UNIVERSITI PUTRA MALAYSIA

MAIN BARRIERS AND POTENTIAL SOLUTIONS IN DEVELOPMENT OF ENERGY EFFICIENT BUILDINGS IN WARM CLIMATE OF IRAN

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FRSB 2018 13

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By

FERESHTEH HAJIGHOLAMI

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

May 2017

DEDICATION

In the Name of Allah swt. ,

Specially dedicated to

My Family

FERESHTEH HAJIGHOLAMI

Date: December 2017

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

MAIN BARRIERS AND POTENTIAL SOLUTIONS IN DEVELOPMENT OF ENERGY EFFICIENT BUILDINGS IN WARM CLIMATE OF IRAN

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May 2017

Chairman : Mohamad Fakri Zaky Bin Jaafar, PhD
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Iran is considered as one of the developing countries in the Middle East with high levels of energy consumption. Enhancing the energy efficiency of buildings can be regarded as a sustainable method of reducing the energy consumption and subsequently, the environmental impacts in Iran. Only a few buildings in Iran are constructed via using EE strategies, but they are built with less or unsuccessful operations and neglects in the implementation of EE technical solutions. The aim of this study is to identify the experiences of EEB in Iran especially in warm climate and identifying the barriers and drivers in the developing of EEBs in Iran. The study adopted a qualitative methodological approach and strategy in data collection and analysis. 8 EEBs and designs in Iran were selected as case studies. Qualitative method by using case study, observation, semi-structured interviews were used to interview architects of 8 EEBs and designs in Iran. Observations were conducted on these 8 case buildings for collecting evidences of neglect in their design, constructions and operation. semi-structured interviews were conducted among 16 architects to understand main barriers and drivers in the developing of EEB in Iran. Due to great diversity of barriers to finding and implementing solutions, it will be useful to group these barriers in some way which should not seen as rigid, but as a framework for identification and analysis. In gauging this understanding, a Trudgill (1990) framework for analysis consist of six major groups of barriers – agreement, knowledge, technological, economic, social and political was used. The study identified 63 barriers deterring the development and implementation of applying EE solutions in Iranian buildings and these were grouped into 8 categories: 1) Low energy prices in Iran, 2) Lack of interest by client for applying EE solutions in their building, 3) Applying EE solutions in building cost too much, 4) Lack of political will, legislation and enforcement, 5) Lack of technical understanding among project team members, 6) Lack of interest by project team members, 7) Lack of some of the EEB components on the Iran markets, and 8) Lack of leadership in EEB projects.

For the solutions to overcome the obstacles 94 answers were suggested by 16 interviewees and these were grouped into 4 categories: 1) Action by government, 2) Action by education Sector, 3) Action by private sector, and 4) Action by Clients. The benefits of research is to identified the EEBs and their opportunities like economic benefits, environmental benefits, reduction in energy usage as well as one of the best strategic solutions for the decreased air pollution and global demand for energy etc. for the Iranian public and Iranian building industry players.

Abstrak tesis ini dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

HALANGAN UTAMA DAN POTENSI PENYELESAIAN BAGI PEMBINAAN BANGUNAN CEKAP TENAGA DI KAWASAN BERIKLIM PANAS SEPERTI IRAN

Oleh

FERESHTEH HAJIGHOLAMI

Mei 2017

Pengerusi : Mohamad Fakri Zaky Bin Jaafar, PhD
Fakulti : Rekabentuk dan Senibina

Iran merupakan salah sebuah negara yang sedang membangun di Timur Tengah dengan mencatatkan penggunaan tenaga yang tinggi. Peningkatan kecekapan tenaga pada sesuatu bangunan merupakan salah satu kaedah yang lestari dalam mengurangkan penggunaan tenaga dan seterusnya memberi impak persekitaran kepada negara tersebut. Setakat ini, hanya beberapa buah bangunan sahaja di Iran yang dibina menggunakan strategi cekap tenaga, namun begitu pembinaan tersebut kurang berkesan atau gagal beroperasi dan penyelesaian terhadap pelaksanaan teknikal cekap tenaga turut terabai. Tujuan utama penyelidikan ini dijalankan adalah untuk mengkaji tentang bangunan cekap tenaga yang sedia ada di Iran terutama sekali mengenai pembinaan bangunan di negara beriklim panas dan mengenal pasti halangan dan penyebab dalam pembinaan bangunan cekap tenaga di Iran. Kajian ini menggunakan kaedah kualitatif dalam pengumpulan dan menganalisa data. 8 bangunan dan rekabentuk bangunan cekap tenaga di Iran telah dipilih sebagai kajian kes untuk kajian ini. Kaedah kualitatif ini dijalankan dengan cara kajian kes, pemerhatian dan temubual dengan pihak arkitek, kontraktor dan pengguna/ pemilik kepada 8 bangunan dan rekabentuk bangunan cekap tenaga yang terpilih sebelum ini. Pemerhatian telah dijalankan untuk mengumpul bukti pengabaian dalam rekabentuk, pembinaan dan operasi terhadap 8 kes bangunan dan rekabentuk yang telah dipilih. Temubual telah dijalankan terhadap 16 arkitek untuk memahami halangan dan penyebab dalam pembinaan bangunan cekap tenaga di Iran. Berdasarkan kepelbagaian halangan dalam mencari dan melaksanakan penyelesaian, penemuan ini harus dikategorikan mengikut kumpulan supaya tidak kelihatan terlalu rumit, tetapi dijadikan sebagai sebuah rangkakerja untuk tujuan mengenalpasti dan menganalisa. Rangkakerja untuk analisa Trudgill (1990) telah digunakan dalam usaha untuk memahami kajian ini. Rangkakerja untuk analisa Trudgill (1990) menyatakan bahawa terdapat enam kumpulan utama dalam halangan iaitu;

