UNIVERSITI PUTRA MALAYSIA

A FRAMEWORK TO UTILIZE BUILDING INFORMATION MODELING (BIM) SYSTEM FOR OPTIMIZING LIGHTING IN HISTORIC BUILDINGS IN MALAYSIA

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By

MEHRDAD SAHRAEI LORON

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

September 2014

DEDICATIONS

This dissertation is lovingly dedicated to my dearest parents whose endless care supported me all through the way

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

A FRAMEWORK TO UTILIZE BUILDING INFORMATION MODELING (BIM) SYSTEM FOR OPTIMIZING LIGHTING IN HISTORIC BUILDINGS IN MALAYSIA

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September 2014

Chairman: Professor Rahinah Ibrahim, PhD

Faculty: Design and Architecture

Unacceptable level of electricity consumption for lighting in historic buildings, mentioned by other experts in Malaysia, has been emphasized as a problem to be investigated for the current study. In this regard, the present research aims to specify the possibilities and limitations for conservation activities in historic buildings especially in terms of lighting components. It also attempts to specify the acceptable methods of utilizing the required tools and devices which support energy efficiency in historic building through reducing electricity consumption for lighting; and finally, the present research recommends the features and specifications of a Building Information Modeling (BIM) system which leads to the reduction of electricity consumption for lighting in historic buildings. Through literature review, firstly the study clarifies the research problem, main and sub-research questions, research objectives, theoretical framework, and theoretical proposition. Secondly, based on the findings through literature survey, qualitative case study research methodology is selected for this inquiry. Lastly, interviewing the experts with an in-depth semi-structured open-ended interview questionnaire is chosen as the suitable method of data collection. In order to achieve the aforementioned goals, two historic buildings which are currently operating as museums including (1) the Muzium Tekstil (National Textile Museum) in Kuala Lumpur; and (2) the Muzium Diraja Abu Bakar (Royal Abu Bakar Museum) in Johor, are selected as the units of analysis for starting the data collection process. In this respect, the findings related to the first objective indicate that despite the limitations for conserving historic buildings in external parts, internal changes through employing suitable methods and approaches are possible and acceptable. Regarding the second

objective, findings reveal that a successful and energy efficient lighting system for historic buildings needs to have two essential factors including 1) installing energy efficient tools and devices and 2) applying suitable methods for installing lighting tools and devices to control any possible damages on historic buildings valuable characteristics. The findings concerning the third objective indicate that a lighting system for being successful in historic buildings needs to be intelligent and simple, provide feedback, consider daylight, consider different levels of heat and humidity inside the historic buildings, and investigate the levels of required illumination for reducing electricity waste. At the end, the study proposes a framework to utilize BIM system for optimizing lighting in historic buildings in Malaysia along with respecting their valuable characteristics.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Sarjana Sains

RANGKA KERJA PEMBINAAN MENGGUNAKAN SISTEM BUILDING INFORMATION MODELING (BIM) BAGI MENGOPTIMUMKAN PENCAHAYAAN DALAM BANGUNAN BERSEJARAH DI MALAYSIA

Oleh

MEHRDAD SAHRAEI LORON

September 2014

Pengerusi : Profesor Rahinah Ibrahim, PhD

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Tahap penggunaan elektrik yang tidak boleh diterima bagi pencahayaan di bangunan-bangunan bersejarah, yang disebut oleh pakar-pakar di Malaysia, telah ditekankan sebagai satu isu yang akan dikaji di dalam kajian ini. Dalam hal ini, kajian ini bertujuan untuk menentukan kemungkinan dan limitasi untuk aktiviti pemuliharaan bangunan bersejarah terutama dari segi komponen pencahayaan. Kajian ini juga dijalankan untuk menentukan kaedah yang boleh diterima bagi menggunakan alat dan peranti yang menyokong kecekapan tenaga dalam bangunan bersejarah melalui pengurangan penggunaan bekalan elektrik bagi bagi pencahayaan, dan akhirnya, kajian ini mencadangkan ciri-ciri dan spesifikasi Sistem Building Information Modeling (BIM) yang membawa kepada pengurangan penggunaan elektrik bagi pencahayaan di bangunan bersejarah. Melalui kajian literatur, pertamanya kajian ini menjelaskan masalah kajian, soalan utama dan sub-soalan kajian, objektif kajian, kerangka teori, dan cadangan teori. Kedua, berdasarkan penemuan melalui kajian literature, kaedah penyelidikan kajian kes kualitatif dipilih bagi kajian ini. Akhir sekali, menemuramah pakar-pakar melalui kaedah temu bual mendalam separa berstruktur dengan soalan terbukatelah dipilih sebagai kaedah yang sesuai bagi pengumpulan data. Untuk mencapai matlamat diatas, dua bangunan bersejarah yang kini beroperasi sebagai muzium telah dinamakan sebagai; (1) Muzium Tekstil (Muzium Tekstil Negara) di Kuala Lumpur; dan (2) Muzium Diraja Abu Bakar di Johor telah dipilih sebagai unit analisis bagi memulakan proses pengumpulan data. Dalam hal ini, hasil berkaitan objektif pertama menunjukkan walaupun terdapat batasan bagi memulihara bangunan-bangunan bersejarah dari segi luaran, perubahan dalaman melalui penggunaan kaedah dan pendekatan yang sesuai boleh dilakukan dan diterima. Berkenaan objektif kedua, hasil kajian mendedahkan

