International Journal of Business, Law, and Education
E-ISSN : 2747-134X
Publisher: IJBLE Scientific Publications Community Inc.
Volume 5, Number 2, 2024
https://ijble.com/index.php/journal/index

Optimization of Work Systems and Ergonomics to Improve Comfort and Efficiency Through the Implementation of Energy Management

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ABSTRACT
This research aims to implement mall operations that are comfortable, efficient, and effective in energy use and determine the value of Energy Consumption Intensity (IKE). This research uses a qualitative method with a literature study approach. Research data was obtained from measurements carried out by researchers at mall buildings in South Jakarta. Instrument data is obtained from the installed Kwh meter. Data analysis technique by comparing measurement results with data results standardized by the Ministry of Energy and Mineral Resources for IKE and Indonesian National Standards for thermal comfort levels. The research results obtained show that the IKE value is classified as efficient. The IKE value during 2023 ranges from 8,79 – 11,37 kWh/m2/month with the total annual IKE value being 263,16 kWh/m2/year. In terms of air conditioning, the average comfort standard in 2023 will be 25℃ and RH (humidity) at 62.9%.

Keywords:
Optimization of work systems, Ergonomics, Comfort and Energy Efficiency, Energy Management

INTRODUCTION

Shopping centers, which have now shifted their function, are not only places for people to shop, but now they have also become places where various groups gather, both for socializing, and traveling, and also as business centers and meetings between colleagues. With this development, shopping centers will become one of the centers of significant economic and business turnover. Of course, managers need special attention to increase comfort for visitors with various facilities. Not only in terms of comfort, managers must also be able to make the building work system operate well and efficiently in terms of energy consumption. Energy is a basic need that cannot be separated from humans. Almost all sectors of life require energy to meet human needs. To preserve domestic energy resources and increase the efficiency of their utilization, efforts need to be made to implement energy conservation by government regulation No. 33 of 2023 concerning Energy Conservation, where Energy Management must be carried out by Energy Providers, Energy Source Users, and Energy Users when consuming energy in one year exceeds a certain threshold. Apart from that, there is also a need for attention from building managers so as not to neglect visitor comfort, both in terms of lighting and air conditioning. In determining comfortable temperature predictions, occupants' thermal sensations are used (Hermawan et al., 2019b).

Based on the thoughts above, the author in preparing this article took the title "Optimizing Work Systems and Ergonomics to Increase Comfort and Energy Efficiency through the Implementation of Energy Management." Where the author limits this research to discussing the room temperature values in the mall area and also the IKE value (kwh/m2/year) obtained in the building from the results of energy measurements and monitoring in 2023. It is hoped that this article can determine the level of Energy

Consumption Intensity in the building and the author also hopes that this article can later become an additional reference and reference for similar research in the future.

Optimizing work systems is an effort to achieve maximum efficiency in developing and managing a business, with a focus on reducing waste and quickly testing new ideas. "The Lean Startup" by Eric Ries (2011). A work system consists of humans, materials, machines, work methods, and environmental elements. These elements interact with each other so that they can influence the performance of the system. Ergonomics is an interdisciplinary scientific approach to applying the principles of human behavior to the design of human-machine systems, which is directed at the adjustment of machines and auxiliary equipment, to improve performance with conditions that are safe, comfortable, efficient, healthy, and safe at work. The use of the application of ergonomics is to, 1) Improve work performance (increase work speed, accuracy, work safety reduce excessive work energy, and reduce fatigue), 2) Reduce wasted time and minimize equipment damage caused by humans. error", 3) Improving human comfort at work.

The definition of energy management based on ESDM Ministerial Regulation No. 14 of 2012 is the management of effective and efficient energy utilization to produce maximum products through structured and well-documented technical actions that have an impact on the optimal use of raw materials and supporting materials. In energy management in a building, several building systems use electrical energy, and the largest system in a mall building is Ventilation and Air Conditioning (VAC). Based on the role of thumb, the distribution of energy use in buildings for VAC systems is around 62.9%. The term "energy efficiency" is a key term in the implementation of energy management, energy conservation, and energy savings. Because all activities and policies focus on energy efficiency. Energy efficiency is defined as the ratio between beneficial output to the amount of energy input used to produce that benefit. Energy Consumption Intensity (IKE), namely the division between energy consumption and unit area of the building. Energy consumption intensity (IKE) is a term used to determine the level of energy consumption in a building. The energy referred to here is electrical energy. Energy management is carried out by making every effort to regulate and manage energy use as efficiently as possible in buildings without reducing the level of comfort in the residential environment or productivity in the work environment. IKE functions as an indicator of a building's energy performance and is expressed in kWh/m2 units. From the calculation concept, IKE is seen from the amount of energy used by a building to expand the floor area of the Air conditioning area in one month or one year. Calculation of energy consumption intensity: IKE = Total kWh in 1 year / The size of the conditioned area.

