A STUDY ON ENERGY SAVING PATTERN FOR AIR CONDITIONING SYSTEM BASED ON GREEN BUILDING CONCEPT

Mohd Ashraf B Mohd Zainuddin
Faculty of Electrical Engineering,
Universiti Teknologi MARA (UiTM),
40450 Shah Alam, Selangor, Malaysia
Email: ashrafzainuddin@gmail.com

Abstract— The main objectve of this research is to study the pattern of power consumption by air conditioning system at existing building. This research involved the process of collecting energy usage data from Block F Jabatan Kerja Raya (JKR) at Jalan Sultan Salahuddin. The data is taken every month inside the control room. In order to see the clear pattern of the energy usage in JKR Building Energy Index (BEI) was calculated. BEI is parameters that show energy consumption in a building. This parameter can help analysis on energy saving more easily. From the data obtained at JKR it can be used as a reference for us to study the pattern of energy usage due to air conditioning system in an existing building after put into practice a few techniques.

I. INTRODUCTION

Green Technology application is seen as one of the sensible solutions which are being adopted by many countries around the world to address the issues of energy and environment simultaneously. Green Technology is a technology that allows us to progress more rapidly but at the same time minimizes the negative impact to the environment. However, the world needs to find more efficient and effective ways to adopt Green Technology against other technologies which have been widely used and though cheaper, not necessarily benevolent.

Promoting green design, construction, renovation and operation of buildings has never been more critical than now due to the ever increasing greenhouse gas emissions that are fuelling climate change more quickly. One of the greatest opportunity for achieving significant reductions in climate change emissions lies in how we create a sustainable approach to construction and development to protect and enhance the natural environment.

Green technology innovation to minimize energy demand load, efficient use of fossil fuel via taking into account the environmental concern, the usage of renewable energy but without compromising user comfort.[1]

Factor that effects temperature inside the buildings.

- Heat from human body
- Heat from lamp, electrical equipment and mechanical equipment
- Heat from outside through wall and roof
- Heat from sun through windows

The temperature inside the buildings can be reducing by natural ventilation or by air conditioning system.

Air conditioning is the dehumidification of indoor air for thermal comfort. In a broader sense, the term can refer to any form of cooling, heating, ventilation that modifies the condition of air.[2] An air conditioner is an appliance, system, or machine designed to stabilise the air temperature and humidity within an area (used for cooling as well as heating depending on the air properties at a given time), typically using a refrigeration cycle but sometimes using evaporation, commonly for comfort cooling in buildings and motor vehicles.[3]

HVAC is an acronym that stands for the closely related functions of "Heating, Ventilating, and Air Conditioning"- the technology of indoor environmental comfort. HVAC system design is a major subdiscipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer. HVAC is particularly important in the design of medium to large industrial and office buildings such as skyscrapers and in

marine environments such as aquariums, where safe and healthy building conditions are regulated with temperature and humidity, as well as "fresh air" from outdoors. [4]

Air handling unit (AHU), is a device used to condition and circulate air as part of a heating, ventilating, and air-conditioning (HVAC) system. An AHU is usually a large metal box containing a blower, heating or cooling elements, filter racks or chambers, sound attenuators, and dampers. AHU usually connect to ductwork that distributes the conditioned air through the building and returns it to the AHU. [5]

Chiller is a machine that removes heat from a liquid via a vapor-compression or absorption refrigeration cycle. A vapor-compression water chiller comprises the four major components of the vapor-compression refrigeration cycle (compressor, evaporator, condenser, and some form of metering device). Absorption chillers use municipal water as the refrigerant and benign silica gel as the desiccant. Absorption chillers utilize water as the refrigerant and rely on the strong affinity between the water and a lithium bromide solution to achieve a refrigeration effect. Most often, pure water is chilled, but this water may also contain a percentage of glycol and/or corrosion inhibitors. [6]

The Building Energy Index (BEI), which can be used to measure the energy efficiency level of a building. To start conserve energy use in building, architects need to understand and make an appropriate energy conservation design and provide a complete human comfort of building environment. It is found that temperature is a major impact factor to energy use inside buildings. Then, the area of building envelops and its materials need to conciliate with. The last factor is equipments and their efficiencies. Those singular factors all together can reduce energy consumption. [7]

II. METHODOLOGY

In this section the method used in reducing the power consumption by mechanical components will be discussed. The process of collecting the energy data that used for every building can be simplified as in figure 1 below.

