

ENERGY AUDITING FOR THE USE OF AIR CONDITIONING (AC) TO OFFICE BUILDING AND CLASSROOMS IN UPI

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Abstract: One of the facilities implemented or installed in office buildings and classrooms, is the air conditioning machines (air conditioning system) or more familiar with the term air conditioning (AC). This AC requires energy or electricity to operate. The research objective is: Calculate the amount of the electrical energy or power used to operate all and one unit AC machines in each new building (faculty and institutions) per month. Analyzing long operated an air conditioning unit in one day. Counting the cost of funds to consumption the electrical energy/power that must be spent in the operating UPI all AC units per month and one unit. Analyzing ways to efficiencies the use of an air conditioning unit.

This research is a policy research with the design of research methods, is a survey to obtain data on energy used for operation of air conditioning (AC) systems. The results of this survey is calculated to determine the maximum load in the operating system of the air. Big energy or electrical power 76,930.672 kWh/month to 257 units, 1 (one) unit of 299.341 kWh/month maximum of 8 work time. Use of the electrical power/energy is significant compared to other needs. Large funds for the cost of the electrical energy/power consumption to operate the UPI issued all air conditioning units for 8 hours/day is: **Rp. 25.002.468,4,-** and for 2 hours/day **Rp. 6.255.492.1,-** As for one unit of AC machines to requires an average of funds per month is Rp. 97.285.87, -/8 hours and Rp. 24.340.44, -/2 hours. Index Coefficient of Energy (IKE) use of the electrical energy/power for operating the AC machines in 7 new buildings (IDB), are in fairly efficient criteria. So for the moment the AC equipments to operational is not require additional equipment to save the electricity energy/power. Ways to efficiencies the use of an air conditioning unit, is the use of air-conditioning machine temperature is adjusted to the needs, where the ideal temperature is around 25 ° C to 20 ° C. Also AC machine should be extinguished (Off) when the study was not used in the long term (there is a need out of more than 3 hours).

The success of this research is to the contribution: operating efficiency of air systems (AC) in the environment UPI, for consideration for the officer of UPI in taking policy in terms of unit air systems (AC) and funding, teaching materials for students in understanding the audit and energy conservation especially those associated with the operation of the unit system of air-conditioning (AC).

Key words: Energy auditing, Air conditioning, Office building and Class room

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A. INTRODUCTION

One facility that is applied or installed in office buildings and classrooms, is the air conditioning machines (air conditioning system) or more familiar with the term air conditioning (AC). This AC requires the electricity energy to operate. This electrical energy sources come from the state electricity company (PLN), is cost. The amount of costs for the operation of AC UPI depends how long he operated. Indonesian National Standard Based SNI, a large consumption of energy is the energy used by buildings in a certain time period and is the product of the power and operating time. The amount of energy consumption required to operate the air conditioning equipment (AC) can be determined by operating costs and thus energy can be saved.

Bandung City is still the category of cities including the cold in Indonesia, although the weather conditions had a lot of climate change, where the increase in average temperatures occur each year with high humidity also. This is due to air pollution and loss of forest land or maked bald of the mountains and hills. Nonetheless, Kota Bandung is still relatively cool/cold, compared with other cities in Indonesia.

The research aimed to explore and learn the use of air systems (air conditioning systems) in buildings in the neighborhood of Education University of Indonesia. The objectives include:

1. Calculate the amount of energy or electrical power used to operate all the AC machines and one unit in each new building (faculty and institutions) per month.

2. Analyzing long operated an air conditioning unit in one day.
3. Counting the cost of funds to consumption the electrical energy/power that must be spent in the operating UPI all AC units per month and a uni course.
4. Analyzing ways the efficiencies to use of an air conditioning unit.

It has been said in the introduction that the notion of energy is something that is not easily defined with a short and precise. The energy is abstract, therefore difficult to prove, but can be felt there. Energy or power is often called, is an understanding that people use very often. Energy can not be created and can not be destroyed, can be converted/transformed from one form of energy into other energy forms, such as the stove in the kitchen, the energy stored in the soil changed the oil into fire. So energy is the ability of a system to do work on other systems.

There are several kinds of energy we know, the mechanical energy, electrical energy, chemical energy, nuclear energy, and thermal energy both natural and artificial. The energy there is in principle already experienced a long time ago and can not be destroyed. Energy can only be transferred and used for the needs of human life. Energy is widely used in public life needs of today, is the electrical energy. This electrical energy is needed in the household, pekantoran, company/industry, educational institutions, and others. This thr electrical energy is generally not available for free, for consumers who need this energy must be paid in accordance with its use. So is the electric energy consumption in Universitas Pendidikan Indonesia (UPI) must be purchased from State Electricity Company, or better known as PLN.

