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The economic benefits of a green building – Evidence from Malaysia

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ABSTRACT

Due to significant environmental and economic benefits associated with reduced energy consumption in green buildings, energy efficiency is considered a key driver for the green building movement. However, factors related to the actual building performance and future energy prices highly impact the actual energy cost of a green building. This research evaluates the actual economic performance of a green building in use in term of energy consumption and examines how different scenarios for energy price inflation would affect the cost saving associated with reduced energy consumption in the building throughout its whole life cycle. Based on actual data record, it is found in the research that the investigated green building saves around 71.1% of energy compared to the industry baseline. From life cycle perspective, the green building saves around 5756 kW h/m^2 which corresponds to $2,796,451 at 1% average annual increase in energy price and it is more than fourfold at 5% average annual increase in energy price and reaches around $12,107,060. This research provides an empirical evidence for the economic benefits associated with reduced energy consumption in the green building.

1. Introduction

The population of the world is expected to increase from 7 billion to 9 billion by 2050 [1]. Undoubtedly, this growth in population is associated with higher demand for water, energy, and natural resources which in return will overburden the ecosystems and increasingly deteriorates the environment. Since more than two decades, an urgent call was raised by the General Assembly of the United Nations to formulate *a global agenda for change* to achieve several strategic goals related to long-term environmental issues. This call to change by the United Nations triggered the concept of sustainable development, or sustainability, on March 20, 1987, by Brundtland Commission in their report entitled *Our Common Future,* in which sustainable development was defined as meeting our needs considering the ability of future generations to meet their own needs [2]. This classical and common definition for sustainable development implies a rational use of natural resources, and technically, bridges development with the environment. Since then, sustainable development has gained significant global attention [3].

Among the other production and manufacturing sectors, the construction sector is placed at the forefront of the sectors that must embrace sustainability, and this was the main driver of sustainable construction and green buildings movement. There is almost a consensus in the literature that green buildings outperform conventional (non-green) buildings in several performance areas. Lower energy and water consumption, improved indoor air quality, enhanced health and productivity, increased property value, among others, are frequently cited benefits associated with green building [4–7].

However, despite the numerous benefits associated with green building, research indicates that building owners and real estate investors are still reluctant to adhere to green solutions [6,8,9]. Issues related to exaggerated higher construction cost, lack of building owners interest of future costs and benefits, lack of proper education about green building practices and benefits are frequently cited barriers for green building [1,4,6,10–12].

This research addresses the economic benefits associated with energy saving in green building by analyzing the actual energy performance of a green building in use. For an elapsed period of 7 years, the actual economic performance of a green building was analyzed and quantified, then based on the current building performance, the economic benefits associated with reduced energy consumption were analyzed and quantified along the whole life cycle of the building. An economic analysis was conducted to investigate how different scenarios for energy price inflation would affect the future cost saving associated with reduced energy consumption throughout the whole building life cycle.

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2. Background information

2.1. The Concept of a green building

Sustainable construction and green buildings are two interchangeable terms emerged from the concept of sustainable development [13]. Green building represents the response from the construction industry to sustainability requirements, and therefore, energy and water efficiency, reduced natural resource consumption, in addition to improved health and environment are key characteristics of a green building [5,14]. Although green building is being promoted as a high potential solution to reduce the negative environmental impacts of the construction industry, yet there is no operational and measurable definition for the term *green building.* Kibert [13] suggests that the term *green building* is used to label the building that is designed and built in accordance with the principles of sustainable construction. He suggests that the green building is: "a *healthy facilities designed and built in resource-efficient manner, using ecologically based principles*". Yudelson [5] defines the green building as: "a *high-performance property that considers and reduces its impact on the environment and human health*".

Since globally recognized performance targets for green building have not been agreed upon yet, several countries in the world have developed their own tools and systems to evaluate the performance of green buildings. According to these tools and systems, which are known as building environmental assessment methods (BEAM) [15,16], a building is rated *green* if it meets a set of performance targets specified by the adopted green rating system. The British Research Establishment Environmental Assessment Method (BREEAM) and the American Leadership in Energy and Environmental Buildings (LEED) can be cited as widely accepted and used green rating systems for green buildings [17,18].