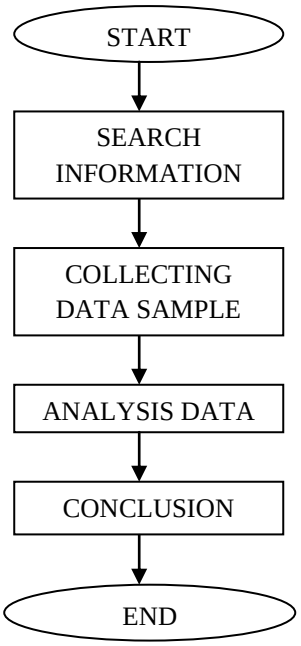

Figure 1: Overall process for this research.

A. *Search Information*

Searching information about green building. Choosing building that implement green energy technologies in Malaysia.

B. *Collecting Data Sample*

Data of energy consumption from the JKR building that implement green technologies are collected.

C. *Analysis Data*

Analyze the data using graph.

D. *Conclusion*

Make suggestion and recommendation of the research.

III. RESULTS AND DISCUSSION

Table 1 : Data for total energy usage in kilo Watt hour (kWh) per month.

Month	AHU Usage kWh	Chiller Usage kWh	Total Energy Usage kWh
January	52.68	125.96	178.64
February	36.35	136.17	172.52
March	43.33	83.75	127.08
April	47.40	102.87	150.27
Mei	52.60	131.16	183.76
June	45.18	101.32	146.50
July	45.09	98.42	143.51
August	44.47	98.79	143.26
September	41.26	111.08	152.34
October	60.85	123.06	183.91
November	40.12	93.60	133.72
December	27.99	92.24	120.23

- In January logger is install to take reading of temperature and moisture at room office. Awareness campaign among staff force them to close the window in order to prevent infiltration. By closing the window the energy used to cool the room is decreases.
- In February total energy is decline about 6 kWh because AHU at cafeteria was shut down.
- In March one of the chiller is not working so the energy used is a bit less. Chiller is the main equipment to air conditioning system and the equipment used more energy. Once the chiller is repaired the energy usage keep increasing until Mei.
- In June, temperature gauge at all AHU were set from 16^{o}C to 23^{o}C. By setting the temperature to 23^{o}C the energy is decreases to 37kWh because AHU used less energy to cool the air.
- In July and August, the server was shut down during working day after 7.00 p.m. Beside that, staff at every floor was given a remind notice to close all the windows.
- In September, one of the AHU controller is broken and JKR need to calibrate the controller. This problem caused the energy usage increases about 9kWh.
- In October, 240 units of new computer were brought into this office and some renovation need to be done. The increasing of computer unit at the office make the temperature of the room increases. So, more energy needed to cool the room.
- In November, the timer for air conditioning at prayer room had been adjusted to turn on from 11.30 a.m until 5.30 p.m. In December, all Uninterruptible Power Supply (UPS) for computer was terminate at this office because it used more power. That is why the energy usage for these two month decreases compared to the previous month.

Table 2 below shows the average data for Air Handling Unit (AHU) at JKR building from January to December 2009.

Table 2 : Average data on energy usage in kWh per month for Air Handling Unit (AHU).

