SMART GREEN ROOF DESIGN IN RESIDENTIAL BUILDINGS APPROACH TO OPTIMIZING ENERGY CONSUMPTION

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Abstract- According to industrial developments and technology progress, human have been forced to use nonrenewable energies and fossil fuels to facilitate life and comfort. In the other hand, Excessive use of these sources has caused some problems such as environmental pollution, changes in the Earth's climate, as well as the natural state of the earth and forests; So that the trees and green spaces in the cities are replaced by buildings day by day that is made cities more polluted, because the sources of air purification are the trees and forests which human eliminate brutally them for their economic gain; Energy sources such as fossil fuels, which human beings are aware of the pollution created by these resources, are using very much while they are limited and we get closer to the end of them. On the other side, we cannot ignore the need for oxygen and the green space to meet the physical and mental needs and to survive. Thus, we are faced with two major issues: First, the green spaces that were destroyed in the cities must be restored to provide per capita requirement of each person to the green space and reducing environmental pollution by planting the trees and secondly, the amount of nonrenewable energy consumption decreases. Since residential buildings have the largest share in energy consumption and waste it, and the people spend most of their time in residential buildings, replacing green space in the roof of residential buildings as a roof garden or green roof with the aim of optimizing energy consumption can be one of the best possible solutions to the problems that have arisen; An important issue at this stage is making them smart toward the environmental factors that make the energy consumption more optimal.

Keywords- Roof Garden, Smart Building, Residential Building, Energy Efficiency Optimization.

I. INTRODUCTION

Green roof is a system that allows the plant to grow in the roof while protect the outer layer and the roofing shell, the vegetation in the green roof is accompanied with a root protector and often with a drainage layer below it and drought tolerant plant species grow well. (Dinsdale et al, 2006,12)
Green roof is not only a surface covered with green, but a living surface of vegetative plants in the soil layer above the roof.These ceilings prevent dust from spreading in the air and protect the building against ultraviolet rays, rain and wind pressure.Therefore, by using solutions such as roofs and green walls, we can succor worthy to more sustainability of contemporary architecture and urbanism and develop and growth in protecting the environment and continuing the human's life by designing in interaction with nature instead of in front of it. In this regard, paying attention to the use of recycled materials and indigenous plant species in terms of weight, cost, guarantees and motivation of the project, maintenance of roof, wall, etc., can help to create a suitable environmentally compatible composition. [1]

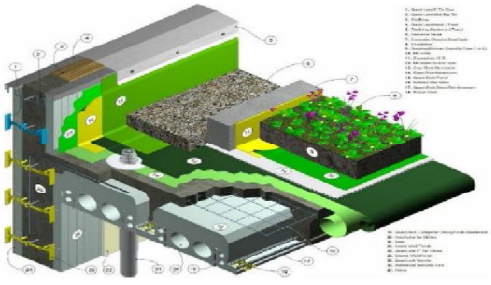


Figure 1: Executive Details of Green Roof [2]

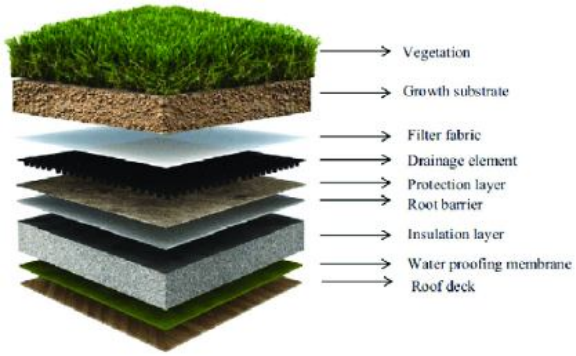


Figure 2:Schematics of different green roof components [3]

One of the most important contemporary issues in the world is the issue of energy. Energy efficient architecture and planning is going to a dominant paradigm for future architecture. [4]

The idea of green roofing is shaped by a smart diagram and based on the physical purification of water by green roof layers. The low consumption water circulation system and its lighting are powered by solar energy, and no water will be wasted with a special cycle of water rotation and as a result, the need for urban utilities such as water and light will be minimized. There are some sensors in this system to use urban light and water in a situation where the water cycle is reduced or it requires more light power than the stored value. This system has a different performance in four seasons. In the hot season, the needs for urban water will be eliminated with water storage. For water heating takes place in winter using sunlight which will prevent water from freezing during the day. The amount of electricity and water

requirements are calculated by determining the initial return on capital, the volume of resources, and solar cells. [5]

