

USE OF ESTIDAMA RATING TOOL TO ASSESS EXISTING BUILDING IN
HOT DRY CLIMATE

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To my beloved parents, brothers, wife and friends

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ABSTRACT

Energy consumption in buildings has significantly increased over the last two decades in the United Arab Emirates (UAE). Moreover, most of the existing buildings in the region were built without any consideration for energy efficiency. To control this trend, the UAE government adopted green building rating systems for new buildings such as Leadership in Energy and Environmental Design (LEED) and Building Research Establishment Environmental Assessment Method (BREEAM), which were not suitable for countries in a hot dry climate. However, the use of Estidama Pearl Rating System (PRS), developed for Abu-Dhabi emirate, was not adopted by the other emirates. In addition, the retrofitting of existing buildings to green building status has not received adequate attention. Thus, the aim of this study is to reduce environmental impacts that have evolved from the high energy consumption of existing buildings. The study involves an assessment of a case study building located at Ajman University of Science and Technology to simulate retrofitting of the building to become environmental friendly using Estidama PRS points that incorporates cool building strategies, daylighting, and water use reduction, which are appropriate in hot dry climate. The building was assessed using a computer simulation software called Integrated Environmental Solutions Virtual Environment (IES-VE), to compare the actual situation of the building against a new suggested situation. The results show that daylighting retrofitting efforts involving changing of the glass type and adding light shelves failed to achieve any score. However, the retrofitting succeeded in achieving a reasonable rating score in the cool building strategies category by installing aluminium cladding on the external walls. In terms of water usage, new toilet fixtures reduced the amount of internal water usage by almost one-third. Based on these results, major changes to daylighting, and minor changes to cool building strategies and water use reduction are needed to help retrofit buildings to become more environmental friendly.

ABSTRAK

Penggunaan tenaga dalam bangunan di Amiriah Arab Bersatu (UAE) telah meningkat dengan ketara sejak dua dekad yang lalu. Tambahan pula, kebanyakan bangunan sedia ada di rantau ini telah dibina tanpa sebarang pertimbangan terhadap kecekapan tenaga. Untuk mengawal trend ini, UAE telah melaksanakan piawaian bangunan hijau untuk bangunan-bangunan baru seperti *Leadership in Energy and Environmental Design* (LEED) dan *Building Research Establishment Environmental Assessment Method* (BREEAM), yang mana ia tidak sesuai untuk negara-negara beriklim panas dan kering. Walau bagaimanapun, penggunaan *Estidama Pearl Rating System* (PRS), yang dibangunkan untuk amiriah Abu-Dhabi, tidak digunapakai oleh amiriah yang lain. Sebagai tambahan, pemuliharaan peralatan pada bangunan yang sedia ada kepada status bangunan hijau tidak mendapat perhatian yang secukupnya. Oleh itu, matlamat kajian ini adalah untuk mengurangkan kesan alam sekitar yang telah dijana daripada penggunaan tenaga yang tinggi pada bangunan-bangunan sedia ada. Kajian ini melibatkan penilaian kajian kes sebuah bangunan yang terletak di *Ajman University of Science and Technology* untuk disimulasi pemuliharaan peralatan bangunan tersebut supaya menjadi lebih mesra alam dengan menggunakan titik-titik Estidama PRS yang mempunyai strategi bangunan sejuk, pencahayaan siang, dan pengurangan penggunaan air yang lebih sesuai untuk iklim yang panas dan kering. Bangunan tersebut dinilai dengan menggunakan aplikasi simulasi komputer yang dipanggil *Integrated Environmental Solutions Virtual Environment* (IES-VE), untuk membandingkan keadaan sebenar bangunan itu terhadap keadaan baru yang dicadangkan. Hasil kajian menunjukkan bahawa usaha-usaha pemuliharaan bagi pencahayaan siang yang melibatkan perubahan jenis kaca dan penggunaan rak cahaya telah gagal mencapai apa-apa skor. Tetapi, pemuliharaan tersebut telah berjaya mencapai skor penilaian yang munasabah dalam kategori strategi bangunan sejuk dengan memasang pelapisan aluminium pada dinding luar. Dari segi penggunaan air, kelengkapan baru pada tandas telah mengurangkan jumlah penggunaan air dalaman sebanyak hampir satu pertiga. Berdasarkan keputusan ini, perubahan besar untuk pencahayaan siang, dan perubahan kecil pada strategi bangunan sejuk dan pengurangan penggunaan air diperlukan bagi membantu memulihkan bangunan supaya menjadi lebih mesra alam.