The term *zero energy building* is being discussed in the literature [19–21]. The concept of zero energy building is that a building does not need to use fossil fuels, rather all the required energy is supplied from renewable energy sources such as solar energy, and this can be achieved in conjunction with various design strategies to reduce the energy demand in the building [13,14].

2.2. Benefits of a green building

The list of green building merits and benefits is extensive and varied and covers the three bottom-line of sustainability which are environmental, economical, and social aspects [22,23]. From building life cycle perspective, advocates of green buildings contend that a green building outperforms its conventional (non-green) counterpart; they identified numerous benefits associated with a green building. Kats et al. [4] argue that the financial benefits gained from reduced energy and water consumption, lower maintenance cost, in addition to improved health and productivity are 10 times higher than the additional construction cost required to meet green design criteria. Kats et al. [4] further argue that the average energy saving in green buildings is around 30%. Yudelson [5] says that green buildings use from 30% to 50% less energy and water than conventional (non-green) buildings. Based on Australian and international case studies and research, Madew [24] reports 60% decrease of energy and water consumption in green buildings which implies a significant reduction of building annual operating costs. He adds that green building has a higher market value reaches 10%, and a higher rental rate ranges from 5% to 10%. Torcellini et al. [19] found that six green buildings are using from 25% to 75% less energy than energy code-compliant buildings in the United States. Ries et al. [7] found that energy consumption decreased about 30% and productivity increased about 25% in a green manufacturing facility certified by Leadership in Energy and Environmental Buildings (LEED) green rating system.

3. Research methodology

This research investigates the actual and future energy cost performance of a green building in use. Therefore, the research can be classified as a case study research. Case study approach allows an in depth investigation of contemporary phenomena over which the researcher has little or no control [25,26]. The case study is located in Kuala Lumpur in Malaysia and it was selected because it is an information-rich case study. Methodologically, the current and future building performance was measured against the industry baseline as determined by the Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings (the Malaysian Standard MS1525:2007). As a reference guide, the International Standard ISO 15686-5:2008 [27] was used as a reference to identify the life cycle cost components and elements.

3.1. Case study description

Located in Kuala Lumpur, the case study which was investigated in the research is the Malaysia Energy Center currently known as GEO (Green Energy Office) Building. The building was commissioned in 2008 as the first officially certified green building by the Green Building Index (GBI) which is the first established and officially adopted green rating system in the Malaysian marketplace [28].

The GEO Building embraces eco-friendly features including thermal insulation, 100% daylight, energy efficient lighting system, storm water harvesting system, building energy management system (BEMS), and floor cooling system. The building is capable to generate 50% of its energy demand through an integrated photovoltaic (BIPV) system that generates around 120,000 kW h/year. The Photovoltaic (PV) panels are installed on the roof and in the external car park area to serve as a shading device for cars as illustrated in Fig. 1. The BIPV system is connected to the national grid to export surplus electricity [29].

According to the used green rating system, which is the Green Building Index (GBI), the building scored full points for energy efficiency and innovation criteria [28]. Fig. 1 is a general view for the case study.

3.2. Data collection

Longitudinal data for the past building performance were collected from the building owners. The data contain information about the actual energy consumption and cost, and cover the actual building performance since its commissioning in 2008 up to the end of 2014. The energy cost data were available in the local currency of Malaysia. The energy cost data were converted to the American dollar (US$) using the average exchange rate for the year 2015 which, according to the Central Bank of Malaysia [30], was equal 3.91 RM/US$. Table 1 shows the collected actual energy consumption and costs of the building.

4. Building energy and cost performance analysis

4.1. Current energy saving benefits

The actual energy performance of the building was measured against the industry baseline as determined by the Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings (the Malaysian Standard MS1525:2007). Despite that a standard building energy index (BEI) of 135 kW h/m^2/year was inferred from the national standard requirements for office buildings [31–33], it is claimed that the energy consumption of a typical office building in Malaysia ranges from 200 to 300 kW h/m^2/year [29,32,34].

However, there is not much empirical evidence supports these claims through a national energy audit. Saidur [35] conducted an energy audit for 68 office buildings and reported a building energy index (BEI) of 130 kW h/m^2/year for office buildings in Malaysia. Although