In recent years, the topic of smart buildings aim to energy optimization has attracted many designers and architects. As regards, concerning presence of Sustainable architectural parameters in this field have been some shortcomings, in this research, we have been trying to design a smart building roof approach to sustainable architecture to further achieve the goal of optimizing energy consumption and providing residents with comfort. Building's heat protection is one of the features of the green roof which can greatly reduce the heat load from above during the summer period. Green roofing is a viable ecological solution which not only helps reduce the heat load of the building's exterior but also helps to improve the quality of dense urban centers with a low natural environment. The foliage of plants protects the building against sun rays and controls the temperature and humidity inside the building. In the closed places that are planted on the roof of the plant, the air temperature below these plants is less than their high air temperature. The difference between planting roofs and ordinary roofs can be classified into two categories: quantitative and qualitative differences. The heat transfer process in the vegetation roofs is completely different. Plants absorb significant amounts of sun rays due to their biological function, such as photosynthesis, sweating, breathing and evaporation. The remainder of the solar radiation is converted to heat, and when it passes through the roof elements, it affects indoor air conditions. [6]

II. ADVANTAGES AND DISADVANTAGES OF GREEN ROOF

2.1. Advantages

- Reducing the effects of thermal islands in cities: Green roofs are very good by modifying the effects of thermal islands regarding the health of the environment and human health. In the summer, the cities are 7 degrees centigrade warmer than from their suburbs, and they are smoke-filled enclosures. General health and more energy demand is one of the problems that are known as the effects of thermal islands. Roofs covered with plants makes microclimates more suitable due to the production of moisture and the formation of cool air. (www.zinco.ca)

- Air purification: The green roof will clean the air by absorbing carbon dioxide and producing oxygen. Only 1.5 m 2 of green live grass provides annual needed oxygen for each person. A square meter (10.73 square feet) of grass green roof can remove 0.2 kg of suspended particles per year. (Luckett, 2009)

- Sewage protection: Sewage is a serious issue of water pollution. Green roofs receive 75 percent of the rainfall. Green roof reduce excessive load of sewage systems. In most of cities, the municipal sewage pipes are connected to the household sewage ducts and so the sewage load will increase which will increase the pressure on disinfection facilities. No repair of sewage ducts, the city waterways will be ineffective. (azarc.blogfa.com)

- Collecting of 30 to 100 percent annual rainfall done through drainage and flood reduction in urban environments which have hard and compact soils, accordingly need for sewage management methods will decline. (greenroof.ir)

- Reduce the building’s heating load (by adding the mass and the thermal insulation layer) and cooling load (through evaporative cooling). (zinco.ca-azarc.blogfa.com)

- Increasing the realm of life and provide a compatible and pleasant atmosphere for building's inhabitants: Green roofs can be used as a recreation and rest space.

- Reduce sound intensity: It reduces the building's sounds from 18 dB as much as 3 dB or more.

- Vegetable planting and flowers on the roofs and mental health: In some countries, food products such as vegetables and fruits is grown in roofs of homes; It has two benefits, First, the food needed is produced by the people themselves and secondly, housewives, elderly and children are busy with agriculture at their home that will have a psychological effects.

- Reduce visual contamination: Visual contamination caused by hard and rough texture building's structures is reduced and improving the scenery around the building will provide a peace of mind for residents and viewers by providing a beautiful green space and creating a landscape with soft texture and color variations of plants. (Luckett, 2009)

- Increase in property value: Unused areas such as building roofs become usable and useful places by creating a green roof. The high price of land can be a factor in preventing the expansion and creation of green space on the earth's surface and the increase in property value is one of the results of using and exploiting the roof space of the building. (Jouzi, 2010)

- Increase life span of roof membrane: Green roof protects the building's roof in front of harmful UV rays and weather damage up to two or three times. (www.zinco.ca)

- Attention to biodiversity and repairing the natural cycle of life: Attention to biodiversity in cities is one of the important issues of urban environment. The lands that are currently located in the cities have already been the habitat of living creatures; In fact, we have been living in animals’ territory such as worms, birds, mammals, and other living creatures and have eliminated these creatures from the natural environment. Each of these creatures has an effective

role in the biological cycles and we can provide a favorable conditions for the return of living beings by creating these green spaces. Of course, , we cannot expect large changes with the construction of small non-same level green spaces in the biodiversity of the city thus these changes will require an inclusive application of non-same level green space. (Luckett, 2009)

- Since green roof has the potential to provide living accommodation, In the arid cities, the effects of the population of consumers decreases with biotic roofing installation with the help of large industrial complexes.

