CASE STUDY OF ENERGY AUDIT IN CV MANNA ANUGERAH SEJAHTERA BUILDING (INDONESIA)

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ABSTRACT

Energy audit is used in this paper as an method/tool to assess and study the energy profile of a building in Semarang city. CV Manna Anugerah Sejahtera is one of the industry which require the existence of an audit and saving energy. One of the parameters used in the energy audit is the intensity of energy consumption (IKE). IKE is a term used to define the energy consumption of a building. Based on calculations, IKE value of CV Manna Anugerah Sejahtera is 13.14 kWh/m2/year, classified into the category of very efficient. Both calculations for lighting and air conditioning indicated value in very efficient range but this condition is expected to affect work comfort and employee performance. The potential energy saving for the proposed modifications was calculated.

Keywords: *Energy Audit, Energy Consumption, Lighting, Air Conditioning*

INTRODUCTION

Currently, Indonesia is still classified as a country with a large energy waste which can be seen in elasticity and intensity energy parameters. The government itself seeks to improve economy and competitiveness to achieve energy security and overcome global climate change through reducing CO2 emission conserving energy [1].

This energy efficiency can be done by regulating energy, for example by conducting an audit energy [2]. The energy audit in this study was conducted by both walkthrough audit and measurement audit. in other words, the energy audit included preliminary energy audit and detailed one. Preliminary audit focused on obvious energy savings, improvement of the energy management, and cutting down of losses. The preliminary audit aimed to record and analyze energy consumption by sector/ department at minimum costs, identification of obvious energy wastes, rough calculation of energy or money losses and rough calculation on saving potentials, thorough analysis of electricity bill, visual inspection of energy saving opportunities, and determine areas or sectors that need more detail analysis [3].

The detailed energy audit (6 months) aimed to perform detailed recording and analysis of energy consumption by sector/department during a longer and representative time span. Specialized instruments to measure equipment efficiency, and thermal energy were used. Calculation of energy or money losses and possible savings have been done. The three months as an average are sufficient to perform detail energy audit provided that reliable measurement methods with experience engineers and technicians are available. The period of detail energy audit depends on the size of the building and project [4, 5].

RESEARCH METHODOLOGY

Building Envelope and Occupancy

CV Manna Anugerah Sejahtera building is located in Semarang city, Central Java province. The building is rectangular in shape with the front side elevation facing north, rear sight elevation facing south, left side elevation facing east, and right side elevation facing West. The building had 2 floors and 15 rooms. First floor consists of operational room and second floor consist of document storage room and packaging room. Table 1 gives a summary of the building specification. The building envelope is made of reinforced concrete and concrete block also glasswool adding in ceiling.

Table 1. Summary of building specifications

Items	Description	Unit
1	Building power supply	16.5 kVA
2	Total rooms	15 rooms
3	Total building areas	951.76 m^2
4	Total lighting	52 pcs
5	Total Air Conditioner	5 pcs
6	Total exhaust fan	5 pcs
7	Total fan	2 pcs

The building is mainly used for sugar manufacturing and office. All the operating departments are housed in the building. The work is six (6) days a week, eight (8) hours per day. The working hours starts at 8:00 AM up to 4:00 PM but usually work overtime until 6:00 PM. The number of personnel working in the building is around 25.

The energy audit study was planned to start with the building data collection which includes the measurements which include heating ventilation air condition (HVAC) system and lighting system. The gathered data includes but not limited to the following :

1. Electrical equipment such as lighting fixtures, types of air conditions, etc.
2. Measurement of lighting intensity (lux).
3. Measurement of temperature inside the building.
4. Relative humidity

Energy Use Intensity Calculation

Based on SNI No 03-6196-2000 to be able to calculate the IKE value based on the following data [6]:

- Details of building area and total building area (m^2)
- Energy consumption of buildings per year (kWh/year)

- Energy Consumption Intensity of buildings per year (kWh/m^2.year)
- Building energy costs (IDR/kWh)

The formula is interpreted in the following equation :

$$IKE = \frac{total\ energy\ consumption\ (kWh)}{building\ area\ (m^2)} \qquad (1)$$

Ornaments that are important in energy saving are lighting load. One of the biggest burdens in using electricity in a building is lighting, but currently for housing there are still many who use incandescent lamps, while for offices, industries and schools many use fluorescent tube lamps.

LEDs use 80% less energy than incandescent and 30% to 40% than most fluorescent lamps, LED source have longer lifespans than traditional technologies which can save cost on replacement and maintenance also it offer illumination without emitting harmful infrared or ultraviolet radiation [7]. The energy consumption of lighting was evaluated by using lux meter.

