

**ASSESSMENT OF GREEN BUILDING CODES  
RELATING TO BUILDING FACADES FOR  
MITIGATING URBAN HEAT ISLAND IN MALAYSIA**

**BY**

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A thesis submitted in fulfilment of the requirement for the  
degree of the Master of Science in Building Services  
Engineering

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**JULY 2020**

## ABSTRACT

Urban Heat Island (UHI) is a major issue in the developed and developing countries. It is one of the consequences of urbanization and a known reason behind the global warming. In fact, such a rapid growth brought about adverse environmental effects including the UHI effect. To mitigate the adverse caused by the rapid development, the nation initiated the Malaysian Standard (MS)1525 and the Green Building Index (GBI). The present study opined that the energy rating tools focused much more on the performances inside the buildings in increasing energy efficiency and affording the comfortability for building occupants. However, such tools have not paid too much attention to the effects on the outside environment of the buildings. In this respect, Biomimicry has emerged as a new science which has been introduced recently for studying the nature's ideas and applying them to our buildings for the purpose of improving the quality of those buildings. Therefore, this study attempts to investigate the performance of the facades that advocated sustainable design principles either by subscribing to GBI directly or to the Biomimicry Life's Principles (BLP) indirectly, focusing on the criteria of the GBI and BLP applications for the facades of commercial buildings. Content Analysis and temperature monitoring are the main methodologies for this study. The analysis of data of the present study revealed that the representation of facades was 16% and 75% in GBI and BLP, while the presentation of UHI was 6% and 35% in GBI and BLP, respectively. Applying this against the two case buildings, the representation of the criteria of facades was 38% and 50% presences. This finding was in line with the energy rating for the buildings, where Silver achieved a lesser percentage and Gold achieved the more percentage. The findings of data monitoring also concurred where the building with the lesser percentage of façade representation was recoded to have a higher ground surface temperature than the others. Moreover, the results of the study expounded on good grounds which help mitigate UHI, and the facades of buildings need to be efficient and follow sustainable guidelines with Biomimicry enhancements. The study provided useful suggestions as well as recommendations for architects in terms of the design which is highly suitable for commercial facades which minimize the effect of temperature of UHI in Malaysia.

## خلاصة البحث

يعد ارتفاع الحرارة في الجزيرة الحضرية من القضايا الأساسية التي تواجه البلدان المتقدمة والنامية، وهو إحدى نتائج التحضر وسبب أساسي للاحتراس الحراري. النمو السريع للبلدان يسبب تأثيرات بيئية كبيرة ومنها ارتفاع الحرارة في الجزيرة الحضرية، ولمواجهة تلك التأثيرات، وضعت ماليزيا معيار المباني الخضراء. فهذه الدراسة ترى أن ذلك المعيار الجديد يركز أكثر على الأداء الحراري في داخل المبنى أكثر من البيئة المحيطة، وتوفير الراحة الحرارية لساكن تلك المباني. إن محاكاة الطبيعة هو علم جديد اكتشف مؤخراً لدراسة أفكار الطبيعة وتطبيقها على المباني لتحسين جودة تلك المباني بالإضافة إلى ذلك محاكاة الطبيعة تتعامل مع كل شيء على أنه جزء من النظام الحيوي بأكمله. ولهذا يهتم هذا البحث بدراسة الأداء للواجهات التي تراعي معايير التصميم المستدام إما عن طريق معيار المباني الخضراء بشكل مباشر أو عبر مبادئ محاكاة الطبيعة بشكل غير مباشر، مع التركيز على معايير المباني الخضراء ومبادئ محاكاة الطبيعة التي لها علاقة مباشرة مع واجهات المباني، وتقييم تلك المعايير مع الواجهات الخارجية لاثنتين من المباني التجارية في ماليزيا. وذلك باستخدام منهجية تحليل المحتوى و مراقبة درجة الحرارة حول تلك المباني. لقد اظهرت نتائج تحليل المحتوى لهذه الدراسة بأن 16% من مبادئ المباني الخضراء في ماليزيا تركز على واجهات المباني بينما 75% من مبادئ محاكاة الطبيعة تركز على واجهات المباني، و تبين أيضاً أن 6% من مبادئ محاكاة الطبيعة تركز على ارتفاع الحرارة في الجزيرة الحضرية بينما كانت النسبة 35% في مبادئ محاكاة الطبيعة. وتقييم معايير المباني الخضراء المتعلقة بواجهات المباني مع اثنتين من المباني التجارية هما Suasana PJH و Menara PJH أوجدت الدراسة أن الأول حقق نسبة 38% بينما الثاني حقق نسبة 50%، حيث تتناسب هذه النتائج مع تقييم المباني التجارية في ماليزيا. كما اظهرت نتائج الدراسة بأن المباني التي لها تقييم أعلى كانت لا تعكس الكثير من الحرارة للبيئة المحيطة. فإن الدراسة سوف تقدم أساس جيد لتخفيف تأثيرات الجزيرة الحضرية في ماليزيا. وأخيراً قدمت الدراسة اقتراحات وتوصيات للمعماريين للتصميم الأنسب والملائم للواجهات التجارية التي تقلل من تأثيرات ارتفاع الحرارة للجزيرة الحضرية في ماليزيا.