Meanwhile, benchmarking energy consumption intensity (IKE) in the mall building sector based on reference data from the Directorate General of EBTKE, Ministry of Energy and Mineral Resources in 2023 is around 350-500 Kwh/m2/year, and also the ASEAN IKE standard is around 192Kwh/m2/year.

Thermal comfort in a room depends on many things, including culture and human customs regarding temperature, humidity, and climate. In addition, odors and air pollution, natural and artificial radiation, as well as building materials, color, and lighting also influence physical and physiological comfort (Frick, 2008: 74). The standards set by SNI 03-6572-2001 have three levels of comfortable temperature for Indonesians, namely:

1. Comfortably cool, between an effective temperature of 20.5°C - 22.8°C
2. Optimal comfort, between effective temperature 22.8°C - 25.8°C
3. Comfortably warm, between an effective temperature of 25.8°C - 27.1°C

Meanwhile, quality air is not just clean and at a comfortable temperature. Proper air humidity levels are also important for our comfort and health. Without being visible to the naked eye, water vapor is all around us. The amount of water vapor affects the level of humidity in the air. Ideally, air humidity should be maintained in the range of 45%-64% (RH). Health experts recommend air humidity levels (or what is called Relative Humidity – RH) in the range of 45% - 65%, as the ideal level.

Previous research was conducted by Muhamad Aris Raharjo and Selamet Riadi in their journal entitled Energy Consumption Audit to Find Out Energy Saving Opportunities in PT Indonesia Caps and Closures Buildings. The results of this research showed that the Energy Consumption Intensity Value at PT Indonesia Caps and Closures during the last year from November 2015 to October 2016 was efficient, with an IKE value of 55.4kWh/m2/year. What will be different from this research is the type of building used as the research object and the thermal comfort value which is measured based on the energy used.

METHOD

The research methodology carried out in this study uses a qualitative method with an approach to collecting data obtained from measurements which will later be analyzed. The data analysis technique used is an experimental technique where the existing measurement results are calculated and compared with data results standardized by the Ministry of Energy and Mineral Resources for Energy Consumption Intensity and SNI standards for thermal comfort levels. The data collection stage is intended to obtain information regarding energy consumption and temperature conditions of the shopping area in the Mall Building. Data collection is carried out in the period January – December 2023. The data required includes. (1) Data or documents relating to the building area. (2) Energy usage measurement data for the period January – December 2023. (3) Average shopping area temperature data for the period January – December 2023. Next, the necessary data processing is carried out, then the next stage is to carry out data processing from energy data and area temperature data. This data processing aims to, (1) Identify the building's energy consumption which will later be useful for seeing opportunities in future energy-saving efforts. (2) To see whether the resulting IKE falls within the limits set by ESDM in the energy-efficient building category. (3) The average temperature value of the area is in the comfortable category or not, given the current condition of the building's cooling system settings.

RESULTS AND DISCUSSION

Based on the data obtained, the total building area in the Mall Building which is the object of research is 78184.51 m2, and the area which is conditioned by air conditioning is 48535.98 m2. The data that has been taken from the total energy used is divided into several system segments based on percentage values including:

Table: i

System	Annual Energy Consumption	% Total Energy
Lighting	775931,50	6,07%
Transportation	352161,80	2,76%
VAC	4626734,20	36,22%
STP	262025,30	2,05%
Pump	115705,39	0,91%
Office	96730,99	0,76%
Other Public Energy	269990,19	2,11%
Tenant Lumpsum	159031,70	1,25%
Other (not measurable)	639037,18	5,00%
Tenant	5475451,75	42,87%
Lighting	775931,50	6,07%
Transportation	352161,80	2,76%
Total Energy	**12772800,00**	

The table above shows that the largest energy use in the building system of the total energy used is in the building's VAC system, which is around 36%. These results can be seen as the highest energy consumption in the building system, so there will be special attention, where this energy becomes the target for later energy efficiency. If we look at the role of thumb for shopping center buildings based on the Benchmarking of Commercial Buildings, UNDP-MTRE3 (BPPT)-KESDM, 2019, the distribution of energy use in buildings for VAC systems is around 62.9%. This means that the distribution of energy use in the mall building where the researcher conducted the research is included in the good category for energy efficiency for the VAC system because it is still below the specified benchmarking.