bahawa system pencahayaan yang berjaya dan cekap tenaga bagi bangunan-bangunan bersejarah perlu mempunyai dua faktor penting termasuk 1) memasang alat cekap tenaga dan 2) menggunakan kaedah yang sesuai bagi pemasangan alat dan peranti lampu bagi mengawal kerosakan yang mungkin berlaku ke atas sifat-sifat bangunan yang istimewa ini. Hasil kajian berkenaan objektif ketiga menunjukkan bahawa sistem pencahayaan dalam memastikan ianya merupakan sistem yang berkesan dan cekap dalam bangunan-bangunan bersejarah, perlulah bijak dan mudah, memberi maklum balas, mempertimbangkan waktu siang, mempertimbangkan tahap haba dan kelembapan yang bebeza di dalam bangunan bersejarah, dan mengkaji tahap tahap pencahayaan yang diperlukan dalam mengurangkan pembaziran elektrik. Akhir sekali, kajian ini mencadangkan rangka kajian bagi penggunaan sistem BIM bagi mengoptimumkan pencahayaan dalam bangunan-bangunan bersejarah di Malaysia dalam masa yang sama menghormati nilai sifat istimewa mereka.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The current study is divided into five chapters. The first chapter provides information concerning the background of the study, definitions of terms, problem statement, research questions and objectives, case study, research methodology and its components, significance of the study, and limitation of the study. The last section clarifies the structure of this thesis in detail.

1.2 Background of Study

Electricity is considered as an important item for economic growth and development of a nation. Unfortunately, the demand for this source of energy is growing rapidly in the world especially in the developing countries and this growing is arriving to the alarming level. Besides the lack of electricity sources, negative impacts of electricity generation and consumption for environment and people, are the other problems in this area. There are lots of global concerns over the environmental depreciation caused by electricity generation especially over the problems of increasing carbon dioxide emissions and other greenhouses gases in the atmosphere. Saidur et al. (2007) declared that electricity generation depends on the fossil fuels and this generation is difficult and problematic for two important reasons; (1) fuels are limited and (2) in the process of generating electricity, a number of poisons such as CO_2 are released from fuels. Many researchers in Malaysia have found out and asserted that the existing problem on high consumption of electricity is threatening environment and human these days. Some of the notions which have been mentioned regarding the high consumption of electricity and the importance of controlling and reducing this consumption are discussed as follow.

Kamaruzzaman et al. (2007) mentioned that using electricity for running and operating lights and lifts are some of the important factors which lead to the high demand for electricity in Malaysia. In addition, Kamaruzzaman et al. (2010) stated that "Malaysian researchers reported that there will be a rapid growth on the electricity supplies with 4 percent growth per year … Energy consumed in Malaysia was 90% in the form of electricity; then, an attempt to breakdown the electricity uses is highly recommended". Oh et al. (2010) mentioned that the situation changed to worse once the electricity, which was in an abundant and cheap supply, came to power. Zain-Ahmad (2008) declared that by 19% demand of electricity in 2010 in Malaysia, electricity will be the second largest energy demand. Based on Malaysia eight Plan, conserving energy

through reducing electricity consumption is the next coming step for Malaysia (Kamaruzzaman et al. 2007). Saidur et al. (2007) also stated that "Malaysia, being a newly industrialized and fast developing country should have concern to evaluate and apply every feasible measure to reduce energy consumption and greenhouse gases (GHG) emissions without sacrificing its economic growth".

