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PROCEEDING OF 3rd INTERNATIONAL CONFERENCE ON REBUILDING PLACE (ICRP) 2018

Towards Safe Cities & Resilient Communities

13 & 14 SEPTEMBER 2018
IMPIANA HOTEL, IPOH, PERAK

ORGANIZED BY :

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ACCESSING ENERGY EFFICIENCY POTENTIAL IN THE MALAYSIAN UNIVERSITIES: THE LITERATURE REVIEW

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Abstract - Energy efficiency has become one of the essential elements in managing energy consumption for universities. In assessing energy efficiency, a few processes of energy audit, energy performance of the buildings and energy management need to be monitored and areas which have the potential for energy savings should be identified. The purpose of this paper is to explore the literature review that focus on the energy audit processes conducted in the Malaysian universities and to identify the best practice that can improve energy consumption of the universities. The initial energy audit framework of the Malaysian universities will be explored in the literature in order to acquire related information on energy efficiency, namely from electrical appliances and lightings systems in order to understand the relationship of these factors with the use of energy. The significant practices in energy audit can help to save electricity by comparing the energy implementation process of Malaysian universities. Through the investigation of energy consumption behavior and the number of electrical appliances, machinery and buildings activities, it will affect the energy consumption that can allow energy-efficiency in building. The Building Energy Index (BEI) will be used as an indicator and combined with the application of building energy simulation software to obtain solution and possible improvement of energy consumption during energy audit implementation. The exploration of literature will be used as a guideline for universities that consume high energy in order to control the excessive energy usage and to achieve energy efficiency for the building.
Keywords - Energy audit, energy efficiency, energy guideline, universities

1 INTRODUCTION

In order to review the energy efficiency of the universities buildings in Malaysia, a number of publications were analyzed. The purpose of the literature review is to study the available information regarding on the research problems and to explain the current development and understanding in this field. To uphold the need of this study, the gap in the previous studies were identified through the review of literature which is divided into the following categories.

a) Energy
b) Energy and its environmental, economic and social benefits
c) Energy Consumption and Performance of the Buildings
d) Energy Efficiency
e) History and Definition of Energy Audit
f) Energy Audit Guidelines and Tools
g) Phases of Energy Audit
h) Building Energy Simulation
i) Building Energy Index

2 DEFINITIONS OF ENERGY

As defined by *Dictionary of Energy*, energy is "the capacity or ability to do work" (Hall and Hinman, 1983). Similar to the definition by (Henry, 1980), which energy is the ability to produce an effect through the transfer of heat of work. Energy exist in various forms such as sound, heat, kinetic, chemical, mechanical, light, potential energy, electrical energy and so forth. It can be transformed from one form to another when being expended.

Confronted to the social misunderstood, "energy" is contrasted with "power". As stated by

Coad (1982), "power" is the rate of consumption or conversion of "energy", it is an expression of how long or how fast a given amount of energy is consumed or converted. Final energy is the energy supplied to the consumer in each end-use sector that will ultimately converted into energy services (Fauziah, 2010). In facilities management, energy is used in buildings to perform functions of heating, lighting, mechanical drives, cooling, and any other related applications to serve the end use of the various functions.

3 ENERGY AND ITS ENVIRONMENTAL, ECONOMIC AND SOCIAL BENEFITS

3.1 Energy and Environment

The process of power generation, transport and utilization will lead to significant environmental pollution. In the last decade, concern for the environmental pollution has increased considerably. The greenhouse is caused by an increase in the level of CO_2, methane and other gases are leading to global warming. CO_2 level in the atmosphere has increased from 280 ppm, in 1850 to about 360 ppm at present. According to World Meteorological Organization (WMO), the world average temperature has risen by 0.74°C since the beginning of the 20th century and the temperature has risen by 0.18°C over the last 25 years (Suruhanjaya Tenaga, 2017). Malaysian's government also has committed to reduce carbon intensity by 40% in 2020 compared to 2005 level (Prime Minister, 2005).

To achieve this, the industry needs to change their energy culture by investing extensively in energy efficiency measures and practices. Therefore, improving industrial energy efficiency is an effective way of reducing and improving both material and water use in industries; consequently, slowing down natural resources depletion (Warrell, 2011). Improvements in energy efficiency a re often suggested as a way of reducing carbon emissions.

3.2 Energy and Economic Aspect

The profit of a business is expressed as difference between sales revenues and input costs; the greater the difference the greater the profit margin. The universities input mainly includes construction costs, utility costs, labor cost and maintenance cost. Consequently, input costs can be reduced in the short-term by optimizing energy consumptions, improving awareness and use energy efficiency and in the long-term by introducing new equipment (United Nations Industrial Development Organization; UNIDO, 2011). Universities can realize large profit margins by implementing energy efficiency by reducing both material resources and energy, when energy forms a large proportion of their input cost.

3.3 Energy and Social

Firms and industries that implement energy efficiency cost- effectively increase productivity; increase in productivity is the main factor responsible for both industrial and economic growth (UNIDO, 2011). The implementation of energy efficiency may also improve the working environment of universities and the quality of life of the campus society.