Energy efficiency carried out in this Mall Building using the VAC system includes, 1) Maximizing cold air circulation by minimizing infiltration of hot air entering the building. This needs to be done so that the air does not enter the building directly but must go through cooling first so that the air temperature also drops. One way is by closing and repairing the perforated side of the return ducting. 2) Set the ON and OFF operational times for the building's VAC system. To suit the conditions of the area's needs and minimize wasted energy. The following are the operational system timings for the VAC system at Gadung Mall that have been implemented. 3) Set the chiller set point at 9.0 degrees to keep the chiller RLA from running limit (< 90% and > 65%). From the system settings that have been carried out, the energy consumption results are obtained as in the table below.

Table: Ii

Unit Chiller	Capacity (TR)	Current Limit	Average Current	CHW Set	Kwh (/Week)
Chiller 1	450	90%	83,43%	8,8^{O}C	15791,0
Chiller 2	450	90%	81,67%	8,8^{O}C	14323,0
Chiller 3	475	95%	79,63%	8,5^{O}C	16067,5

Chiller 4	265	95%	84,63%	8,5^{O}C	4609,3
Chiller 5	480	90%	0	8,5^{O}C	0

From the system settings and scheduling of the building's VAC system, data on the average building temperature in 2023 is obtained. As well as data on the overall energy usage of the building in the last 1 year:

Table: Iii

Zone	Temp. Zone	RH Zone	Average Temp	Average RH
Zone B	25,4 ^{o}C	62,59%		
Zone C	25,1 ^{o}C	63,45%	*25,03 ^{o}C*	*62,9%*
Zone D	24,6 ^{o}C	62,78%		

The calculation of the IKE value for this Mall Building in 2023 is:

Known: Kwh value in 1 year (2023) = 12772800 Kwh
Air conditioning conditioned area = 48535.98 m^2

Energy Consumption Intensity Value 2023:

$$IKE = \frac{\text{Kwh value in 1 year}}{\text{Air conditioning conditioned area}}$$

$$= \frac{12772800}{48535.98}$$

$$= \mathbf{263,16\ kWh/m^2/year}$$

The calculation results above, based on the data obtained, show the recapitulation of the Energy Consumption Intensity value in the mall building where this research was conducted, for the calculation of IKE kwh/m2/year, by calculating the amount of electrical energy used during the year divided by the area of the conditioned area. So the IKE value obtained from this calculation is 263.16 kWh/m2/year. These results show that this building is still in the energy-efficient building category because it is still below the benchmarking set by the Directorate General of EBTKE of the Ministry of Energy and Mineral Resources in the mall building sector in 2023, around 350-500 Kwh/m2/year.

CONCLUSION

Based on the results of the data processing and analysis described in the previous chapter, several conclusions can be drawn including. 1) The value of energy consumption intensity in the mall building where the research took place during the last year from January - December 2023, is in the efficient category with an IKE value of 263.16 kWh/m2/year. Where the standard value for mall buildings based on reference data from the Directorate General of EBTKE of the Ministry of Energy and Mineral Resources in 2023 is 350 - 500 kWh/m2/year. 2) The largest energy consumption in the building system is the VAC system, accounting for 36% of the total energy consumption, where according to the rule of thumb for shopping malls, the

average VAC system energy consumption is 62.9%. This result could be something that needs to be monitored and maintained so that savings on the VAC system in this building remain good and continue to maximize system performance, at least maintaining energy consumption so that it does not exceed the existing role of thumb. 3) The average area temperature value with the average temperature results in 2023 is 25℃ and RH 62.9%. These results fall into the category of optimal and ideal comfort based on the standards set by SNI 03-6572-2001. Based on the results of energy monitoring that has been carried out, it is recommended that companies maintain efficient use of electrical energy in the future. To be able to maintain the efficiency of energy use, tools are needed to monitor energy use so that it can be known if something abnormal occurs and causes waste of energy use. Apart from that, we continue to maintain the air quality in the mall area so that it remains in good condition, by continuing to improve the quality of the maintenance system.

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