Based on the previous studies on historic buildings in Malaysia, it was found and clarified that electricity consumption for lighting in buildings is not plausible and need to be reduced. Historic buildings in Malaysia have diverse definitions according to the experts in this area. In this regard, Laws of Malaysia (1976), Majid (2003), and Ahmad (1997) explained that historic buildings, in Malaysian context, are defined as buildings that were built in the past 80 - 100 years or more. The importance of these buildings comes from the factors such as historical aspect, the uniqueness of design and their characteristics. The importance of re-using of the historic buildings was mentioned by the other researchers such as Kamaruzzaman et al. (2010) who believed that a little change in historic buildings in order to meet the demands is very important. In addition, Sulaiman et al. (2011) mentioned that changing the performance of historic buildings to other type of buildings to response the need of the big cities such as Kuala Lumpur, Johor Bahru, and Penang is more acceptable than demolishing them.

As mentioned above, experts in Malaysia believe that based on their studies, electricity consumption for lighting in historic buildings in Malaysia is not acceptable. In this respect, Kamaruzzaman and Edwards (2006) analyzed electricity consumption in four specific historic buildings and found out that electricity consumption for lighting in these buildings is not plausible. Then, they declared that "…lighting should be the priority area in any energy efficiency programme". Moreover, Kamaruzzaman et al. (2010), based on their studies on historic buildings in Malaysia, asserted that reducing electricity consumption for lighting in these buildings is necessary and is highly suggested. In addition, through referring to an existing energy benchmark (CIBSE, 1991, 1998, and 2004) it was clarified that consumption of electricity for lighting components in historic buildings met or exceeded the consumption level of particular buildings. Furthermore, BRECSU (2000) stated that even though the energy performance is lower than the benchmark, still there will often be scope for further effective savings.

Many tools, technologies and techniques were used by experts to measure and reduce electricity consumption for lighting in building sector. In this regard, researchers such as Hocheng (2010), Fischer (2007), Harvey (2006), Klammt et al. (2012), Yozell-epstein (2003), Kriegel and Nies (2008), and Azhar et al. (2011) proved the success story of using tools and facilities such as energy efficient lighting components, lighting controls, feedback system, daylight as a natural source of energy for providing illumination, sunlight directing devices, sensors, and lighting analysis softwares for reducing electricity consumption for lighting in building sector. Besides these tools, a suitable technology which provides a platform for improving energy efficiency in buildings is Building Information Modeling (BIM) system. Researchers such as Motawa and Carter (2013), Stadel et al., (2011), Stumpf et al. (2009), Schlueter and

Thessling (2009), Azhar et al, 2008, and Autodesk (2008) believe that BIM technology through providing a multi-disciplinary set of information about a model is known as a valuable tool for energy analysis, performance analysis, and sustainability in building sector. Lawrence et al. (2010) and Azhar and Brown (2009) also asserted that BIM system can be integrated with other 3D simulation programs such as Ecotect to analyze building performance in terms of energy use even for artificial lighting. On the other hand, nothing was done in the past to analyze the possibility of using BIM system for providing sustainability in historic buildings successfully. The only attempt that employed in this regard was using virtual reality softwares and systems for creating a 3D model of these buildings. Therefore, the main goal of this research is "proposing a framework for utilizing BIM system for optimizing lighting in historic buildings in Malaysia" through respecting their valuable characteristics.

1.3 Definitions of Terms

In this section, the researcher explains the frequently used terms.

Historic buildings in Malaysia: historic buildings, in Malaysian context, are defined as buildings that were built in the past 80 - 100 years or more (Laws of Malaysia, 1976; Majid, 2003; Ahmad, 1997).

Building Information Modeling (BIM) system: Eastman et al. (2008) defined BIM as a modeling technology and related set of processes to produce, communicate and analyze building models.

Carbon footprint: total amount of the produced carbon dioxide emissions (CO_2) directly or indirectly, caused by activities in building life-cycle (Wiedmann and Minx, 2008).

Greenhouses emissions: gases such as carbon dioxide (CO2), sulfur dioxide (SO2), nitrogen oxide (NO) and carbon monoxide (CO) which have increased in the atmosphere in the last decades (Mahlia, 2002).

