AN OVERVIEW OF ELECTRICAL ENERGY CONSUMPTION TRENDS IN MALAYSIAN GOVERNMENT HOSPITALS: A CASE STUDY OF SERDANG HOSPITAL

BY

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A dissertation submitted in the fulfilment of the requirement for the degree of Masters of Science in Building Services Engineering

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ABSTRACT

Hospitals have unique and intensive energy use requirements. In addition to the need for lighting and heating 24 hours a day, hospitals demand extensive energy for ventilation, equipment, sterilization, and laundry and food preparation. Studies on hospitals abroad have shown that lighting contributes about 25 percent and HVAC contributing almost 45 percent of a typical hospital's energy bill. Those studies also show that energy saving initiatives have the potential to reduce energy cost significantly. This study aims to compare the Building Energy Index (BEI) and load apportioning performance of different public hospitals in Malaysia with specific focused example of Serdang Hospital which no audit has been done yet. Serdang Hospital was selected for this study since it is one of the recently commissioned and operationalised hospital in the Klang Valley. The data was collected over 24 hour electricity utilisation for a one week period by using datalogger tool to map the energy consumption trend. The detailed audit study was summarised and compared with other BEI's compiled from secondary sources. A comparison is made between the energy use trends of different hospitals. Discussion is done on the possible approach towards increased energy savings in hospitals.

ABSTRACT IN BAHASA MALAYSIA

Hospital mempunyai keperluan penggunaan tenaga yang unik dan intensif. Selain dari keperluan pengcahayaan dan penggunaan alat pemanas sepanjang hari, hospital memerlukan tenaga untuk pengudaraan, peralatan, sterelisasi, pencucian pakaian dan penyediaan makanan. Kajian di hospital luar negara mendapati pengcahayaan menyumbang 25 peratus dan pendingin hawa menyumbang hamper 45 peratus kepada bil tenaga hospital. Kajian berkenaan juga menunjukkan bahawa inisiatif penjimatan tenaga mempunyai potensi merendahkan kos tenaga secara berkesan. Kajian ini bertujuan untuk membandingkan 'Building Energy Index (BEI)' dan prestasi pecahan bebanan tenaga di hospital-hospital kerajaan dengan tumpuan kepada Hospital Serdang kerana setakat ini tiada laporan audit yang telah dilaksanakan. Hospital Serdang telah dipilih untuk kajian ini kerana ia adalah hospital yang terbaru beropeprasi di Lembah Kelang. Data penggunaan elektrik selama 24 jam telah direkod bagi tempoh seminggu dengan menggunakan alat 'datalogger' untuk menghasilkan corak penggunaan tenaga. Kajian audit yang terperinci telah dirumus dan disbanding dengan BEI lain yang diperolehi melalui data sekunder. Perbandingan corak guna tenaga antara beberapa hospital kerajaan telah dibuat. Perbincangan mengenai pendekatan penjimatan tenaga di hospital juga telah dilakukan.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholar presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Building Services Engineering.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degree at IIUM or other institutions.

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'My thanks to Allah Azza Wa Jalla for giving me the strength to complete the dissertation. I dedicate this work to Mariam, Nor Azri, Nor Aina, Ahmad Faiz, Ahmad Latifi and both my parents. May Allah bestow His blessings upon all of you.'

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LIST OF ABBREVIATIONS

AHU	Air handling unit
ALC	Autoclave lightweight concrete
BEI	Building Energy Index
CUCMS	Cyberjaya University College of Medical Sciences
DHSS	Department of Health Social and Services
EEUI	Electrical Energy Used Index
ENEA	Ente Nazionale Energia e Ambiente
GFA	Gross Floor Area
GJ	Gigajoules
HVAC	Heating ventilation air-conditioning
kWh/m2/yr	Kilowatt hour per metre square per year
m2	Metre square
MCA	Mechanical Conditioned Area
MHM	Ministry of Health Malaysia
NHS	National Health Services
PFI	Private Financial Initiative
PTM	Malaysian Energy Centre
PWD	Public Works Department
RH	Relative humidity
SKVE	South Klang Valley Expressway
THIS	Total Hospital Information System
UiTM	Universiti Teknologi MARA
USAID	US Agency for International Development
VSD	Variable Speed Drive

