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IMPROVEMENT OF ENERGY PERFORMANCE INDICATOR FOR BUILDINGS IN MALAYSIA

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IMPROVEMENT OF ENERGY PERFORMANCE INDICATOR FOR BUILDINGS IN MALAYSIA

By

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IMPROVEMENT OF ENERGY PERFORMANCE INDICATOR FOR BUILDINGS IN MALAYSIA

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February 2019

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Buildings are the leading energy consuming sectors that represents 40% of the global energy consumption. The building energy performance indicator is a comparative measurement indicator. More than 53 building energy performance indicator exists with various key performance indicators and methodological approaches. The objective of this research is to propose an improved methodology approaches and obtained an improved energy performance indicator for buildings in Malaysia. Upon data collection and analysis, building samples are analyze using three (3) parameters. These parameters are building categories, net floor area and building energy consumption. In addition, the building samples and reference buildings will be accessed and calculated based on similar climate and building function in order to produce a relatively consistent with less significant disparity results. Finding indicate 18 buildings out of 55 Land Plots that fulfilled overall improved requirements of building energy performance indicator. The building energy consumption that fulfilled the overall requirement is regressed against net floor area. As a result, a linear regression graph and variance value is produced. The early result indicates that the overall building energy performance indicator value of 153.2 kWh/m².year with unsatisfying R^2 of 0.278. Thus, an addition requirement will be imposed which is the data will be comparing based on United States (Star, 2014) Primary Function compared to KETTHA Guideline for Energy Efficiency in Buildings dan GBI Malaysia existing building energy performance indicator. The result indicates building energy performance indicator of 137.0kWh/m².year with satisfying R^2 of 0.910 for office building. The result is specifically compared with three (3) reference buildings that which are Wisma Rozali, Wisma Sunway and Menara Persekutuan Melaka. The result verification is -8.27%, +12.71 and a merely

2.02% respectively. The results conclude that sample buildings that passed improved parameter assessment method are more credible. While, improved building energy performance indicator method finding result a stunning value of 137kWh/m^2.year when compared to the KETTHA propose standard case building energy performance indicator. The result reflected that improved building energy performance indicator is in line with previous Malaysia study on building energy performance indicator to a certain extend.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENAMBAHBAIKAN PENUNJUK ARAS TENAGA BAGI BANGUNAN DI MALAYSIA

Oleh

HAIRI BIN PONICHAN

Februari 2019

Pengerusi : Nor Mariah Adam PhD PE
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Bangunan merupakan sektor penggunaan tenaga utama yang mewakili 40% daripada penggunaan tenaga global. Penunjuk prestasi tenaga bangunan adalah penunjuk aras perbandingan. Sebanyak lebih daripada 53 petunjuk prestasi tenaga untuk bangunan wujud dengan pelbagai penunjuk aras utama dan metodologi. Objektif kajian ini adalah untuk mencadangkan metodologi yang lebih baik dan mendapatkan penunjuk prestasi tenaga yang lebih baik untuk bangunan-bangunan di Malaysia. Melalui pengumpulan data dan membuat analisa, sampel bangunan dianalisa menggunakan tiga (3) parameter. Parameter ini adalah kategori bangunan, luas lantai bersih dan penggunaan tenaga di bangunan. Di samping itu, sampel bangunan dan bangunan-bangunan rujukan, dinilai dan dikira berdasarkan iklim dan fungsi bangunan yang sama untuk menghasilkan penemuan yang agak konsisten dengan perbezaan yang tidak signifikan. Penemuan menunjukkan 18 bangunan daripada 55 Plot Tanah memenuhi keperluan keseluruhan penunjuk prestasi tenaga bangunan. Penggunaan tenaga bangunan yang memenuhi keperluan keseluruhan di regrasi dengan luas lantai bersih. Keputusannya, graf regresi linear dan nilai varians terhasil. Hasil awal menunjukkan bahawa nilai penunjuk prestasi keseluruhan bangunan 153.2kWh/m². tahun dengan R2 yang tidak memuaskan iaitu 0.278. Oleh itu, satu keperluan tambahan akan dikenakan yang mana data akan dibandingkan berdasarkan Fungsi Utama Amerika Syarikat (Star, 2014) berbanding dengan Garis Panduan KETTHA Kecekapan Tenaga di Bangunan dan Garis Panduan Bangunan Sediaada GBI Malaysia Penunjuk Aras Kecekapan Tenaga di Bangunan. Hasilnya menunjukkan penunjuk prestasi tenaga bangunan berjumlah 137.0kWh/m². tahun dengan R2 yang memuaskan iaitu 0.910 untuk bangunan pejabat. Hasilnya secara khusus dibandingkan dengan tiga (3) bangunan rujukan iaitu Wisma Rozali, Wisma Sunway dan Menara Persekutuan Melaka. Pengesahan keputusan adalah masing-masing -8.27%, +12.71 dan 2.02%. Hasilnya menyimpulkan bahawa bangunan sampel yang lulus kaedah

