Majority Science Journal (MSJ) Vol. 2 No. 2, May 2024
P-ISSN: 0000-0000; E-ISSN: 3025-1990
Available: https://jurnalhafasy.com/index.php/msj DOI: https://doi.org/10.61942/msj.v2i2.135

Audit Of Kediri Sub-District Office Building For Optimizing Electric Energy

I Wayan Dikse Pancane[1], I Wayan Sutama[2], Made Fandy Santra Ari Gunawan[3], I Wayan Gede Suarjana[4], Yudhi Gunardi[5], Agus Supranartha[6]
[1,2,3] Electrical Engineering Study Program, Universitas Pendidikan Nasional, Denpasar, Indonesia
[4] Dept. of Public Health, Faculty of Sport Science and Public Health, Universitas Negeri Manado, Indonesia
[5] Department of Elekrtical Engineering Universitas Mercubuana (UMB) Jakarta, Indonesia
[6] Departement of Electro Enginering, Elektrical Engineering Program Study Politechnic Negeri Bali, Indonesia
E-mail: diksapancane@undiknas.ac.id

Abstract

An energy audit is a technique used to calculate the amount of energy consumed in buildings and identify ways to reduce it. The Kediri District Office Building currently uses electrical energy efficiently. However, an energy audit is still necessary to determine the amount of electrical energy used, the IKE value, and identify opportunities for energy savings in the Kediri Sub-District Office Building. The data shows that several rooms in the building do not meet the IKE criteria. Out of 13 rooms, 5 are categorized as wasteful, 1 as efficient, 5 as efficient, and 2 as very efficient based on their IKE calculation. To save electrical energy, consider replacing the AC unit and calculating the necessary cooling capacity (PK) for each room based on its area. Additionally, changing the type of load can help meet IKE criteria without compromising the load's function. After implementing the energy-saving method, the Kediri Sub-District Office Building's average monthly electrical energy consumption decreased to 3,233.52, resulting in an annual consumption of 38,802.24. The IKE calculation for each of the 13 rooms showed that 2 rooms were categorized as very efficient, 8 rooms as efficient, and 3 rooms as quite efficient. This resulted in an average energy savings of 746.28 per month and cost savings of Rp. 1,268,325 per month. The English version of the abstract is written using English in the form of past tense and appropriate sentences. Results and conclusions are written in present tense. Abstracts are expected to be more communicative and not monotonous. Text length between 150-250 words. Writing abbreviations and mathematical formulas in the abstract needs to be avoided. The abstract briefly explains the problem, objectives, methods, results and conclusions.

Keywords: *Energy Audit, Electricity Energy Saving, IKE, Efficient, energy consumption.*

1. Introduction

Electricity is a crucial aspect of daily life, particularly in the form of electrical energy (Price, 2021). It is the most used form of energy due to the abundance of electronic devices that require it. The utilization of electrical energy is especially important in building operations and maintenance, as it directly impacts user comfort (Dall'O', 2013). Standards have been established to regulate the use of electrical energy in buildings, ensuring that it is used efficiently and effectively (Hasanbeigi & Price, 2010). Standards have been established to regulate the use of electrical energy in buildings, ensuring that it is used efficiently and effectively. The applicable standard serves as a guideline for building managers to monitor electrical energy usage and identify areas of waste in the event of a spike in power consumption (K. Li, 2022).

To minimize the costs associated with high energy usage, steps must be taken to adopt an energy-efficient lifestyle (Dall'O', 2013). One effective approach is to conserve energy (J. Li & Just, 2018). Energy conservation is the efficient use of energy to maintain consumption levels. It is a crucial activity that promotes national development (Farooq & Al-Qahtani, 2022).

