



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

**BY**

**AZRIN BIN MOHD DIN**

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

**Kulliyyah of Architecture and Environmental Design  
International Islamic University  
Malaysia**

**AUGUST 2012**

## **ABSTRACT**

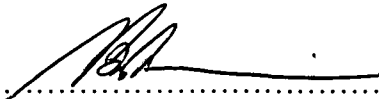
Hospitals have unique and intensive energy use requirements. In addition to the need for lighting and heating 24 hours a day, hospitals demand extensive energy for ventilation, equipment, sterilization, and laundry and food preparation. Studies on hospitals abroad have shown that lighting contributes 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 pencahayaan dan penggunaan alat pemanas sepanjang hari, hospital memerlukan tenaga untuk pengudaraan, peralatan, sterilisasi, pencucian pakaian dan penyediaan makanan. Kajian di hospital luar negara mendapati pencahayaan menyumbang 25 peratus dan pendingin hawa menyumbang hampir 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 beban 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 beroperasi 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

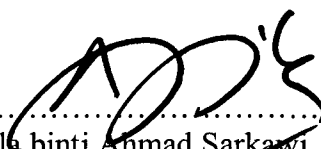
I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholar presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Building Services Engineering.

  
.....  
Puteri Shireen binti Jahn Kassim  
Supervisor

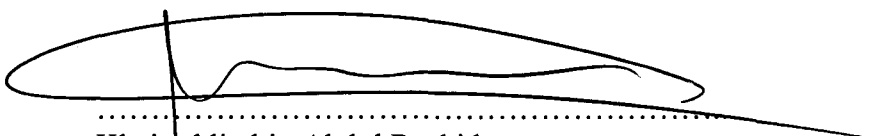
I certify that I have read this study and that in my opinion, it conforms to acceptable standards of scholar presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Building Services Engineering.

  
.....  
Maisarah binti Ali  
Examiner

This dissertation was submitted to the Kulliyah of Architecture and Environmental Design and is accepted as fulfilment of the requirement for the degree of Master of Science in Building Services Engineering.

  
.....  
Azila binti Ahmad Sarkawi  
Deputy Dean ( Postgraduate ), Kulliyah of  
Architecture and Environmental Design

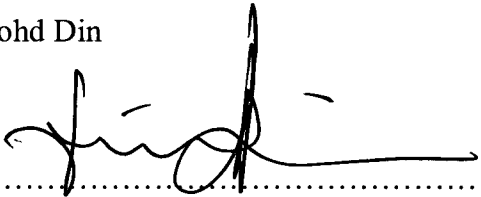
This dissertation was submitted to the Kulliyah of Architecture and Environmental Design and is accepted as fulfilment of the requirement for the degree of Master of Science in Building Services Engineering.

  
.....  
Khairuddin bin Abdul Rashid  
Dean, Kulliyah of Architecture and  
Environmental Design

## 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.

Azrin bin Mohd Din

Signature ..... 

Date ..... 13/8/2012

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

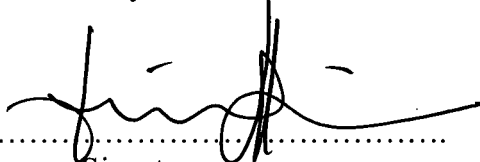
**DECLARATION OF COPYRIGHT AND AFFIRMATION  
OF FAIR USE OF UNPUBLISHED RESEARCH**

Copyright © 2012 by International Islamic University Malaysia. All rights reserved.

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

I hereby affirmed that the International Islamic University Malaysia (IIUM) holds all rights in the copyright of this Work and henceforth any reproduction or use in any form or by means whatsoever is prohibited without the written consent of IIUM. No part of this unpublished research may be reproduced, stored in a retrieval system, or transmitted, in any form or by means, electronic, mechanical, photocopying, recording or otherwise without prior written permission of the copyright holder.

Affirmed by Azrin bin Mohd Din

  
.....  
Signature

13/8/2012  
.....  
Date

*My thanks to Allah Azzu 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.'*

## **ACKNOWLEDGEMENTS**

I would like to thank my supervisor Asst. Prof. Dr. Puteri Shireen Jahn Kassim for her patience in motivating me to complete the dissertation when I had lost the zeal to continue at times.

