



# Investigating The Role of Green Roof in Reducing Energy Consumption of Educational Buildings (Case Study: Hagh Panah Primary School for Girls in Isfahan City)

Mohammad Niroumand<sup>1\*</sup>, Negar Faramarzi Fard<sup>2</sup>

1- Department of Architecture Engineering, Islamic Azad University, Borujerd, Iran

2- Department of Architecture Engineering, Islamic Azad University, Borujerd, Iran

\* Mohammad.n.architect@gmail.com

Received: 08 September 2020 Accepted: 18 January 2021

## Abstract

One of the concerns in the current world is the depletion of non-renewable energies reserves. In the urban space, the factor affecting such energies are educational buildings with high energy consumption. Green roof system is a suitable solution to improve energy consumption in these buildings. This research aims to optimize energy consumption in educational buildings and with descriptive-analytical research method, has addressed the issue of green roof system with Minimum load on the roof structure and its impact on energy consumption of these buildings. Also, a sample of primary school in Isfahan city with a simple roof was simulated in terms of energy consumption by Design builder software. After that, this primary school was simulated again with all main information about green roof system. Finally, the results show that green roof system with grass vegetation that has shallow depth of root and growing medium, has caused a minimum load on the roof structure and optimized energy consumption of cooling and heating systems of this educational building and reduced the total energy consumption of this building by 4.8% during one year.

**Keywords:** Green roof, Energy consumption simulation, Educational buildings, Design builder software

## 1. INTRODUCTION

Increased industrialization and urbanization in recent years have significantly affected the number of urban buildings that play a major role in energy consumption [1]. Schools as educational buildings have a percentage of energy consumption in urban buildings, so green roof can be used to improve energy consumption in these buildings. Green roofs have significant effects on the environment, including optimizing energy consumption, air conditioning, and reducing the impact of urban heat islands. Good thermal protection may greatly reduce the high thermal loads that the structure suffers from during the summer [2,3].

Green roof can also be effective in heat protection of the school building structure in summer, but the important issue is the positive impact of this architectural solution on the energy consumption of the building in all seasons. Green roof is divided into three main categories based on the type of vegetation, the depth of the growing medium and the method of applying it on the roof of buildings with intensive, extensive and modular systems. Intensive green roofs require a lot of maintenance and are designed to be similar to landscaping. They usually use a variety of plant species, which may include trees and shrubs, and thus require a deeper growing medium (usually more than 15.2 cm) than wide roofs. Because they are often areas such as publicly accessible parks, they are

generally limited to flat roofs. In contrast, extensive green roofs require little maintenance; They are usually inaccessible to the public and may not even be visible. Due to the shallow depth of the growing medium (less than 15.2 cm), plant species are restricted to grasses, grasses, mosses, and drought-resistant succulents such as sodum. In addition, extensive green roofs can be built on sloping surfaces [4,5]. Modular green roof is a system for covering the roof by plants, which includes modules such as trays, boxes and blocks. These provide the roof structure for the growing medium and the plants of this type of green roof and may be arranged in a grid-like manner [6,7]. Therefore, in this research, by simulating the green roof with the minimum load on the roof structure for Haghpanah girls' primary school in Isfahan, which has a normal roof, the amount of energy consumption reduction in this educational building has been investigated.

## 2. MATERIAL AND METHOD

In this article, based on the main nature of the research, which is a descriptive-analytical study, library research has been conducted on the subject of green roof with the least load on the roof structure and its role in optimizing energy consumption in educational buildings. Also, by simulating the green roof by Design Builder software for Haghpanah primary school for girls in Isfahan, the energy consumption of this educational building in normal roof

and green roof modes has been studied and the results have been expressed with a quantitative approach.

### 3. Results and Discussion

The green roof system applied to the roof of the studied educational building puts the least load on the roof structure because the grass has less root depth and growing medium than other vegetation. Growing medium has less weight and imposes a minimum final load of 50 kg / m<sup>2</sup> on the roof structure. Also, the results obtained from the software show that the simulated educational building in normal roof mode has a power consumption of 40659.93 kWh and gas of 33450.89 kWh, which after applying the green roof, the amount of electricity and gas consumption It has been reduced to 39.39100 and 314231.71 kWh and the main reason for this has been the reduction of energy consumption of cooling and heating systems by green roofs.

In the case of simple roof, the energy consumption of cooling systems was 16419.58 kWh and heating was 21313.39 kWh (Figure 1), which the green roof system has changed the energy consumption to 14860.02 and 19286.21 kWh (Figure 2).