1.4 Problem Statement

The importance of electricity for the next generations and the negative impacts of its consumption on environment and human's wellbeing are the main reasons which convince energy concerned people to propose solutions for controlling and decreasing its consumption. In Malaysia, many scholars and experts mentioned the problem of high consumption of electricity. In this regard, Kamaruzzaman et al. (2007) mentioned that using electricity for the goals such as operating lights is an important factor which

leads to the high demand for electricity in Malaysia. In addition, Kamaruzzaman et al. (2010) warned the increase in electricity consumption in Malaysia as follow, "Malaysian researchers reported that there will be a rapid growth on the electricity supplies with 4 percent growth per year… Energy consumed in Malaysia was 90% in the form of electricity then, an attempt to breakdown the electricity uses is highly recommended" (Kamaruzzaman et al., 2010). Zain-Ahmad (2008) declared that by 19% demand of electricity in 2010 in Malaysia, electricity will be the second largest energy demand. The importance of reducing electricity consumption can be seen in the Malaysia eight Plan mentioning this point that conserving energy through reducing electricity consumption is the next coming step for Malaysia (Kamaruzzaman et al. 2007). The mentioned notions from other experts prove the high consumption level of electricity in Malaysia and highlight the importance of reducing this usage.

Besides the above mentioned notions, some researchers and experts in Malaysia such as Kamaruzzaman and Edwards (2006) and Kamaruzzaman et al. (2010) focused on historic buildings and analyzed their performance in terms of energy efficiency namely electricity consumption. In this context, Kamaruzzaman and Edwards (2006) analyzed electricity consumption of the three main end-uses of electricity (including lighting, air conditioning, and electrical equipment) in four specific historic buildings in Malaysia. The buildings comprised of two offices, one hotel and one church. Two of the buildings were located in the capital city of Kuala Lumpur and the other two were in Penang. The description and features of these buildings were shown in Table 2.1. According to Kamaruzzaman's and Edwards' (2006) study, electricity consumption for lighting in these buildings is not acceptable when compared to the established benchmark; then, they declared that "…lighting should be the priority area in any energy efficiency programme". Figure 1.1 shows the percentage breakdown of electricity usage on four mentioned historic buildings.

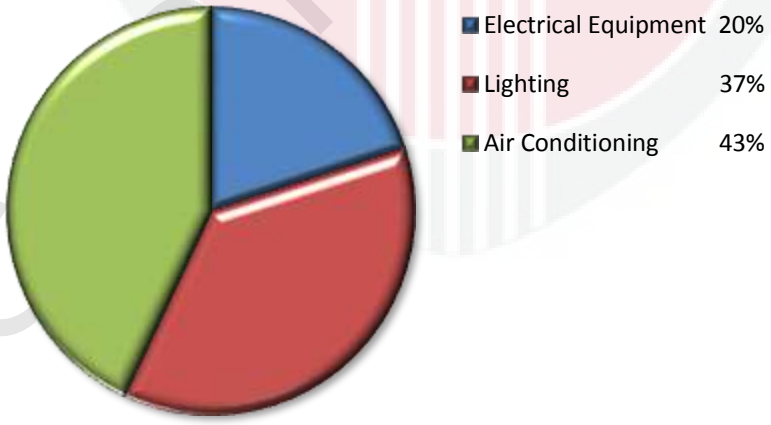

Figure 1.1 Percentage breakdown of electricity usage on four historic buildings (Source: Kamaruzzaman and Edwards, 2006).

In addition, Kamaruzzaman et al. (2010), based on their studies on historic buildings in Malaysia, asserted that reducing electricity consumption for lighting in these buildings

is necessary and highly suggested. Moreover, through referring to an existing energy benchmark (CIBSE, 1991, 1998, and 2004) it was clarified that consumption of electricity for lighting components in historic buildings met or exceeded the consumption level of particular buildings. All these notions from Malaysian scholars demonstrate that the area of problem for historic buildings in Malaysian relates to the unacceptable amount of electricity use for lighting components which needs to be reduced. Besides that, BRECSU (2000) stated that even though the energy performance is lower than the benchmark, still there will often be scope for further effective savings. Then, conserving energy is necessary and vital even if its consumption is acceptable and logical.

According to the abovementioned notions, it can be concluded that electricity consumption for lighting components in historic buildings in Malaysia is not acceptable and needs to be reduced and controlled. Therefore, the researcher of this study focused on the mentioned issue to propose a solution for successful reduction of electricity consumption for lighting in historic buildings besides respecting these buildings valuable characteristics. The main reasons for the researcher to focus on the mentioned problem of Malaysian historic buildings were points such as the importance of historic buildings for each country and nation, increasing the number of buildings which are considered as historic buildings each year, the significance of electricity for the next generations, and the negative impacts of electricity consumption and generation for environment and human. For proposing a solution concerning the mentioned problem, the main goal of this study is proposing "a framework to utilize BIM system for optimizing lighting in historic buildings in Malaysia".