perjanjian, pengetahuan, teknologi, ekonomi, sosial dan politik. Kajian ini telah mengenalpasti 63 halangan dalam pembinaan dan pelaksanaan bangunan cekap tenaga di Iran, halangan-halangan tersebut telah dibahagikan kepada 8 kumpulan kategori iaitu; 1) Harga bahan tenaga yang murah di Iran 2) Pemilik bangunan kurang berminat untuk mengaplikasikan penyelesaian cekap tenaga di bangunan mereka 3) Kos yang tinggi untuk mengaplikasikan penyelesaian cekap tenaga di bangunan 4) Kurang campur tangan dari pihak politik, undang-undang dan penguatkuasaan 5) Kurang pemahaman teknikal antara ahli pasukan projek 6) Kurang minat di kalangan ahli pasukan projek 7) Kurang bekalan komponen bangunan cekap tenaga di pasaran Iran, dan 8) kurang kepimpinan dalam projek bangunan cekap tenaga. Berdasarkan kepada 16 temubual yang telah dijalankan, terdapat 94 cadangan dikemukakan untuk mengatasi halangan-halangan tersebut. Cadangan-cadangan tersebut diketegorikan kepada empat kumpulan, iaitu; 1) Tindakan oleh pihak kerajaan 2) Tindakan oleh pihak pengajian 3) Tindakan oleh sektor swasta, dan 4) Tindakan oleh pihak pemilik bangunan. Manfaat daripada kajian ini adalah untuk megenalpasti bangunan cekap tenaga dan peluang mereka terhadap ekonomi, persekitaran, pengurangan penggunaan tenaga dan dijadikan strategi utama dalam mengurangkan pencemaran udara, permintaan tenaga global dan sebagainya terhadap negara Iran amnya dan secara khusunyas kepada pihak industri pembinaan di Iran.

ACKNOWLEDGEMENTS

Firstly with the blessing of God, I have successfully completed this project in time. First of all I would like to thank my supervisor Dr.Zaki and my Co.supervisor Dr.Zalina for their guidance and encouragement. They are patient, kind and willing to teach me in every way they can. Without my supervisor and Co supervisor, I could never accomplish my final year project smoothly.

My greatest gratitude, however, is to my beloved family who have always encouraged and prayed for my success and enduring the hardships whilst I was away, their sacrifices and support shall always be remembered.

I certify that a Thesis Examination Committee has met on 26 May 2017 to conduct the final examination of Fereshteh Hajigholami on his thesis entitled "Main Barriers and Potential Solutions in Development of Energy Efficient Buildings in Warm Climate of Iran" 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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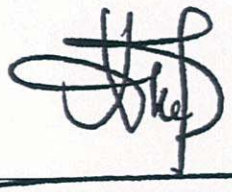

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science**.** The members of the Supervisory Committee were as follows:

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This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
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LIST OF ABBREVIATIONS

AC	Air Conditioner, Air conditioning
BHRC	Building and Housing Research Center
BTC	Building Technical Code
CO2	Carbon dioxide
DOE	Environment Department of Iran
EEB	Energy Efficient Building
EVAPCOOL	Passive evaporative cooling system
GHG	Greenhouse Gas
IFCO	Iranian Fuel Conservation Company
INBC	Iranian National Building Code
IPCC	Intergovernmental Panel on Climate Change
LEED	Leadership in Energy and Environmental Design
PDEC	Passive Downdraught Evaporative Cooling tower
PV	Photovoltaic
ROI	Return of Investment
U.S. DOE	United States Department of Energy
U.S. EPA	United States Environmental Protection Agency
USGBC	United States Green Building Council
WBCSD	World Business Council for Sustainable Development
WEC	World Energy Council

