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Relationship between sustainable technology and building age: Evidence from Australia

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Abstract

The overall energy performance of existing buildings is an important consideration in decisions to demolish or refurbish. To refurbish means to use sustainable technologies (STs) to improve energy efficiency, health of occupants, energy cost and environmental sustainability. This paper examines the use of STs to streamline energy efficiency in existing buildings. It analyses various buildings of different ages retrofitted over the last 5 years and the various STs used to enhance energy efficiency through an in-built case study in a survey. The results show that buildings less than 15 years old have been improved with fewer façade technologies compared to those between 16-30 years old. Overall, buildings aged between 16-30 years are the most improved with STs followed by buildings less than 15 years old and those between 31-45 years, in that order. Buildings over 45 years are the least improved with STs for energy efficiency. They had received less than 10% of ST technology injection. The lighting systems, sensors, energy efficient equipment and passive strategies have been applied improve energy efficiency across all ages. However, solar technologies, HVAC systems, façade technologies and building management systems are the least adopted across all ages

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Keywords: Building age; sustainable technology; energy efficiency; energy consumption; refurbish

1. Introduction

It is estimated that new buildings add about 1% to 1.5% to the building stock each year. More specifically, the Office of Climate Change, UK reported in 2007 that new buildings add at most 1% a year to the existing stock, the other 99% of buildings are already built and produce 27% of all carbon emissions. The Australia percentage variations

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of building stock is similar to that of the UK. Indeed the Department of Climate Change and Energy Efficiency (DCCEE) in Australia has reported that the total area of existing buildings increased from 113 million m^2 in 1992 to 138.8 million m^2 in 2010. This figure is expected to increase to 165 million m^2 by 2020. The United Nations Environmental Program (UNEP) in 2008 stated that the building stock in the world consumes approximately 40%, 25% and 40% of the energy, water and land resources respectively, and is responsible for emitting one third of the total greenhouse gases (GHG) emissions. This is because many of the existing buildings are old with poor energy savings technologies. Interestingly most of these old buildings were constructed decades ago, where there was little innovation in the construction industry. Energy efficiency retrofit of existing buildings has the potential of reducing energy demand throughout the year [1, 2]. Sustainable Technologies (STs) installed in existing buildings through renovation and refurbishment are improving energy consumption. Buildings installed with sustainable technologies and other construction procedures improve the ecological, human health and environmental life cycle [3]. Sustainable construction technologies lead to the creation of an environmentally sound and resource efficient environment, high performance buildings and a reduction of GHG emissions [4, 5].

Many authors have studied energy performance of existing buildings improved with various sustainable technologies. Quite a number discuss energy use in existing buildings through the development of methods and strategies including roof top photovoltaic (PV) retrofitting for old structures in Egypt [6], energy retrofit techniques for various building ages in Tehran [7], and energy saving potential in retrofitting of non-residential buildings in Denmark for old buildings [8]. However, existing literature indicates that energy efficiency regulations apply mostly to new buildings, which add on the average a mere 1% to the built environment yearly [9]. Also the application of sustainable technologies for energy efficiency does not cover old apartment buildings that need to be refurbished [10, 11]. There is lack of detailed studies indicating relationships between sustainable technologies and building ages. What are the technologies for improving existing buildings built before and after 1980? Are all the technologies improving all the various building ages? These are questions which need to be answered in order to address the shortfalls in energy savings of existing buildings. The aim of this paper is to investigate the relationship between ST and building age. Further to identify which class of building age is improved with STs through refurbishment for energy efficiency.

2. Definition and types of sustainable technologies

A ST is any well designed technology capable of addressing high energy demands without posing negative effects to the environment. Any technology that exceeds the benchmark of conventional systems in reducing energy can be classified as a sustainable technology [12]. There are many types of these technologies. Thus, [13] provides a range of various sustainable technologies. They include solar thermal, low energy techniques for cooling, geothermal, wind energy, photovoltaic cells and bioenergy. For each technology [13] provides the types, functions, advantages and disadvantages and concluded with their efficiency potentials needed to reduce energy demand or consumption. However, [12] improved the various types of sustainable technologies for new and existing buildings provided by [13]. They include the underfloor air distribution system, radiant cooling, displacement ventilation, chilled beams, and displacement induction unit. Others are high performing envelope, solar energy, geothermal systems, and cogeneration. Quite recently [14] improved the studies on the HVAC systems conducted by [12] and provided detailed descriptions of the functions of each component required for energy efficiency. Although these studies were extensive, key technologies such as lighting and lighting control systems were not addressed by [12-14]. Lighting is an important electrical end use in every sector and building type across the world. These gaps relating to lighting and lighting control systems were filled by [15] and [16].

3. Sustainable technologies applied to improve buildings of varying ages

Energy consumption of some old buildings is expected to improve when upgraded with STs. Many studies have been undertaken on how to improve energy efficiency of old buildings with various technologies. The main aim of this section is to identify building ages as well as technologies applied to improve energy efficiency of existing buildings by focusing on studies undertaken internationally. These technologies vary from renewable to simple energy efficiency technologies. A study conducted in Tehran, [7] presented findings of schools built before and after 2000 using low quality construction materials. The schools had no exterior insulation but single glazing windows with metal