## APPROVAL PAGE

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

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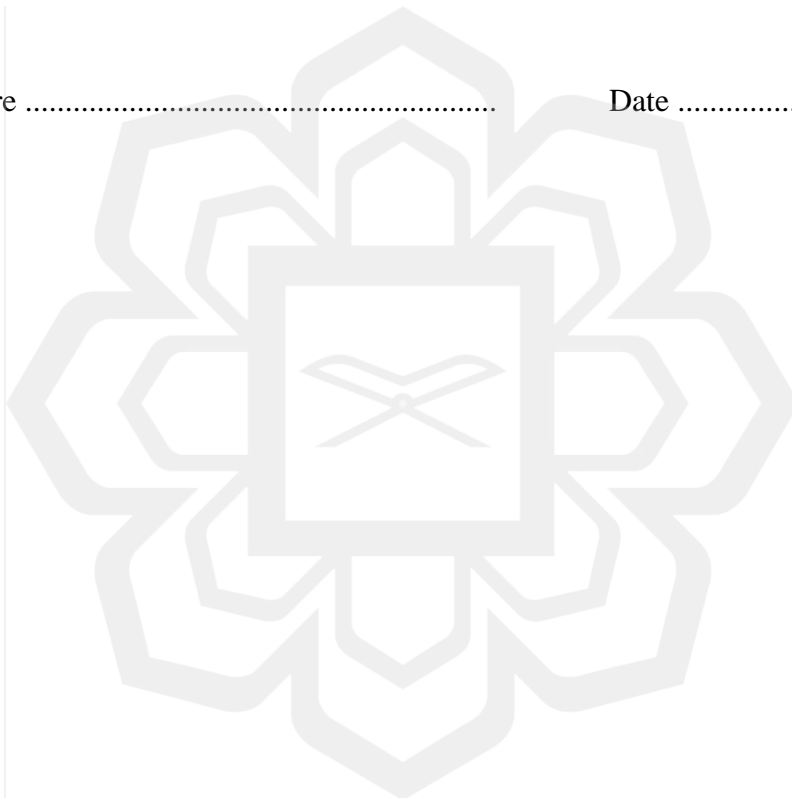
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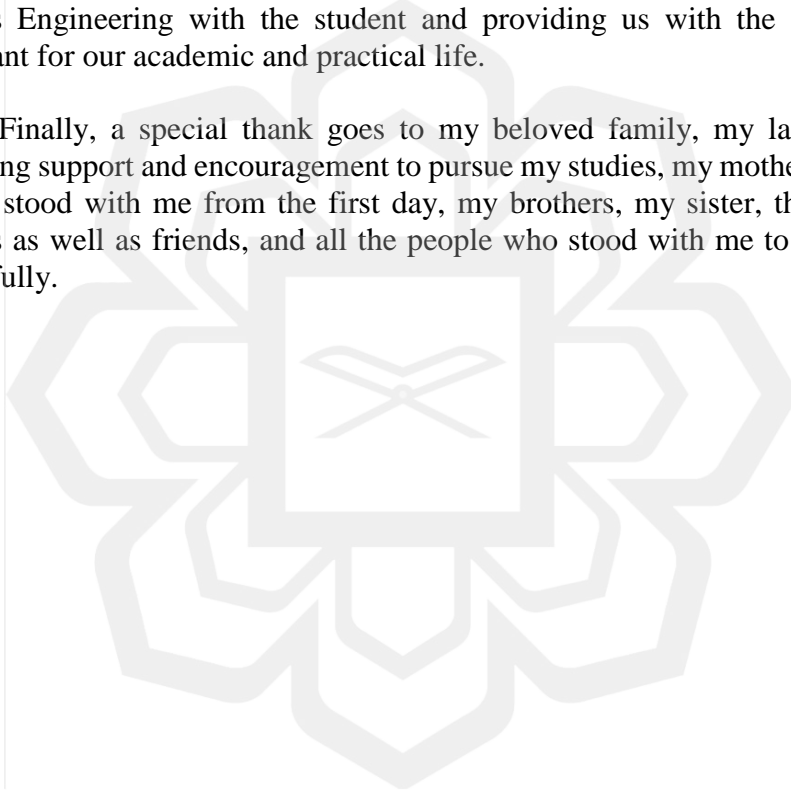
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## ACKNOWLEDGEMENTS