4 ENERGY CONSUMPTION AND PERFORMANCE OF THE BUILDINGS

As stated in ASHRAE, energy performance is the energy consumption in certain buildings. Building can be defined and their performance assessed (Baird, 1984; Hartkopf, 1992). Although the basis for assessing the energy performance of many building components and individual systems have been fairly well established, there is a lack of understanding of the overall energy performance of building. Figure 2.3 shows the major components of building energy consumption and there are 2 main groups:

(a) HVAC related components and
(b) The components related to general building equipment.

The present study focuses on the HVAC related components since they are usually the most complicated part of building energy analysis. This is also applies for university buildings.

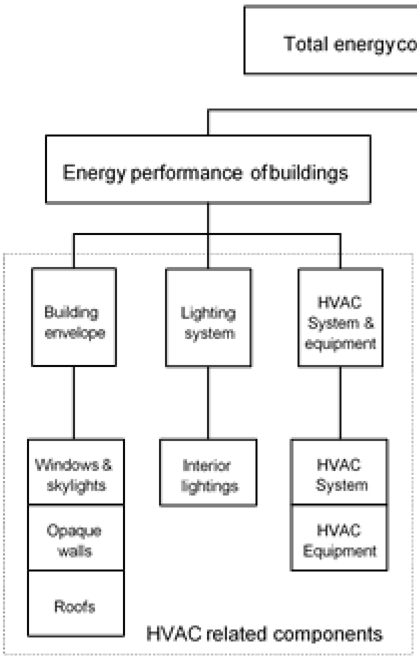

Figure 4.1 Major Components of Building Energy Consumption

For Malaysian cases, the total energy consumption for buildings is recorded based on the type of electrical appliances used in the buildings. However, there are minimal research have been obtained for the energy consumption in universities in Malaysia. Figure 2.1 show the result from a study conducted by Malaysia Energy Centre (PTM) in 2003 on government building (Malaysia Energy Centre, 2003).

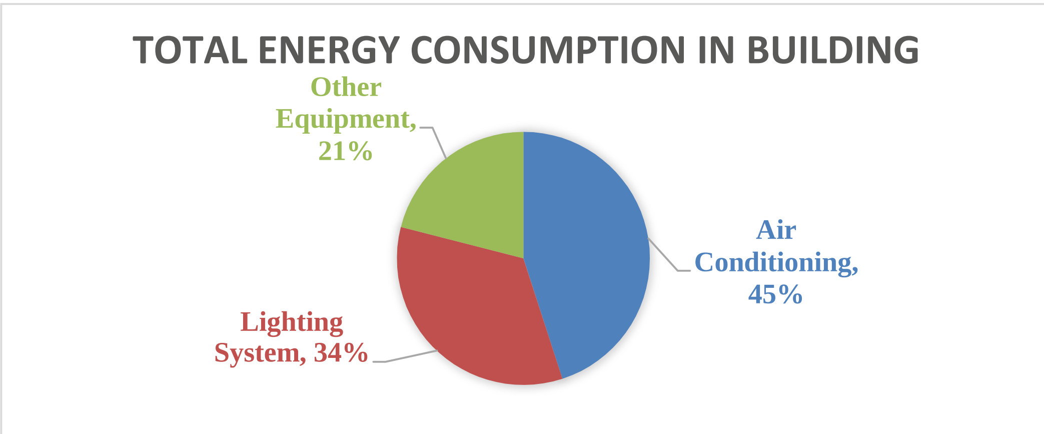

Figure 2.1 Total Energy Consumption in Malaysia Building

Figure 2.2 show the result U.S Energy Information Administration on a typical university energy consumption. A typical university spend an average of RM 4.70 per square foot (ft^2) on electricity (National Grid, 2003).

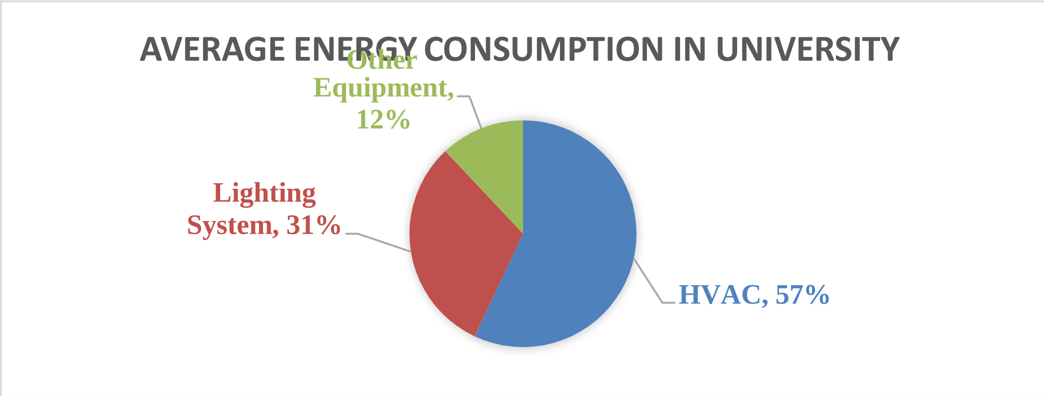

Figure 2.2 Total Energy Consumption in Malaysia Building

From Figure 2.1 and 2.2, it is shows that the HVAC system consumed more energy than other electrical appliances in the building. This shows how significant is the energy efficiency processes to be obtained in the buildings, especially for managing the use of HVAC efficiently.