1.5 Research Questions

The main research question for this study is stated below:

> *Main RQ:* How can BIM system play a successful role in reducing electricity consumption for lighting in historic buildings?

To answer the main research question, there are three sub-research questions:

> *Sub-RQ1:* What are the possibilities of Malaysian historic buildings in accepting new and modern tools and devices in order to reduce electricity consumption for lighting through respecting their valuable characteristics?

> *Sub-RQ2:* In what circumstances will the available tools and facilities contribute to the reduction of electricity consumption for lighting in historic buildings?

Sub-RQ3: What are the recommendations on how BIM system could be utilized with needed tools and facilities to reduce electricity consumption for lighting in historic buildings without damaging their characteristics?

1.6 Research Objectives

The three objectives of this research are as follow:

1. To specify the possibilities and limitations for conservation activities in historic buildings especially in terms of lighting components
2. To specify the acceptable methods of utilizing the needed tools and devices which support energy efficiency in historic building through reducing electricity consumption for lighting.
3. To recommend the features and specifications of a BIM system that leads to the reduction of electricity consumption for lighting in historic buildings.

1.7 Research Methodology

In light of providing an interpretive view, this research is based on a qualitative study to gain in-depth and detailed information from respondents to answer main and sub-research questions. Denzin and Linkoln (2005) recommend qualitative approach, when data comes from the experts' knowledge which is perceived under the thinking phenomena. Qualitative research provides a platform for the researcher to collect rich data from respondents in more realistic setting (Bogdan & Biklen, 1998). It needs to be noted that this research deals with knowledge and work experiences of respondents. Since knowledge and work experience are types of thinking phenomenon, qualitative method is proposed for this research. According to Yin (2003), a case study research methodology is an appropriate strategy in this particular research when (a) manipulating the behavior of people involved in the study is not possible, (b) main research questions are started by "How" and "Why" (c), and when many more interesting variables than data points may exist.

1.7.1 Research Framework

According to the purpose of the study, the researcher concluded that the ideas of people, who are well qualified and skillful based on the criteria list of this study, can be best investigated if the study progresses through the proposed research framework as shown in Figure 1.2.

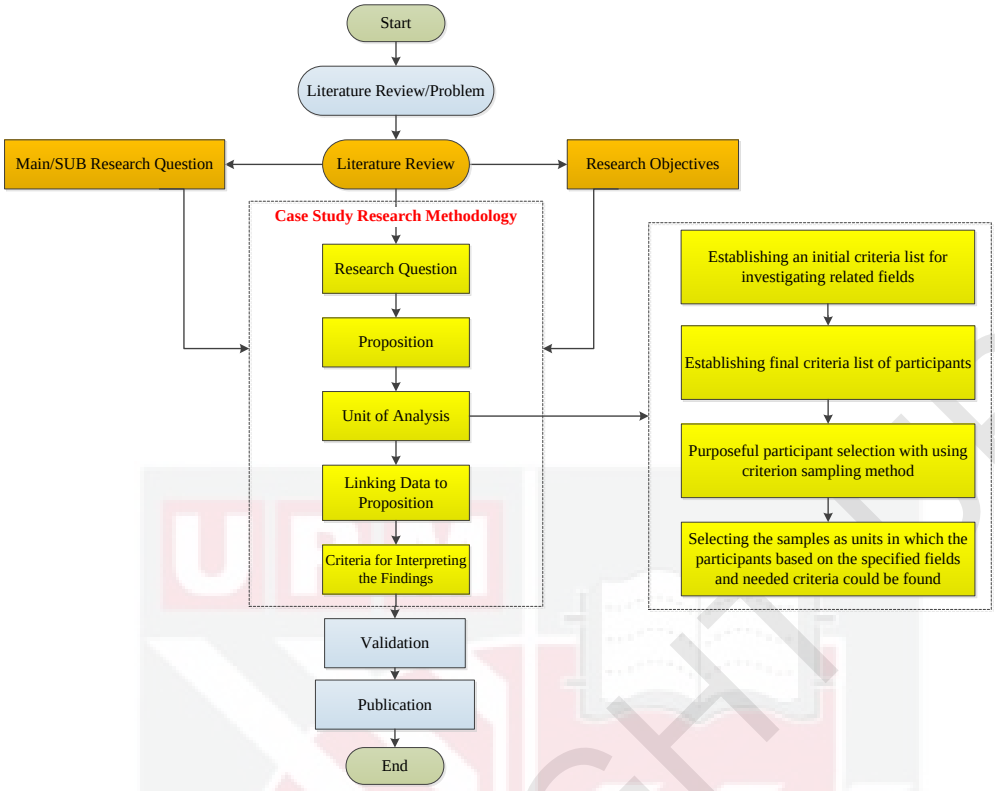

Figure 1.2 Case Study Research Framework.