First of all, I would like to thank my supervisor Dr. Noor Aziah Mohd Ariffin from Kulliyah of Architecture and Environmental Design at International Islamic University Malaysia for her guidance and for the constructive feedback and suggestions I received from her during my study. The door to Dr. Noor Aziah Mohd Ariffin's office was always open whenever I ran into a trouble spot or had a question about my research or writing. She consistently allowed this dissertation to be my own work but steered me in the right direction whenever she thought I needed it.

Secondly, I would like to thank all my lecturers in the International Islamic University for sharing their expertise in the course of Master of Science in Building Services Engineering with the student and providing us with the skills which are significant for our academic and practical life.

Finally, a special thank goes to my beloved family, my late father for his continuing support and encouragement to pursue my studies, my mother who supported me and stood with me from the first day, my brothers, my sister, their families and relatives as well as friends, and all the people who stood with me to finish this work successfully.



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## LIST OF ABBREVIATIONS

UHI	Urban Heat Island.
UHII	Urban Heat Island Intensity.
GBI	Green Building Index.
BLP	Biomimicry Life's Principles.
BEI	Building Energy Intensity.
IAQ	Indoor Air Quality.
OTTV	Overall Thermal Transfer Value.
RTTV	Roof Thermal Transfer Value.
HVAC	Heating Ventilation and Air Conditioning.
DL	Data Logger.



## LIST OF SYMBOLS

GWH	Giga Watt per Hour.
°C	Degrees Celsius
T	Temperature
W/m <sup>2</sup>	Watt/ meter square
M/s	Meter/ second



# **CHAPTER ONE**

## **INTRODUCTION**

### **1.1 INTRODUCTION**

This chapter presents an overview of the study and states the research problem, research questions and research objectives. Moreover, it elaborates on the methodologies adopted in this study to achieve the research aims and objectives. Besides, it explains the limitations and the significance of the study; and finally, it presents the structure of the dissertation.

### **1.2 BACKGROUND OF THE STUDY**

Urban Heat Island is a common phenomenon in the cities. One common consequence for UHI is urbanization. Urbanization produces substantial changes in the properties on the land surfaces which changes the surface energy balance in the urban areas. Therefore, it affects energy consumption, thermal discomfort, air quality, local and regional atmospheric circulation, and the rate of mortality. UHI does not have direct effects on the global temperature, but it has a direct impact on the local temperature, which is used to assess the climatic temperature (Morris et al., 2015).

Building facades are an essential element in the building, which is the first building elements in saving energy consumption in the building. The good design of building facades helps to maintain the energy inside and outside the building. In hot climates, efficient facades stop or reduce the heat from reaching the internal space and thus reduce the energy needed for cooling the building. Building facades have a significant role in reducing the Urban Heat Island effects; non or less-reflective facades reflect less heat to the outdoor environment. However, the materials of the facades may

absorb and emit heat later. Thus, the selection of the materials and design facades are vitally important (Rossi et al., 2015).

