MONITORING ENERGY PERFORMANCE IN HIGHER EDUCATION BUILDINGS FOR SUSTAINABLE CAMPUS

Dr Maimunah Sapri[1]

Shehu Muhammad[2]

[1]Centre for Real Estate Studies
[2]Department of Property Management
Faculty of Geoinformation Science and Engineering
University Teknologi Malaysia, Skudai, Malaysia
Correspondant Author's E-mail: maimunahsapri@utm.my

Abstract

Energy management is one of the environmental management issues which needs to be addressed by facilities managers, as part of their support to their organisation's effectiveness and well-being. Overall energy consumption and carbon dioxide emission is significant in majority of higher educational institutions due to their large number of buildings. Improving the energy performance of buildings is one of the ways to address this challenge. A strategy for achieving this is proper targeting and monitoring of energy consumptions. The aim of this paper is to review the state of knowledge of energy performance monitoring in the context of higher education institution. It ~~is~~ discusses the concepts underlying current energy performance theories and attempts to identify the need for developing a comprehensive building energy performance information system for higher educational institutions as one of the ways of promoting environmental sustainability in higher educational institutions.

Keywords: Energy performance, facilities management, information systems, higher education institutions, Environmental sustainability.

1.0 INTRODUCTION

In recent years there is growing interest in energy consumption and costs among property owners. Concerns about rising energy costs and the need to address sustainability in the workplace are making organisations to realise how facilities management affects the bottom line (Walker et al. 2007). From an environmental and economic point of view, reducing energy consumption and cost is becoming central to planning, construction, and use of buildings (Stoy et al. 2009). A study of the UK higher education sector identified energy costs and energy consumption among 14 key estate ratios which would assist estate and senior managers in managing and improving their facilities (Hedley et al. 2001). This paper presents the review of literature in energy performance monitoring and its relationship with sustainable campus. The discussion on energy performance monitoring focuses on higher education buildings. It demonstrates the need of higher education institution to develop efficient energy performance monitoring system for sustainable campus.

2.0 Research Background

Higher educational institutions generally own a large stock of buildings which results into their significant overall energy consumption. This implies overall high emission of CO2 and its associated consequence on the environment. Good energy management practices result into buildings with high energy performance. One of the ways to achieve this is through proper targeting and monitoring of energy consumption. Energy monitoring and targeting is the use of management techniques to control energy consumption and cost (BRECSU, 2000).

The large number and diverse types of buildings in higher educational institutions makes the process time consuming and tedious. To enhance the process of monitoring and benchmarking there is the need to develop an energy performance information system. In addition to economic benefits, there are social and environmental advantages to reducing energy consumption such as preserving fossil fuels and minimising climate change (Carbon Trust, 2007).

Reducing energy consumption not only reduces cost, but helps to minimise the environmental impact of an organisation, by reducing carbon dioxide (CO2) emission and other gases associated with global warming (BRECSU, 1997). Good energy management also helps organisations to achieve enhanced indoor environmental quality, which would lead to productivity improvement. It also helps to improve the corporate image of an organisation. This article attempts to identify the need for developing efficient energy performance monitoring system in reducing the effect of energy consumption on the environment.

3.0 Review of literature

3.1 Energy Consumption and Environmental Sustainability

Carbon dioxide (CO_2) is a major greenhouse gas and the principal contributor to global warming. There is direct relationship between energy consumption and CO_2 emission. Each KWh of energy, delivered to a building, incurs atmospheric emission of the CO_2 (BRECSU, 2000) from the extraction, processing, delivery and consumption on site. The most established way of estimating emission of CO_2 from buildings is, indirectly, through energy consumption.

There is increasing demand from owners of facilities to take measures for ensuring environmental sustainability. Energy management is one of the environmental management issues, which needs to be addressed by facilities managers, as part of their support to their organisation's effectiveness and well-being (Cooper, 1996). One of the key areas is by reducing the amount of CO_2 emissions from buildings. Legislations and regulations in this regard are becoming more stringent therefore organisations must take measures to ensure compliance. For these to be achieved, the energy performance of buildings must be given the desired attention by the facilities manager (Action Energy, 2003).