There are various types of energy conservation, including Energy Audit. An energy audit is a process that measures the electrical energy consumption of a building and identifies opportunities for energy savings (International Energy Agency, 2021). This includes identifying energy sources that can be used to save energy. It is important to note that an energy audit does not involve making any changes to the building itself, but rather provides

P-ISSN: 0000-0000; E-ISSN: 3025-1990
Available: https://jurnalhafasy.com/index.php/msj DOI: https://doi.org/10.61942/msj.v2i2.135

recommendations for energy-saving measures (Wu & Zhang, 2020). The process is crucial for reducing energy costs and improving energy efficiency (Jovanović, 2022).

According to Regulation number 13 of 2012 from the Minister of Energy and Mineral Resources (ESDM) regarding the conservation of electricity, all government buildings, both central and regional, must implement energy-saving programs for air conditioning systems, lighting systems, and other supporting systems (No.13, 2012).

To optimize the use of electrical energy and identify energy-saving opportunities (PHE), an energy audit must be conducted at the Kediri District Office Building (Badan Standardisasi Nasional, 2014). This will involve streamlining the use of air conditioning and lighting. The goal of this program is to serve as a reference for improving energy efficiency (Makkar & Ince, 2019).

2. Method

The collected data includes literature and field studies. The literature data consists of historical electricity usage bills for the past year, total energy usage for one month, and the energy consumption intensity per month (Lee, 2020). The methods or steps for energy-saving opportunities that can be applied should be determined. Contains how data is collected, data sources and how to analyze data.

Calculating Total Electricity Consumption Based on Load Type, Quantity, and Working Hour

To calculate the total power load based on the type, number, and working hours of the load, use the following equation: (Mishchenko & Mekhovych, 2022)

$$P\ total = P \times n \times t \quad (1)$$

Calculating the total load to determine daily consumption.

$$\frac{W'}{d} = P1 + P2 + Pn \quad (2)$$

Calculating the total load to determine monthly consumption.

$$\frac{W'}{d} = P/day \times 1\ months\ of\ work \quad (3)$$

Calculating Room Lighting Intensity

When planning a room's lighting installation, calculations are made to determine the number of lights required to achieve the desired illuminance level(Zhao et al., 2013). The layout and number of lights are also considered to ensure adequate illumination. To calculate the number of lamps needed (N) for a room based on the predetermined light intensity, follow these steps:

$$N\ (unit) = E.\ A1.\ \rho/z.\ \emptyset \quad (4)$$

Another way to determine lighting strength or desired intensity is by measuring in lux.

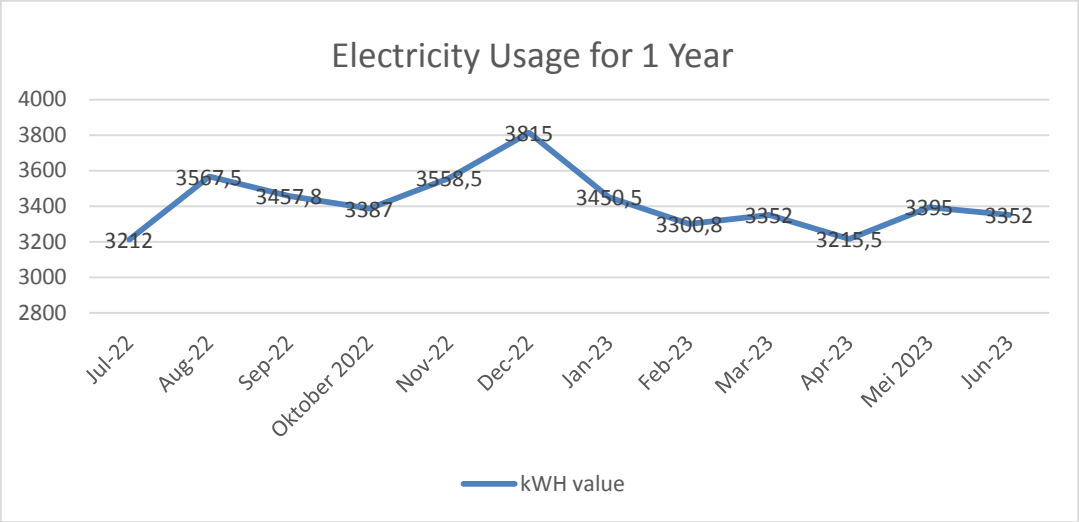
$$z.lux) = N.\ z.\ \emptyset\ .\ \mu/A1.\ P \quad (5)$$