Energy rating tools like MS1525 and Green Building Index GBI in Malaysia aimed to raise awareness on the importance of dealing with the Urban Heat Island effects for buildings. The cause of UHI is anthropogenic, and the heats rejected from buildings in urban areas were identified as part of the leading cause. However, as observed in the study, most of the GBI codes were more concerned on the performance of the indoor buildings: i.e. to save energy consumption and increase the thermal comfort for the occupants. However, there is a limitation towards the performance of the buildings towards the outdoor environment. To achieve sustainably, a building should be part of the whole ecosystem. Provisions pertaining to the building's impact on the outdoors should be pertinently included into the energy rating index as well

A more natural alternative, like biomimetic design, should be, thus, considered so as to enhance the existing rating tools. Biomimetic or biomimicry is the imitation of the models, systems, and elements of the nature for the purpose of solving complex human problems (Benyus, 1997). It is a new science that studies the nature's ideas and models, and then emulates those shapes, process, ecosystem, and strategies to solve human problems from a sustainable perspective. Biomimicry Life's Principle represents the nature's strategies for sustainability and provides a lens to improve the design strategies (Biomimicry 3.8, 2013). Building façades should behave like a mediator to the environment, like plants. Plants do not reflect the heat to the surrounding environment; instead, they absorb the heat and releases it back as other forms of energy that keeps the climate cool. If the building façades behave like trees, absorb the heat and do not reflecting the heat to surrounding environment, then the building façade will

participate in mitigating the effects of Urban Heat Island in the city and will be friendly to the environment.

### **1.3 PROBLEM STATEMENT**

Urban Heat Island (UHI) is a major issue in Malaysia, and the process of the urbanization is one of the main causes of UHI. In fact, UHI plays a key role in changing the air temperature and urban pattern in the city (Elsayed, 2011).

Building facades design is responsible for determining the energy consumption of buildings. On the other hand, facades may also increase the heat to the surrounding environment by reflecting the sunlight of the glass facades and increase the Urban Heat Island effect.

“The application of Retroreflective materials as new urban coatings is a novel and unexplored research field and presents considerable potential in: (i) reducing the heat content in the UHI boundary, (ii) reflecting the solar radiation beyond the urban canopy, (iii) reducing possible inter-building effects in terms of mutual reflection between facing buildings located in close proximity”

(Rossi et al., 2015, pp: 9)

Most of the building facades materials of commercial buildings are glazed facades. Some types of glazing facades reflect too much heat to the surrounding environment, and finally, it will increase UHI. The building facades of the commercial buildings, if treated using the Biomimicry principles, could reduce the effects of UHI in the Malaysia city.

Green Building Facades (GBI) is similar to other global green rating tools, aimed to reduce the negative impacts of buildings (Green Building Index, 2009). GBI focused

much more on the performances inside the buildings in increasing energy efficiency and affording the comfortability for building occupants. However, such tools have not paid too much attention to the effects on the outside environment of the buildings.

Therefore, this thesis attempted to examine the codes of GBI with the enhancement of BLP in relation to building facades of the commercial buildings in Malaysia. The main aim of this study is to understand whether the building facades, if enhanced further, could aid in reducing the effects of UHI in Malaysia.

#### **1.4 RESEARCH AIM**

The aim of this research is to assess the codes of GBI and BLP which are related to the facades of commercial buildings to mitigate the effects of UHI in Malaysia.

#### **1.5 RESEARCH OBJECTIVES**

Three objectives have been formulated based on the problem statement and the research aim; These objectives are as follows:

- i. To investigate the percentages of GBI and BLP codes which are related to building facades.
- ii. To examine how much the codes of GBI and BLP are related to the building facades and mitigation UHI effects from tall commercial buildings in Malaysia.
- iii. To discover the effects of facades of commercial building on the surrounding environment and UHI mitigation.
- iv. To elaborate the effects of double skin facades to the surrounding environment and UHI.