- Material recycling: most green roofing companies use at least a few recycled materials to produce their own products, for example, as suitable drainage materials in green roofs such as brick rubble, volcanic lava and synthetic material (LAVA & LECA). (www.zinco.ca) Volcanic lavas have a natural origin, but Leca and bricks are artificial .As a result, the stations used for storing and landfill will be preserved, and recycling will bring many economic benefits.

2.2. Disadvantages

- Need to strengthen existing roof structures to deploy green roof and the fact is that most roofs are not designed for human presence.

- In some cases, design adaptation of these roofs to the area climatic conditions is difficult

- Green roofs require acceptable structural criteria. Many of the existing roofs are not suitable because of the load weight of soil and vegetation requirements for green roofing. (www.archnoise.com - www.sefidbam.ir)

* Disadvantages that occur over time include: subsidence, deposition of fine particles and soft soil, drainage problem, hardening of surface layer of the soil, formation of pond, root penetration and thick and heavy ceiling. (Dabbaghian, Hooshmand, 2009)

III. IMPORTANCE AND NECESSITY OF RESEARCH

The development of industry and technology has led to the untapped use of fossil fuels, the increase in population around the world has also increased the role of energy sources in human life. (Taylor *et al.*, 2014) But because of the severe crisis in the reduction of fossil fuel resources and environmental degradation and environmental pollution caused by fossil fuels, reducing energy consumption and its optimizing is an essential issue. Another reason to increase the inclination to use renewable energy is the adverse effect of carbon emissions caused by fossil fuels which has led to global warming and climate changes. [7]

The use of renewable energy is a very serious and controversial issue, not only in countries that are concerned with energy resources, but also all around the world and a general move of renewable energy use has been launched in many parts of the world, leading to increased sustainability in resources. [8]

According to the statistics, the most energy consumed in the countries is allocated to the building sector consequently, the introduction and use of energy efficient buildings can reduce global energy consumption. Green roofs have also been planted in the world's advanced cities due to improved social, economic and environmental conditions. In buildings, the heat dissipation is often high through the roof, so the energy consumption of the units in the last floor increases, therefore, the green roof is considered to be a solution to this problem. Green roof acts as a thermal insulation by increasing roofing layers and controls the exchange of heat between inside and outside the building; that's why it's essential to use it.

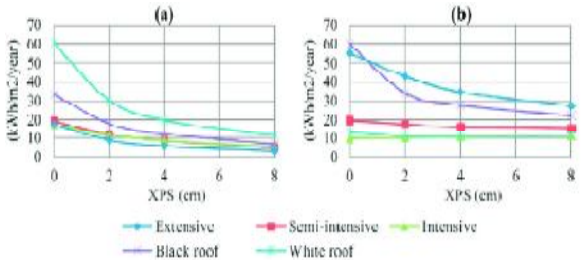


Figure 3:Heating (a) and cooling (b) energy demands [9]

IV. REDUCING HEAT TRANSFER BY BUILDING'S ENERGY STORAGE

Green roofs reduce energy consumption for heating and cooling. From the total solar radiation that received by green roofs, 27% is reflected, 60% is absorbed by the plant and 13% penetrates into the soil. (RyersonUniversity, 2005, p.8)

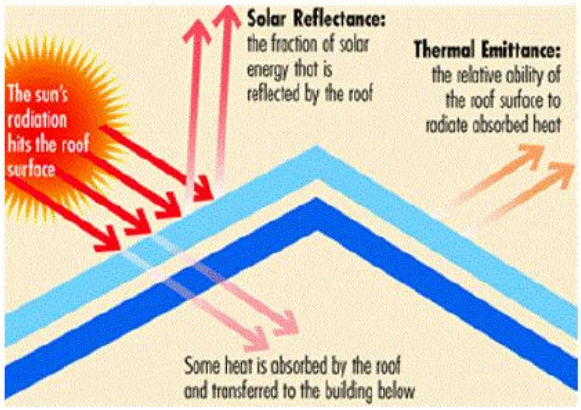


Figure 4: Roof surface behavior in front of the solar energy [10]