penaksiran parameter yang lebih baik adalah lebih dipercayai. Sementara itu, kaedah penunjuk prestasi tenaga yang bertambah baik menghasilkan nilai yang menakjubkan iaitu 137kWh / m2. tahun apabila dibandingkan dengan Garis Panduan KETTHA Kecekapan Tenaga di Bangunan. Hasilnya mencerminkan bahawa penunjuk prestasi tenaga yang bertambah baik ini adalah selaras dengan kajian-kajian penunjuk prestasi tenaga bangunan di Malaysia lain sebelum ini tertakluk kepada suatu jangkaan tertentu.

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Hairi Bin Ponichan

August 2019

I certify that a Thesis Examination Committee has met on 18 February 2019 to conduct the final examination of Hairi bin Ponichan on his thesis entitled "Improvement of Energy Performance Indicator for Buildings in Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

UPM	Universiti Putra Malaysia
KETTHA	Kementerian Tenaga, Teknologi Hijau dan Air
GBI	Green Building Index
BEPI	Building Energy Performance Indicator
NFA	Net Floor Area
BREEAM	Building Research Establishment Environmental Assessment Method
LEED	Leadership in Energy and Environmental Design
PAM	Persatuan Arkitek Malaysia
ACE	Asean Centre of Energy
SEDA	Sustainable Energy Development Authority
BEI	Building Energy Index
EEI	Energy Efficiency Intensity
CUSUM	Consumption Actual Consumption and Cumulative Sum
PWD	Public Work Department Malaysia
ACA	Air-conditioned space
GHG	Greenhouse Gases
GDP	Gross Domestic Product
UBBL	Uniform Building By-Laws 1984
BEETG	Building Energy Efficiency Technical Guideline
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
IGBC	India Green Building Council
NE	North East
SW	South West
EUI	Energy Use Intensity
EMS	Energy Management System
AEMAS	Association of Southeast Asian Nations Energy Manager Accreditation Scheme
TNB	Tenaga Nasional Berhad
LPG	Low Pressure Gas
MBSA	Shah Alam City Council
EMGS	AEMAS Energy Management Gold Standard
BECS	Building Electricity Consumption Spreadsheet
BECAS	Building Electricity Consumption Account Spreadsheet

CHAPTER 1

INTRODUCTION

1.1 Research Background

As world population increase competition for land become competitive. More people move into cities or suburbs. The cities need to cater existing and future population needs, sensitive towards their environment and to ensure their lifestyle and facilities do not adversely affect the environment. (KETTHA, 2011), Kementerian Tenaga, Teknologi Hijau dan Air.

One of the major components for achieving sustainable city is managing energy conservation and efficiency. Policy-maker parties such as federal government, government related agencies and local governments are role models that need to assess the trends towards managing energy conservation and efficiency (KETTHA, 2011). Building consume 40% of energy consumption.(Tsai, 2010), the building energy performance indicator is a comparative measurement indicator between buildings to show operator success in managing energy. (Abdallah & El-rayes, 2015).

Current trend in the building sector is to promote green building which in turn strive towards energy efficient buildings. This sentiment is displayed through 50 certification methods that measure building success in managing energy such as Green Star Australia, BREEAM United Kingdom, LEED United State, GBI Malaysia and others that depend on each country exclusive design. (Sood, Chua, & Peng, 2011)

Meanwhile, more than 53 building energy performance indicator are in existence with various key performance index and methodological approaches (Boemi & Tziogas, 2016). The building energy performance indicator are divided into four (4) major classified methods for assessing and calculating the energy performance of buildings which based on (Boemi & Tziogas, 2016) (Beusker, Stoy, & Pollalis, 2012).:-

i) Standard assumptions
ii) Designated factors (e.g., climatic data, operating time)
iii) Physical and thermal quantities of individual buildings;
iv) Quantitative parameters.