4 ENERGY EFFICIENCY

The term of energy efficiency is best described by the statement of "Something is more energy efficient if it delivers more services with the same output for less energy input" (International Energy Agency, 2016). This statement clearly explained that the energy efficiency is the process of eliminating wastage while using t h e energy. Optimizing the energy consumption pattern in the building is the key to energy efficiency. Some of the buildings in industries don't implement energy efficiency because they are faced with the financial, cultural, technical and awareness of the consumers. Despite many efforts and benefits of energy efficiency, several technical, financial and policy barriers have constrained the implementation of energy efficiency projects. The major barriers are:

4.1 Lack of Awareness

The main barriers to energy efficiency is the lack of awareness among consumers that leads to energy wastage. Management must take into account the potential benefits of increasing efficiency.

4.2 Lack of knowledge and training

An extensive knowledge opportunity in energy audit and appropriate training are limited to certain people. This may become difficulties to give exposure to consumers since they do not know the benefit of this activities.

4.3 Lack of financing

Non-availability of adequate credit facilities and difficulties in obtaining the necessary financing for energy saving projects are strong deterrents to investments in energy efficiency.

5 HISTORY AND DEFINITION OF ENERGY AUDIT

Energy audit procedures was first used in the early of 1970s in the United States during the energy crisis (Energy Audit Institute, 2010). In order to reduce energy consumption, state funds have been used to provide incentives for energy-efficient building in the Supplement State Energy Conservation Program. Buildings that receive government funding have to follows several needs such as; (1) mandatory lighting efficiency standards; (2) mandatory thermal efficiency and insulation standards; (3) public education efforts to implement energy efficiency measures; (4) encouraging and conduct buildings energy audit for commercial and industrial applications. In addition, energy audits have been used to provide government loan guarantees for implementing energy efficiency program (Thumann, 1998). These methods may or may not help reduce the environmental effects or global warming impacts; however, emphasize methods such as energy audit, not only reduce consumption but also save utility costs.

There are several definitions of energy audit. The simplest definition of energy audit is a process that serves to identify where a building consumes energy and points to energy conservation opportunities (Thumann, 1998). Some guidebooks define energy audit as systematic, documented verification process of objectively obtaining and evaluating energy audit evidence, in conformance with energy audit criteria and followed by communications of results to the client (Canadian Industry Program for Energy Conservation; CIPEC, 2002). Energy audit also can be defined as the analysis of energy flows in buildings, systems, processes or equipment to reduce the amount of energy input into the system without negatively affecting the energy output (Raghav, Srijaa, Rao, Bhavya, & Y.Suchitra, 1970). In the Indian Energy Conservation Act 2001 (Energy Management and Audit, Bureau of Energy Efficiency; BEE, 2008), an energy audit is defined as the verification, monitoring and analysis of the use of energy and submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption. An energy audit is an examination of energy consuming equipment/system to ensure that energy is being used efficiently which building manager examines the energy account of energy consuming equipment/system, checks the way energy is used, checks for areas of inefficiency and identifies the means of improvement (Guidelines on Energy Audit; Hong Kong, 2007).

However, in Malaysia, it was defined as a process which is very much central for conducting an energy audit program or a study conducted to identify where, when and how much energy is being used in the business and how to reduce the cost of energy for the business (Guidelines for conducting Energy Audit Commercial Buildings in Malaysia). Even though there are several definitions, the objective is the same which is to reduce the energy consumption without compromising comfort and quality of the building. This guideline is meant for registered energy managers who have basic understanding on energy audits and for them to confirm the requirement of the Efficient Management of Electrical Energy Regulation 2008 (EMEER, 2008). a. Phases of Energy Audit

As refer to *Oxford Thesaurus of English*, "phase" is "stage, period, step, or a distinct stage of development" (Waite, 2004). In energy audit practices, it also involves some phases and each phase contains some key practices. Phases in energy audit may be referred as some stages or steps in a cycle of the energy audit process. Any program or development to be successfully implemented, it must be planned and carry out systematically according to the phases. For an example, there are four phases in an energy audit as suggested by Moncef Krarti (2011), which consists of walk-through audit, utility cost analysis, standard energy audit and detailed energy audit. However, refer to opinions from Thumann and William (2007) in their books 'Handbook of Energy Audit', there are three phases which are walk- through audit, standard audit and computer simulation. Despite that, there are several standard and regulation such as ASHRAE and ISO 50001: Energy Management System that are pioneer in energy audit guideline. ASHRAE stated that energy audit has four phases which are benchmarking audit, walk- through audit, energy survey analysis and detailed audit. Many countries have come out with their own guideline that referring to ASHRAE and ISO 50001. For example, Malaysia energy audit guideline stated that energy audit has two phases only which are walk-through audit and detailed audit. This shows that an energy audit may consist of a series of very definite phases that must be executed in sequence to assure maximum effectiveness. Selecting and naming of the phases is depending on the needs of the study. In that case, author ascertained two phases for an energy audit which are walk-through audit and detailed audit phases.

Basically, energy audit can be classified into two types. There are:

i. Walk-through/preliminary energy audit
ii. Detailed audits.