Studies at the National Research Institute of Canada have shown that green roofs can reduce heat flux on roofs 70% to 90% in the summer and 10% to 30% in the winter and reduce building energy consumption up to about 75%. (Liu & Bass, 2005)

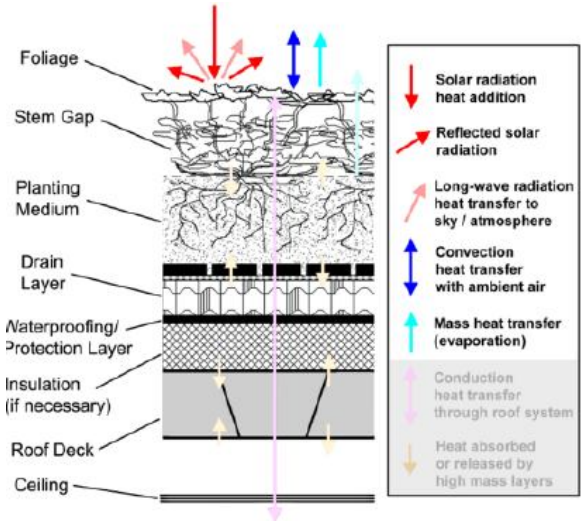


Figure 5: Vegetated roof heat flow [10]

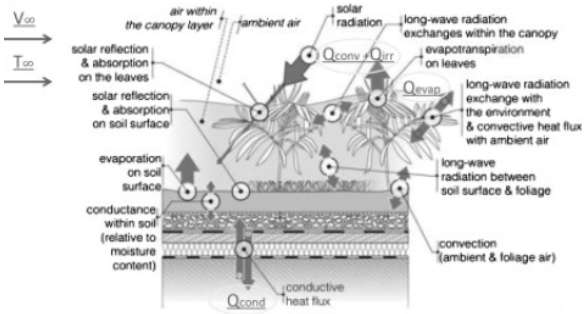


Figure 6: Effects of the presence of green roof elements in relation with energy [11]

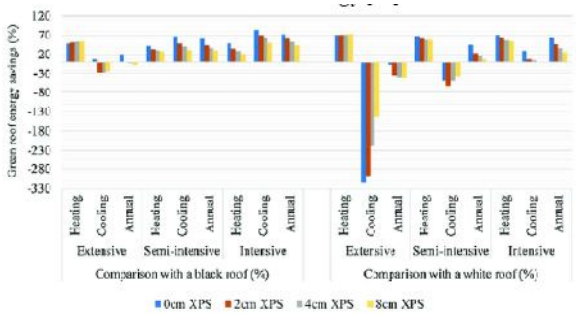


Figure 7: Green roofs energy saving when compared to black and white roof solutions [12]

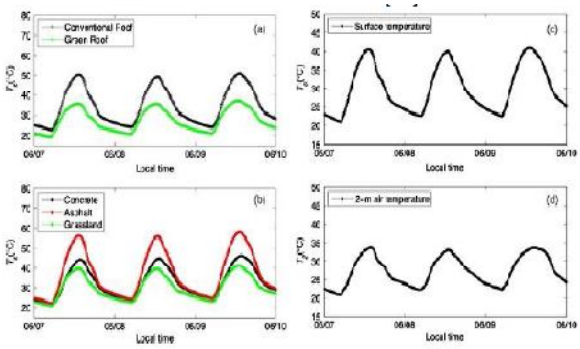


Figure 8: (Left panel) Surface temperatures of different subfacets in the PUCM from a simulation with 0% green roofs and 0% cool roofs. (Right panel) The surface (top) and 2 m air (bottom) temperatures calculated from equations (3) and (5), respectively. All results are averaged over all urban grid cells in domain 3. [13]

V. SOCIAL INTRACTIONS

Green space inspires a sense of social place and allows a person to learn from others; it also provides an opportunity to show their personal and social values and promote their spiritual growth. In general, green space allows its users to feel freedom and independence while it is not possible in the home and the work environment. Green spaces bring the natural environment into the artificial environment and alter the rough spaces of the cities to a relaxing and refreshing place and with eye-catching colors and clean air, prepare the human spirit to cope with the difficulties of urban living. Green spaces establish a solid relationship between members of the community and the natural environment; this makes the city more habitable and more tolerant. This is fundamental to the community that wants to be sustainable.