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LIST OF ABBREVIATIONS

AD-UBC	-	Abu Dhabi Urban Planning Council
AIA	-	American Institute of Architects
ANSI	-	American National Standards Institute
ASHRAE	-	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
AUST	-	Ajman University of Science and Technology
BRE	-	U.K. Building Research Establishment
BREEAM	-	Building Research Environmental Assessment Method
CIE Clear Sky	-	<i>Commission Internationale de l'Éclairage</i> : the International Lighting Commission (Clear Sky)
CIWMB	-	California Integrated Waste Management Board
EPA	-	The Environmental Protection Agency
FEWA	-	Federal Electricity and Water Authority
FTE	-	Full Time Equivalent
GBCI	-	Green Building Certification Institute
gbXML	-	Green Building eXtensible Markup Language
GCC	-	Gulf Cooperation Council countries
HK-BEAM	-	Hong Kong Building Environmental Assessment Method
IEA	-	International Energy Agency
IESNA	-	Illuminating Engineering Society of North America
IES-VE	-	Integrated Environmental Solution – Virtual Environment
LCA	-	Life Cycle Assessment
LEED	-	Leadership in Energy and Environmental Design
MWh	-	Megawatt hour
PRS	-	Pearl Rating system
PV	-	Photo Voltaic
UAE	-	United Arab Emirates
USGBC	-	United State Green Building Council
U-Value	-	Overall Heat Transfer Coefficient (W/m ² K)

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

Peoples who live in areas with a hot dry climate sometimes face many difficulties in that environment. Average daily outdoor high temperatures can exceed 38°C. Peak afternoon temperatures can exceed 43°C, with relative humidity levels consequently being less than 30% (Hastbacka *et al.*, 2012). These rates are subjected to significant change due to global warming, which leads to an increase of energy consumption to accommodate the need for a more comfortable environment. The United Arab Emirates (UAE) is considered as one of these countries, and its major cities extend to the coastal areas (Francis, 1995), where the relative humidity is very high, ranging between 60% - 80% in the study area, with low rainfall (less than 100 mm per year), high temperatures and extremely high evaporation rates. The UAE depends mainly on groundwater and desalination as its main sources of drinking water (DSC, 2010).

The UAE has experienced a huge urban, economic and social rise in the last two decades, from 1990 to the present day, covering all the seven emirates. Satellite broadcasting has contributed immensely in marketing these developments of the Emirates. Moreover, many events and activities have emerged during this period, such as the Dubai Air show in 1991, the International Defence Exhibition in 1993, the Dubai Festival in 1996 and the Dubai World Cup in 1996 (Heard-Bey, 2005).

According to the annual report for the year of 2008 issued by the Regional Office for the Eastern Mediterranean Region of the World Health Organization, the annual rate of population growth in the UAE is 6.2%. This increase is because of the high per capita income, which has reached 47,500 US dollar per capita, making it among the ten richest countries in the world. All of these factors have led to the construction boom that is currently taking place (Khalifa, 2009; Pasquali, 2013). In 2011, the cost of construction projects completed over the GCC (Gulf Cooperation Council) countries reached 46.52 US billion dollars. It is expected to increase to 79.7552 US billion dollars in 2012 by a rate of 71%. The UAE, which is a member of the GCC, garnered the largest percentage of the construction projects, accounting for almost half (ME, 2012). Most of these mega constructions in the region have been built without consideration for the environment and green concepts from all clients. For instance, buildings have been designed with large glass openings and a large amount of curtain wall glass, which will cause damage to the environment, since the production of the glass negatively affect the environment through the emission of CO₂ (Alnaser, 2008). Moreover, some of these building are considered as iconic towers in the UAE, such as the World Trade Center in Dubai, built in 1971, where 40% of the façade material is glass, the National Bank of Dubai (NBD) built in 1995, where the façade is 80% curtain wall glass and the 21st Century Tower in Dubai, built in 2000, where 90% of the façade is curtain wall glass (Aboulnaga, 2006). Some other examples with images can be seen in Appendix A.

All of these factors are the major causes of high rates of energy consumption, which negatively affect the environment. The energy consumption of the Emirates increased significantly from 2003 to 2012 to meet the demand of the buildings. The following chart (Figure 1.1) shows the increasing electricity consumption in the UAE by agency and years. The amount of electricity consumed has increased by 140% between 2003 and 2012. Data showed that emirate of Abu Dhabi has consumed about 46% of the total consumption in the UAE, while it contributes about 59% of the electricity production, while Dubai in 2012 consumed 35% of the total electricity generated, and produced 34% of the total electricity (NBS, 2014). The increase of usage in electricity is due to the growth in population and the change in consumption patterns, which results from modernity and the increase in economic projects that consume water (NBS, 2014).