6.1 Walk-through Audit

According to Merriam-Webster, walkthrough is defining as an activity in which someone walk through an area or building in order to inspect it. It also can be defined as a step by step test of all aspects of an environment, plan or process to verify it is ready for its intended purposes by Business Dictionary. In energy audit, walk-through is a process used to create an overview of potential energy savings through visual inspection of the buildings. Basically, walkthrough is looking ahead, therefore energy audit committee need to anticipating potential energy saving in the future and deciding the course of action to be taken next during this phase.

According to Moncef Krarti (2011), this phase consists of a short on-site visit of the facility to identify areas where simple and inexpensive actions can provide immediate energy use or operating cost savings. It allows the collection of basic information about the building envelope, as well as lighting systems and appliances. In energy audit, recognize the potential improvement of energy efficiency is a must. Walk-through audit are a long term planning, addresses specific timetables and measurable targets. It involves designing in the feasible way to achieve energy goals and objectives. Some engineers refer to these types of actions as Operating and Maintenance (O&M) measures. The main purposes of this phase is to provide recommendations for improving the energy efficiency by investigating operating and maintenance (O&M) measures and energy efficiency measures (EEM) with short payback periods.

According to Wayne Turner (2009), this phase must be done before auditor makes actual energy audit visit to a facility. Data collection on the facility's use of energy through examination of utility bills and some preliminary information should be compiled on the physical description and operation of the study. This data should be analyzed so that the auditor can do the most complete job to identify Energy Conservation Measures (ECM) during actual site visit of the facility. ECM are identified and evaluated to determine their benefits and their cost effectiveness.

As mentioned by Albert Thumann and William Younger in Handbook of Energy Audit (2007), the walkthrough audit is a tour of the facility to visually inspect each of the energy using systems. An evaluation of energy consumption data to analyze energy use quantity and patterns as well as provide comparison of benchmark for similar facilities. This audit can yield a preliminary audit estimate of savings potential and provide a list of low cost saving opportunities through improvements in operational and maintenance practices.

As stated in Electrical Energy Audit Guidelines for Building (Suruhanjaya Tenaga, 2008), walk- through audit is a process used to create an overview of potential energy savings through visual inspection of the buildings including air conditioning system, lighting, metering, building automation, building maintenance and other factors affecting energy consumption of the building. References to the records of equipment ratings, technical catalogues, operation and maintenance (O&M) manuals that are readily available will be very helpful to quickly determine whether equipment or systems are operating efficiently. The walk-through/preliminary energy audit is usually carried out in a day or two by either REEM alone or with a team, depending on the size, complexity of the building and the scope of audit. Often, simple instruments such as a clamp amp meter, thermometer, hygrometer (humidity meter) and lux meter will serve the purpose. Then, identify the no-cost, low cost, medium cost and high cost improvement on energy saving. Also study on potential capital improvement of cost and energy saving.

According to Brunei National Energy Research Institute (BNERI), preliminary audit is the first step to perform any energy audit where it determines a building's current energy and cost efficiency with the comparison of other similar buildings. Gather the utility bills and summarize them for at least one- year period. Compare the building energy index (BEI) with buildings that have similar characteristics. Perform a brief walk-through survey of the facility to become familiar with its equipment, operation and maintenance. Then, meet with owner of the buildings to learn a special problem or needs of the facility. Similar with Malaysia guidelines, Brunei guidelines also stated that to identify the no-cost, low cost, medium cost and high cost improvement on energy saving and potential capital improvement.

Walk-through audit is a simplest type of energy audit and is the most basic requirement of energy audit as stated in Guidelines on Energy Audit by Hong Kong authorities. The activities in this guideline are similar with Malaysia energy audit guidelines for preliminary audit phase. Singapore guidelines are similar with ASHRAE guidelines, such as gather utility bills, meet with owner to learn special problems, identify the no-cost, low cost, medium cost and high cost improvement on energy saving and potential capital improvement.

From all of the opinions by researchers, guidelines and the regulation of some countries, this phase require a several vital practices. The following discussed each of them.

i. Focus on major consuming systems

Visual inspection of the facilities including HVAC, lighting, metering and building maintenance.

This activity will help auditor to get a first impression of systems at the facilities.

ii. Reference to record of equipment rating, technical catalogues and Operation & Maintenance manual.

Building owner must give cooperation and provide all necessary document without hiding anything.

iii. Carry out in 1 or 2 days only

The preliminary audit activity purpose is to get the visual and idea of improvement, so the auditor do not need many days for this activity.

iv. Using simple instruments

Auditor will only use a simple instrument only such as clamp meter, thermometer, lux meter and hygrometer.

v. Identify low cost, no cost or simple action on energy cost saving

This is most vital activities because in the end of the day building owner want to reduce energy consumption and increase energy efficiency.

vi. Meet with owner

The important of this practice is auditor need to know any special failure or malfunction systems that contribute energy wastage to the systems.

vii. Identify potential capital improvement Auditor must study any potential capital improvement.

viii. Gather utility bills

Building owner must provide auditor with monthly utility bills for auditor study the Building Energy Index and Building Utilization Index.