The energy consumption of the AC was measured using room thermometer and hygrometer. Existing AC is Panasonic standard 1PK. Energy consumption was measure in one-minute interval over 3 consecutive months, so that the effect of fluctuation of ambient temperature may be assumed to be cancelled out.

Payback Period

Payback period is the time take to obtain return of the money that has been invested. The formula is interpreted in the following equation :

$$Payback = \frac{total\ investment\ cost\ (IDR)}{yearly\ operation\ cost\ (IDR/year)} \qquad (2)$$

RESULTS AND DISCUSSION

Energy Consumption Calculation

The result of monthly energy consumption during the 6 months study period in CV Manna Anugerah Sejahtera is presented in Table 1.

Table 1. Monthly Energy Consumption Data in CV Manna Anugerah Sejahtera

Month	Power source	Power Consumption	Cost (IDR)
October 2020	16.5 kVA	1484 kWh	1.494.721
November 2020	16.5 kVA	893 kWh	900.036
December	16.5	760 kWh	763.882

2020	kVA		
January 2021	16.5 kVA	979 kWh	980.136
February 2021	16.5 kVA	933 kWh	934.082
March 2021	16.5 kVA	1205 kWh	1.081.749
	Total	5049 kWh	5.072.857

The energy use intensity for CV Manna Anugerah Sejahtera based on calculation from the total recapitulation of PLN accounts per building area for the 6 months study period is 1042.33 kWh with 951.76 m2 floor area which can be shown in the Table 2. Based on formula (2) the energy use intensity value is 1.095 kWh/m^2/month or 13.14 kWh/m^2/year.

Table 2. Energy Use Intensity (IKE) Calculations

No	Month	Total KWH per month	Floor area (m^2)	EUI (kWh/m^2) per month	EUI (kWh/m^2) per year
1	October 2020	1484	951,76	1,559	18,708
2	November 2020	893	951,76	0,938	11,796
3	December 2020	760	951,76	0,798	9.576
4	January 2021	979	951,76	1,028	12.077
5	February 2021	933	951,76	0,980	11.76
6	March 2021	1205	951,76	1,266	15.192
	Average	1042,33	951,76	1,095	13.14

Lighting Load

CV Manna Anugerah Sejahtera building used two types of lighting system u, which are mercury lamp 125W and fluorescent tube 40 W. The building doesn't use natural lighting (direct sunlight from the window) due to requirement for production line. The types of lighting fixtures used in the building are shown in the Table 3. The illuminance measurement was carried out in every point of the room using pre-calibrated lux meter.

Table 3. Lighting type

Room name	Lamp type	Duration	Illuminance Result (lux)
Storage	Merkury 6	12 hours	36.06
Baked sieve	TL 1x40	11 hours	65.51
Oven	TL 10x40	11 hours	96.47
Packing	TL 3x40	11 hours	101.76
Laboratory	TL 2x40	11 hours	42.32
Liquid sugar	TL 2x40	11 hours	36.95
Raw sieve	TL 10x40	11 hours	65.51
Mushola	TL 4x40	11 hours	48.92
Director	TL 2x40	10 hours	57.16
Changing room	TL 4x40	11 hours	48.81
Canteen	TL 4x40	11 hours	50.02
Meeting room	TL 4x40	5 hours	57.26
Office room	TL 4x40	11 hours	57.42
Security	TL 1x40	12 hours	49.10
Storage 2nd floor	TL 1x40	5 hours	56.97

Based on the results of a field survey, the lighting load range in CV Manna Anugerah Sejahtera is at range 36 – 101 lux. The data obtained is still far below standard compared with the standard from SNI (150-350 lux). Overall, this condition can be said that the use of energy for lighting has been efficient, but considering the comfort of people working it can be said that this is not ideal.

The type of lamp used on average uses 40 watt TL-T8 lamps and mercury lamps where this type of lamp can still be said to be wasteful. To improve energy efficiency in the future, these lamps can be replaced with LED lamps. Based on the survey results, it is known that the number of lamps surveyed are 52 units with a power of 40 watts each with an average lighting duration of 10.3 hours per day for 6 days a week.

The result of the calculation of lighting needs can be seen in the Table 5. Calculation of the estimated lighting requirements using LED lamps Phillips 20 Watt and for storage room using Phillips LED 40 Watt. From the calculated data, it can be seen that the most needed light points are the warehouse for raw materials and packaging materials, which is indeed the most spacious room in CV Manna Anugerah Sejahtera.