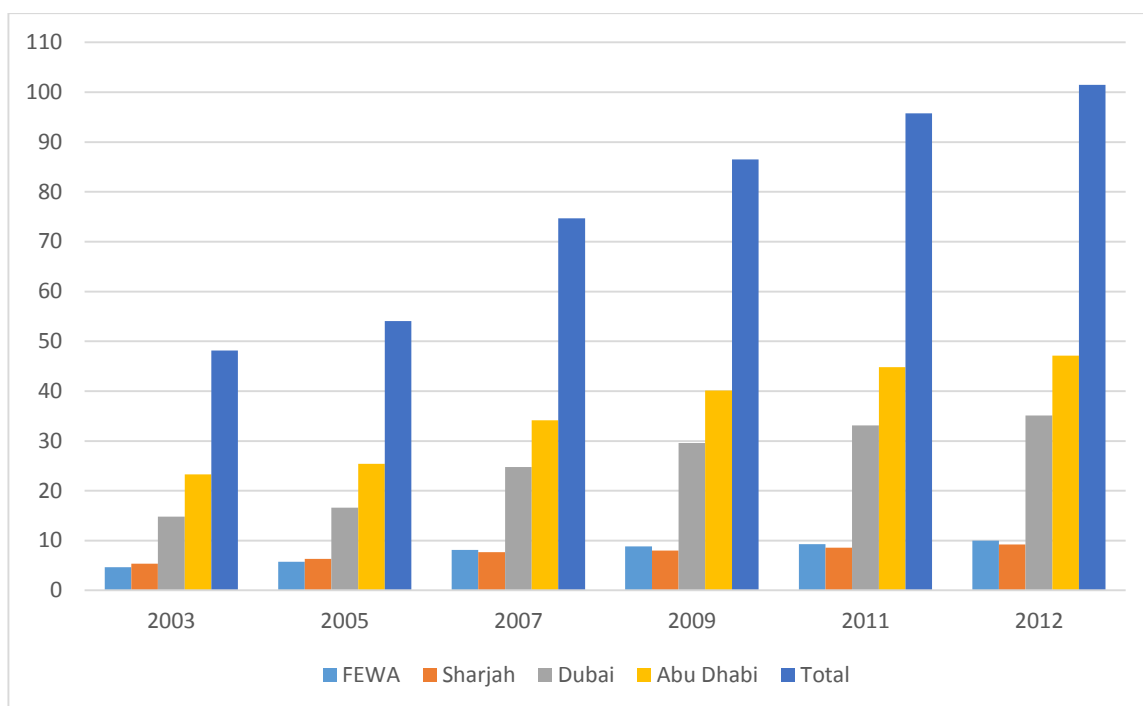


Figure 1.1 Annual electricity consumption by agency and years (Source: NBS, 2014), summarised by author)

Electricity consumption in 2012 increased by about 6% from 2011. The data from 2012 also showed that electricity consumption at the Federal Electricity and Water Authority (FEWA) and the Sharjah Electricity and Water Authority was higher than the production from their stations since 2008, so electricity was provided from Abu Dhabi Water and Electricity Authority: this covered about 60% of the electricity consumed in Sharjah and 82% in FEWA (NBS, 2014).

Moving toward the green concept become a very important factor in that region in reducing energy consumption. If they do so, there will be a less need to increase the generation of energy in the long term. For that reason, the UAE has started to move toward renewable energy and implement green building standards in the main cities for all governmental buildings. The emirate of Abu Dhabi has approved a green building assessment system called "Estidama", based on the Pearl Rating System (PRS), and requires all new buildings to be bound by it (Estidama, 2010).

Dubai represents an economic capital of Emirates, and one of the most important tourist destinations in the world, started to develop the Dubai green

structure by applying “Green Building Regulations & Specifications” to all new governmental buildings during 2011, although it was optional for private buildings until 2014 (Saleh, 2012). The problem of new constructions and their effect on the environment in the UAE will be almost solved within the coming years. However, there is no awareness of the effect of the existing buildings on the environment, and how to solve this problem. This problem is highlighted and discussed in this research.

1.2 Problem Statement

In countries like the UAE, the main concern for all the stakeholders (client and policy makers) is to build their buildings quickly and in an aesthetic way. Thus, most of the existing buildings in the region were designed and built without any consideration of energy efficiency, which could create damage to the environment (Alnaser, 2008).

The energy crisis was expected in the area. Therefore, the UAE increased its energy generation in parallel with the new construction. According to statistics provided by the Dubai Statistical Center, the energy consumption of Emirates increased by 140% from 2003 to 2012 to meet the demand of the buildings (NBS, 2014). Moreover, the Emirates will need to increase their energy supply by 71% to match demand by 2019. That demand will be met if they generate annual energy growth of 5.4% every year (Jones, 2010).

A variety of countries worldwide have already registered to submit their projects using foreign green building standards, including the UAE, which has moved toward using foreign green building standards such as American LEED (Leadership in Energy and Environmental Design) and British BREEAM (Building Research Environmental Assessment Method). These standards were developed based on specific climatic conditions, which are not suitable over wide range of countries (Saunders, 2008).