	ASHRAE		M. KRARTI	W. TURNER	W.THUMANN		MALAYSIA	SINGAPORE	BRUNEI	HONG KONG
Focus on major consuming systems				X	X		X		X	X
Reference to record of equipment rating, technical catalogues and Operation & Maintenance manual			X				X			X
Carry out in 1 or 2 days only			X				X			X
Using simple instruments				X			X			X
Identify low cost, no cost or simple action on energy cost saving	X		X	X	X		X	X	X	X
Meet with owner	X							X	X	
Identify potential capital improvement	X						X	X	X	
Gather utility bills	X		X					X	X	

6.2 Detailed Audit

According to Merriam-Webster, detail is defining as extended treatment or attention to particular items. In energy audit, detailed energy audit can be defined as a comprehensive audit and provides detailed energy project implementation plan for a facility, since it evaluates all major systems. It considers the interactive effects of all projects, the energy use of all major systems and includes detailed energy cost saving calculations and project cost (Bureau of Energy Efficiency).

According to Moncef Krarti (2011), this audit is the most comprehensive but also time-consuming energy audit type. It includes the use of instruments to measure energy consumption the whole building or energy systems in the building such as lighting systems, office equipment and air conditioning systems. Simplified tools are used to develop baseline energy models and to predict the energy saving measures. Moncef Krarti stated in his books, there are four general procedures can be outlined for most buildings. Step 1; building and data analysis, step 2; walkthrough survey, step 3; baseline for building energy use, and step 4; evaluation of energy conservation measures.

According to Electrical Energy Audit Guidelines for Building (Suruhanjaya Tenaga, 2008), the detailed energy audit involves in-depth investigations into how the energy is currently being consumed, current performance of existing system and identification of various potential Energy Conservation Measures (ECMs). The detailed energy audit in this guideline involves the following four (4) main processes:

i. Data collection
One of the key tasks in Energy Auditing is the collection of all energy related data required by the Energy Manager to divide the total facility energy consumption into various energy end-uses. The collected data is then used to build a reliable picture of where and how much energy is being consumed and the cost of energy being used at the building. It is recommended to uses these steps, (1) desktop data collection; using all available facility data such as as-built drawing, utility bills, M&E drawings and floor area of the buildings, (2) field data collection; understanding closely with building by using measurement tools and (3) cross-checking of load demand data; use data loggers to record building energy consumption to verify the accuracy of estimated building energy consumption.

ii. End-use load apportioning
The Energy Manager can use the above suggested three steps in energy audit data collections to apportion the total building load into its major end-use loads.

iii. Identifications of ECMs
The effectiveness of an energy audit is related to the understanding in depth of the nature and operations of the audited building by the Energy Manager. Knowing the acceptable level of comfort and tolerance for lighting, temperature and humidity level by employees are essential to come up with effective and acceptable ECMs.

Table 6.1 Energy Conservation Measures

Categories	Description	Potential Saving
No/low cost measures	No cost investment and without any disruption to building operations	0-5%
Medium cost measures	Medium cost investment with some minor disruption to building operations	1-10%
High cost measures	Involve relatively high capital cost investment with much disruption to building operation	5-25%

iv. Reporting and presentation
After completing all necessary finding and recommendation, energy manager must submit full report to building owners and present the ECMs and guide building owner to start their implementation of energy improvement.

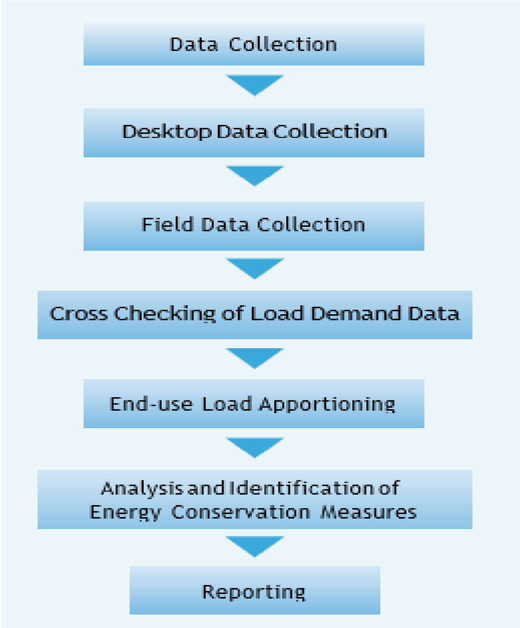

Figure 6.2 Detailed Energy Audit Process Flow

6 ENERGY AUDIT GUIDELINES AND TOOLS

There is a critical need for an effective energy audit and with the increasing interests towards energy efficiency, government has introduced energy audit authorities from government agencies such as Suruhanjaya Tenaga, Kementerian Tenaga Teknologi Hijau Dan Air (KeTTHA) and Sustainable Energy Development Authority (SEDA). There are numbers of standards, guidelines and tools provided in each country including Malaysia. Below are the standards that widely used around the world and modified by each country according to their needs:

6.1 ISO 50001

ISO 50001:2011, Energy Management Systems – Requirements with guideline for use, is a voluntary International Standard developed by ISO (International Organization for Standardization). The purpose of this International Standard is to enable organization to establish systems and processes which are necessary to improve the energy performance in terms of energy efficiency, energy wastage and energy consumption. It is applicable to all types and sizes of organization nevertheless of their geography, culture or social conditions. To achieve success in implementing this standard, all levels and functions of the organization must show high level of commitment