Different strategies may be adopted by HEI's to promote environmental sustainability. Riddel et al. (2009) listed six-part strategy adopted by New Jersey Higher Education Partnership for Sustainability (NJHEPS) for reducing their green house gas emission as: education for sustainability; green energy measures; green building design; green procurement; student involvement; and outreach and publicity. Although there are several metrics that may be used to assess sustainability, four key metrics were developed by Rauch and Newman (2009) for higher education institutions. These are carbon dioxide (CO_2) emission, energy use, water use and recycling rate.

Measuring energy consumption and CO_2 emission serve the purpose of monitoring energy use internally within an organisation. It is also useful for public reporting of energy consumption and CO_2 emission (Carbon Trust, 2008). Whereas energy consumption can be measured directly, CO_2 emission from buildings is measured indirectly. Contribution of various energy sources to CO_2 emission can be obtained using conversion factors given in Table 1.

Table 1: Energy Conversion Factors

Energy Source	Kg CO_2/KWh
Gas	0.19
Oil	0.25
Coal	0.30
Electricity	0.46*

*Figure varies with fuel mix used for generation.
Source: BRECSU, 2000.

3.2 Energy Performance of Buildings

The built environment contributes a significant proportion of energy consumption as well as carbon dioxide emission. Although figures on energy consumption vary from one region to

another, buildings contribute 20-50%. The total building stock within EU consumes over 40% of energy consumed in Europe. They also contribute more than more than 40% of its carbon dioxide emission and the trend is on the increase (Booty, 2006). Energy efficiency is one of the requirements that a building should satisfy (BSI, 2007). Energy efficiency of buildings can be determined based on its energy performance which has been defined as the amount of energy actually consumed or estimated to meet the different needs associated with a standardised use of the building (EC, 2003). It can, therefore, be stated that buildings with 'good' energy performance promote environmental sustainability.

Energy benchmarks, also referred to as energy use indicators (EUI) or performance indicators (PI), are values against which a building's actual energy performance can be compared (Action Energy, 2003). Such benchmarks are normally given for common building types and expressed as energy use per square metre of floor area (BRECSU, 2000). Comparison of buildings' actual energy performance with standard benchmarks would enable assessment of energy efficiency, thereby helping to identify if remedial action needs to be taken. More detailed benchmarks would even help to identify the specific areas where action is required.

Recent trends in promoting energy efficiency in buildings have evolved energy performance labelling, which is gradually becoming a requirement in many countries. It is a process whereby the energy consumption of a building is assessed and rated based on a performance scale. The European parliament has recently approved the 'Energy Performance of Building Directive' on energy certification of buildings (EC, 2003). A similar project, aimed at reducing pollution emission and energy usage in existing buildings, is the ENERGY STAR Buildings Programme in US. Buildings that perform in the top 25%, in terms of energy efficiency, are recognised through the ENERGY STAR Label for Buildings (Lancashire, 2004). The Association of South-East Asian Nations (ASEAN) through its Centre for Energy operates a closely related but competitive programme. The centre promotes best practice competition for energy efficient buildings (Ismail, 2005). Awards are given to buildings that demonstrate exemplary energy performance.

An organisation with large building stock should not only be concerned with the overall but also energy performance of its respective buildings. The assessment of energy consumption helps to achieve the following (BRECSU, 2000):

i. Obtain an indication of the scope for potential improvement
ii. Identify which utility should have priority
iii. Compare buildings with typical and good practice
iv. Measure progress overtime

Energy efficient operation of buildings is achieved only by a continuing monitoring of proper performance and energy consumption (BSI, 2007).