Energy consumption is the amount of energy used by buildings in a certain time period and is the product of the power and operating time. Konsumi intensity Energy (IKE), namely the division between the consumption of energy by unit area buildings. Energy conservation efforts for energy efficiency is a need to waste energy can be avoided. Energy management of all efforts to regulate and manage the use of energy-efficient as possible in the building without reducing the level of comfort in residential environment or productivity in the workplace.

Energy audit aims to find "Portrait of Energy Use" and look for efforts to increase the efficiency of energy use. Energy auditing technique used to calculate the amount of energy consumption and identify ways to savings. Energy conservation, is an effort to streamline the use of energy to a need for energy waste can be avoided. Energy management, ie any attempt to regulate and manage the use of energy efficient as possible in buildings without reducing the level of comfort in residential environment or productivity in the workplace. Energy-saving opportunities (PHE) (Energy conservation opportunity) is a way that might be obtained in an effort to reduce energy waste. Portrait of energy use, is a picture of the energy utilization of buildings, including: type, amount of energy usage, energy equipment, energy intensity, energy usage load profiles, energy equipment performance, and energy saving opportunities, as well as overall and per area in buildings at a certain period.

Energy planning, the entire annual energy consumption calculated for a planned building.

1. The process of energy audit

Wikipedia, the free encyclopedia, states: An energy audit is an inspection, survey and analysis of energy flows in a building, process or system with the objective of understanding the energy dynamics of the system under study. (wikipedia.org/wiki/Energy_audit). So the energy audit can be done through an inspection (inspection), data collection (survey), and analyze the flow of energy in a buildings. Initial energy audit be conducted on the principle owner/manager of building a visual observation. Initial energy audit activities include the collection of buildings energy data with the available data and does not require measurements. The data include:

- Documentation required building is appropriate technical drawing of the building construction (as built drawings), consisting of:
 - a) Tread, plans and pieces all over the floor buildings.
 - b) Plan the installation of lighting the entire floor of the building.
 - c) diagram of an electric line, complete with an explanation of the use of electrical power and size of switching power and the amount of PLN's power reserves of Diesel Generating Set.
- 1. Payment of monthly electricity bills for the building last year and the account purchase fuel (kerosene), fuel gas (CNG), and water.
- 2. The level of residential buildings (occupancy rate).

2. Detailed energy audit

Detailed energy audit done when IKE value greater than the specified target value, it is necessary to be held:

- Research and measurement of energy consumption

- a) detailed energy audit needs to be done if the initial energy audit gives an overview of Energy Consumption Intensity values (IKE) electricity for more than a specified target value;
- b) detailed energy audit needs to be done to know the profile of energy use in buildings, so that the user equipment can identify what the energy consumption of energy is enough;
- c) the activities carried out in energy research is to collect and examine a number of inputs that can affect the amount of building energy demand, and the results of research and profile measurements made energy buildings energy usage.

- Measurement of energy

The entire energy analysis based on measurement results. The results of measurements must be reliable and has an error (error) which is still acceptable. It is important to ensure that the measuring instrument used was calibrated by the relevant authorities. Measure used to gauge the form of fixed (permanent) at instalasi'atau mounted gauge is not fixed (portable).

- Identification of energy-saving opportunities

- a. The results of data collection, then followed up with IKE magnitude calculation, and preparation of the profile of energy use buildings.
- b. If the amount of IKE calculation results were equal to or less than the target IKE, the detailed energy audit activities can be stopped or continued to obtain lower IKE again.

- c. If the result is more than IKE targets, meaning there is an opportunity to continue the process of following detailed energy audit to obtain energy savings.

Guidelines for implementation based on energy conservation and environmental monitoring in the Ministry of National Education (2004), obtained the value of Energy Consumption Intensity (IKE) of electricity, as follows:

- 1) 4.17 to 7.92 kWh/m²/month very efficient creteria.
- 2) 7.92 to 12.08 kWh/m²/month efficient creteria.
- 3) 12.08 to 14.58 kWh/m²/ month quite efficient creteria.
- 4) 14.58 to 19.17 kWh/m²/month somewhat wasteful creteria.
- 5) 19.17 to 23.75 kWh/m²/ month wasteful creteria.
- 6) 23.75 to 37.5 kWh/m²/ month very wasteful creteria .