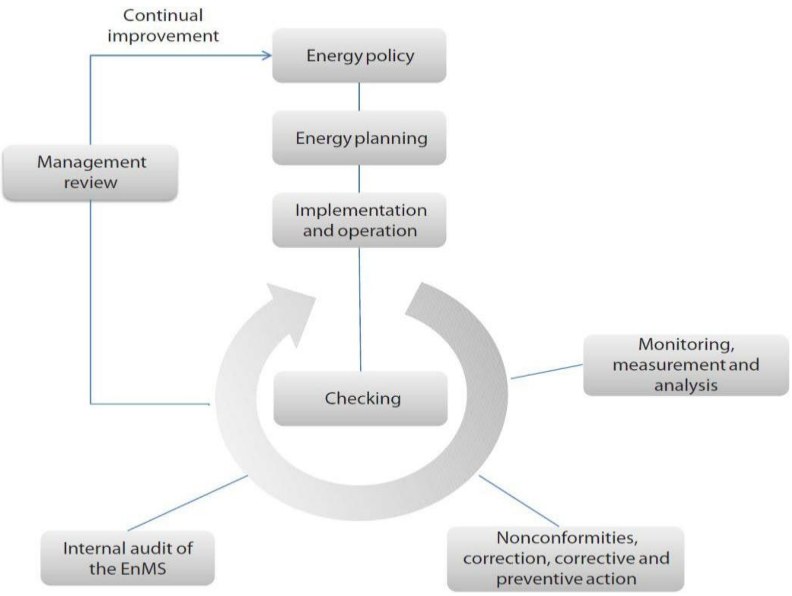

Figure 7.1 ISO 50001:2011(E) – Energy Management System

7.2 ASHRAE

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is one of the pioneers in this area where it published a series of Energy Efficiency Guides for building owners and managers. The objective of the guide is to allow building owners to implement the process for evaluating current operations and perform economic analysis to selected better improvement options. In addition, the guide shows ways to benchmark performance against comparable buildings, describe which energy consumption and cost can be reduced and explain the method, considering minimizing capital investment and maximizing return on investment.

Generally, there are four levels of analysis of energy audits (ASHRAE).

(1) Level 0 – Benchmarking/Preliminary audit:

The purpose of this preliminary audit is to get a good overview of the buildings and how it performs. Usually utility data and general building characteristics are required. Analyzing the historical data is conducted in a monthly basis for preferably three years. This analysis is used to identify different utility structures, malpractice use of facilities, and identify areas for reducing costs. Normally the main focus is to reduce the electrical load at peak demand times since this is when the utility companies charge more in order to help reduce the overall electrical demand of the grid (Thuman, 1998). Result of this analysis will be used to compare the performance of the building with similar building for benchmarking.

(2) Level I – Walkthrough audit:

This audit consists of a visual-walkthrough of the building to get familiar with the operation or maintenance problems. Several meetings with building owner were also carried out to determine any special problems or needs of the facility may have that affect energy efficiency of the buildings. Simple and no-cost improvements are suggested to provide immediate energy and operation costs savings. In addition, this report will provide a list of potential capital improvements which suggest further efforts in energy audit analysis (Krarti, 2011).

(3) Level II – Energy survey and analysis:

This level of analysis requires the use of basic calculations and measuring devices to establish a facility energy consumption baseline. Simple tools and devices are used to provide cost effective project implementation plan and more detailed analysis on building performance.

(4) Level III – Detailed energy audit analysis:

Detailed energy audit is similar to previous audit, however there is an even greater level of detail as well as higher initial costs. The detailed energy audit provides financial structure through engineering studies and computer simulation program to justify the investment on the buildings.

7.3 MS 1525

The Malaysian Standard MS1525:2014, Code of Practice on Energy Efficiency (EE) and Use of Renewable Energy for Non-Residential Building (Department of Standard Malaysia, 2014) purposes are to:

a) Encourage the design, construction, operation and maintenance of buildings in a manner that reduces the use of energy without constraining creativity in design, building function and the comfort of the occupants and cost considerations
b) Provide the criteria and minimum standards for energy efficiency in the design of buildings and methods for determining compliance with these criteria and minimum standards
c) Provide Guidance for energy efficiency designs that show good professional judgment to comply with minimum standards
d) Encourage the applicant of renewable energy in buildings to minimize reliance on non-renewable energy resources, pollution and energy consumption whilst maintaining comfort, health and safety of the occupants.

This standard only sets out the minimum requirements, so designers are encouraged to design and select equipment above those stipulated in this standard.

7.4 Electrical Energy Audit Guidelines for Building

This guideline is a reference for Registered Electrical Energy Manager (REEM), under Efficient Management of Electrical Energy Regulation 2008 (EMEER) by Suruhanjaya Tenaga**.** Any installation which a total electricity consumption equal to or exceeding 3,000,000 kWh as measured at one metering point six consecutive months must comply with requirements in the regulations. The Malaysian governement has put special emphasis to ensuring adequate, reliable, secure and costs effective supplies and to utilizing energy resources efficiently while minimizing the negative impacts on the environment. An energy audit is an examination of the energy consumption of the equipment or system to ensure that energy is being used efficiently. This is a guideline for REEM during their energy audit exercise but REEM must establish their own justification in oreder to meet facilities requirement according to the types and purposes such as offices, hotels, hospitals and universities.