3. Results and Discussion

This document presents the electrical energy usage profile of the Kediri Sub-district Office Building over a 12-month period, from July 2022 to June 2023. Table 1 shows that air conditioning accounts for a significant portion of energy consumption, at 77.6%. The remaining energy is consumed by lighting and office electronic devices. The disproportionate energy use in air conditioning is due to the cooling capacity of the AC not being appropriately sized for the room (International Energy Agency, 2021).

Vol. 2 No. 2, May 2024
DOI: https://doi.org/10.61942/msj.v2i2.135

Electricity Usage Graph in Kediri District Office Building for 1 Year



Source: Data Processing

Table 1. Table of Percentage of Energy Use by Load Type

No	Load Name	Power (Watt)	total	work hours	Total Capacity (kWH)	% Usage
1	AC 2 PK	1700	2	8	27,2	19,4
2	AC 1,5 PK	1100	6	8	52,8	37,7
3	AC 1 PK	900	4	8	28,8	20,5
4	PC	50	12	8	4,8	3,4
5	Printer	10	4	8	0,3	0,2
6	TV LED 42"	35	4	8	0,7	0,5
7	Dispenser	450	4	5	9	6,4
8	Downlight Lamp	25	37	9	8,3	5,8
9	TL	18	8	9	1,3	0,9
10	Sound System	900	1	4	3,6	2,6
11	LCD Proyektor 2500 Lumen	450	2	4	3,6	2,6
	Total				140,4	100

Source: Data Processing

The data below shows the calculation of electrical energy usage and the IKE value for the Kediri Sub-district Office Building:

P-ISSN: 0000-0000; E-ISSN: 3025-1990
Available: https://jurnalhafasy.com/index.php/msj DOI: https://doi.org/10.61942/msj.v2i2.135

Table 2. Data on Electrical Energy Usage and IKE 1st Floor Before Savings in Calculation

No	Room Name	kWh/day (kWh)	kWh/moon (kWh)	Room Size	IKE	Category
1	Subdistrict Room	14,58	364,4	16,32	22,3	Wasteful
2	Sub Space. Officership	7,91	197,6	7,5	26,4	Wasteful
3	Subdistrict Secretary Room	7,91	197,6	7,5	26,4	Wasteful
4	Toilet	0,43	10,8	2,89	3,7	Highly Efficient
5	Sub. General Services Room	11,83	295,6	26,18	11,3	Efficient
6	Finance Sub. Room	9,16	228,87	17,5	13,1	Efficient
7	1st Floor Lobby	15,38	384,47	65	5,9	Highly Efficient
	Quantity	**67,20**	**1679,4**			

Source: Data Processing

Table 3. Electric Energy Usage Data and IKE Floor 2 Before Savings in Calculation

No	Room Name	kWh/day (kWh)	kWh/moon (kWh)	Room Size	IKE	Category
1	Governance Room	8,28	206,87	18,06	11,45	Efficient
2	PMD Kasi Room	9,88	246,87	18,06	13,7	Efficient
3	Social Welfare Kasi Room	9,88	246,87	17	14,5	Quite Efficient
4	Trantib Kasi Room	14,68	366,87	17	21,6	Wasteful
5	Meeting Room	34,97	874,2	42,5	20,6	Wasteful
6	2nd Floor Lobby	14,35	358,67	30	11,95	Efficient
	Quantity	**92,04**	**2300,4**			

Source: Data Processing

Table 4. shows the electrical energy usage data and IKE of the Kediri Sub-District Office Building before savings were calculated.