CHAPTER 1

INTRODUCTION

1.1 Introduction

Climate has a major effect on the performance of the building and its energy consumption. Reducing energy consumption, using natural resources and providing comfortable, healthier and sustainable living spaces are the aims of a climatically responsive sustainable building design (Hui 2000). Sustainable design and energy efficiency are of great importance nowadays. All over the last decades, several concepts and approaches have emerged concerning EE in buildings. There are different climates in the world, which means different levels of cooling and heating energy demands in buildings. Adopting EE design strategies are relatively complicated in climates with hot summers and cool winters as energy is required for both cooling and heating demand in the buildings (IPCC, 2013). Most of the energy consumed in the region is produced by fossil fuels causing considerable amounts of GHG emissions. Environmental problems and huge amount of energy consumption is important issue in some developing countries such as Iran (World Energy Council, 2013).

In last decades, frost and cold days and nights have become less frequent while hot days and nights, and heat waves have become more frequent. In addition, precipitation has decreased. Wind patterns have also changed and the areas affected by drought have been expanded. Human activities have contributed to striking raises of greenhouse gases (GHGs) emissions. Further warming and changes in global climate would be caused by continuous global GHG emissions at or above present rates. Energy consumption in various sectors is the main source of the most important GHG, carbon dioxide (CO2) emissions (IPCC, 2013).

According to the Ministry of Energy of Iran, energy consumption in Iran is high and it causes of environmental impacts specially in building sector. Commercial and residential buildings represent 42% of total energy consumption in Iran. Also the largest amounts of CO2 emissions are produced by this energy consumer section. Enhancing the EE of buildings can be regarded as a sustainable method of decreasing the energy consumption and subsequently, the environmental impacts in Iran (Ministry of Energy of Iran, 2013).

Developing EE buildings in Iran is a proper method to decrease energy consumption and associated environmental impacts in Iran. The focus of this research is identifying the main barriers and subsequently solutions of developing EE buildings in Iran.

1.2 Research Problem

In order to find a solution to develop and construct buildings which are EE in this region, it is essential to discover and introduce barriers and technical solutions and strategies about the local potentials and conditions. Thus, having a clear understanding of the existing barriers and experiences and the ongoing local conditions is essential in evaluating the employed solutions (Aboulnaga, 2013).

As per the studies of Homod and Sahari (2013), recognized that by using EE, it able to help reduce environmental problems but there is not any standard energy EE project in Iran yet as well as any study on finding the barriers of implementing EE building in Iran.

Rezaie, Esmailzadeh and Dincer (2008) stated that, finding barriers to implementing EE practices and features in buildings in Iran is essential. A few buildings designed base on EE in Iran. However they are built with less or unsuccessful operations and neglects in the implementation and some projects were stopped upon designing and were never implemented. Also there is not any study on the level of practice and barriers of implementing EE in Iran.

1.3 Research Questions

The research study aims to find the answers to these questions:

1- What are the main barriers and solutions for developing energy efficiency in buildings in Iran especially in warm climate area?
2- What are the experiences and results of constructing energy efficient buildings in Iran especially in warm climate area?
3- Taking the innovative techniques of passive design strategies as well as Iranian traditional elements of architecture into consideration, in what way are energy efficient buildings constructed and designed in Iran especially in warm climate area?

1.4 Research aim

The aim of this study is developing of energy efficient buildings in Iran through identify the experiences of energy efficient buildings in Iran and main barriers and potential drivers in the developing of energy efficient buildings in Iran.

1.5 Research objectives

This study carried out based on following objectives:

1- To identify the level of energy efficient practices in buildings in warm climates of Iran.
2- To analyse the potential barriers and sensible and practical solutions through amplifying the drivers and barriers.
3- To identify the experiences of technical solutions from innovative and traditional design features which being employed in Iran.

1.6 Scope of the research

The study explores the experiences of EEB in Iran through study existing energy efficient buildings and designs in Iran as well as other relevant factors and elements like technologies, methods, actors and policies to find the barriers and drivers of development of energy efficient building in Iran. After proper review of all accessible information sources such the interconnected reports, authorities, conference reports, websites, articles and etc., totally 8 energy efficient projects were identified in Iran. All existing case studies in this research are located in two big cities of Iran, named Tehran and Yazd which are located in warm climate zone of Iran. The results were utilized for choosing the relevant energy efficient case studies, as well as interviewees for conducting observations and interviews of the research. The area of study is in Iran, with focusing on warm climate area of Iran. The total area of Iran is 1,648,195 square kilometers. Iran is the 2nd largest country in the Middle East and 18th largest country of the world. In reference of Statistical Center of Iran, a total population of Iran is around 78.5 million in 2014 which increased from 75 million in 2013. Iran has a hot, dry climate with long, hot, dry summers and short, cool winters.