7 BUILDING ENERGY SIMULATION

In the 1970s, building energy simulation was developed in order to meet the demands for building construction and reduce energy consumption (Stephany, 2011). Special government agencies focus on the research and development program of various building energy model simulation (Thuman, 1998). These programs are intended for modelling of large, multizone building and their HVAC systems (ASHRAE, 1993). The interactions in buildings are by their nature very complex. While some simplified design tools and guidelines exist to help designers understand the phenomena involved, more elaborate, often computer-based tools are required for detailed analysis.

Most of the building energy analysis programs are developed in USA and Europe; directories and lists of energy analysis software have been published to show people what is available on the market, such as AEE (1991), ASHRAE (1991), Williams (1992), Degelman (1987) and Weiss and Brown (1989). There are more than 200 programs in USA and 100 programs in Europe and elsewhere (Seth, 1989), but only a handful of them are frequently used by building designers (Bloomfield, 1989; BEDTDC, 1988). Table 2.2 gives a list of the programs commonly used nowadays.

Table 10.1 List of Common Building Energy Simulation Programs

Program	Reference source(s)	Country
APEC ESP-II	(Wickham, 1985)	USA
ASEAM2.1	(Ohadi, Meyer, and Pollington, 1989)	USA
BESA	(BESA, 1993)	Canada
BLAST	(BLAST, 1991)	USA

BUNYIP	(Moller and Wooldridge, 1985)	Australia
Carrier HAP	(Carrier Corporation, 1990) 2	USA
DOE-2	(Birdsall, *et al.*, 1990; LBL, 1981)	USA
ESP-r	(Clarke, 1993)	UK
EnergyPlus™	(DOE-2 & BLAST)	USA
TRACE 600	(Trane Company, 1992a & b)	USA
TRNSYS	(TRNSYS, 1988)	USA

To select the appropriate energy simulation program, it is important to be aware of its capabilities and limitations. Some of the well-known energy simulation programs are briefly presented below:

7.1 DOE-2

Developed at the Lawrence Berkley National Laboratory by the U.S. Department of Energy, DOE-2 is widely used because of its comprehensives. It can predict hourly, daily, monthly, or annual building energy use. DOE-2 is often used to simulate complex buildings. Typically, significant efforts are required to create DOE-2 input files using a programming language called the Building Description Language (BDL). DOE-2 has become a standard building energy simulation tool in the United States and several other countries using interfaces such as QUEST and Visual DOE (Krarti, 2011).

7.2 EnergyPlus™

EnergyPlus™ uses new integrated solution techniques to correct one of the deficiencies of both BLAST and DOE-2. EnergyPlus has several features that should aid engineers and architects in evaluating a number of innovative EEMs that cannot be simulated adequately with either DOE-2 or BLAST. These features include free cooling operating strategies using outdoor air, realistic HVAC system controls, effects of moisture absorption in building elements, and indoor air quality with a better modeling of contaminant and air flows within the building. A complete list of the interfaces is periodically updated on the EnergPlus website (Krarti, 2011).

8 BUILDING ENERGY INDEX

The Building Energy Index (BEI) being used in this research to demonstrate the performance of electric consumption at residential colleges in the unit of kWh/m^2/year (Chou, 2004). Building Energy Index (BEI) is an evaluating method from (Saidur, Masjuki, & Jamaluddin, 2007), who estimated energy intensity, BEI, in kWh/m^2 by using following equation:

$$\text{BEI} = \frac{\text{Energy Consumption/Input (kWh/year)}}{\text{Gross Floor Area (m}^2\text{)}}$$

Basically, the energy use per unit floor area can be described as “Normalized Performance Indicators” (NPI), also known as Energy Efficiency Index (EEI) or Building Energy Index (BEI) (*Kamaruzzaman and Edwards, 2006*). It basically calculates the ratio of total energy used against the total built-up area to calculate building yearly consumption. The energy consumption in buildings normally in term of Energy Efficiency Index (Aziz, Zain, Baki, & Hadi, 2012). According to MS 1525 standard, recommended building energy index in Malaysia is 135kWh/m^2/year. The saving targets are based on the lowest BEI.

9 CONCLUSIONS

As recommended by the government, public and private universities should improve their energy efficiency in order to reduce the cost of university’s operational. This research can be used as an important guidance and provide useful information for universities in Malaysia particularly on current energy consumption and potential of energy saving improvement through the best practice of energy audit that has been identified through the research.

REFERENCES

Suruhanjaya Tenaga Malaysia, (2008) "Efficient Management of Electrical Energy Regulations," p. 19. International Organization for Standardization, (2011) "Energy Management System," p. 52.

S. Tenaga, "Efficient Management of Electrical Energy Regulation 2008," *Effic. Manag. Electr. Energy Regul. 2008*, pp. 1–30, 2008.

T. Star, (2015) "The Star Online," The Star, Petaling Jaya.

V. Galis and P. Gyberg, (2011) "Energy behaviour as a collectif," *Energy Effic.*, vol. 4, no. 2, pp. 303–319.

C. Teh, (2016) "Extraordinary mind discuss ideas,". [Online]. Available: http://www.christopherteh.com/blog/2010/09/electricity-demand/.

