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Prospects of green roof technology for energy and thermal benefits in buildings: Case of Jordan

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ABSTRACT

Heat transfer has a substantial impact on thermal comfort for indoor architectural spaces, which is mainly dependent on building envelopes. Improving the quality of indoor spaces means applying a climate-conscious design that is very beneficial in decreasing energy consumption in buildings.

In this paper, a study based on thermal calculations and computer simulation is conducted to demonstrate the thermal benefits on energy saving as an approach to increase energy efficiency through green roof technology. The study focuses on roof surfaces as they account for a large portion of the insulation impact on built environments. A comparison between regular roof and green roof technologies was conducted to explore the effect of green roof materials on thermal transmittance and eventually on energy consumption of HVAC systems in buildings.

1. Introduction

Energy prices have gradually risen in recent years worldwide. As Jordan is mainly dependent on imported crude oil and natural gas, it should meet this challenge to keep up with the on-going energy demands (HDM & RSS, 2009).

Energy consumption integrated with thermal control in the environments of the households sector rapidly grows up in Jordan in recent years. This is attributed to climate changes resulted from the worldwide global warming, which makes thermal comfort in spaces more difficult to be achieved.

Built environment has great influence on the national economy, society, and other environmental consideration (Tatari & Kucukvar, 2011). The issues of energy and water conservation in Jordan have gained a public interest due to their direct impact on the budget of both the individuals and the government. Thus, there is an urgent need to minimize the energy consumption "energy cost" which exhausts the gross domestic product "GDP" as it accounts for 18% of the GDP. At the same time, the energy consumption bills receive around 20–40% governmental supports from the annual budget (Jordan GDP, 2012).

The case of the residential sector is presented here because it consumes high amount of electrical energy; it reaches a percentage of 41% from the energy consumption of all sectors, see Figs. 1 and 2 (JMEMR, 2011). The other energy resources in Jordan are consumed by the residential sector for HVAC systems and other household uses.

It was estimated by Jordan Ministry of Energy and Mineral Resources, JMEMR, that the consumption of electricity per capita reached a value 2000 kWh in 2010. The awareness of this problem has been enhanced due to its high impact on the residential energy bills as well as all energy resources as shown in Fig. 3 (Akash & Mohsen, 1999; JMEMR, 2011).

Generally, there are two types of residential buildings in Jordan; the first type is single-family house (Villas) and the other is apartment building. In this research the apartment buildings are studied as they are highly used in Amman according to the given data from the Department of Statistics in Jordan.

The main objectives of this paper are to examine the relation between the green roof technology and the associated energy saving for different combinations of roofs in residential building in Jordan.

2. Green roof, components and technology

Generally, the concept of green roofs uses a regular roof covered with vegetation to help absorb rainwater and to improve the thermal insulation. Basically, it provides a protection against

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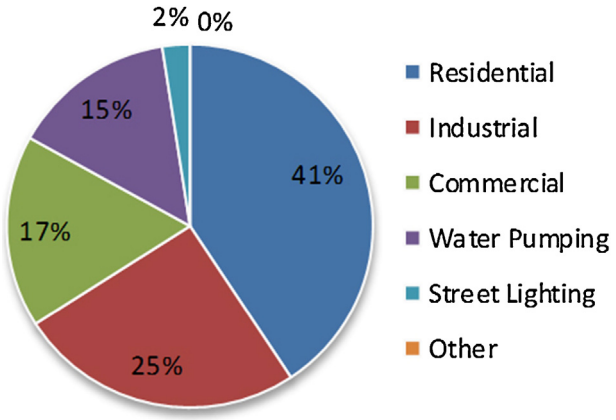

Fig. 1. Percentage rate of consumption of electrical power in Jordan.

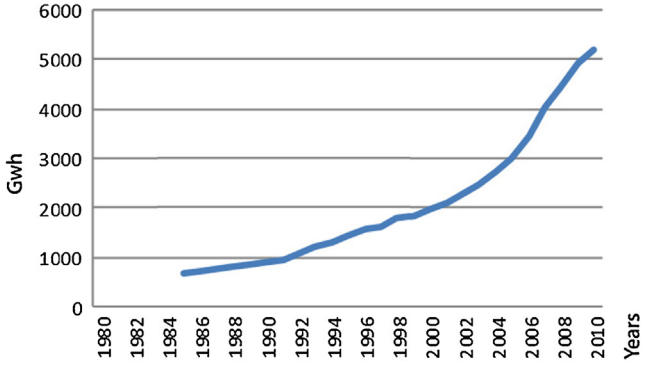

Fig. 2. Consumption of electricity in residential sector in Jordan.