3.3 Energy Performance of Higher Education Buildings

Energy performance benchmarks are given for different type of buildings and uses. This is due to the fact that several factors affect energy consumption, such as period of occupancy, type of equipment, nature of activities, etc. Higher Educational institutions consist of several buildings, running into hundreds in some cases. Benchmarks and methodologies for assessing performance have been developed in some countries such as the UK. Energy consumption targets are given for different space types. Table 2 shows the classification of space types and typical energy consumption target for higher education institutions in the UK. The actual percentage constituted by each space type would vary from one institution to another. It should be noted that a significant percentage of the energy in the form of fossil fuel (oil and gas) is consumed directly in building (particularly for space heating). This explains why fossil targets are higher than those of electricity. The targets serve as benchmarks against which institutions can assess their energy performance. The targets given here are to show an example

of benchmarks and may not be applicable in regions where the situation is different from that of the UK.

Table 2: Annual Target Consumption Figures (Typical Higher Education Campus)

Space Type	% of Average Higher Education Campus	Electrical target (kWh/m^2)	Fossil Target (kWh/m^2)
Teaching	25	22	151
Research	20	105	150
Lecture hall	5	108	412
Office	30	36	95
Library	10	50	150
Catering	2.5	650	1100
Recreational	7.5	150	360
Total academic	100 of academic (75% of total)	75	185
Residential	100 of residential (25% of total)	85	240

Source: BRECSU (1997).

A methodology for assessing energy performance of higher educational buildings is shown in Figure 1. The methodology requires segregating various building stock according to space type, so that comparison of actual performance against benchmarks can be done. One major limitation of this methodology is that the performance of a group of buildings is measured as against that of respective buildings. If this approach is adopted, the opportunity to identify individual buildings with excessive energy consumption would be missed.

Developing a building performance monitoring system that would enable comparison of actual consumption of individual buildings against target is desirable. This would enable the identification of 'poor' performing buildings, i.e. those with energy consumption that exceeds targets or benchmarks by a given magnitude or proportion. It would also provide the opportunity to learn the good practices in high performing buildings.

Several strategies for reducing energy consumption may be adopted by an institution. One good example is set by Imperial College, which has established energy performance both in terms of energy consumption and CO_2 emission targets for all its buildings (Imperial College, 2005). The only way of determining whether they are working or not is through proper monitoring and benchmarking of the energy performance of the buildings.

4.0 Higher Educational Facilities

Higher education institutions are organisations that provide substantial services. The core higher education services are teaching and learning. According to Pereira and Da Silva (2003), traditionally higher education institutions have two main goals: to create and disseminate knowledge. The creation of knowledge is done through the research and its dissemination is done through the education. Therefore education and research are their central processes (Pereira and Da Silva, 2003).

Sirvanci (2004) classifies the higher education institutions services into two categories: academic programmes and the facilities available (**Figure** 2). His model presented the student flow in higher education from admission to graduation. In this context, Sirvanci (2004) postulates that those services will have an impact on students' teaching and learning experience.

In order to deliver their core teaching and research mission, higher education institutions need to main substantial infrastructures. This often includes an extensive estate and buildings, which include not only laboratories, lecture theatres, and offices, but also residential accommodation, catering facilities, sports, and recreation centres.

According to Gupta (2005), higher education institutions require a number of support services in order to achieve their primary missions – research and teaching. Furthermore, Gupta (2005) is of the views that support services,

such as building and ground maintenance, waste disposal and recycling, and utilities, are all essential to maintaining a safe and enjoyable learning environment. Barret (1992) suggests that the property of higher education institutions and buildings in particular are facilitators of organisational performance.

