2015, [Online]. Available: http://eprints.dinus.ac.id/17544/1/jurnal_16391.pdf
- [9] M. Piccioni, F. Martini, C. Martini, and C. Toro, “Evaluation of Energy Performance Indicators and Energy Saving Opportunities for the Italian Rubber Manufacturing Industry,” *MDPI*, vol. 17, no. 1584, pp. 1–24, 2024.
- [10] R. H. Salim Nur Rohman, Z. Abidin, and M. I. Arsyad, “Energy audit of lighting system, air conditioning system and medical equipment in yarsi pontianak general hospital,” *Telecommun. Comput. Electr. Eng. J.*, vol. 1, no. 2, p. 150, 2023, doi: 10.26418/telectrical.v1i2.72005.
- [11] S. N. Illahi, E. Priatna, and N. Hiron, “Analisis konservasi energi pada sistem pencahayaan dan sistem pendingin di kantor sekretaris daerah kabupaten garut,” *J. Energy Electr. Eng.*, vol. 1, no. 2, pp. 29–36, 2020, doi: 10.37058/jeee.v1i2.820.
- [12] S. Alim, “Audit energi sistem pencahayaan dan sistem tata udara pada gedung admin pltu tanjung jati b unit 3 & 4,” *J. DISPROTEK*, vol. 12, no. 2, pp. 78–84, 2022, doi: 10.34001/jdpt.v12i2.2638.
- [13] G. Bruni, C. Martini, F. Martini, and M. Salvio, “On the Energy Performance and Energy Saving Potential of the Pharmaceutical Industry : A Study Based on the Italian Energy Audits,” *MDPI*, vol. 11, no. 1114, pp. 1–29, 2023.
- [14] F. S. Desky, S. Hardi, and M. Harahap, “Intensitas konsumsi energi listrik dan analisa peluang hemat energi pada gedung a, b Dan m di kampus universitas pembangunan panca budi,” *RELE (Rekayasa Elektr. dan Energi) J. Tek. Elektro*, vol. 4, no. 2, pp. 104–108, 2022, doi: 10.30596/rele.v4i2.9532.
- [15] P. K. Hanawati, B. Minto Basuki, and E. S. Wirateruna, “Audit dan rancangan implementasi manajemen energi listrik berbasis iso 50001 di gedung utsman bin affan (b) universitas islam malang,” *Sci. Electro*, vol. 07, no. 07, pp. 1–6, 2023.