Faculty of Mechanical Engineering

GREENING THE EXISTING BUILDING (CHANCELLERY BUILDING - UNIVERSITY TEKNIKAL MALAYSIA MELAKA)

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Master of Mechanical Engineering

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GREENING THE EXISTING BUILDING (CHANCELLERY BUILDING - UNIVERSITY TEKNIKAL MALAYSIA MELAKA)

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A master project report submitted in fulfillment of the requirements for the degree of Master of Mechanical Engineering (Energy Engineering)

Faculty of Mechanical Engineering

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2016

DECLARATION

I declare that this report entitles "Greening the Existing Building (Chancellery Building - University Teknikal Malaysia Melaka)" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : .....

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APPROVAL

I hereby declare that I have read this report and in my opinion, this report is sufficient in terms of scope and quality for the award of Master of Engineering in Mechanical Engineering (Energy Engineering).

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DEDICATION

This report work is dedicated to my beloved mother and father, whose have been a constant source of support and encouragement during the challenges of graduate school and life. I am truly thankful for having you in my life. This work is also dedicated to my brother who has always helped and support me. I also dedicate this thesis to my wife, without whose helpful support it would not have been possible, and my wonderful children, Aws and Mohanad.

ABSTRACT

Buildings contribute significantly to the environmental and economic issues, as they consume a high amount of energy and water. As a building consumes energy, it contributes to emissions of carbon dioxide which lead to environmental pollution. These factors have a negative impact on the environment and the economy among other issues. Green building practices and approaches can considerably reduce or eliminate negative ecological and economic impacts. This study aims to "greening the existing building" (Chancellery Building - University Teknikal Malaysia Melaka) and achieve the "Certified" rating level according to the GBI classification, taking into consideration estimated cost. The green building audit results show the total current building rating level is only 18 off 100 points based on the major six criteria. Including Energy Efficiency (EE), Indoor Environment Quality (EQ), Sustainable Site Planning & Management (SM), Materials & Resources (MR), Water Efficiency (WE), and Innovation (IN), this shows the existing Chancellery building achieves a low rating level when evaluated according to the GBI rating system. To achieve a "Certified Rating Level" of (50 points) this study proposes improvements of existing building's criteria (Retrofitting). The economic analysis involves the estimation of costs included in "Greening Existing Building" and the potential savings acquired from "Retrofitting". The estimated cost of greening the proposed building is RM 800,764. This demonstrates the "Greening Existing Building" requires several improvements aspects which are considered very costly to attain. Additionally, the potential savings includes cutting costs from Lighting System and Building Integrated Photo Voltage. The potential savings from Lighting System is (67345.9 RM/year) and the payback period is (1.68 years). Also, the potential saving from Building Integrated Photo Voltage is (30492RM/year) and the payback period is (4.9 years).

ABSTRAK

Bangunan menyumbang kepada masalah alam sekitar dan ekonomi secara ketara, kerana infrastruktur ini menggunakan sumber tenaga dan air yang tinggi. Penggunaan tenaga ini turut menyumbang kepada pelepasan karbon dioksida di mana membawa kepada pencemaran alam sekitar. Persoalannya adalah bagaimana kesan terhadap alam sekitar dan ekonomi hasil dari faktor-faktor yang dinyatakan dapat dikurangkan. Pendekatan dan praktis bangunan hijau dapat mengurangkan atau menghapuskan impak ekologi dan ekonomi. Kajian ini bertujuan untuk "penghijauan bangunan sedia ada" (Bangunan Canselori – Universiti Teknikal Malaysia Melaka) dan mencapai tahap penilaian persijilan berdasarkan klasifikasi GBI berserta kos dipertimbangkan. Keputusan yang diperoleh dari Audit Tenaga menunjukkan jumlah paras penilaian bagi Bangunan Canselori pada Energy Efficiency (EE), Indoor Environment Quality (EQ), Sustainable Site Planning & Management (SM), Material & Resources (MR), Water Efficiency (WE), and Innovation (IN) hanya pada 18 dari 100 markah. "Penghijauan Bangunan Sedia Ada" melibatkan cadangan penambahbaikan terhadap kriteria bangunan (Retrofit) untuk mencapai paras penilaian persijilan (50 markah). Analisis ekonomi melibatkan penganggaran kos Penghijauan Bangunan Sedia Ada dan penjimatan yang berpotensi dari Retrofit. Kos yang dianggarkan bagi Penghijauan Bangunan Sedia Ada adalah (RM 800,764). Tambahan pula, penjimatan yang berpotensi juga termasuk dengan penjimatan dari Sistem Lampu dan BIPV. Potensi penjimatan dari Sistem Lampu adalah (RM 67345.90/tahun) dan tempoh pembayaran balik adalah (1.68 tahun). Di samping itu, potensi penjimatan untuk BIPV adalah (RM 30492/tahun) dan tempoh bayaran balik adalah (4.9 tahun).