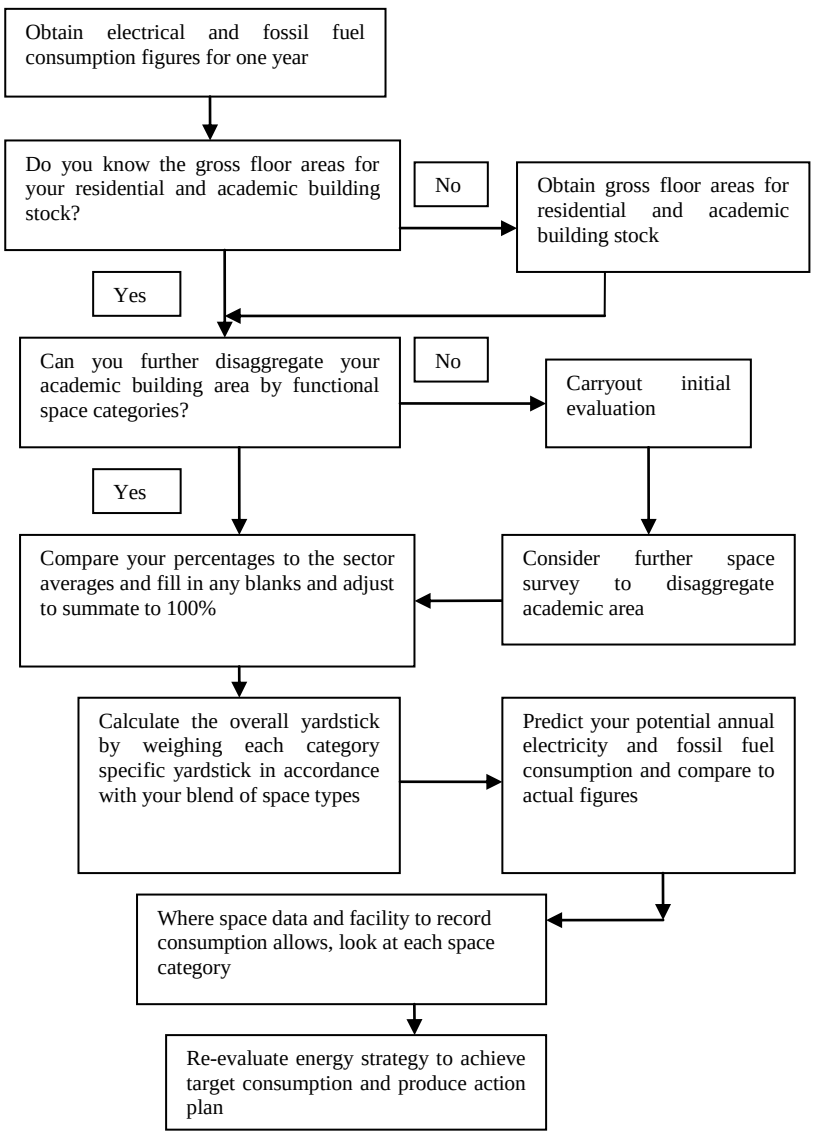

Figure 1: Steps to Energy Performance Assessment.
Source: BRECSU (1997)

5.0 The Need for Energy Performance Monitoring System in HEI's

The ability to manage information effectively is a strategic role of the facilities organisation. This requires systems which support appropriate information flows to enable facilities function to take informed decision (Walker et al. 2007). Information systems enable both management and staff of an organisation to forecast process and access important information faster. Two primary reasons for computerising facility management information systems are given: to save time (and hence cost of information), and to deal with complex and diverse data more efficiently (Rondeau et al. 2006). A well developed information system ensures that quality records are available, that the decision-making process can be traced, and feedback and feedforward mechanisms are in place to ensure effective communication among the facilities team (Joudah, 1996).

Designing a good information system involves considering the whole process of adequate data input, meaningful analysis, and appropriate reporting (BRECSU 1993). Investment in a comprehensive system of energy metering and monitoring can be worthwhile where there is a wide range of building types in use, different periods of occupancy, a range of building services, and/or a diversity of energy/fuel supplies (BRECSU, 1997). The key benefits of information systems have been summarised by Barret and Baldry (2003) as:

i. More efficient use of information at all managerial levels,
ii. Improved decision making,
iii. Improved managerial responsiveness, and
iv. Improved learning capacity and capability.

A properly designed and developed energy performance information system would serve as a database for recording and storing energy performance data of various buildings. This includes both the actual as well as target energy consumption. The system would enable easier allocation and adjustment of appropriate benchmarks for individual buildings. Information for decision making on building energy performance can be more accessible and timely. An important attribute of building performance information system is the ability for quick identification of areas needing attention, and to confirm whether energy saving measures are working (Energy Star, 2002).