Month	Day per month	Total AHU Usage kWh
January	31	52.68
February	28	36.35
March	31	43.33
April	30	47.40
Mei	31	52.60
June	30	45.18
July	31	45.09
August	31	44.47
September	30	41.26
October	31	60.85
November	30	40.12
December	31	27.99

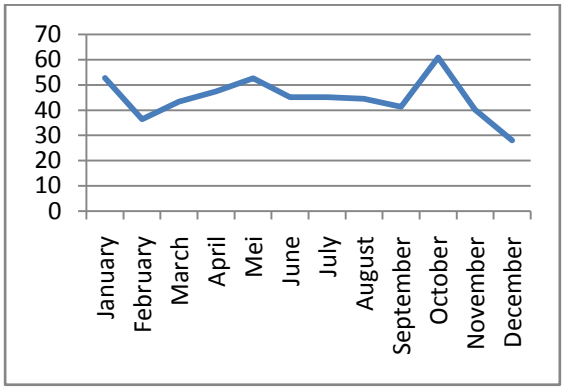

Figure 2 : Graph of energy used for AHU per month.

Table 3 below shows the average data for Chiller at JKR building from January to December 2009.

Table 3 : Average data on energy usage in kWh per month for chiller.

Month	Day per month	Total Chiller Usage kWh
January	31	125.96
February	28	136.17
March	31	83.75
April	30	102.87
Mei	31	131.16
June	30	101.32
July	31	98.42
August	31	98.79
September	30	111.08
October	31	123.06
November	30	93.60
December	31	92.24

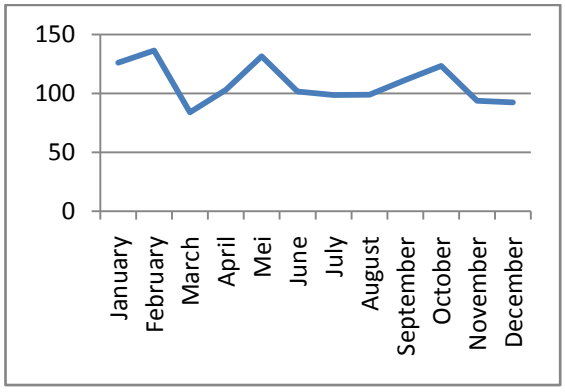

Figure 3 : Graph of energy used for chiller per month.

From all the data mentioned above, the most energy usage is from the chiller because chiller is the main part in air conditioning system. Chiller is use to produce and circulate cold water in a closed system in order to maintain air temperatures for cooling the building. The cold air produced by the chiller will be transferred to AHU. The second equipment use more energy is AHU. The primary function of AHU is to provide conditioned air to various rooms in a building.

Table 4 shows the data for Building Energy Index (BEI) at JKR from January to December 2009.

Table 4 : Data for BEI saving per month.

Month	Total Energy Usage kWh	BEI (kWh/m^2/year)	BEI saving (%)
January	178.64	113	44.47
February	172.52	109	46.44
March	127.08	80	60.69
April	150.27	95	53.32
Mei	183.76	116	42.99
June	146.50	93	54.30
July	143.51	91	55.28
August	143.26	90	55.77
September	152.34	96	52.83
October	183.91	116	42.99
November	133.72	84	58.72
December	120.23	76	62.65

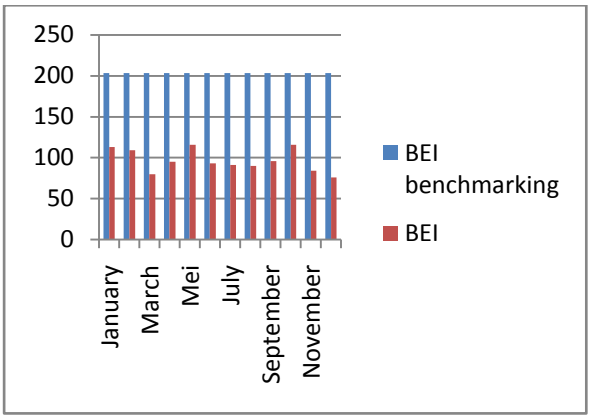

Figure 4 : Graph for BEI per month.

