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Energy-Efficient House in the GCC Region

Chaham Alalouch*, Mohamed Salah-eldin Saleh, Saleh Al-Saadi

Department of Civil & Architectural Engineering, College of Engineering, Sultan Qaboos University, P.O.33, Al-Khod, Muscat 123, Oman

Abstract

The residential sector is a major contributor to energy consumption and carbon emissions. The concept of energy-efficient house appeared as a response to the need to reduce energy demand in this sector. Energy-efficient houses have been designed and constructed widely in cold regions, the concept is however still under experimentation in extreme hot and arid climates such as in the Gulf Cooperation Council (GCC) region where the priority is to reduce space cooling load. This paper examines the concept of energy-efficient house and its applicability to the GCC region by reviewing two case studies where energy-efficient houses were designed and constructed. The paper concludes with GCC-specific considerations regarding the design and construction of energy-efficient houses and recommendations for future research.

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Keywords: *Energy-efficient house; GCC countries; Energy consumption; Sustainability; Passive house.*

1. Introduction

Kyoto protocol triggered political and public concern regarding the effect of energy use on climate change and environmental degradation, resulting in a move at a global level toward a low-energy consumption culture. As a response to this, many countries have put in place energy reduction measures in several fields including industry, transport and building.

* Corresponding author. Tel.: +968-92085769.
E-mail address: c.alalouch@squ.edu.om / ch_alalouch@hotmail.com

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The building sector is a major energy consumer and contributor to the greenhouse gases emission and ozone layer depletion (United Nations Environment Programme, 2009). Pe´rez-Lombard, et al. (2008) found in their review of the World energy use that the building sector consumes between 20% and 40% of the total energy used and exceeding other major sectors such as transportation and industry. Another research suggested that the global average of energy used in building is about 36% (Elgendy, 2012). The building sector in the US for example consumes 40% of total energy produced (US Department of Energy, 2010). In Singapore, a hotter country, the figure is as high as 57% due to the continues need for space cooling (Dong, et al., 2005). These figures are expected to increase due to the rapid growth in the World's population which has been resting in an inflation in the building sector size.

Among all building types, the residential sector contributes to an average of 27% of the total energy used by the building sector (Elgendy, 2012). In Canada for example, the residential sector uses 16% of the total energy produced in the country accounting for 14% of the total greenhouse gas emissions (Natural Resources Canada, 2013). The figure for the US is 22% and for the UK is 28% of the total final energy use (Pe´rez-Lombard, et al., 2008). The high energy consumption in the residential sector creates an opportunity for energy saving if effective energy efficiency measures are put in place.

This opportunity was realized by the building sector community and supported by the maturation of the concern about the environment, the global interest in building performance in terms of energy use, and the unprecedented increase in oil prices. As a response, the concept of energy-efficient house has emerged based on inspiration from vernacular and traditional architectural practices and supported by modern technologies. Although principles of energy-efficient houses can be applied to any building type, most of the built energy-efficient buildings are residential (Mekjian, 2014). Since the concept appeared, many terms were used. For example, passive house, Near-zero energy house, high performance house and green house are all relevant terms. Arguably, the first passive house constructed in the modern era was in Germany, Darmstadt, in 1991 (Mekjian, 2014).

An energy-efficient house is simply a house that achieves high thermal comfort with excellent air quality at minimum energy consumption. It is the house that makes use of day light, natural ventilation, shading devices and strategies, appropriate orientation on the site, optimized geometrical properties, suitable surface-to-volume ratio, and have no or minimum thermal bridges with super thermal insulation ,double- or triple-glazed windows with inert gas between panes, and air-tightness to maintain comfortable temperature along the year with minimum energy consumption while utilizing solar power to produce its energy needs, as well as treatment and recycling of waste including gray water. The Passive House Institute (PSI) sets up the technical specification for energy-efficient houses as follows: space heating/cooling energy consumption of no more than 15 kWh/m2/year, airtight building shell ≤0.6 ACH @ 50 Pa pressure, and primary energy demand of no more than 120 kWh/m2/year (Mekjian, 2014). This could be achieved by using passive design strategies such as super thermal insulation and reduction of thermal bridges, Figure (1).