No	Floor	kWh/day (kWh)	kWh/moon (kWh)	kWh/year (kWh)	Room Size	IKE
1	1st Floor	67,20	1679,4	20.152,8	180	111,96
2	2nd Floor	92,04	2300,4	27.604,8	180	153,36
	Quantity	**159,24**	**3979,8**	**47.757,6**	**360**	

Source: Data Processing

P-ISSN: 0000-0000; E-ISSN: 3025-1990
Available: https://jurnalhafasy.com/index.php/msj DOI: https://doi.org/10.61942/msj.v2i2.135

According to Table 4, the Kediri District Office Building is classified as Energy Efficient based on the IKE Criteria for Standard Buildings 'ASEAN USAID Year 1987'. Therefore, it must be maintained by following the standard procedures set by the company. Based on the calculation of IKE in each room, 5 out of 13 rooms are categorized as wasteful, 1 as efficient, 5 as efficient, and 2 as very efficient.

To improve the efficiency of electrical energy usage in the Kediri Sub-District Office Building, room arrangement and energy-saving measures can be implemented, particularly in the use of cooling loads (Silveira & Mata-Lima, 2020). An electrical energy audit was conducted, and calculations were made according to Table 4.20. The Kediri Sub-District Office Building consumes 159.24 kWh of electrical energy in a day and 3979.8 kWh in a month if all loads are turned on simultaneously. Using the installed load information in Table 7, the total electricity cost for one month can be calculated as follows:

Electricity cost = total usage (kWh) x basic electricity tariff = Rp 6.763.747, - / Month

According to Table 1, air conditioning loads (AC) account for 77.6% of the total installed load in the Kediri Sub-District Office Building, consuming 108.8 kWh/day. Lighting and office electronics account for the remaining load. To save energy, the cooling capacity (PK) needed in each room of the building can be readjusted based on the room area (Gellings, 2020). If the air conditioner installed in several rooms has a cooling capacity (PK) value that does not match the needs of the room or if its value is greater than necessary, it can cause issues. To determine the appropriate Cooling Capacity (PK) value for each room based on its area, use the following formula:

$$\text{Cooling Capacity Value (PK)} = \frac{Area\ (m2)\ x\ value\ Btu/h/m2}{9000} \quad (6)$$

Table 5. Cooling Capacity Value Data Based on Room Area

No	Room Name	Room Size (m^2)	Great AC Before (PK)	AC Quantity	Air Conditioning Size Based on Room (PK)	AC Quantity
1	Subdistrict Room	16,32	2	1	1	1
2	Sub Space. Officership	7,5	1	1	0,5	1
3	Subdistrict Secretary Room	7,5	1	1	0,5	1
4	Sub. General Services Room	26,18	1,5	1	1,5	1
5	Sub Finance Room	17,5	1	1	1	1
6	Governance Room	18,06	1	1	1	1
7	PMD Kasi Room	18,06	1,5	1	1	1
8	Social Welfare Kasi Room	17	1,5	1	1	1
9	Trantib Kasi Room	17	2	1	1	1
10	Meeting Room	42,5	1,5	3	1,5	2

Source: Data Processing

Light Intensity Data for Each Room by Calculation

To calculate the light intensity (Lux) can use the following formula:

$$E\ (Lux) = (N\ .\ z\ .\ Ø\ .\ LLF\ .\ Cu)/A1 \quad (6)$$

The data below shows the light intensity of each room in the Kediri District Office Building:

P-ISSN: 0000-0000; E-ISSN: 3025-1990
Available: https://jurnalhafasy.com/index.php/msj DOI: https://doi.org/10.61942/msj.v2i2.135

Table 6. Light Intensity Data on Floor 1 in Calculation

No	Room Name	Room Size (m^2)	Number of Lights 1 Armague	Lumen	Number of Light Points	Lux
1	Subdistrict Room	16,32	1	2700	3	278
2	Sub Space. Officership	7,5	1	2700	1	202
3	Subdistrict Secretary Room	7,5	1	2700	1	202
4	Toilet	2,89	1	1100	1	213
5	Sub. General Services Room	26,18	1	2700	5	289
6	Finance Sub. Room	17,5	1	2700	3	259
7	1st Floor Lobby	65	1	4800	8	331