Building Energy Index (BEI) can be calculated as follow:

$$BEI = \frac{energy\ usage \times 12\ month}{area}$$

Where, selected area at JKR = 19000m^2

BEI is important because it can shows energy consumption for a building. Instead of BEI, % BEI saving also can be calculated using the formula given below:

$$\%\ BEI\ saving = \frac{BEI\ benchmarking - BEI}{BEI\ benchmarking}$$

BEI benchmarking is a parameter set by Green Building Index Malaysia (GBI). As for JKR BEI benchmarking given is 203.50. The BEI benchmarking represent the value before the green building program is started. After the program is start the building must have target to achieve a lower BEI value compared to BEI benchmarking.

IV. CONCLUSION

A few solutions for reducing the energy usage have been found. From the data obtained it can be divided into two categories, which is without cost and with cost. For an existing building without cost is more preferable. For example, awareness campaign. All windows and door must keep closed between air-conditioned space and non-conditioned spaces in order to prevent the infiltration. Infiltration is uncontrolled inward air leakage to conditioned space through unintentional opening in ceilings, floors, and walls from unconditioned space or the outdoors. It also caused by the same pressure differences that induce exfiltration. Infiltration also can costs extra annual cooling bills. Infiltration of outside air into building also brings moisture and more energy will use to remove this moisture. It also make uncomfortable and unhealthy environment because it can produce mould due to very high humidity.

For a new building with cost category is recommended. A several useful technique can be implement as below:

i. Usage of timer will automatically turn off and on the air conditioning system. This can reduce the time for the equipment to run and the same time reduce the energy usage.

ii. Ensure the chiller is running at greater than 60% load. So the chiller do not consume more power to support the load.

iii. Use a variable-frequency drive (VFD) in controlling the rotational speed of an electric motor by controlled the frequency of the electrical power supplied to the motor. This variable-frequency motor on fans can save energy by allowing the volume of air moved to match the system demand.

iv. Use electric Air Cleaners to maintain efficient air filtering system. It also can reduce losses due to less dust accumulation.

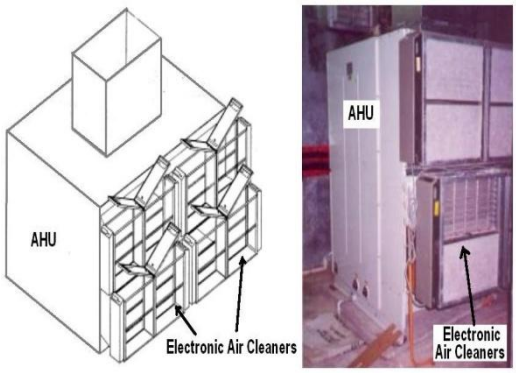

Figure 5 : Air cleaners

V. FUTURE DEVELOPMENT

In future, for a new building an efficient air conditioning system can be introduced. Figure 6 shows all the components that contribute to air conditioning system.

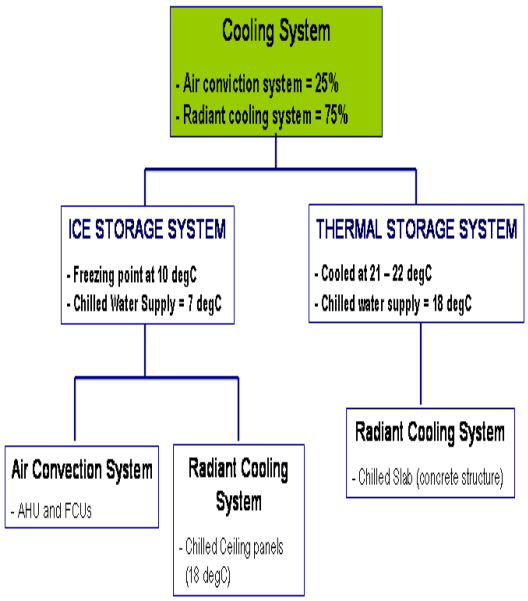

Figure 6 : Air conditioning system (full load storage system).