My thanks also to the Radicare Sdn. Bhd. Personnels that have assisted me in collecting the data, particularly En. Ali Husin (Chargemen), En. Ahmad Nazarudin Mohd Jawahir (Manager Facility Engineering), En. Ahmad Wira Ahmad Khair (Manager Biomedical Engineering) and En. Mohd Rafii Abdul Razak (Technician).

To others who are directly or indirectly involved in the preparation of this dissertation, my sincere thank you.



## TABLE OF CONTENTS

Abstract .....	ii
Abstract in Bahasa Malaysia .....	iii
Approval Page .....	iv
Declaration page .....	v
Copyright page .....	vi
Dedication .....	vii
Acknowledgements .....	viii
List of Tables .....	xii
List of Figures .....	xv
List of Photographs .....	xvi
List of abbreviations .....	xviii
<b>CHAPTER ONE: INTRODUCTION .....</b>	<b>1</b>
Overview .....	1
Aims and Objectives of this dissertation .....	8
Structure Of Study .....	10
Scope Of Study .....	11
<b>CHAPTER TWO: LITERATURE REVIEW .....</b>	<b>13</b>
Hospital’s Energy Usage Profile .....	13
Energy Baseline Benchmarking .....	16
Influence of Passive Design of Hospital Buildings on Energy Consumption .....	21
Energy Patterns in Malaysian Hospitals .....	24
Level of Healthcare in Malaysia .....	24
Electrical Energy Trends .....	24
Selayang Hospital’s Energy Report .....	29
Langkawi, Slim River and Putrajaya Hospitals .....	33
<b>CHAPTER THREE: RESEARCH METHODOLOGY .....</b>	<b>35</b>
Overview .....	35
Part 1 – Data Collection .....	35
Langkawi Hospital .....	36
Slim River Hospital .....	36
Putrajaya Hospital .....	36
Selayang Hospital .....	36
Part 2 – Energy Audit .....	37
List of Energy Audit Equipment .....	37
Field Survey .....	40

<b>CHAPTER FOUR:</b>	<b>A CASE STUDY: HOSPITAL SERDANG, JALAN PUCHONG, KAJANG, SELANGOR DARUL EHSAN .....</b>	<b>42</b>
Introduction .....		42
The Site .....		44
Inventory Recording .....		53
General .....		53
Air conditioning chillers .....		56
Lighting .....		57
Level of temperature and humidity .....		61
Electrical Supply And Distribution .....		63
Energy Cost .....		64
Relative Humidity .....		66
<b>CHAPTER FIVE:</b>	<b>ANALYSIS AND FINDINGS .....</b>	<b>69</b>
Introduction .....		69
Air-Conditioning Rating .....		70
Building Orientation .....		73
Envelope specification in Solar Reflectance .....		73
Entrance Doors .....		74
Population Catchment .....		74
Lighting .....		75
Lux Level .....		78
Temperature and Relative Humidity .....		80
Summary .....		82
<b>CHAPTER SIX: CONCLUSION .....</b>		<b>88</b>
Summary .....		88
Recommendation .....		93
Shading Devices .....		94
Self-Closing Doors or Double Doors .....		94
Air-conditioning .....		94
Lighting .....		95
Limitations of Studies .....		96
<b>BIBLIOGRAPHY .....</b>		<b>98</b>

APPENDIX 1 .....	101
APPENDIX 2 .....	144

## LIST OF TABLES

<u>Table No.</u>		<u>Page No.</u>
2.1	Energy use in Malaysian hospitals and office buildings	26
2.2	Representative Benchmark in Annual kWh/m <sup>2</sup> GFA for Malaysian Hospitals (Estimated from Survey Data 2003)	28
2.3	Services provided at Selayang	30
2.4	Load values	31
2.5	Load values between Selayang Hospital and other large hospitals	32
2.6	Detail energy survey of 3 hospitals	33
2.7	Energy survey of large hospitals, Selayang, Slim River, Langkawi and Putrajaya hospitals	34
4.1	Floor area and departments' location.	46
4.2	Medical services provided	52
4.3	Space function and location	54
4.4	Type, specification and quantity of light fittings	58
4.5	Type and quantity of light fittings installed	59
4.6	Type and location of light fittings installed	59
4.7	Non-air-conditioned spaces	62
4.8	Electrical energy bill for September	64
4.9	Electricity cost from February to October 2009.	65
4.10	The RH value for every level (air conditioning area)	66