Tehran is the capital as well as largest city of Iran and the largest city in Western Asia with a population of around 14 million. Yazd is the capital of Yazd Province, Iran with a population of around 1.274 million in 2013.

1.7 Methodology

The study adopted a qualitative methodological approach. The technique of inquiry is divided to 2 parts: (1) the preliminary phase and (2) final phase. The first phase of data collection involved literature review, preliminary personal communications and interviews and preliminary observation and analysis of photos of selected case studies. The purpose of preliminary phase is to become familiar with selected energy efficient case studies. In this stage focus was on identifying the energy efficient features which designed for these project as well as main problems in

implementation of these energy efficient features in construction stage. The final phase involved semi-structured interview and final observation in order to finding main barriers and potential solutions in the developing of energy efficient building in warm climate of Iran.

8 energy efficient buildings (completed and under design stage) were selected to identify their energy efficient features, strategies and technical solutions. The barriers and solutions in the development of these 8 case study buildings were identified using semi-structured interviews among 16 architects. The questions employed in the semi-structured interviews were conducted based on the experience of interviewee on the discussed topic and the role they play in the subject. Observations were conducted for collecting evidences of neglect in design, construction and operation of the chosen case studies.

This study used triangulation to examine the outcome of interviews. Three steps of data analysis were conducted namely, data preparation, data description and making conclusions from the data. Data preparation includes: (1) logging the data, (2) checking the data for accuracy, (3) developing a database structure, (4) triangulation of data, (5) transforming the raw data into a form usable for the analysis.

Analysis of data in the initial stage was limited to main strategies as well as experiences of the energy efficient buildings in warm climate of Iran. Main passive design strategies as well as barriers and evidences of neglect in design, construction and operation of implementing in the chosen case studies were analyzed which understanding them aid to finding the main berries and drivers in the topic of research.

Information about the energy efficient solutions that were employed in selected case studies where carefully inspected in an attempt to find the reason and the way they were employed. Afterward, the errors, problems and neglects of selected case studies in practice which found through observation were analyzed. Furthermore, main barriers and potential solutions in the development of energy efficient buildings in Iran were analyzed with consideration of semi-structured interviews with the main actors of selected case studies. The process of data analysis leads to establishment of this research principle conclusions.

1.8 Significance of research

Findings main barriers and drivers to apply energy efficient building practices in warm climate of Iran lead to more usage of this method and consequently, reduce further consumption of energy from fossil fuels and lower level of environmental impact such as greenhouse gases (GHGs) and carbon dioxide (CO2) emissions in Iran. The benefits of the research is to identified the EEBs and their opportunities like economic benefits, environmental benefits, reduction in energy usage as well as

one of the best strategic solutions for the decreased air pollution and global demand for energy etc. for the Iranian public, especially for Iranian building industry players such as: designers, owners, constructors as well as policy makers.

1.9 Layout of thesis

The first chapter introduces the overall structure of the study include an overview of research background, problem statement, research aim, objectives, questions, as well as scope and significant of study and a brief about methodology which was adopted for this study.

Chapter 2, the energy demand in building sector of Middle East and Iran are reviewed. Also, environmental impacts of building sectors of Iran as well as the energy efficiency policies in Iranian buildings and building materials in construction market of Iran are reviewed. Afterward, passive design strategies in general which are common energy efficient solutions among building constructions are reviewed. Also, green building program, bioclimatic design and examples of passive house in warm climate of Europe as an example in other regions are described. Afterward, the common design features and elements in traditional architecture of Iran are highlighted to understand the local climatic-responsive design solutions for improving the level of energy efficiency in the future building construction in Iran. Also, Trudgill's AKTESP framework was used to literature of six major groups of barriers (Agreement, Knowledge, Technology, Economic, Social and Political) in development of energy efficient buildings in Iran.

Chapter 3 describes the research design, methodology and appropriate strategies to collect relevant data in order to answer the research questions. The chapter ends with an explanation on study area.

Chapter 4 presents the result and analysis of the data gathered through the physical observation method of 8 selected energy efficient buildings projects as case studies in Iran. It describes the related data on technical solutions, energy performance and associated costs. The descriptive analysis of the data collected from case studies observation is also elaborated in this chapter.

Chapter 5 offers the result, analysis and discussion of the gathered data through interviews with experts which consists of architects of the selected energy efficient building (completed and under design stage) based on their experience. The main finding of interview in this chapter is classified into two parts. The first finding presents the main barriers in the development of energy efficient buildings in Iran and the second finding presents the potential solutions in the development of energy efficient buildings in Iran.

And finally, chapter 6 is the conclusion of the study. This chapter ends with some recommendations for further studies.

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