Source: Data Processing

Table 7. Light Intensity Data on Floor 2 in Calculation

No	Room Name	Room Size (m^2)	Number of Lamps 1 Armague	Lumen	Number of Light Points	Lux
1	Governance Room	18,06	1	2700	3	251
2	PMD Kasi Room	18,06	1	2700	3	251
3	Social Welfare Kasi Room	17	1	2700	3	267
4	Trantib Kasi Room	17	1	2700	3	267
5	Meeting Room	42,5	1	4800	6	379
6	2nd Floor Lobby	30	1	4800	4	358

Source: Data Processing

IKE Level After the Electric Energy Saving Instrument is Performed

After the electric energy saving method is carried out by replacing the AC unit according to the size of the room, the following data is obtained: :(Chen, 2022)

Table 8 Data on Electrical Energy Usage and IKE 1st Floor After Savings Method in Calculation

No	Room Name	kWh/day (kWh)	kWh/month (kWh)	Room Size	IKE	Category
1	Subdistrict Room	8,18	204,4	16,32	12,52	Efficient
2	Sub Space. Officership	5,35	133,6	7,5	17,81	Quite Efficient
3	Subdistrict Secretary Room	5,35	133,6	7,5	17,81	Quite Efficient
4	Toilet	0,43	10,8	2,89	3,73	Highly Efficient
5	Sub. General Services Room	11,83	295,6	26,18	11,3	Efficient
6	Finance Sub. Room	9,16	228,87	17,5	13,07	Efficient
7	1st Floor Lobby	15,16	379,1	65	5,83	Highly Efficient
	Total	**55,35**	**1385,97**			

Source: Data Processing

Vol. 2 No. 2, May 2024
DOI: https://doi.org/10.61942/msj.v2i2.135

Table 9 Data on Electrical Energy Use and IKE of Floor 2 After Savings Method in Calculation

No	Room Name	kWh/hari (kWh)	kWh/bulan (kWh)	Luas Ruangan	IKE	Categori
1	Governance Room	8,28	206,87	18,06	11,45	Efisien
2	PMD Kasi Room	8,28	206,87	18,06	11,45	Efisien
3	Social Welfare Kasi Room	8,28	206,87	17	12,17	Efisien
4	Trantib Kasi Room	8,28	206,87	17	12,17	Efisien
5	Meeting Room	26,46	661,4	42,5	15,56	Cukup Efisien
6	2nd Floor Lobby	14,35	358,67	30	11,95	Efisien
	Total	**73,93**	**1847,55**			