1.3 Research Aim

The aim of this research is to provide a solution to reduce the impact of the existing buildings on the environment in a hot dry climate by emphasizing the importance of developing local green building standards for the region according to the climatic conditions to encourage energy efficient buildings.

1.4 Research Objectives

In order to study the problem highlighted in section 1.2, this study aims to achieve three objectives:

- a) To identify the relative strength of Estidama rating assessment tools in a hot dry climate;
- b) To assess a case study building in the UAE with Estidama PRS using the points that have more relative strength in a hot dry climate as identified in objective (a); and
- c) To propose and evaluate the retrofitting of the case study building into a more environmental friendly building using Estidama PRS.

1.5 Research Questions

- a) What are the main points of Estidama rating assessment tools that have more relative strength in a hot dry climate?
- b) How can we implement green building concepts on existing buildings in hot dry areas using the region's green building standard?
- c) What are the possible strategies to retrofit existing buildings into green buildings with minor changes?

1.6 Research Scope and Limitations

The study involves review assessment analysis and simulation assessment. The review is between LEED and Estidama in a hot dry climate to find out the elements of Estidama PRS that are more relevant to that climate. The review is based on information and guidance published by Abu Dhabi Urban Planning Council (AD-UBC) and the United States Green Building Council (USGBC) as well as recent articles and papers. This analysis review each system by giving a general overview of the current versions for existing buildings, and is more focused on the environmental assessment area.

The simulation assessment was done by applying IES-VE software (Integrated Environmental Solution – Virtual Environment) to an existing case study building in the UAE. The case study is part of the Sheikh Humid Al-Naimi building (Block J2) located in Ajman University of Science and Technology (AUST). The assessment will concentrate on the points that are more relevant to hot dry climates from the Estidama rating system, which was concluded from the review assessment. The points are Cool Building Strategy, Daylighting and Water Use Reduction. The simulation was run twice: once for the current situation of the case study building and then a second time for the proposed design of the case study building with minor changes in order to provide suggestions and recommendations. Previous studies have shown that the cost of a green building can be the same as that of a non-green building, since the green building considers life cycle costs, unlike conventional buildings (Bartlett and Howard, 2000; Kats *et al.*, 2003; Kats and Capital, 2003). Therefore, this study does not cover the financial consequences of retrofitting existing buildings into green buildings.

1.7 Significance of the Study

The study reviews, compares and analyses current green building standards practiced in the UAE, to find out how effective Estidama PRS is; not only in the emirate of Abu Dhabi but also in the other emirates in the UAE. The outcome of this study provides researchers and professionals interested in green building development with important information on the effectiveness of retrofitting buildings in hot dry climate, such as that of the UAE.

It helps to expose the climate factors in developing green building standards for the UAE. Moreover, it also encourages the use of the local standard of the emirate of Abu-Dhabi, which is Estidama, to the other emirates, instead of using the American LEED, which was not designed for hot dry climates.

1.8 Thesis Outline

The thesis is divided into five chapters with an introduction at the beginning of each chapter. The first chapter is the introduction to the research showing the problem background in the hot dry zone and especially in the UAE. It then goes on to explain the objectives and questions towards the problem statement, and finally shows the importance of this research. The second chapter provides a literature review which describes green building and its rating tools used to assess green buildings, and the effectiveness of these rating tools in different climates. This chapter is divided into three subsections: the first covers generally green building and the green building movement in addition to the importance of developing green building, the second describes the types of green building assessment tools with more focuses on previous studies that shows the relation between the environmental rating tools and the climate, and the third subsection reviews the green movement in the UAE and the buildings' requirement in the hot dry climate with an evaluation of LEED and Estidama rating tools, and it also covers the possible retrofitting strategies in the UAE that have been implemented by other researchers.

The methods used to review the two rating systems and select additional points to assess a case study building are explained in detail in Chapter Three. It also discusses the results of the review analysis between LEED and Estidama environmental assessment areas and the selection of the points that are relevant to the hot dry climates. The selection of the case study building and the data collection procedure are presented, in addition to the software selection and validation. The analysis process for assessing a case study building on the selected points is discussed in detail in this chapter.

Chapter Four presents the results, analysis and discussion. It covers the analysis of three selected points; heat gain, daylighting and water use, for the current situation and proposed design, starting with the category of cool building strategies, which focuses on the reduction of the annual external heat gain of the building. This is followed by the analysis of the daylighting effecting on three classrooms in the same building in different directions. Finally, it covers the calculation of the water consumption for the case study building, focusing on interior water use reduction.

The last chapter is Chapter Five, which represents the conclusion of the study and assesses whether or not the final findings have met the research objective. It also sets out recommendations and suggestions for retrofitting an existing building into a green building in a hot dry climate and suggests future work that could be done.

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