6.0 EMERGING RESEARCH NEED

Generally this paper has determined an area of proliferation in the energy performance monitoring system for higher educational buildings. Developing efficient energy performance monitoring system contributes to sustainable campus environment. Since Higher Educational Institutions consists of large stock of buildings with different functions, monitoring the consumption of individual buildings is a great task. The assessment and comparison of actual consumption of individual buildings with target is an added challenge. However, questions, for an ongoing research before developing energy performance monitoring system, are as follow:

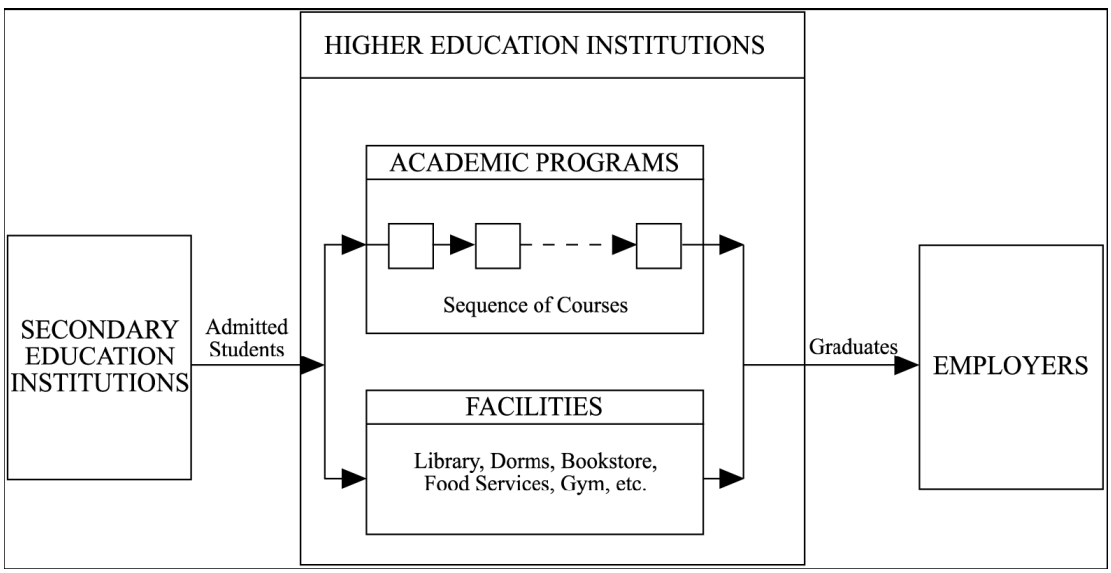

Figure 1: Student flow in higher education**.**
Source: Sirvanci (2004)

The system would also enable the adjustment of consumption targets when improvement measures, in the form of building components or services installation, have been put in place. Once the system is developed and basic information about the individual buildings is captured, the task of benchmarking building energy performance and overall energy management function would be greatly enhanced. This would likely impact positively on efforts at reducing energy consumption as well as CO2 emission, thereby promoting a more sustainable campus.

i. How the system can easily be used to assign appropriate consumption target for buildings of similar use, but of different qualities?
ii. How does FM relate the energy performance system on a sustainable campus?
iii. What is mechanism to measure the effect of the system to the environment?

One of the requirements of such a system is the recording energy consumption at building level (sub-metering). Energy performance

standards/consumption targets applicable at local/regional level are also necessary. The target would be applicable for typical buildings while adjustment may be made for those with special or peculiar characteristics. A computerised information system would certainly enhance the various processes involved, particularly storage and processing of a large amount of data that is critical to decision making.

7.0 CONCLUSION

Higher education institutions generally own large stock of facilities (buildings and other infrastructure) for the delivery of their services. A lot of resources (human, material and financial) are devoted for the acquisition, operation and management of the facilities. It is imperative for institutions to manage their facilities by adopting good practices in various aspects of their operations. Energy management initiatives can help organisations to significantly reduce their energy consumption and costs. This will help them to improve their financial and environmental performance, thereby becoming more sustainable. Monitoring and targeting of consumption, through the use of appropriate benchmarks, can be employed as a means of improving building energy performance in higher educational institutions. This can be aided by computer based energy information systems which would provide timely information, thereby improving decision making process and management action.

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