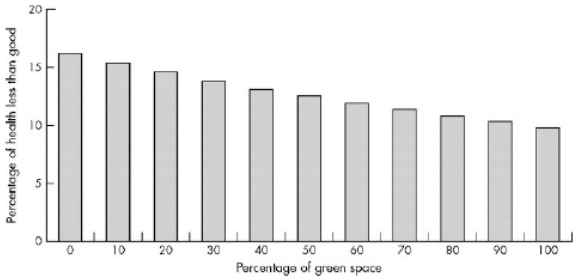


Figure 9: Relation between amount of green space (in a 3 km radius) and self-perceived health [14]

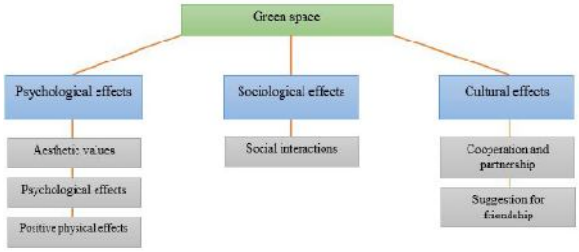


Figure 10:Effects of green space on people's satisfaction [source: Authors]

VI. ENVIRONMENTAL DIMENTIONS OF RESIDENTIAL BUILDINGS

Residential spaces that most of the people's time spend in this space and interior and exterior architecture has a lifetime as much as human lifetime. The home and the neighborhood have the origin of the universe for mankind. According to the law of phenomena's influencing from each other, it can be claimed that the health of residents and the quality of spaces between residential buildings are interrelated. Physical or visual access to open spaces and nature is a criterion for the quality of buildings and housing. If the architectural design provides access to natural light and natural ventilation and exposed natural and green perspectives, it will be effective in providing human's health. The bonding of natural elements such as water and vegetation with the building and

the environment has positive psychological effects on the inhabitants. The presence of trees in the adjoining spaces of residential complexes helps to increase friendly and neighborhood relations. [15]

Interactive perspectives in psychology believe that humans communicate, manipulate and affect with the environment. On the other hand, human's need to home is far beyond the basic need to shelter. By emphasizing economic and demographic considerations and ignoring other human needs, the living environment cannot reach to suitable quality and inhabitants of residential areas lose their Identity by reducing sense of belonging to the living environment. In addition, due to problems in mega cities, there is no escape from prefabrication; accordingly, it is necessary to attention to the human aspects of the design of such collections. [16]
Therefore, consider the per capita amount of green space needed in buildings and interactive spaces, which green roof can be the best answer to this question is an essential for designers and architects.

VII. CASE STUDIES

In Table 1, four examples of the most successful Green Roofing projects have been carried out to better achieve this research.

Projects	Projects	Features
Century-old city hall, Chicago-2001 [17]		Planting and breeding different native and non-indigenous species of plants, which in different seasons create different colors for spatial diversity
Life expression chiropractic center, Sugar Loaf- 2001 [18]		A Green Roof with Public Access. Adjustment of the internal temperature of the building and the conduct of rainwater, which is consequently a great example of optimizing energy consumption and economic savings.
Campus of the Delft University, Netherland-1998 [19]		Improve the air condition Reduced rain waste Reduced noise pollution Create a climate for people to socialize and have Recreation
Campus of Singapore University, [20]		Green roofs have created an interactive open space that makes the air purify and makes the roof insulated. Optimal use of rain water Planting native and non-native plant varieties

Table 1: Sample projects in the world with green roof design [source: Authors]

CONCLUSIONS

Industrial changes and technological advancement despite the potentials that have made people easier to live, lead to environmental pollution and excessive use of fossil fuels which are not renewable resources. Given that these resources are coming to an end and human needs are still the main goals of designers and architects, optimizing energy use and using renewable energies is one of the key points in pursuing sustainable architecture goals. For this purpose, the design of smart roof gardens in residential buildings should be considered by designers to compensate for the per capita demand for green space that was lost due to neglect in metropolises and creating interactive space for residents of the building. Green roofs are smart toward environmental factors and can provide different spaces for people In terms of shading, providing proper lighting, providing insulation for the roof of the top floor, providing adequate moisture in winter, receiving, collecting and useful conducting rainwater and breeding various plants in various seasons. It ultimately reduces the use of non-renewable energies and with intelligence and the use of clean energy, comfort will bring residents in all aspects of physical and mental health.

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