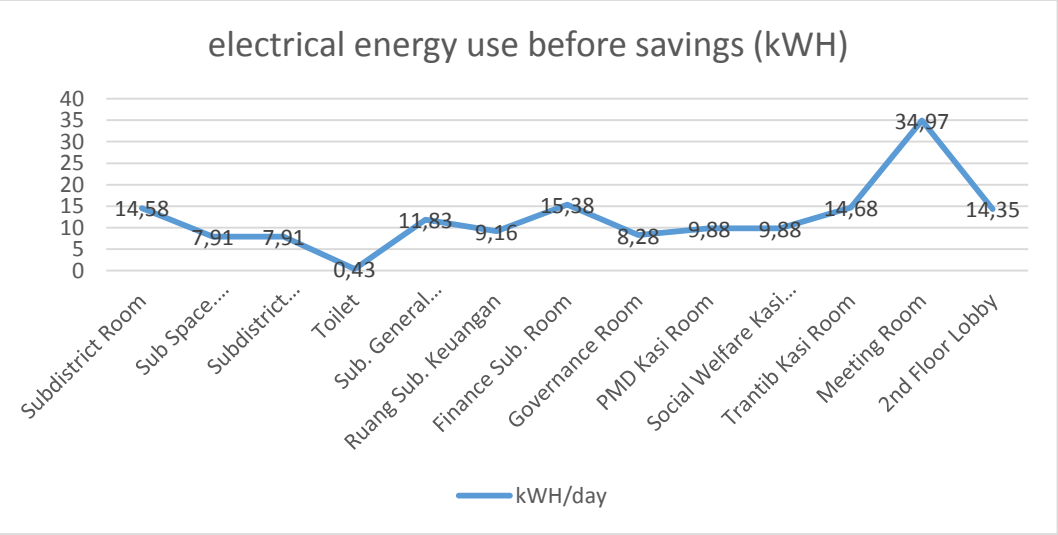
Source: Data Processing

Table 10 Data on Electrical Energy Use and IKE of Kediri Sub-District Office Building After the Savings Method in Calculation

No	Lantai	kWh/day (kWh)	kWh/month (kWh)	kWh/year (kWh)	Room Size	IKE
1	1st Floor	55,35	1385,97	16.631,64	180	92,40
2	2nd Floor	73,93	1847,55	22.170,6	180	123,17
	Jumlah	**129,28**	**3.233,52**	**38.802,24**	**360**	

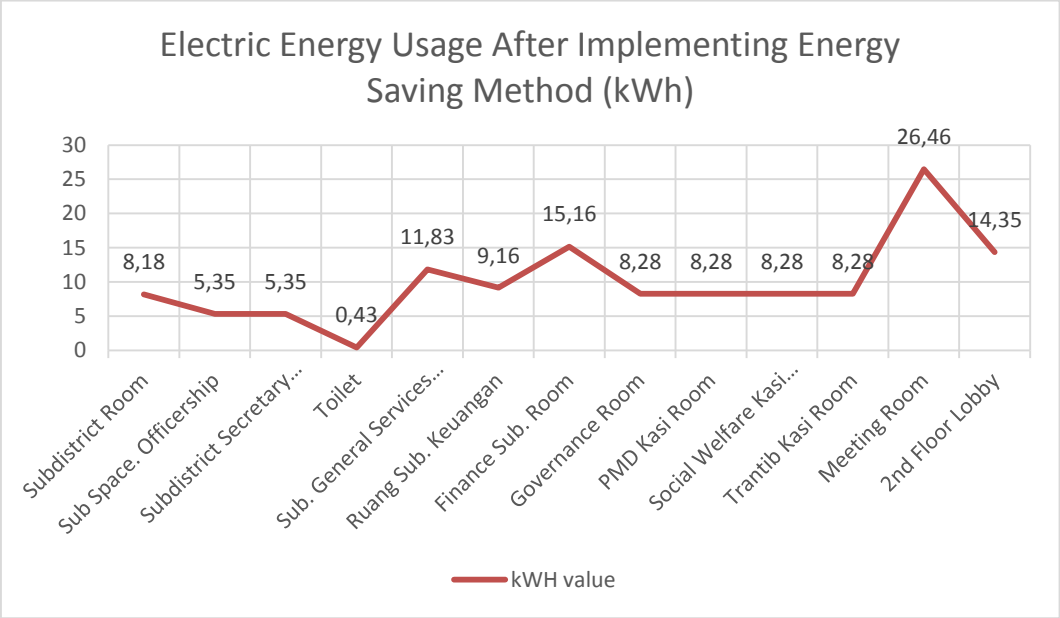
Source: Data Processing

Comparison chart of electricity consumption before and after the energy saving method



Source: Data Processing

P-ISSN: 0000-0000; E-ISSN: 3025-1990
Available: https://jurnalhafasy.com/index.php/msj DOI: https://doi.org/10.61942/msj.v2i2.135



Source: Data Processing

Based on the data in Table 12, the Office of the District Head Building in Kediri is classified as Energy Efficient according to the ASEAN USAID Building Standard Criteria of 1987.