The radiant cooling and ice storage was charge at night and stored at the floor slabs and ice storage tank respectively. During the day, the source of cooling of these sources was distributed by the building's control system to the radiant cooling and air convection system respectively.

In order to keep the cooling system at 20°C, Poly Ethylene (PEX) can be install on the floor slab as shown in figure 7.

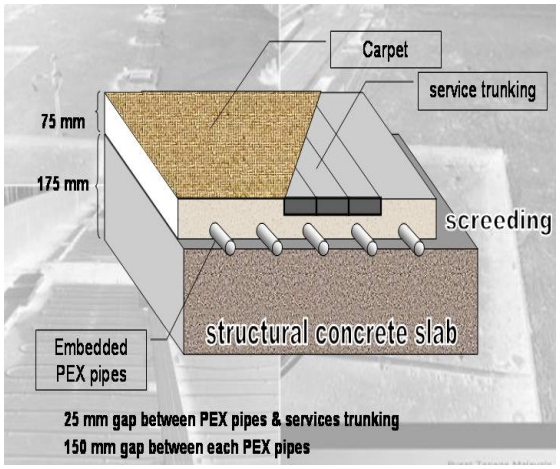

Figure 7 : View of the Poly Ethylene crosslink (PEX) pipes installation on the floor slab.

Another technique is by using chilled metal ceiling as in figure 8.

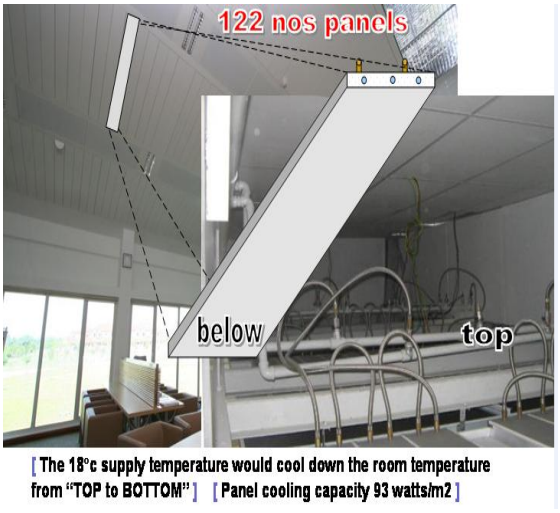

Figure 8 : Chilled metal ceiling.

Figure 9 show the thermal comfort temperature room after installing the PEX and chilled metal ceiling.

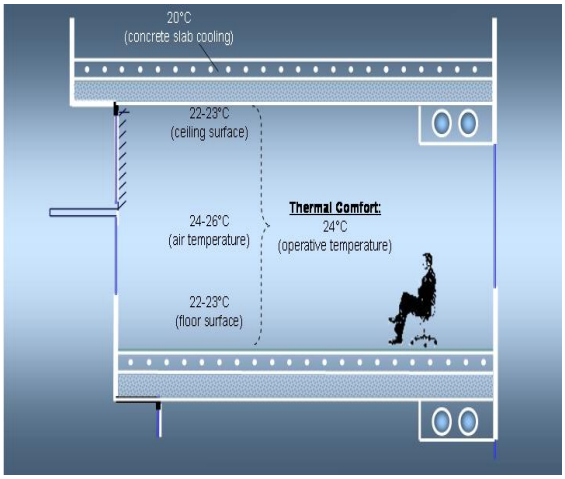

Figure 9 : Indoor operative temperature.

Other sustainable features integrated are rain water harvest system as in figure 10 which helps to conserve water in the building. Rain water is used for air conditioner chiller condenser cooling system, watering the landscape and general cleaning purposes. The average water consumption of the office building is very little compared to conventional office building.

Figure 10 : Rain water harvesting.

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