In Malaysia, there are four (4) most established building energy performance indicators which are developed or adopted by Persatuan Arkitek Malaysia (PAM), Suruhanjaya Tenaga, Asean Centre of Energy (ACE) and Sustainable Energy Development Authority (SEDA). Table 1.1 shows the organization and their related established building energy performance indicator in Malaysia.

Table 1.1: Organization and their related established Building Energy Performance Indicator in Malaysia

Organization	Building Energy Performance Indicator
(GBI Building, 2011)	Total annual energy per unit area, Building Energy Intensity (BEI) (kWh/m^2/year)
(Suruhanjaya Tenaga, 2014)	Total annual energy per unit, Energy Efficiency Intensity (EEI) Total annualized energy (kWh) Forecast energy consumption (kWh) from regression analysis (y=mx+c), Difference between forecast consumption actual consumption and Cumulative Sum (CUSUM) analysis
(Asean Centre of Energy (ACE), 2014)	Total annual energy per unit, Energy Efficiency Intensity (EEI)
(Greentech Malaysia ; SEDA Malaysia, 2013)	Total annual energy per unit area, Building Energy Index (BEI) (kWh/m^2/year)

1.2 Problem Statement

Several variations of standard general value the building energy performance indicator are mentioned in few Malaysian publishing as tabulated in Table 1.2.

Based on (Mohd Tarmizi Mat Asim, 2015), the Building Energy Index (BEI) for commercial building in Malaysia is 135kWh/m^2.year which is quoted from (Noranai, 2011). (Noranai, 2011) mentioned that the value was referred from MS 1525. However, Direct reference on MS1525:2014 standard indicated that the BEI mentioned is untraceable. While, (Mohd Tarmizi Mat Asim, 2015) has further mentioned that (Rashid et al., 2011) stated that baseline set by Public Work Department Malaysia (PWD) for their target in energy saving program for various categories of government building is 150kWh/m^2.year.

The KETTHA guideline published in 1989 for energy efficiency suggested the Building Energy Index (BEI) for the buildings area divided into four categories. These categories are worst case building with 216kWh/m^2.year, base case building with 166kWh/m^2.year, proposed standard case building with 136kWh/m^2.year and good practice case building with 82kWh/m^2.year. (Ministry of Energy, 1989).

Meanwhile, the PAM Green Building Index (GBI) mentioned that the building energy performance indicator is divided into several building categories which are new building, existing building and existing building (24 hours). The GBI rating system indicates that the standard value of 150kWh/m^2.year, 200kWh/m^2.year and 290kWh/m^2.year respectively.

However, the building energy performance indicator value tabulated is not satisfying. The reason was the building energy performance indicator referred to Public Work Department Malaysia (PWD) is just a suggested baseline, while KETTHA guideline and PAM GBI rating system building energy performance indicator is applicable to all building types. This mismatch is illustrated in Table 1.2 where Mohd Tarmizi Mohd Asim mentioned 150kWh/m^2.year but guideline set by KETTHA was 82 - 216kWh/m^2.year while that of GBI Malaysia is 150 - 290kWh/m^2.year.

Table 1.2: Malaysia Building Energy Performance Indicator Reference

Organization / Reference Party	Case Scenarios	Building Energy Performance Indicator Value (kWh/m^2.year)
(Mohd Tarmizi Mat Asim, 2015), (Noranai, 2011),	Commercial building	135 kWh/m^2.year
(Mohd Tarmizi Mat Asim, 2015), (Rashid et al., 2011)	Government building related to Public Work Department Malaysia (PWD)	150kWh/m^2.year
KETTHA guideline	Worst case building	216 kWh/m^2.year
	Base case building	166 kWh/m^2.year
	Proposed standard case building	136 kWh/m^2.year
	Good practice case building	82 kWh/m^2.year
PAM GBI Rating System	New Building	150 kWh/m^2.year
	Existing Building	200 kWh/m^2.year
	Existing Building (24 Hours)	290 kWh/m^2.year

Meanwhile, building energy performance indicator in Malaysia commonly use total energy consumption and net floor area as their parameter as mentioned in Table 1.1. The further complexity raised from the method used to evaluate the parameter. There are variation and no standardized method in evaluating parameters.