1.7.2 Research Questions

Main research question of this research is, "How can BIM system play a successful role in reducing electricity consumption for lighting in historic buildings?"

1.7.3 Theoretical Proposition

Yin (2003) believes that there are two general analytic strategies consisting of: (1) relying on theoretical proposition and, (2) developing a case description. In this research, the author relied on a theoretical proposition since it is available. Further elaboration on literature development towards reaching this theoretical proposition can be referred to Chapter 2.

Based on literature survey -regarding BIM system, its ability in integrating with energy analysis softwares, its capability in managing and controlling artificial lights in buildings through integrating with suitable 3D simulation softwares, improving energy efficiency in lighting sector and the available methods and tools which contribute to the reduction of electricity consumption for lighting, the valuable characteristics of historic buildings in Malaysia, and the points that need to be considered to have a

successful conservation program- the study proposes, "Building Information Modelling (BIM) system through integrating with 3D simulation softwares can be linked to the lighting tools and devices to reduce electricity consumption for lighting in historic buildings in Malaysia without any possible damages for their valuable characteristics".

1.7.4 Unit of Analysis

The units of analysis in this research are two historic buildings in Malaysia which are currently operating as museums. They are (1) the Muzium Tekstil (National Textile Museum) in Kuala Lumpur and (2) the Muzium Diraja Abu Bakar (Royal Abu Bakar Museum) in Johor. The main reasons for choosing these buildings as the units of analysis for this research will be discussed and explained in research methodology Chapter 3, section 3.3.3.

1.7.5 Linking Data to Proposition

Table 1.1 shows a summary of the process of linking data to proposition.

Table 1.1 linking data to proposition.

Construct	SUB RQ	Source of Data	Data Collection	Data Analysis	Expected Outcomes
Historic buildings in Malaysia	What are the possibilities of Malaysian historic buildings in accepting new and modern tools and devices in order to reduce electricity consumption for lighting through	• Lighting designers • Lighting technicians • Museum directors	• Interview with lighting designer, lighting technician, and museum director who participated in lighting conservation in historic buildings	Specify the flexibility and susceptibility of historic buildings in terms of conservation activities through respecting their valuable characteristics	Identification on the possibilities and limitations for conservation activities in historic buildings especially in terms of lighting components through installing new tools and facilities.
		• Lighting designers • Lighting	• Interview with lighting designer, lighting technician,	Specify the flexibility and susceptibility of historic	Determining the acceptable and suitable

Possible damages for valuable characteristics of historic buildings	respecting their valuable characteristics?	technicians • Museum directors	and museum director who participated in lighting conservation in historic buildings	buildings in terms of accepting new tools and devices for optimizing lighting without damaging these buildings' valuable characteristics	methods of conserving lighting system in historic buildings without damaging their valuable characteristics.
Lighting tools and devices	In what circumstances will the available tools and facilities contribute to the reduction of electricity consumption for lighting in historic buildings?	• Lighting designers • Lighting technicians • Museum directors	• Interview with lighting designer, lighting technician, and museum director who participated in lighting conservation in historic buildings	Distinguish the most suitable tools and devices which reduce electricity consumption for lighting	Specifying the most suitable lighting tools and devices which contribute to the success of a lighting system in terms of reducing electricity consumption for lighting in historic buildings
Reducing electricity consumption for lighting		• Lighting designers • Lighting technicians • Museum directors	• Interview with lighting designer, lighting technician, and museum director who participated in lighting conservation in historic buildings	Specify the possibility of utilizing the needed tools and devices for reducing electricity consumption for lighting in historic buildings	Determining the acceptable and suitable methods of utilizing the needed tools and devices with a lighting system to reduce electricity consumption for lighting in historic buildings without damaging their valuable characteristics.
Building Information Modelling (BIM) system	What are the recommendations on how BIM system could be utilized with needed tools and	• Lighting designers • Lighting technicians • Museum directors	• Interview with lighting designer, lighting technician, and museum director who participated in lighting conservation in historic buildings	Identify the factors which need to be considered for having a successful lighting system in terms of energy efficiency	Determining the features and specifications of a BIM system as a lighting system that leads to the reduction of electricity consumption for lighting in historic buildings through respecting these

	facilities to reduce electricity consumption for lighting in historic buildings without damaging their characteristics?				buildings' valuable characteristics.
3D simulation softwares		• Lighting designers	• Interview with lighting designer who participated in lighting conservation in historic buildings	Specify the possibility of proposing a successful lighting system through applying 3D simulation softwares	Determining the role of 3D simulation softwares in proposing a successful and energy efficient lighting system

