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## A review of green roof research and development in China

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## ABSTRACT

Green roof is an effective energy efficiency measure to reduce the building cooling load in summer and heating load in winter, in addition, it can add ecological benefit and landscape value to the community. Therefore, it has attracted extensive attention worldwide. This paper studies the selection of planting materials, plant configuration patterns and plant growth medium of the green roofs in China, and presents the researches on ecological benefits, thermal performance, and applications of the green roofs in China. This paper also introduces and analyzes the green roofs development policies in China, including the incentive mechanism, laws and regulations, and finally presents the analysis and suggestions on their application prospects.

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## 1. Introduction

Although China is a developing country, the energy consumption in China already becomes number one in the world. At the same time, the average energy efficiency on the utilization of primary energy resources is only 30%. The building energy consumption in China accounts for 30% in 2009 and still keeps increasing. There is a need to increase the energy performance of the buildings thus to reduce the total energy consumption. Of the various thermal loads, one from the building roof accounts for about 20–40% in China, therefore, it is very important to improve the building roof thermal performance. Green roof is one of the measures that can help to improve the building energy performance and reduce the building energy consumption.

With the rapid urbanization spreading across China, more and more buildings are constructed, as a result, the building density keeps increasing and the usable area for urban greening is decreasing. Ideally, there needs to be a certain amount of greening area to ensure the quality of ecological environment in the city. However, because the urbanization process is speeding up and the population in cities is exploding, more and more ecological and environmental problems appear. It is of vital importance to improve the quality of ecological environment with limited usable space [1]. According to the investigation from the international organization on ecology and environment, the average per-capita greening area needs to be above 60 m<sup>2</sup> for a city to have an ideal environment. However, with large population and high building density in the big cities of China, it is very difficult to hit this target. Base on the studies from the statistical data of China City Statistical Yearbook published in recent years (Figs. 1 and 2), the average urban per-capita greening area in China has been increasing since 2000, however it is still well below the recommendation limit of 60 m<sup>2</sup>. Since the building roof is considered as the 5th cubic plane, roof greening has become a potential opportunity to increase the greening area and improve the quality of the ecological environment [2].

There exist many problems in the modern society, e.g., the natural resources are shrinking and biodiversity is diminishing due to the rapid growth in population and increase in per-capita living space, and energy and environmental crisis due to industrial and transportation development. All those problems can be partially

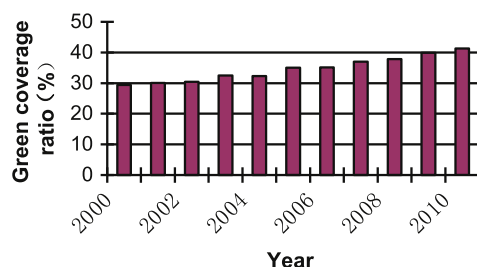


Fig. 1. Green area coverage ratio in the cities of China from 2000 to 2010 (China City Statistical Yearbook).

resolved by extensively implementing green roof technology. Therefore, green roof has become a must in modern urban planning.

A green roof is a building roof that is partially or completely covered with vegetation and a growing medium. The vegetation is planted over a waterproof membrane suited to load capacity of the roof, structural and ecological environmental conditions, to form a green landscape. Compared with planting ground, green roof is special in that it combines greening with the building itself. Therefore, it is a simple but effective way to restore the ecological balance that has been disturbed by urbanization.

Roof greening is an effective energy efficiency measure to reduce the building energy consumption in addition to adding its ecological and landscape value to the community. It has attracted extensive attention from environmental specialists.

Due to constrains from cost, technology and material, the research and application on green roof started relatively late in China, compared with that of the developed countries. However, the territory of China is large and there are different climate zones, furthermore, there are different regional environmental policies and the economic development levels for each region are quite different. Therefore, the green roof research and application in China has its own features. Therefore, it is necessary to have a survey to investigate on those features, as they can provide an insight for academic research and policy making. This paper firstly studies the planting materials, configuration patterns and growth medium for the green roof in China, and secondly introduces researches on ecological benefits, thermal performance, and applications of the green roof in China. Thirdly, it presents and analyzes China's green roof development policies, including the incentive mechanism, laws and regulations, and in the end it presents the analysis and suggestions on green roof application prospects.

## 2. Research on green roof in China

### 2.1. Plant material for green roof

#### 2.1.1. Principle on selections of plant material

Typically green roof is categorized by its planting patterns. Two of the main categories of green roof are vegetated roof and roof garden. Roof garden is rich in species, where small trees, bushes,

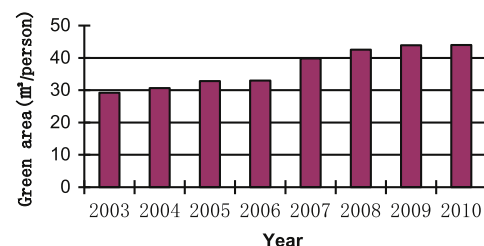


Fig. 2. The average urban per-capita greening area in China city average green area per capita 2003–2010 (China City Statistical Yearbook).

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