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LIST OF SYMBOLS

°C	-	Degrees Celsius
cfm	-	Cubic feet per minute
m	-	Meter
ft	-	feet
hr.	-	Hour
KW	-	kilowatt
KWh	-	kilowatt per hour
$KW/m^2/year$	-	kilowatt / hour / meter square / year
W/m^2	-	Watt per meter square
%	-	Percentage
RH	-	Relative Humidity
rpm	-	Revolutions per Minute
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
Ppm	-	Parts per Million
m/s	-	velocity
OTTV	-	Overall Thermal Transfer
WWR	-	Window-to-gross exterior wall area ratio
U	-	Thermal transmittance
SC	-	Shading coefficient
CF	-	Correction factor
α	-	Solar absorption factor
K	-	Thermal Conductivity
R	-	Thermal Resistance

t	-	Thickness
Lux	-	Lighting illuminance
DF	-	Daylighting Factor
L_o	-	Outdoor illuminance
L_i	-	Indoor illuminance
dB	-	Decibel
L_{Aeq}	-	Average sound level, equivalent continuous sound level
L	-	Liter

LIST OF ABBREVIATIONS

ACMV	-	Air Conditioning and Mechanical Ventilation
AHU	-	Air Handling Unit
ASHRAE	-	American Society of Heating, Refrigerating, and Air Conditioning
ACE	-	Air Change Effectiveness
BEI	-	Building Energy Intensity
BAS	-	Building Automation System
BIPV	-	Building Integrated Photo Voltaic
BREEAM	-	Building Research Establishment Environmental Assessment Methodology (UK)
CASBEE	-	Comprehensive Assessment System for Built Environment Efficiency
C×S	-	Commissioning Specialist
EE	-	Energy Efficiency
EQ	-	Environment Quality
EA	-	Energy Audit
EMS	-	Energy Management Control System
ETS	-	Environmental Tobacco Smoke Control
FCU	-	Fan Coil Unit
FRP	-	Fiberglass Reinforced Plastic
GBCI	-	Green Building Certification Institute
GBI	-	Green Building Index
HVAC	-	Heating, Ventilation, and Air Conditioning
HED	-	House Energy Doctor
HUKM	-	Hospital Universiti Kebangsaan Malaysia
IBS	-	Industrialized Building System

IEQ	-	Indoor Environmental Quality
IAQ	-	Indoor Air Quality
IN	-	Innovation
ISO	-	International Organization for Standardization
LEED	-	Leadership in Energy and Environmental Design
LED	-	Light-Emitting Diodes
MR	-	Materials and Resources
MS	-	Malaysian Standard
MDF	-	Medium Density Fiberboard
MCC	-	Motor Control Center
NREB	-	Non-Residential Existing Building
NRNC	-	Non-Residential New Construction
NLA	-	Net Lettable Area
OTTV	-	Overall Thermal Transfer Value
OFEE	-	Office of the Federal Environmental Executive
OPD	-	Ozone Depleting Potential
PU	-	polyurethane
RE	-	Renewable Energy
Rn	-	Radon
REB	-	Residential Existing Building
RNC	-	Residential New Construction
RP	-	People Outdoor Air Rate
SRI	-	Solar Reflectance Index
SM	-	Sustainable Site Planning and Management
USGBC	-	U.S. Green Building Council
UHI	-	Urban Heat Island
UTeM	-	Universiti Teknikal Malaysia Melaka
UTM	-	Universiti Teknologi Malaysia
VOCs	-	Volatile organic compounds
WE	-	Water Efficiency

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

"Greening buildings" is considered one of the solutions proposed to address global climate changes and economic issues due to unbalanced energy consumption in various types of infrastructure. The global annual energy consumption of buildings is of high impact as it accounts for more than 68% of the total electricity consumption and 39% of the aggregate energy consumed. Moreover, the use of water in buildings is more than 12% of the aggregate water consumption (EPA, 2009). Buildings are considered one of the causes of the global warming phenomenon since it accounts for over 40% of total carbon dioxide (CO_2) emissions. While currently, United States, Canada, Western Europe, and Japan are the major contributors to greenhouse gas emissions, this situation is going to change radically in the upcoming years. Carbon dioxide emissions from China, India, and the rest of Asia, Russia and Brazil are dramatically increasing which arise the need for global participation in reducing the carbon footprint. That can be defined as the environmental impact of produced greenhouse gasses, measured in the units of carbon dioxide of urban buildings over the next 30 years (Yudelson, 2007). The practices of green buildings can significantly decrease or eradicate negative impacts on the environment by utilizing high-performance, cutting-edge designs, constructions, and operations practices. Green operations and management decrease operating costs, boost building marketability, increase workers' productivity and decrease potential accountability resulting from indoor air quality (IAQ) issues (Green Building Council, 2009).

"Leadership in Energy and Environmental Design (LEED)", a private third-party building certification program managed by the "Green Building Certification Institute" ("GBCI") and established by the "U.S. Green Building Council" ("USGBC") aims to accomplish the "triple bottom line," that promotes the incorporation of sustainable design techniques and strategies for the benefit of the environment, society, and the economy. At each LEED rating system, building categories, requirements and credits are developed with this aim in mind. Four levels of LEED certification are stated: "Platinum (more than 80 points) ; Gold (60 to 79 points); Silver (50 to 59 points); and Certified (40-49 points)" (Joshua Winefsky, 2016).

The "Green Building Index (GBI)" is the recognized "Rating Tool" for green buildings in Malaysia. Which encourages sustainability in the built environment and increase awareness of these matters among related stakeholders, including developers, contractors and architects. The evaluation of residential and commercial properties using the "GBI Rating Tool" depend on six main criteria: "Indoor Environment Quality (EQ), Sustainable site planning & Management (SM), Energy Efficiency (EE), Materials and Resources (MR), Innovation (IN), and Water Efficiency (WE)". Alternatively, buildings are divided into the following categories: "Non-Residential New Construction (NRNC), Non-Residential Existing Building (NREB), Residential New Construction (RNC), and Residential Existing Building (REB)". There are four levels of GBI certification: "(more than 86 points) Platinum; (76 to 85 points) Gold; (66 to 75 points) Silver; and (50 to 65 points) Certified" (GBI Malaysia, 2011).

This study aims to "Greening" the Non-Residential Existing Building (Chancellery Building - Universiti Teknikal Malaysia Melaka).