CHAPTER ONE

INTRODUCTION

OVERVIEW

Recently there has been a resurgent interest in energy efficiency and energy savings targets for large buildings in Malaysia. Of particular interest is the reduction of energy consumption of energy intensive buildings such as hospitals. This is due to the increasing realisation of the continued depletion of non-renewable energy sources and the rise of the green building movement. Due to these and various other developments, there has been a continued pressure and realisation that there is a need to re-assess and further develop and update codes, standards and benchmarks in order to represent standards of good practice which are in turn transformed to practical implementation in the building industry.

Energy consumption in buildings is related to factors linked to the design and operations of a building. It has been found that as much as 30 percent of energy can be saved if the design of the building is linked to energy performance targets and guidelines. Apart from the development of standards, various measures were also undertaken by the Malaysian government on energy efficiency such as the formulation of a national energy policy, the construction of demonstration projects such as KeTTHA's (Kementerian Tenaga, Teknologi Hijau dan Air) LEO (Low Energy Office) building in Putrajaya and PTM's (Pusat Tenaga Malaysia) ZEO (Zero Energy Office) building in Bangi and the labelling of stand-alone energy consuming equipment such as fan coil units and refrigerators in terms of energy efficiency.

Of rising concern in the industry is the absence of energy benchmarks for buildings. Benchmarks are necessary because they give a standard target which they become the measure of performance. Benchmarking is an important guideline in buildings and also an important tool in the management process of building operations. It assists designers and manager in making decisions that will impact on operation costs and the facility's financial performance. Building managers will be able to set the direction of the facility or organisation in order to achieve the required targets and goals determined by the owners and stakeholders.

Leah B. Garris (2008) pointed that benchmarking to obtain information on performance of properties against peers best practices is crucial for decision making on controlling energy use and costs. As energy costs escalate, it becomes even more important to monitor its movement. Upper management almost always doesn't understand the results of energy benchmarking enough to support it. Energy benchmarking won't make a difference unless the results are properly translated into business-friendly language that non-technical people can appreciate. Another factor is on work habits that don't change because facilities staff rarely sees the utility bills and personnel paying the bills have no clue how energy is being utilised.

A study conducted by Lawrence Berkeley National Laboratory, California (2007) the main reasons given by facilities professionals for benchmarking energy use are:

i. to identify energy-efficiency opportunities,

ii. to prioritize investments,

iii. to make comparisons to other facilities,

iv. recognition,

v. to make the business case for efficiency investments,

vi. to track current projects expected to save energy, money, etc.,

vii. to see how a certain building compares to a portfolio or peer group,

viii. to assess a building's performance before you buy/lease it,

ix. to present building performance to a potential buyer or lender,

x. to set targets for improved performance, and

xi. to facilitate assessment of property value and marketing rental properties.

Customers will become more sensitive to the energy performance of buildings, and they'll demand benchmarking data as part of the lease or sale documentation with the understanding that, if the building fails to perform, there will be some recourse.

Cleanrooms that are critical to a wide range of industries, including universities and government facilities, are extremely energy intensive as pointed by William Tschudi, et. al. (2001). The study conducted indicates the following:

i. energy represents a significant operating cost for these facilities,

ii. improving energy efficiency in cleanrooms will yield dramatic productivity improvement,

iii. base load reduction will also improve reliability,

iv. benchmarking energy use allows direct comparisons leading to identification of best practices, efficiency innovations, and highlighting previously masked design or operational problems,

v. buildings with cleanrooms typically include energy intensive HVAC systems consisting of large central plant heating and cooling, large amounts of air recirculation, and make-up and exhaust ventilation,

vi. although activities performed in cleanrooms vary greatly, the environmental systems (primarily HVAC) typically utilize a large percentage of total building energy (up to 50%),

vii. energy intensity varies with the cleanliness level (IEST-ISO std. 14644-1, 2000) and use of the cleanroom,

viii. energy benchmarking is an effective tool to aid in visualizing the energy end uses in complex cleanroom facilities,

