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ORIGINAL ARTICLE

Renewable energy technologies for sustainable development of energy efficient building

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Abstract The energy conservation through energy efficiency in the building has acquired prime importance all over the world. The four main aspects for energy efficiency in a building include first and foremost the nearly zero energy passive building design before actual construction, secondly the usage of low energy building materials during its construction, thirdly use of energy efficient equipments for low operational energy requirement and lastly integration of renewable energy technologies for various applications. These aspects have been discussed along with their economics and environmental impacts briefly in this paper.

The first aspect is related to the prior design before construction of a solar passive building techniques adapted all over the world not only for passive heating/cooling but also for daylighting the building. Second is utilizing the low embodied energy building materials for building construction. The third aspect deals with the operational energy conservation using energy efficient equipments in the building. Lastly, the building has to include utility of integrated renewable systems for hot water heating, solar photovoltaic electrification, etc.

1. Introduction

In the present day, the dwelling and habitat are invariably linked to making buildings as comfortable and convenient possible all over the world. The building sector is growing at a rapid pace by investing 30–40% of total global basic resources. The present day buildings have become the third largest consumer of fossil energy after industry and agriculture. The Asia-Link program is an initiative by the European Commission to promote and spread the knowledge on sustainable built environment with nearly zero energy approach. In this sustainable built environment program, there is promotion toward the integration of proven renewable energy technologies with the building for various applications such as water heating, heating/cooling and electricity production. The operational energy use in the building is of growing importance all over the world.

The building labels have been introduced in European countries, such as 'Passive House' in Germany and 'Minen-

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ergy' in Switzerland to certify standardized low energy buildings [1]. Sources place the amount of energy expended in the building sector in Europe to about 40–45% of total energy consumption [2]; about two-thirds of this amount is used in private buildings. Other sources claim, that in industrialized countries, energy usage in buildings is responsible for approximately 50% of carbon dioxide emissions [3,4].

Hence, sustainability assessment of buildings is becoming necessary for sustainable development especially in the building sector all over the world. The main goals of sustainable design were to reduce depletion of critical resources such as energy, water, and raw materials; prevent environmental degradation caused by facilities and infrastructure throughout their life cycle; and create built environments that are safe, productive and effective utility of the water and solar energy. The tool for building environmental assessment system (BEAS) has been proposed by Burdova and Vilcekova and carried out at Slovakia given in Table 1 [5] for all resource conservations.

Hence, there exists a tremendous potential to conserve energy in buildings. Energy conservation measures are developed for newly constructed buildings and for buildings under refurbishment. However, to achieve a significant reduction in energy consumption in the building apart from the standard energy-efficiency methods, proven renewable energy technologies should be implemented and integrated with the passive building [6]. In the European Union, from year 2020 all new buildings are going to implement all the aspects to achieve the nearly zero energy building for the operational energy conservation. The four main aspects for energy efficiency in a building are discussed in this paper for sustainable development in the building sector all over the world.

The first aspects are related to the utility of solar daylight, passive heating/cooling designs and provision for rain water harvestation to be integrated with passive building based on the prevailing climatic conditions of the site in the world. In the cold countries, the passive heating designs are integral part of passive buildings e.g. sunspace, Trombe wall, air handling unit with air-air heat exchangers and the air tightness with the required air change per hour. In the hot and dry climatic zones, passive cooling designs include the heavy design of wall and roof cooling using water evaporation, roof texture designs, the earth-water heat exchangers, passive downdraft space cooling, solar refrigeration, etc. Secondly, the aspect regarding usage of the low energy building materials (such as fly ash bricks; fiber reinforced bricks; wood and stabilized adobe blocks) is becoming popular especially in India, Middle East, Europe, USA and UK. The embodied energy of the building should be low so as to achieve building a low energy houses for sustainable habitat development. The third aspect deals with the operational energy conservation using energy efficient equipments such as LED lighting, five star rated fans, refrigeration and air-conditioning equipments in India. Lastly, the aspect of using integrated renewable systems such as solar water heater for the hot water utility, small wind turbine or solar photovoltaic electricity generation at the roof top of building are discussed in this paper with their economic analysis and environmental emissions.

2. Energy conservation in building

There are four broad ways to reduce the energy consumption of building which ultimately results in mitigating emissions of CO_2 emissions through energy conservation. These aspects are described as follows:

a. Comfort passive building design and its orientation for harnessing solar energy.
b. Low embodied energy materials for building construction.

Table 1 The building environmental assessment system (BEAS) at Slovakia [5].

A. Site Selection and project planning	A1. Site Selection	Use of land with high ecological sensitivity value; Land vulnerable to flooding; Land close to water endangered contamination; Distance to commercial and cultural facilities; Distance to public green space, etc.
	A2. Site Development	Development of density; Possibility of change of building purpose; Impact of the design on the existing streets scapes, etc.
B. Building Construction	B1. Materials	Use of materials that are locally available, Re-use and recycling, etc.
	B2. Life cycle analysis	Embodied energy of building materials; Global warming potential of material for construction, etc.
C. Indoor Environment		Thermal comfort; Humidity, Acoustic; Day lighting; Indoor air quality; Total volatile organic compound, PM 10, etc.
D. Energy Performance	D1. Operational Energy	Heating energy consumption; Energy consumption for domestic hot water; Energy for Air handling unit; Energy for cooling, energy for lighting, energy for appliances, etc.
	D2. Active systems using renewable energy sources	Solar water heaters; Heat pump; Photovoltaic technology; Heat recuperation, etc.
	D3. Energy Management	Operation and management; Control of lighting systems; occupant sensors and technical control of appliances, etc.
E. Water Management		Reduction and regulation of water flow; surface water run-off, drinking water supply; filtration 'gray water', etc.
F. Waste Management		Measures to minimize waste resulting from building operation; Measures to minimize emission from building construction, operation and demolition; Handling risk of hazardous waste resulting from facility operation, etc.

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