1.7.6 Criteria for Interpreting the Findings

As mentioned by Yin (2003, P.26), this subject is "the least well developed components of case study". In this study, the criteria for interpreting findings is checking and comparing the results of collected data through in-depth interview with semi-structured open-ended questions against the theoretical proposition of study. Based on the literature survey, the study proposes, "Building Information Modelling (BIM) system through integrating with 3D simulation softwares can be linked to the lighting tools and devices to reduce electricity consumption for lighting in historic buildings in Malaysia without any possible damages for their valuable characteristics". The study expects more than 80% of interviews respondents support the mentioned theoretical proposition. In this regard,

- Flexibility and susceptibility of historic buildings in Malaysia in terms of conservation programs through accepting the installation of needed tools and facilities for conserving lighting system will be verified and accepted if more than 80% of respondents of interviews support it.
- Possibility and acceptance of utilizing and installing the available tools and devices which can contribute to the reduction of electricity consumption for lighting in historic buildings will be verified and accepted if more than 80% of interviews respondents support it.
- BIM as a suitable system for providing a platform for reducing electricity consumption for lighting in historic buildings will be verified and accepted if more than 80% of interviews respondents support it.

1.8 Significance of Study

The first significance of this research is relates to the importance of historic buildings and their conservation in Malaysia based on experts' opinions. In this regard, Azhari

and Mohamed (2012) stated that placing Malaysia in the heritage tourism map after listing the Penang and Melaka as UNESCO World Heritage Site proves the significance of historic buildings and their conservation. Therefore, focusing on historic buildings in Malaysia to propose a conservation approach for improving their performance in terms of energy efficiency is the first significance of this research.

Researchers in Malaysia have only mentioned to the problems of historic buildings without any attention to propose solutions for these problems. As can be seen from the previous literature such as Kamaruzzaman and Edwards (2006) and Kamaruzzaman et al. (2010) about the energy efficiency in historic buildings in Malaysia, electricity consumption for lighting in these buildings is not acceptable when compared to the established benchmark. Then, the other great significance of this research is proposing a solution for the mentioned problem of historic buildings in Malaysia. In this respect, the second and main value of this research is "proposing a framework for utilizing BIM system for optimizing lighting in historic buildings in Malaysia".

As mentioned by researchers like Barker (2011), English Heritage (2011), Brereton (1991), and Smith (1978) the characteristics of historic buildings limit experts to implement conservation programs to improve their performance. According to the area of this research, none of the experts mentioned to the possibilities and approaches for conserving historic buildings through reducing electricity consumption for lighting without damaging their valuable characteristics. Therefore, the third significance of this research is relates to its attempts for clarifying the possibilities and limitations of historic buildings for accepting new and modern tools and facilities for both reducing electricity consumption for lighting and having successful conservation activities. Besides that, the forth significance of this research is proposing the most suitable and acceptable approaches of installing new tools and devices for conserving lighting system in historic buildings without damaging their characteristics. This research through interviewing experts specified the possible extent of changes and the acceptable methods for providing alteration for conserving lighting system in historic buildings.

Researchers such as Motawa and Carter (2013), Stadel et al., (2011), Stumpf et al. (2009), Schlueter and Thessling (2009), Azhar et al, 2008, and Autodesk (2008) believe that BIM system through providing a multi-disciplinary set of information about a model is known as a valuable tool for energy analysis, performance analysis and sustainability in building sector. However, nothing has been done to see what features and factors are needed to be considered by BIM system to play the same role for sustainability in historic buildings besides respecting their valuable characteristics. Therefore, the fifth significance of this research is specifying the needed features and factors of a BIM system for both playing a successful role in reducing electricity consumption for lighting in historic buildings and controlling any possible damages to these buildings' valuable characteristics.