3. Analysis of energy-saving opportunities based on the Indonesian National Standard (SNI) 03-6196-2000

- a. If the energy saving opportunities have been identified, the next should be followed up with analysis of energy-saving opportunities, in particular by comparing the energy-saving potential acquisition cost to be paid to the implementation of energy conservation plan is recommended.
- b. Analysis of energy-saving opportunities can also be done with the use of computer programs that have been planned for the interests of the community and recognized by the profession.
- c. Energy savings in buildings must remain concerned resident comfort.

Analysis carried out energy-saving opportunities to the business include:

- a. suppress the use of energy to small as possible (reducing power installed/used and hours of operation);
- b. improve the performance of equipment;
- c. using a cheap energy source;

4. Air Conditioning (AC) System

Air conditioning systems is a process to the air cools/heats so as to reach the temperature and humidity of the desired/required. In addition, regulate the flow of air and cleanliness. Air refresher system is generally divided into two main groups namely:

- a. Refreshing air for comfort

Refreshing air of the room to provide comfort for those who work do certain activities.

- b. Air refresher for industry

Air refreshing of the room as required by the process, materials, equipment or goods in them.

The air conditioning systems, is an attempt to control the air processing room temperature, relative humidity, air quality, and air refreshing to maintain comfort conditions for the occupants of the room.

If someone is in a closed room for a long time, then at some point he will feel less comfortable, so if we are in open space during the day with the sun on our bodies will feel less comfortable. This is due to two main things the

temperature (temperature) and moisture (humidity) air is not in accordance with that required by the body.

The air conditioning system is installed in newly constructed buildings on the campus of Universitas Pendidikan Indonesia (UPI). This new building was built from the IDB funds (Islamic Development Bank) in collaboration with the Indonesian government through the Ministry of National Education.

5. Energy audits to Use Air Conditioning (AC) in the Office Building and Room Lectures In UPI

Energy conservation system of air, is a system of AC that can work with efficient energy without compromising its function requirements. According to research results in the article Nasution Hendry -2007 (internet), that energy consumption will change with changes in the compressor motor rotation. When the compressor motor rotation increases, temperature decreases and the COP increases the energy consumption will also increase. With the increasing use of energy will be less energy can be saved and vice versa. Energy consumption will change with changes in the compressor motor rotation. When the compressor motor rotation increases, temperature decreases and the COP increases the energy consumption will also increase. With the increasing use of energy will be less energy can be saved and vice versa.

6. Consumption And Saving Energy

1) Analysis of Energy Saving Opportunities

- a. If the energy-saving opportunities have been identified, the next should be followed up with analysis of energy-saving opportunities, by way of

comparing. Potential gains in energy efficiency costs to be paid to the implementation of energy conservation plan is recommended.

- b. Analysis of energy-saving opportunities can also be done with the use of computer programs that have been planned for the interests of the community and recognized by the profession.
- c. Energy savings in buildings must remain concerned resident comfort.

2) Analysis of energy-saving opportunities with the business conducted, among others:

- a. suppress the use of energy to small as possible (reducing power installed / used and hours of operation);
- b. improve the performance of equipment;
- c. using a cheap energy source;

B. Research Methods

Implementation of research conducted on the campus of the University of Education Indonesia with the object of research, is the air conditioning machines (AC) to installation/pair in the new building. New building with a grant from the IDB (Islamic Development Bank) in the neighborhood of Education University of Indonesia campus there are 14 buildings, but taken as an object in this study as many as 7 new buildings built, namely FPTK, FPBS, FPIPS, FIP, FPOK, UPI-Center, and LPPM. This is determined based on considerations of time data acquisition, data processing, the extent of the location. Time set for the implementation of the study 6 months, ie in the beginning of May to October 2009.

Research is carried out policy research, and research methods used, is a field survey to capture and obtain data about the energy used for operation of the air conditioning systems. The results of this survey is calculated to determine the maximum and minimum load in the operating of the air conditioning system. The results of this calculation will be obtained amount of electrical energy required in the operation of one unit of the AC system and the price of electrical energy used. According SNI 03-6196-2000 Calculating the amount of energy consumption intensity (IKE) can be done with the building:

- a) Details of area buildings and total building area (m²).
- b) buildings Energy Consumption per year (kWh / year).
- c) Energy Consumption Intensity (IKE) buildings per year (kWh/m².tahun).
- d) building energy costs (USD / kWh).

Therefore in this study that the object is a user made the Air Conditioning (AC) to Office Building and Room Lecture At UPI especially for new buildings, then the IKE calculations mentioned above only focused on areas that use the AC. Furthermore the AC data obtained were analyzed to obtain results. Processing or analysis done on each building and as a combined result of all buildings.