The building's electricity consumption was reduced to 129.28 kWh after implementing energy-saving methods, and it uses 3,233.52 kWh of electricity per month if all loads are turned on. Based on the load attached in Table 12, the total electricity tariff to be paid for one month can be calculated as follows: (Zhang et al., 2012)

Electricity cost = total usage (kWh) x basic electricity tariff (Rp) (7)
= 3.233,52 kWh x Rp. 1699,53 = Rp. 5.493.843, - / Month

Based on the calculations above, the monthly electrical energy usage is 3,233.52 kWh and the corresponding tariff is Rp. 5,493,843/month. The IKE calculation for each of the 13 rooms shows that 2 rooms are categorized as very efficient, 8 rooms as efficient, and 3 rooms as quite efficient.

4. Conclusions and Suggestions

Based on the calculation of the Energy Performance Index (IKE) in each of the 13 evaluated rooms, 5 were found to consume energy wastefully, 1 was classified as moderately efficient, 5 were efficient, and 2 were very efficient. Additionally, after implementing energy-saving methods, the building's average monthly electrical energy consumption is 3,233.52 kWh, or 38,802.24 kWh per year.

Regarding energy efficiency improvement, there is a noticeable change after applying the savings method. Out of the 13 assessed rooms, 2 have reached the highly efficient category, 8 are efficient, and 3 are moderately efficient. This indicates a significant improvement in managing electrical energy at the Kediri Sub-District Office Building.

To reduce the IKE value in each room, one strategy is to replace the AC unit with a cooling capacity that matches the size of the room. Additionally, reducing the working hours of air conditioners can effectively reduce energy consumption without sacrificing user comfort. This effort serves as a good example of achieving optimal electrical energy efficiency in the Kediri District Office Building.

Acknowledgment

We are grateful to all those who supported and assisted us in our research titled 'Energy Audit to Achieve Electrical Energy Efficiency in the Kediri District Office Building.' The support from related parties was instrumental in collecting the necessary data and information for the energy audit of the building. We thank the Kediri Sub-District Office for granting us permission and for their cooperation in the process of data collection and field observations.

Additionally, we express our gratitude to the research team for their hard work and dedication in carrying out the electrical energy audit at the Kediri Sub-District Office Building. Effective collaboration and cooperation among team members are crucial to successfully completing this research. Thank you for your dedication, thoroughness, and hard work in achieving the expected energy efficiency goals.

Finally, we would like to express our appreciation to those who provided input, suggestions, and constructive criticism during the research process. These inputs are valuable in improving the quality of our research. The results of this energy audit can contribute to achieving better electrical energy efficiency in the Kediri District Office Building and benefit the community.

References

Anonim. (2012). Penghematan Pemakaian Tenaga Listrik. *Peraturan Menteri Energi Dan Sumber Daya Mineral Republik Indonesia Nomor 13 Tahun 2012*, 1–14.

Badan Standardisasi Nasional. (2014). *Statistik SNI*. http://bsn.go.id/main/sni/isi_sni/27

Chen, T. A. (2022). Energy Consumption Analysis and Energy-Saving Improvement Methods. In *Energy Saving and Carbon Reduction* (pp. 311–371). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-5295-1_9

Dall'O', G. (2013). Green Energy Audit: General Aspects. In *Green Energy Audit of Buildings* (pp. 9–34). Springer London. https://doi.org/10.1007/978-1-4471-5064-0_2

Dall'O', G. (2023). Definition of the Green Energy Plan. In *Green Energy Audit of Buildings* (pp. 163–209). Springer London. https://doi.org/10.1007/978-1-4471-5064-0_8

Farooq, Z., & Al-Qahtani, A. (2022). Sustainable Energy Efficient Industrial Facility Design. In *Energy Consumption, Conversion, Storage, and Efficiency [Working Title]*. IntechOpen. https://doi.org/10.5772/intechopen.108829

Gellings, C. W. (2020). CO2 Reductions through Expanded End-Use Applications of Electricity. In *Saving Energy and Reducing CO2 Emissions with Electricity* (pp. 39–61). River Publishers. https://doi.org/10.1201/9781003151647-3