1.9 Limitation of the Study

This research comes under the broad topic of "proposing a framework for utilizing BIM system for optimizing lighting in historic buildings in Malaysia". Some of the limitations that bound the researcher's ability for achieving the expected goals of this inquiry are mentioned below.

First, this research is limited to the historic buildings which are operating as museums. In this regard, the results and findings cannot cover non-museum facilities that are conserved for other historic buildings such as private residences. The researcher limited the risks of the study through selecting and using only museums as the units of analysis for data collection.

Second, this research is limited to recommending the features and specifications of BIM system that leads to the reduction of electricity consumption for lighting in historic buildings. In this respect, BIM system can be used to analyze buildings' performance in many parts such as energy, thermal, lighting, and shading analysis. In this research, the researcher only focused on recommending the features of this system that controls and reduces lighting electricity consumption in historic buildings.

1.9.1 Biases and Researcher Role

Miles & Huberman (1994) identified two sources of researcher's bias (A), and termed bias (B), which happens at any stage of a qualitative study. The influence of researcher on the respondents is determined as termed bias (A) and the influence of the respondents on the researcher is determined as termed bias (B). When the qualitative researcher interrupts or grants a threat to the living social interaction the influences of Bias (A) can be seen. It leads to two negative effects which are refusing the researcher by the respondents directly or indirectly and considering him or her as a spy or antagonist (Miles & Huberman, 1994). On the other hand, bias (B) helps the researcher to be accepted as a native person not a marginal one. The most important advantage of bias (B) is providing a platform for the researcher to have social relationship with the respondents without interfering in their activities (Adler & Adler, 1987).

In qualitative studies, data collection, analysis, and interpretation are almost done by the researcher; that's why the researcher operates as the main instrument of the study (Paisley &Reeves, 2001). In addition, Lincoln & Cuba (1985) stated that "the instrument of choice in naturalistic inquiry (qualitative research) is the human" (P.236). Then, the researchers' inherent biases in their studies must be recognized and identified (Miles & Huberman, 1994).

According to Onwuegbuzie & Leech (2004) the qualitative researchers gain meaning from their data based on three crises which threaten them:

> The crises of representation, legitimation, and praxis threaten qualitative researchers' ability to extract meaning from their data. In particular, lack of representation means that the evaluator has not adequately captured the data. Lack of legitimation means that the extent to which the data have been captured has not been adequately assessed, or that any such assessment has not provided support for legitimation. Thus, the significance of findings in qualitative research is affected by these crises (P778).

Therefore, the researcher is aware of the possibility of worsening the crises through using his biases in the study. Then, before starting the process the researcher provided some offers to control such possible crises. Based on Lincoln & Cuba (1985) and Merriam (1998) one significant role for the researcher as the data collector is preparing the identification of any personal biases at the outset of the study. Furthermore, a qualitative design provides the usefulness of the personal biases that cannot be removed from the qualitative study. Identifying and understanding all these issues and sustaining a stance of "empathic neutrality" (Patton, 1990, P.55) in describing and interpreting the setting based on their real situation can be possible through using the researcher as an instrument.

In addition, to "clarify and confirm" (Breen et al., 2001, P.482) the researcher's understanding from interviews, the strategy of member checking or respondent validation (Denzin & Lincoln, 1998) was applied by inquirer both during and at the end of the study. Member checking or respondent validation, which was done mostly through informal and friendly conversation with respondents, protected the study from any misunderstandings, misinterpretations, and personal biases about the meaning of respondents' words. During the study, the follow-ups mostly were done by phone whenever respondents' oral explanations were acceptable for clarification. On the other hand, in some cases a time was considered to have a face to face conversation.

1.10 Structure of Thesis

The structure of this thesis is based on the following instruction. The first chapter includes the background of the study, research problem, research framework, and significance of the study. At the second chapter, the researcher will go through the details and connection of the constructs of this research which are historic buildings in Malaysia, improving energy efficiency in lighting sector, and BIM system. Third chapter is about the methodology of this research. In this chapter, the selected research methodology and its components are explained in detail. The important parts of research method such as data collection, data analysis, and validation of data are discussed. At the fourth chapter, the most important parts of interviews with the respondents and their responses to the interview questions are explained. The emerged categories and themes in regard to each sub-research questions were mentioned and highlighted. At the fifth chapter the accuracy of data and the validation of findings has been analyzed and proved. Chapter six includes summary, conclusion, knowledge

contribution, and recommendations for future studies. In this section discussions based on the results of data collection and data analysis have been stated.

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