## 1.6 RESEARCH QUESTIONS

In order to achieve the aim, the research questions were formulated:

- i. What are the percentages and the codes of GBI and BLP which are related to building facades and UHI?
- ii. How do the codes of GBI and BLP participate in mitigating the effects of UHI in Malaysia?
- iii. What are the effects of the commercial building facades to the surrounding environment and UHI in Malaysia?
- iv. What are the effects of double-skin facades to the environment and UHI?

## 1.7 OVERVIEW OF RESEARCH METHODOLOGY

The methodology of this research can be divided into some parts, as shown in Figure 1.1.

1.1.

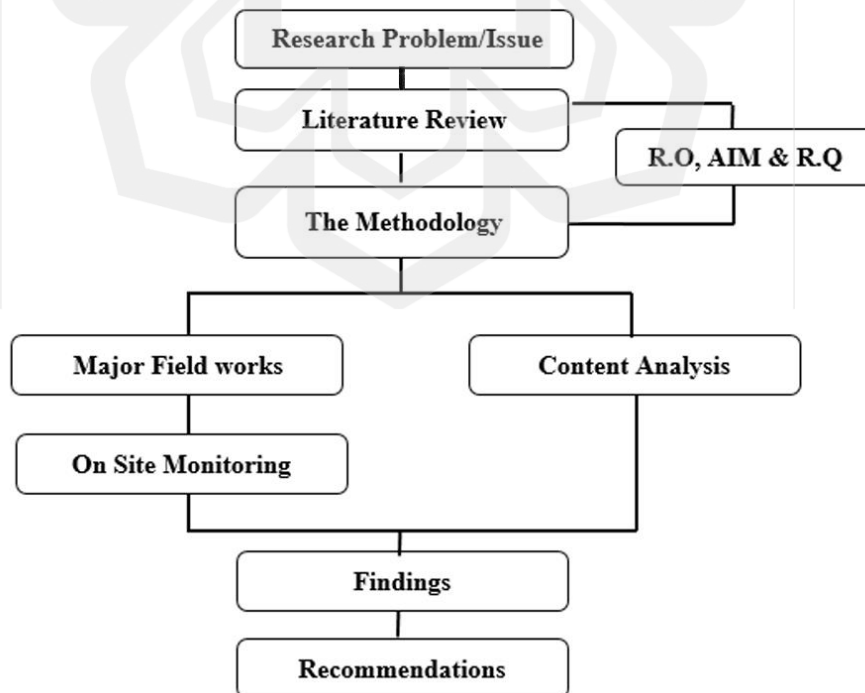


Figure 1.1 Research Methodology.

The first part of the methodology was concerned with conducting the content analysis of GBI and BLP to define the codes which are related to the building facades and UHI. The content analysis was carried out using the software Atlas.Ti (Elo & Kyngäs, 2008). Utilizing Atlas.Ti for analysis include three main steps, namely, preparation, organizing, and reporting. Atlas.Ti is a suitable method for conducting the content analysis and extracting the codes from GBI and BLP which are related to the building facades and UHI. Atlas.Ti gives the possibility to add many documents related to the BLP and GBI and then performs the coding based on the quotations that match each code. The results were then analyzed and the findings were reported.

The second part was related to the collection of the facades data from the two case studies buildings in Putrajaya: Suasana PJH and Menara PJH. Suasana PJH and Menara PJH are commercial buildings whose height reaches 14 stores. Both buildings are rated at GBI standards; Suasana PJH got Silver rating while Menara PJH got a Gold one. Putrajaya was chosen because it is regarded as one of the cities with high UHI (The Star, 2007). Since then, the efforts were done to improve the UHI conditions. Suasana PJH and Menara PJH were selected as their locations were ideal being located in the same area. This part will concentrate on the data of the buildings in general and building facades in particular. Then, the study evaluates the selected codes from GBI which are related to the building façades of Suasana PJH and Menara PJH.

The third part was concerned with the temperature monitoring through the data loggers of outdoors area surrounding Suasana PJH and Menara PJH. The data was collected to validate or to correlate with the findings obtained from Part 2. The climatic temperatures were collected from the Department of Environment (DOE) in Putrajaya at the same dates of the field monitoring. The reference temperature is to evaluate the similarities and differences among the collected temperature.