Hasanbeigi, A., & Price, L. (2010). *Industrial Energy Audit Guidebook: Guidelines for Conducting an Energy Audit in Industrial Facilities*. Office of Scientific and Technical Information (OSTI). https://doi.org/10.2172/992484

International Energy Agency. (2021). *Saving Electricity in a Hurry*. OECD. https://doi.org/10.1787/9789264109469-en

Jovanović, V. (2022). Conclusions: Energy-Efficient Buildings in Southeast Europe. In *Energy-efficient building design in Southeast Europe* (pp. 109–116). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-24165-0_5

Lee, S. (2020). Changes in Abnormal Audit Fees and Audit Quality during the Audit Contract Period : Focused on Initial Audit. In *Accounting Information Review* (Vol. 38, Issue 1, pp. 107–129). Korean Accounting Information Association. https://doi.org/10.29189/kaiaair.38.1.05

Li, J., & Just, R. E. (2018). Modeling household energy consumption and adoption of energy efficient technology. In *Energy Economics* (Vol. 72, pp. 404–415). Elsevier BV. https://doi.org/10.1016/j.eneco.2018.04.019

Li, K. (2022). *Energy audit for building energy conservation*. The University of Hong Kong Libraries. https://doi.org/10.5353/th_b3125319

Makkar, L., & Ince, M. (2019). Demonstration Of Energy Efficient Houses As Integrated Systems. In *Passive and Low Energy Architecture* (pp. 743–758). Elsevier.

https://doi.org/10.1016/b978-0-08-030581-3.50091-8

Mishchenko, V., & Mekhovych, S. (2022). FINANCIAL CHALLENGES OF INTERNATIONAL BUSINESS EDUCATION. In *Energy saving. Power engineering. Energy audit.* (Issue 7, pp. 18–24). National Technical University Kharkiv Polytechnic Institute. https://doi.org/10.20998/2313-8890.2021.07.03

No.13, P. E. (2012). Penghematan Pemakaian Tenaga Listrik. *Peraturan Menteri Energi Dan Sumber Daya Mineral Republik Indonesia Nomor 13 Tahun 2012*, 1–14.

Price, T. (2021). Energy Audit of MC-1. In *Energy Audit of MC-1*. US DOE. https://doi.org/10.2172/1656619

Silveira, A. P. P. da, & Mata-Lima, H. (2020). Energy audit in water supply systems: a proposal of integrated approach towards energy efficiency. In *Water Policy* (Vol. 22, Issue 6, pp. 1126–1141). IWA Publishing. https://doi.org/10.2166/wp.2020.203

Wu, Y., & Zhang, L. (2020). Evaluation of energy saving effects of tiered electricity pricing and investigation of the energy saving willingness of residents. In *Energy Policy* (Vol. 109, pp. 208–217). Elsevier BV. https://doi.org/10.1016/j.enpol.2017.07.011

Zhang, F., Anta, A. F., Wang, L., Hou, C.-Y., & Liu, Z.-Y. (2012). Network Energy Consumption Models and Energy Efficient Algorithms. In *Chinese Journal of Computers* (Vol. 35, Issue 3, pp. 603–615). China Science Publishing & Media Ltd. https://doi.org/10.3724/sp.j.1016.2012.00603

Febriani, G. S.,dkk. 2023. Pentingnya Kemampuan Berkomunikasi Secara Efektif Dalam Supervisi Hotel.Majority Science Journal (MSJ),Vol. 1No. 3, November.78.

Zhao, L., Liang, R., Zhang, J., Ma, L., & Zhao, T. (2013). A new method for building energy consumption statistics evaluation: ratio of real energy consumption expense to energy consumption. In *Energy Systems* (Vol. 5, Issue 4, pp. 627–642). Springer Science and Business Media LLC. https://doi.org/10.1007/s12667-013-0111-3