The results obtained through field survey data on the number of rooms and number of the air conditioner machine used. Further data was obtained by the processing performed to determine the amount of electrical energy used, if the AC machines was operated attachments. This AC machines operations at the base hours of operation, in this study was taken hours of operation: 8 hours maximum

and minimum 2 hours a benchmark to calculate the electrical power used. Next is the result of data processing

The amount of the electrical energy/power used for operation of the air conditioning machines 257 unit on the 7 new buildings constructed for the help IDB (Islamic Development Bank) of the 14 new buildings, are:

1. Maximum usage (8 hours/day) for one month (kWh/month) = FPTK + FPOK + FIP + NEW + (FPIPS and FPES) + LPPM + FPBS UPI CENTER = 5269.792 + 3374.448 + 8117.664 + 9962,656 + 18,824.608 + 18,824.608 + 12,556.896 = 76,930.672 kWh/month. The average for 1 unit of AC machine requires energy/ power = 299.341 kWh/month.

2. Minimum usage (2 hours/day) for one month (kWh/month) = FPTK + FPOK + FIP NEW + (FPIPS and FPEB) + LPPM + FPBS UPI CENTRE = 1317.448 + 843.612 + 2044.416 + 2490.664 + 4706.152 + 4706.152 + 3139.224 = 19,247.668 kWh/month. The average for 1 unit of the AC machine requires energy/power = 74,894 kWh / month.

3. Total area of rooms that were installed a new building on the campus of IDB assistance UPI, is: FPTK FPOK + FIP + NEW + (FPIPS and FPES) + LPPM + FPBS UPI CENTER = 470.08 + 241.28 + 392.65 + 854.4 + 1600.5 + 1601.85 + 1181.51 = 6342.27 m².

4. IKE - maximum = $\frac{\text{Using of electrical energy}}{\text{Totals of room space}} = \frac{76.930,672 \text{ kWh/month}}{6.342,27 \text{ m}^2} = 12,13 \text{ kWh/month/m}^2$.

$$\text{IKE - minimum} = \frac{\text{Using of electrical energy}}{\text{Totals of room space}} = \frac{19.247,668 \text{ kWh/month}}{6.342,27 \text{ m}^2} =$$

3,035 kWh/month/m².

Based on the data summary reports UPI month electric bill in August 2009 installed capacity of power (kVA) for the New Building in 3465 IDB is the price/kVA Load = Rp. 29,500, - so that every month to pay UPI load (used or not) = Rp. 102,217,500, -. While the price/kVA OPLT-block 1 = Rp. 325, - and PLT-block 2 = Rp. 325, -. So the amount of funds/expenses that should be issued for the use of AC UPI every month, are: maximum = 76,930.672 kWh/month x Rp. 325, - = Rp. 25,002,468.4, - kWh/month and minimum = 19,247.668 kWh/month x Rp. 325, - = Rp. 6255492.1, - kWh/month. Electrical energy consumption costs to operate this air conditioner, only apply to new buildings 7.

$$\text{IHE - maximum} = \frac{\text{Totals to Using of electrical energy}}{\text{Totals of room space}} = \frac{\text{Rp. 25.002.468 ,4,-}}{6.342,27 \text{ m}^2} =$$

Rp. 3.942,2,-

$$\text{IHE - minimum} = \frac{\text{Totals to Using of electrical energy}}{\text{Totals of room space}} = \frac{\text{Rp. 6.255.492, 1,-}}{6.342,27 \text{ m}^2} = \text{Rp.}$$

986.32, --

Index Coefficient of Energy (IKE) use of the electrical energy/power for operating the AC machines in 7 new buildings (IDB), a maximum of 12.13 kWh/month /m² and a minimum of 3.035 kWh/month/m², so IKE here in a fairly efficient criteria. While the cost of electrical energy consumption per m² per month is: masimum Rp. 3942.2, - and a minimum of Rp. 986.32, --

The user of the electrical energy to operate the Air Conditioning (AC) machines which is the 7 (seven) new buildings built on the IDB funding, was the most widely installed the AC machines is a new building and LPPM FPBS respective number of 61 units of the AC machines, next UPI Center as many as 45 units of the air-conditioning machines.