KeTTHA, 26 June 2016. [Online]. Available: http://www.kettha.gov.my/portal/index.php.M. Z. Abd-Razak, N. K. F. Mustafa, A. I. Che-Ani, N. A. G. Abdullah, and M. F. I. Mohd-Nor, (2011) "Campus sustainability: Student's perception on campus physical development planning in Malaysia," *Procedia Eng.*, vol. 20, pp. 230–237.

S. Ahmad, Y. H. Mohammad, A. Hayati, H. Rahman and M. Majida, (2012) "Energy Efficiency Measurements in a Malaysia," in *IEEE International Conference on Power and Energy*, Kota Kinabalu Sabah, Malaysia.

M. B. Raghav, M. S. Srijaa, G. S. Rao, K. N. Bhavya, and Y.Suchitra, (1970) "ENERGY CONSERVATION ANDAUDIT-A CASE STUDY," *Int. J. Adv. Res. Electr. Electron. Instrum. Energy*, vol. 2013,

J. E. Piper, Operations and maintenance manual for energy, New York: Sharpe Professional, 1999

V. Galis and P. Gyberg, (2011) "Energy behaviour as a collectif," *Energy Effic.*, vol. 4, no. 2, pp. 303– 319

KeTTHA, 26 June 2016. [Online]. Available: http://www.kettha.gov.my/portal/index.php

Wong, (1997) "Energy Conservation and Human Behaviors: The Professional Faculties Building," in *University of Calgary*, Calgary

M. Haji-Sapar and S. E. Lee, (2005) "Establishment of energy management tools for facilities managers in the tropical region," *Facilities*, vol. 23, pp. 416–425.

G. Keeffe and B. Grimshaw, (1994) "Energy Management," *Managing Educational Property: A Handbook for Schools, Colleges and Universities*, pp. 196-209

A. Loozen and C. D. Moosdijk, (2001) "A Consumer Advise on Energy Efficient Use and," *Energy Efficiency in Household Appliances and Lighting*, pp. 468-474

S. R. Bhawarkar and S. Y. Kamdi, (2011) "Electrical energy audit of a electroplating unit - A case study," *2011 Int. Conf. Recent Adv. Electr. Electron. Control Eng. IConRAEeCE'11 - Proc.*, pp. 25–29,

C. Daniel, N. Barron, G. President, D. B. President, and P. S. Association, (2008)"the Educational Attributes of Some of the World ' S ' Top 50 ' Universities – a Discussion Paper," no. May, pp. 1– 140

J. P. Meriac, D. J. Woehr, and C. Banister, (2010) "Generational Differences in Work Ethic: An Examination of Measurement Equivalence Across Three Cohorts," *J. Bus. Psychol.*, vol. 25, no. 2, pp. 315–324.

A. A. Jamaludin, N. Z. Mahmood, N. Keumala, A. R. M. Ariffin, and H. Hussein, (2013)"Energy audit and prospective energy conservation: Studies at residential college buildings in a tropical region," *Facilities*, vol. 31, pp. 158–173,

G. H. Brundtland, (1987) "Our Common Future: Report of the World Commission on Environment and Development," *Med. Confl. Surviv.*, vol. 4, no. 1, p. 300

T.Prugh, (2000) "The Local Politics of Global Sustainability," p. 196

S. A. Roosa, (2008) *Sustainable development handbook*. Fairmont Press. Jayamaha, (2006) Energy Efficiency Building Systems, New York: McGraw-Hill.

Economic Planning Unit, 26 June 2016. [Online]. Available: http://www.epu.gov.my/en/tenaga.

W. W. Choong, A. H. bin Mohammed, and B. Alias, (2010) “Energy Conservation Model for Malaysian Higher Learning Institution,”.

Wong, (1997) "Energy Conservation and Human Behaviors: The Professional Faculties Building," in *University of Calgary*, Calgary,.

Krarti, M. (2011). *ENERGY AUDIT OF BUILDING SYSTEMS*. *Taylor & Francis Group* (Vol. 2). http://doi.org/10.1017/CBO9781107415324.00.4

B. S. K. Chou, (2004) “Performance-based Standards for Energy Efficient Buildings Introduction-Situation and Observations,” no. February

R. Saidur, H. H. Masjuki, and M. Y. Jamaluddin, (2007)“An application of energy and exergy analysis in residential sector of Malaysia,” *Energy Policy*, vol. 35, no. 2, pp. 1050–1063.

Kamaruzzaman and Edwards, (2006) "Evaluating performance characteristics of electricity use of British historic building in Malaysia," in *Facilities Vol. 24 Nos 3/4*, pp. pp. 141-52

M. B. A. Aziz, Z. M. Zain, S. R. M. S. Baki, and R. A. Hadi, (2012) “Air-conditioning energy consumption of an education building and it’s building energy index: A case study in engineering complex, UiTM Shah Alam, Selangor,” *Proc. - 2012 IEEE Control Syst. Grad. Res. Colloquium, ICSGRC 2012*, no. Icsgrc, pp. 175–180.

Ministry of Higher Education, "Ministry of Higher Education," 16 June 2016. [Online]. Available: https://www.mohe.gov.my/en/muat-turun/awam/statistik/2014

Suruhanjaya Tenaga & Pusat Tenaga Malaysia (2007) for Energy Efficiency and Conservation Guidelines