ix. measured energy use determined by a benchmarking program can provide a baseline for tracking energy performance over time,

x. benchmarking can also be used to prioritise where resources need to be applied to achieve improvements in energy efficiency,

xi. use of the metrics developed for this project provides a mechanism of system and component comparison to other cleanrooms,

xii. by analysing the variation in the data, best practices can be identified,

xiii. finding the root cause of the discrepancy could solve on going operational or maintenance problems or correct problems originally built into the facility,

xiv. future activity should be directed at developing a more robust database through additional benchmarking and collection of existing measured data,

xv. as an alternate to collecting physical measurements, it would also be useful to build a database of design-based values which would provide some needed guidance to designers and owners in deciding on various design options, and

xvi. finally, a self-benchmarking tool is needed to allow building operators to perform their own assessments and then compare performance over time or compare to others.

Steven Carlson, P.E. (2006) in discussing benchmarking as an Energy Management Tool identifies the following resultant benefits:

i. identify savings potential,

ii. prioritise where to look for improvements,

Identifying actions to improve performance include identify issues (metrics), collecting internal data as baseline and collecting external data for comparison framework. These actions will assist in analysis exercises conducted, implementing change and monitoring the intended impact. The often use comparison unit as he pointed are Energy Cost ($/sqft) and Energy Use (kBtu/sqft). The analysis is useful in identifying the ranking, the energy distribution pattern and positioning against standards or best practices.

Currently in the effort to develop energy benchmarks for buildings, Malaysia Greentech Corporation in collaboration with National University of Singapore have studied the energy consumption data from more than 50 recent office buildings and found that a conventional 8am to 5 pm office building will consume about 231 kwh/m2/yr. This study on average data is an important step in the development of energy efficient standards as it highlights the average consumption of a building and hence points to a minimum acceptable standard for the energy consumption of an office building. Office buildings are relatively easier to analyse and generalise. They operate typically during office hours and the equipment and occupants within the buildings are relatively standard.

However benchmarks for more complex buildings such as hospitals and transportation buildings are more complex to develop. They are various types of hospitals and various types of occupancy and use patterns and this will be highlight later in this study.

It is beyond the scope of this study to develop benchmarks. However before a benchmarking study can be developed, existing data or energy audit studies must be compiled and these consumptions levels must be tabulated, categorised and analysed in terms of any patterns or a link between the building type, occupancy or usage patterns and the energy consumption of the buildings.

Hospitals have unique and intensive energy use requirements. The energy demand generally comprises of the need for lighting, heating 24 hours a day, ventilation, equipment, sterilization, laundry and food preparation. Research conducted has shown that lighting and HVAC contribute 25 and 45 percent respectively, of a typical hospital's energy bill. Hence energy savings initiatives have the potential to dramatically impact a hospital's operational expenses.

Hospital is an institution established to care for the sick and injured, and it functions 24 hours daily throughout the year. The establishment normally consists of many buildings of different floor areas to cater for each specific use and function. Each building's internal climate are controlled and maintained for a particular need, for example, an operating theatre needs 24 hours clean and cool air with pressurised environment during a medical operation, or laboratories that may require air conditioning with fume extraction capability.

Human and equipment generate substantial heat and it is critical for an air conditioning system to extract and regulate the temperature in that particular space. An effective cooling and ventilation systems combined with good insulation usually reduces the hospital's sensitivity to outside temperature. These preset climate conditions demand enormous amount of energy to run mechanical equipment for the desired output. More importantly is the supply pattern of energy that is devoid of large cyclic slag in the generated alternating current which will render medical equipment to dysfunction. Thus the hospital's energy supply design would also be incorporated with standby electrical generators to ensure a continuous supply of energy in especially during emergencies and critical medical operations.

Energy issues are taking centre stage in this millennium due to growing awareness among the public resulting from campaigns and media coverage of programmes initiated and conducted by non-governmental organisations either locally or abroad. The depletion of natural resources and emission of greenhouse gases into the atmosphere are direct results from the generation and utilisation of energy. This makes initiatives to reduce energy consumptions all more important.