Judging from the data recap UPI electric bill in August 2009 for the building that was built from IDB grants burden costs Rp. 102,217,500, - and charges Rp. 44,568,492, -, mean that the cost of electrical energy for use on AC 7 new buildings (IDB) when operated on during work hours will reach 36.4% of the cost of usage. If if all the AC machines in all buildings (new and old) is operated, the cost of electrical energy to be issued by UPI could reach more than Rp. 25,002,468.4, - kWh/month and a minimum of Rp. 6255492.1, - kWh/month or more than 56.1% of the use of new building for the present.

C. Discussion

Government of Indonesia through the Ministry of National Education Department received funding from the Islamic Development Bank (IDB), these funds are used to build courses, offices, religious facilities, accommodation for students, the building where the training and lodging, as well as laboratory facilities and equipment within the campus of the University Education Indonesia (UPI). Infrastructure and facilities in the UPI located in Bandung, built with modern concept, so that new buildings are equipped with the air conditioning machines or better known as AC.

The air-conditioning machines require electricity to operate. Based on a survey of 7 new buildings (IDB) if the AC machines is operated maximum 8 hours in a day, significant labor, 76,930.672 kWh/month to 257 units of installed power capacity, while the average unit 1 requires 299.341 kWh/month. Although the analysis of Energy Coefficient Index (IKE) use of the electrical energy/power for operating the AC machines in 7 new buildings (IDB), is in fairly efisien. Tetapi criteria, if all the air conditioner machines in the new building is operated in a joint, then it is clear load electrical energy required increasingly large.

The electrical energy/power consumption depends on the length of time to operate the AC machines. If the air-conditioning machines 257 units is operated for 8 hours in a day, it takes funds Rp. 25,002,468.4, - this means more than half the burden of payment charges for the use of all new buildings (IDB) in August 2009 (UPI electricity bill data). However, if the AC machine is operated for 2-hour day, then the funds spent on electricity bills only Rp. 6,255,492.1, - so significant enough to save. Whereas for 1 unit of the AC machines requires an average of funds per month is Rp. 97,285.87, -/8 hours in a day and Rp. 24,340.44, -/2 hours in a day. If all the air-conditioning in the new building 7 (IDB) which operated the cost burden of the electrical power/energy is the largest new building and LPPM FPBS, and UPI Center.

Given the climate or weather conditions in the city of Bandung, especially in the hills like the DR Setiabudhi streets, where the UPI campus is located, is still relatively cool and added again UPI mission that will make the forest to increase the comfort of the campus environment. There are several employees complained

to the administration when we do surveys, because they feel cold when the AC diopereasikan machine, this is only a coincidence, or incidental (for example). The air-conditioning machines also require care and maintenance to periodic, operated or not.

D. Conclusions

Based on data analysis and discussion in this study can be summarized as follows:

Big the electrical energy or power used to operate the air-conditioning systems, is 76,930.672 kWh/month to 257 units of installed power capacity, while the average unit 1 requires 299.341 kWh/month. After building a new building (IDB) started to use an the air-conditioning machines unit is operated for two hours in a day. The results of data analysis shows, if a the AC machine is operated maximum 8 hours work in a day, consumption of the electrical power/ energy is significant compared to other needs.

Large funds for the cost to consumption the electric energy/power which must be paid for UPI in operating all the air-conditioning machine units, when operated for 8 hours in a day funds are: Rp. 25,002,468.4, - and for 2 hours in a day Rp. 6255492.1, - As for one unit of the AC machines requires an average of funds per month is Rp. 97,285.87, -/8 hours in a day and Rp. 24,340.44, -/2 hours in a day.

Index Coefficient of Energy (IKE) use of the electrical energy/power for operating the AC machines in 7 new buildings (IDB), are in fairly efficient criteria. So for the moment the AC machines to operation not require additional

equipment to save the electrical energy/power. Ways to efficiencis the use of a the air conditioning machines unit, is the use of the air-conditioning machines temperature is adjusted to the needs, where the ideal temperature is around 25 ° C to 20 ° C. Also the AC machines should be extinguished (Off) when the study was not used in the long term (there is a need out of more than 3 hours).

E. Advice

- 1) Given the amount of the electrical energy/power is large enough for all the AC machines menoperasikan UPI environment, its use should be regulated for the purposes of vitality.
- 2) Seeing the number of the machines installed/pairs of relatively very much, if not should be reduced.
- 3) Taking into account the needs to large the electrical energy/power to the implementation of the learning process or learning process, especially in the learning process lab/practice. Practicum learning processes/practices that require the electrical power/energy is large enough in FPTK and FPMIPA.
- 4) Learning materials for students in understanding the audit and conservation energy, especially related to the operation of the AC system unit.

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