climatic conditions and rainwater. This provides support to the environment during the constant increase in the alternative energy resources such as solar radiations and wind energy. It also reduces the dependency on the non-renewable energy resources such as oil and natural gas; this could be achieved using different technologies such as stormwater harvesting, gray water usage for landscape

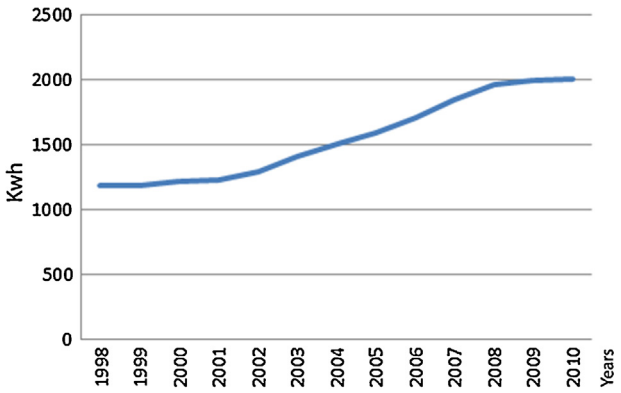

Fig. 3. Consumption of electricity per capita in Jordan.

irrigation, utilization of solar energy by using photovoltaic cells, solar water heating system, and soil media & planting on the roof (Van Woert et al., 2005).

A basic green roof design contains a waterproof membrane and growing medium, additional layers could be added to reach more intensive green roof as shown in Fig. 4. Green roofs are classified into two general categories: intensive and extensive. A green roof should be designed, installed, and calibrated to operate efficiently in moderating the indoor environments of buildings.

Compared to those of regular roofs, green roof applications have higher cost. Yet, the added benefit of the synergistically combined green roof to energy consumption and rainwater reuse covers major part of the high cost in the long run.

The green roof application refers to the concept of a roof of a building that is partially or completely covered with a planting media that increases the thermal benefits supported by a multi-layered of water proofing membrane, root barrier, and drainage layer. As roofs extend horizontally, they have positive contribution to the heat Loss/Gain. Therefore, the role of a green roof in controlling the amount of heat transfer in buildings becomes very important. This type of roofs leads to less energy consumption in buildings and moderates the temperatures of indoor environments. This assumption requires environmental evaluations of the

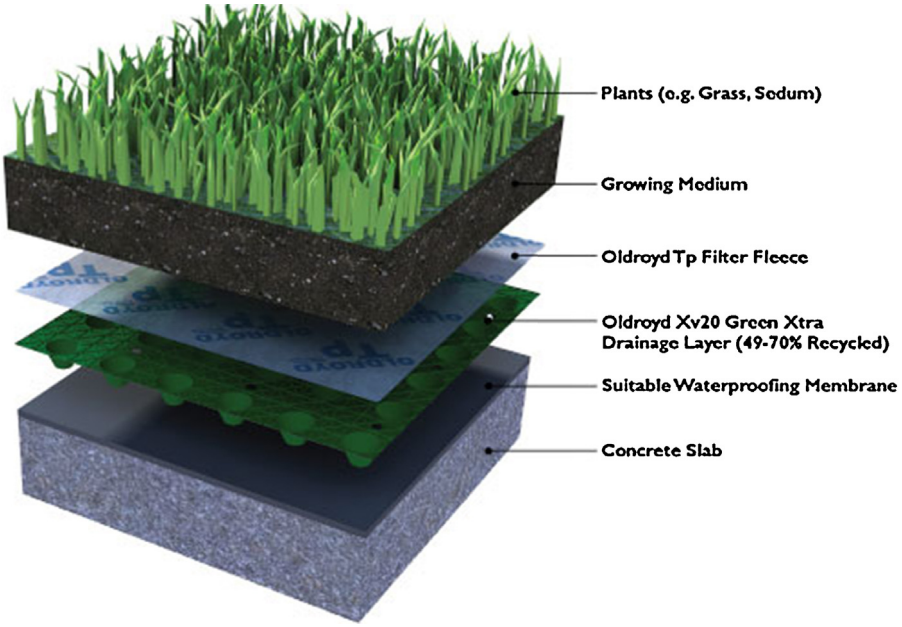

Fig. 4. Green roof layers.