## **1.8 SIGNIFICANCE OF THE STUDY**

The study focuses on elaborating the importance of studying UHI, and develops an understanding of its effects on the surrounding environment in the context of Malaysia. Besides, the study enhances the significance of GBI and BLP codes for the environment to reduce the impact of UHI through the facades of the commercial buildings in Malaysia. Furthermore, the study offers an evaluation of the buildings based on the GBI and BLP codes which are related to the building facades. Finally, the study helps the designers to treat the facades accordingly so as to reduce the impacts of UHI.

## **1.9 LIMITATION OF THE STUDY**

This study is concerned with investigating the effects of building façade on Urban Heat Island in Putrajaya because it is registered as one area in Malaysia with high UHI. Suasana PJH and Menara PJH are two commercial buildings in Putrajaya which are certified by GBI standards. On the other hand, the study examined the temperature only to identify the effects of those commercial buildings on the surrounding environment and UHI in Malaysia. Moreover, the study has chosen GBI tools because it is one of the green building tools concerned with the environmental issues. The BLP has been also chosen as a tool to mitigate the effects of UHI in Malaysia.

## **1.10 THESIS STRUCTURE**

This thesis is divided into five chapters. These chapters are as follows: Introduction, Literature Review, Research Methodology, Data Analysis and Findings, and Conclusion and Recommendations.

Chapter One provides background of the study, problem statement, research questions, research objectives, significance of the study and the overall structure of the study.

Chapter Two presents a discussion of the related literature which is considered as the core part of the study. The chapter defined the energy situation in Malaysia in all sectors, and the phenomena of UHI; it also discusses the codes of Green Building Index in Malaysia. After that, the chapter continued with the explanations of Biomimicry Life's Principles. Finally, this chapter highlights the relationship between building facades and UHI.

Chapter Three explains the methodologies adopted for this study. Firstly, the chapter sheds some light on the method of content analysis. Secondly, it elaborates on the process of content analysis to extract the codes of GBI and BLP, which are related to the building facades. Thirdly, the chapter defines the two commercial case study buildings, namely, Suasana PJH and Menara PJH. Fourthly, the chapter highlights the experiment procedures for the commercial buildings in Putrajaya for temperature monitoring. Besides, it describes the instrument used for collecting the data. Finally, the chapter presents the method of data analysis.

Chapter Four discusses the results of the study. Firstly, the chapter explains the codes of GBI and BLP, which are related to the building facades and UHI. Secondly, the chapter evaluates the codes of GBI and BLP, that are related to the building façade of Suasana PJH and Menara PJH. Finally, the chapter presents the result of the experiment conducted around the commercial building in Putrajaya, Malaysia.

Chapter Five is the final chapter of this study and presents the discussion of the findings and the recommendations of the study. The chapter concludes with the discussion of the major findings in the research and then displays the limitations of the

study. After that, it presents the recommendations for the architects. Finally, this chapter offers some suggestions for future studies, which will be carried out to mitigate the effects of Urban Heat Island in Malaysia.



## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 INTRODUCTION**

This chapter presents the literature review of the study. It explains the energy situation in Malaysia with a special emphasis on the commercial sector. Moreover, it defines the phenomena of Urban Heat Island in Malaysia as well as the notion of Green Building Index GBI and its applications in Malaysia. Besides, it highlights the biomimicry and its principles as well as the Biomimicry Life's Principles BLP and its components. Finally, the chapter sheds light on the relationship between building facades and UHI.

#### **2.2 ENERGY SITUATION IN MALAYSIA**

Energy is the key aspect of running the economy and promoting the sustainability development in a country. The continuous challenge of electricity is generating and dealing with the increasing demands which exerts huge pressure on the energy infrastructure in the developed and developing countries. Malaysia relies deeply on the fossil fuels such as coal, natural gas, and oil for supply which are non-renewable energy (Chattri, Yahoo, & Othman, 2018).

Recently, there have been many ways which are created for saving energy consumption and its effects on the environment. Malaysia is headed to a high economic development requiring a dramatic increase of energy consumption, specifically the electrical energy used in both commercial and residential sectors; the electrical energy consume about half of the electricity generated in Malaysia. The rising in Gross Domestic Product leads to an increase in the demand for electricity in different