This calculation is based on the standard of comfort limits and potential energy saving. The proposed this solution for number of lighting can be carried out with payback period analysis below

Table 4. Proposed Lighting Replacement

Existing lamp	
Total power	2.08 kW
Duration	10.3 hours
Operating frequency	80.00%
Energy consumption	6170.112 kWh/years
Electricity cost	1007.224 IDR/kWh
	6.214.687,32 IDR/years
Replacement with LED lamp	
Number of lamps	100 pcs
Savings of lamps	20 Watt
Energy consumption	8009.28 kWh/year
Electricity cost	8.067.139,04 IDR/kWh
Investment cost	22.745.000 IDR
Payback period	2.8 years

Air Conditioning

At CV Manna Anugerah Sejahtera, on average, they use 1 PK AC with manual operation and several other rooms use exhaust fan. In table 6 shows average measurements results for air temperature and humidity in CV Manna Anugerah Sejahtera. The existing AC have a life time of more than 8 years. Currently, only few of the rooms in CV Manna Anugerah Sejahtera that have AC, some of them still using exhaust fan. Within 6 months of collecting data, in the table 6 shows air temperature and humidity measurement results. CV Manna Anugerah Sejahtera has an average room temperature of 29.63° C, compared to the SNI Standard for room temperature, the result obtained is still above the comfort limit where the limit for warm and comfortable is around 25.8°C – 27.1°C. As for the humidity at CV Manna Anugerah Sejahtera, the lowest humidity value is 65.10% for room without AC, 59.31% for exhaust fan and 50.10% for room with AC. Based on SNI Standard which says that for a tropical climate the humidity is 50% - 70%, all rooms are still included in the category according to SNI .

Table 5. Average Temperature and Humidity Measurement

Rooms	Temp (°C)	RH (%)	Air system
Warehouse	30.52	74.68	Non AC
Baked sieve	30.65	59.31	Exhaust fan
Oven room	30.39	63.41	Exhaust fan
Packing room	27.57	50.13	AC 1 PK
Laboratory	28.81	50.21	AC 1 PK
Liquid sugar	30.43	68.53	Exhaust fan
Raw sieve	30.44	62.71	Exhaust fan
Mushola	30.85	65.10	Non AC
Director room	27.57	50.19	AC 1 PK
Changing room	30.86	65.10	Non AC
Canteen	30.85	65.48	Fan
Meeting room	27.55	50.10	AC 1 PK
Office room	27.58	50.14	AC 1 PK
Security	30.85	65.48	Fan
Storage 2nd floor	29.57	63.43	Exhaust fan

For a room with temperature that does not meet the standard, it can be caused by several things, such as the age of the air conditioner or an on exhaust fan. The replacement of AC system was studied and taking into consideration two options. First consideration is partial replacement of AC system which includes the electronic parts of AC and the controller. Second is full replacement AC system. Table 7 shows these option including the cost needed for each one.

Table 6. A/C's improvement option and cost

Options	A/C system option	Cost (IDR)
1	Cleaning service	65,000
2	Overhaul	350,000
3	Adding Freon R22/R32	150,000/200000
4	Change capacitor	225,000
5	Bracket & sensor	250,000
6	Thermistor	150,000
7	Installation service	250,000
8	Replacing new AC R32	4,290,000

In the case 6 months of research, due to since the beginning of CV Manna Anugerah Sejahtera establish they never change the A/C until now so every month they need to do cleaning service and every 6 months need to adding freon. The existing A/C still use freon R22 with power 840 watt. Usage average around 10 hours/day.

Table 7. Pay-back period for A/C

Items	Cost/year
Cost of saved energy	9,201,998
Cost of maintenance existing A/C	4,975,000
New A/C 1 PK R32	21,450,000
New installation & cleaning service	1,550,000
Payback period	20 months

CONCLUSION

In the energy audit research at CV Manna Anugerah Sejahtera, the value of energy consumption intensity (IKE) for CV Manna Anugerah Sejahtera is 1,095 kWh/m^2/month or 13.14 kWh/m^2/year. Based on the Minister of Energy and Mineral Resources Regulation No. 13 of 2012, the monthly IKE value is considered very efficient, while based on the ASEAN USAID reference in 1987, the annual IKE value for office types is quite ideal. But day by day the usage of electricity will increase globally due to increasing demand. In small factory like CV Manna Anugerah Sejahtera to anticipate this increasing demand, it have to change or modified the electricity usage, to change the machines production will cause huge cost so the alternative way is change electricity usage for lighting and AC for energy savings.

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