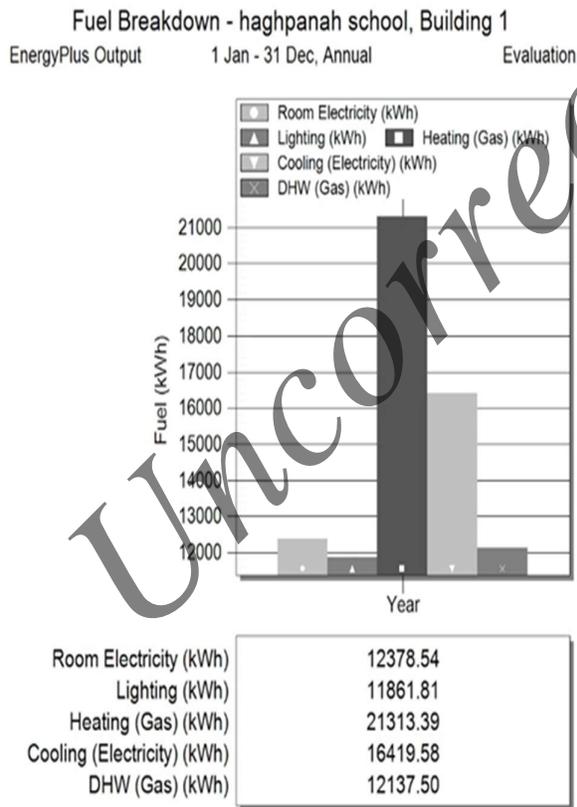


Figure 1. Energy consumption of heating and cooling systems in normal roof mode

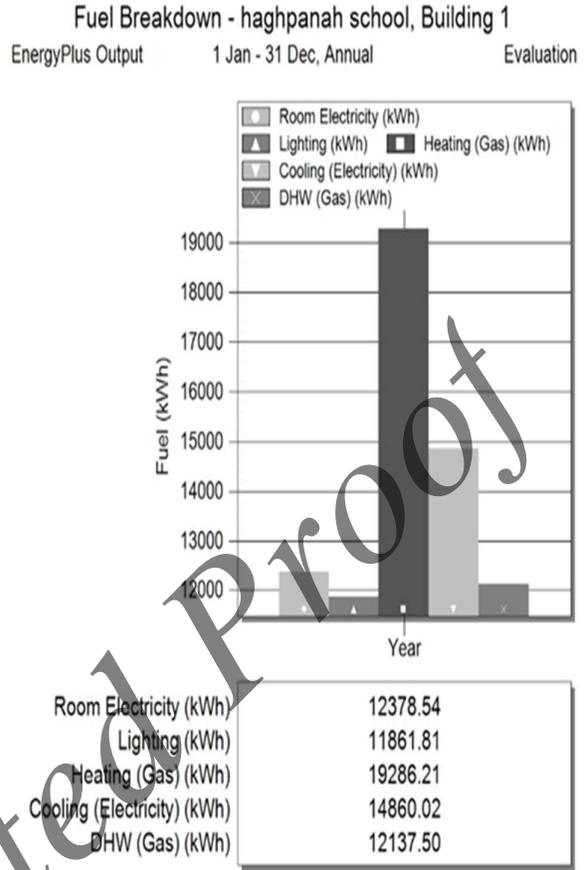


Figure 2. Energy consumption of cooling and heating systems in green roof mode

### 4. Conclusions

The studies conducted in this study show that The total energy consumption of the studied educational building, which includes electricity and gas, in the normal roof condition was 74110.82 kWh, which has been reduced to 70524.08 kWh after the application of the green roof system; Therefore, it can be concluded from this research that the green roof with the minimum load on the roof structure, which was caused by grass vegetation, has reduced the energy consumption of the studied educational building by 4.8% during a year and has improved energy consumption.

### 5. References

- [1] M. Santamouris, *Energy and Climate in the Urban Built Environment*, London: James& James, 2001.
- [2] A. Niachou, K. Papakonstantinou, M, Santamouris, A.Tsangrassoulis, G. Mihalakakou, Analysis of the Green Roof Thermal Properties and Investigation of Its Energy Performance, *Energy and Buildings*, Vol. 33, No. 7, pp. 719-729, 2001.

- [3] Y. He, H. Yu, P. Chen, M. Zhao, Thermal Performance Evaluation of a New Type of Green Roof System, *Energy Procedia*, Vol. 152, pp. 384-389, 2018.
- [4] K. Getter, B. Rowe, The Role of Extensive Green Roofs in Sustainable Development, *Hortscience*, Vol. 41, No. 5, pp. 1276-1285, 2006.
- [5] K. Yeung, W. Li, A Comprehensive Study of Green Roof Performance from Environmental Perspective, *Sustainable Built Environment*, Vol. 3, No. 1, pp. 127-134, 2014.
- [6] E. Korol, N. Shushunova, Benefits of A Modular Green Roof Technology, *World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium*, Prague, Czech Republic, 2016.
- [7] B. Dvorak, A. Volder, Rooftop Temperature Reduction from Unirrigated Modular Green Roofs in South Central Texas, *Urban Forestry & Urban Greening*, Vol. 12, No. 1, pp. 28-35, 2013.

Uncorrected Proof