## LIST OF TABLES (CONTINUED)

<u>Table No.</u>		<u>Page No.</u>
4.11	RH value for non-air conditioned area	66
4.12	Non-air conditioned areas	67
5.1	Power rating of components for the air conditioning system	71
5.2	Air-conditioning BEI rating of Serdang, Large Hospitals, Selayang, Slim River, Langkawi and Putrajaya	72
5.3	Healthcare service and air-conditioning rating BEI for Serdang, Selayang, and Putrajaya	75
5.4	Type and quantity of light fittings installed	75
5.5	Lighting BEI and healthcare service of Serdang, Large Hospitals, Selayang, Slim River, Langkawi and Putrajaya	76
5.6	Lighting BEI and healthcare service of Serdang, Selayang and Putrajaya	77
5.7	Lighting BEI against the number of beds for Serdang, Selayang and Putrajaya	78
5.8	Lux level at specific location	79
5.9	The temperature and RH value (air conditioned area)	81
5.10	The average temperature and RH value (non-air conditioned area)	81
5.11	The average temperature and RH value for air conditioned area and non-air conditioned area	82
5.12	Overall BEI of Serdang, Large Hospitals, Selayang, Slim River, Langkawi and Putrajaya	83
5.13	Consumption data of Serdang and Selayang Hospitals	84
5.14	Medical services provided	85

## LIST OF TABLES (CONTINUED)

### Table No.

5.15	Consumption data of Serdang and Putrajaya Hospitals	86
6.1	Comparison on load apportionment between Serdang, Selayang, Slim River, Langkawi and Putrajaya	90
6.2	Comparison of BEI rating for Serdang, Selayang, Slim River, Langkawi and Putrajaya	91
6.3	Comparison of load apportionment, BEI and GFA between Serdang, Selayang, Slim River, Langkawi and Putrajaya	92
7.1	Details of Light Fittings and Lighting Load	101
7.2	Lux Level Comparison	140

--

## LIST OF FIGURES

<u>Figure No.</u>		<u>Page No.</u>
2.1	Breakdown of hospitals' energy end users	14
2.2	Energy source	15
2.3	Generic Referral System Diagram 1	22
2.4	Generic Referral System Diagram 2	23
2.5	Average percentage of energy use by hospitals	27
3.1	Research Methodology Flowchart	35
4.1	Energy demand pattern	63
4.2	Electricity cost pattern in Serdang Hospital	65
4.3	RH value for every level	67
5.1	Air Conditioning Load Apportioning	71
5.2	Breakdown of Monthly Energy Consumption	82

--

## LIST OF PHOTOGRAPHS

<u>Photograph No.</u>		<u>Page No.</u>
3.1	Lux meters	38
3.2	Elcontrol Data loggers Model VIP System 3	38
3.3	Fluke 337 True RMS Clamp Meter	39
3.4	Psychrothermometer	40
4.1	Satellite image of Hospital Serdang's showing the building orientation.	45
4.2	Hospital Serdang's steel structure frame.	47
4.3	Hospital Serdang's cone shaped atrium with aluminium cladding.	48
4.4	Hospital Serdang's cone shaped atrium (taken from below, at the centre.	48
4.5	Hospital Serdang's receptions counter adjacent to the glass wall at atrium.	49
4.6	Hospital Serdang's rooftop gardens, on the right and left of the building.	50
4.7	View of Hospital Serdang's main lobby entrance.	51
4.8	Windows and openings at building façade	57
4.9	Lighting at a typical reception area using fluorescent lamps	59
4.10	Lighting at a typical corridor area using fluorescent lamps	60
4.11	Lighting at lift lobby area using PLC lamps	60
4.12	Lighting at Main Entrance lobby area using PLC amps	61
4.13	Lighting cafeteria area using PLC amps	61



## LIST OF PHOTOGRAPHS (CONTINUED)

<u>Photograph No.</u>		<u>Page No.</u>
4.14	Psychrothermometer (portable meter recording temperature and humidity)	62
4.15	Natural ventilation along the corridor for every level	68
5.1	Lights are switched on during day time	79
5.2	Lights are switched on along the corridor area.	80

## 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/m <sup>2</sup> /yr	Kilowatt hour per metre square per year
m <sup>2</sup>	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/m<sup>2</sup>/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.