The total energy consumption assessment detail is based on month of data collection period while net floor area assessment detail is based on the minimum space area of each building feasible for building energy performance measuring. Table 1.3. shows various record time for collecting energy consumption and net floor area assessment by Malaysian publishers.

Table 1.3: Malaysia Building Energy Performance Indicator Reference

Organization / Reference Party	Total Energy Consumption assessment	Net Floor Area Assessment (m^2)
(Mohd Tarmizi Mat Asim, 2015),	60 months	
(Suruhanjaya Tenaga, 2014)	36 months	
(Asean Centre of Energy (ACE), 2014)	24 months	
PAM GBI Rating System	36 months	
(Department of Standard Malaysia, 2007)		1000m^2/4000m^2

(Mohd Tarmizi Mat Asim, 2015) recorded a staggering 60 months of energy consumption collecting period. (Suruhanjaya Tenaga, 2014) meanwhile stated that it was suggested the total energy consumption record of at least 36 months of electricity bill. While, the (Asean Centre of Energy (ACE), 2014) stated that the minimum required record of electricity consumed is 24 months of electricity bill and PAM mentioned 36 months period of energy consumption as an alternative assessment.

Whereas, Based on (Department of Standard Malaysia, 2007) sub-chapter 5.2 mentioned that the minimum air-conditioned space (ACA) 1000m^2 is needed to comply the Overall Thermal Transfer Value (OTTV). A different value is stated by (Department of Standard Malaysia, 2007) in sub chapter 9.1 stated that Energy Management System (EMS) should only consider for building with more than 4000m^2 of air-conditioned space (ACA).

1.3 Objectives of Research

The aim of this research is to develop an improvement to the existing building energy performance indicator for related agencies in Malaysia. The project is to study the current building energy performance indicator. Therefore, due to these differences, the standard total energy consumption record collection period and minimum net floor area that can be used to calculate building energy performance indicator are varies and need to be standardized. Taking mentioned discrepancy of the available references of Malaysian building energy performance indicator and method used to evaluate the parameter, there is a great need to investigate and improvement method on building energy performance indicator in order for the operator to have a simple, fast and workable evaluation method.

The specific objectives are as follows: -

a) To identify parameters floor space / electricity bill / category that can improve the building energy performance indicator
b) Develop simplified model for building operator
c) To verify the develop model using buildings outside Shah Alam City Centre.

1.4 Scope and Limitation

The Shah Alam Section 14 City Center was chosen for the case study due to existence of many high-rise buildings. Due to availability of the existing comprehensive data framework in related factors and parameters, availability background information for data collection, data analysis and identifying Shah Alam gave a clear opportunity be selected for data sampling.

The constraints encountered throughout this project amongst others, includes the data collected is solely from Shah Alam Section 14 City Center several buildings which lack of data required manual measurement, where there was a disparity for net floor area value. There are two (2) bodies that classifying building energy performance indicator through building function with a huge database. It was LEED United States and BREEAM United Kingdom with over 90,000 and 16,000 buildings respectively.

However, due LEED United State provide an open data which can be retrieved easily. LEED United State building function categories are used. Moreover, LEED United State, Energy Star offer a classification variety such as banking / financial service, education, public assembly, lodging and religious worship which hardly available in other.

1.5 Thesis Report Structure

This research started with a discussion on the background of the building energy performance indicator. Chapter 1 brings the reader into the background of the research, problem statement and objectives of the research. The chapter also discusses the scope and limitation of the research. Chapter 2 traces the building energy performance indicator background solely on policies, regulation, related guideline and related references. The chapter focuses on building energy performance indicator parameters improvement opportunities and current building energy performance indicator available in Malaysia. Then, Chapter 3 provides research methodology adopted. Thus, describe data collection improve method together with research flow chart. Later in Chapter 4, we examine the results / findings from the research. The results started with the contribution parameter result and ended with suggested significant building energy performance indicator. Finally, Chapter 5 is the conclusion chapter which includes conclusion derived from this study and recommended future work.

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LIST OF PUBLICATIONS

Journals

Hairi Ponichan, Nor Mariah Adam and Eris Elianddy Supeni (2018). Shah Alam Malaysia Office Building Energy Index Model. *Journal of Building Engineering*. JOBE_2018_332. Submitted

Hairi Ponichan, Nor Mariah Adam and Eris Elianddy Supeni (2018). Shah Alam Malaysia Retail Building Energy Index Model. *Journal of Building Performance Simulation*. TBPS-2018-0093. Submitted

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