

## **Necessity and Methods of Designing Green Buildings in Cities and its Effect on Energy Efficiency**

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### **Abstract**

Population growth, increasing development of cities and subsequent destruction of green spaces and finally an increase in air pollution and global warming, have increased the need to find ways to coexist with the natural conditions, conserving energy, preventing land pollution, protecting the environment and reducing energy consumption. In order to increase green space in urban areas and greater energy efficiency in buildings, especially in cities, attitudes and new approaches of modern architecture are one of the strategies toward green architecture which has attracted the attention of many contemporary designers and architects in the world in recent years. This architecture is derived from the concept of sustainable development in harmony with environmental compatibility in order to meet the needs of people, step for the survival of human interaction and environment. To create green buildings, after examining the need to use them, first, we must be familiar with the principles of green architecture and then proceed to the design and construction. This paper attempts to investigate different parts of a building (green views, indoor and outdoor living walls, green walls and green roofs area), due to the possibility of planting and principles of construction. Then by examining samples of green buildings in the world today and expressing characteristics and their impact on the environment, some steps should be taken towards creating healthy cities and reducing energy consumption.

**Keywords:** Sustainable development, green building, energy efficiency

### **Introduction**

Some issues such as the indiscriminate use of fossil energy and the explosive growth of greenhouse gases in the atmosphere have caused intensified atmosphere activities against increasing destruction of the environment and global warming (Shaghayeghi and Mofidi, 2008). On the other hand, increasing population of the world and, as a result of indiscriminate construction has faced cities with serious problems such as air pollution and the urban poor appearance. Today, the concept of a city without green space is not imaginable in its various forms. Paying attention to the green space, as the breathing lungs of the city, is very important, because the uncontrolled urban development has led to the destruction of nature (Majnoonian, 1995). Nature and green spaces that served many years as the heart of the human habitat because of being ignored by its inhabitants are going to decline and destruct. Due to the crisis, the need to consider new strategies to combat the problems is obvious. With the release of the Brundtland report in 1987 entitled "Our Common Future" and "Earth summit conference" and the United Nations in 1991 and Rio Conference in 1992, the issue of sustainable development was presented throughout the world (Bahreini, 2008) Regarding the issue of sustainability and sustainable planning and design facilities in the theoretical area, a lot of lessons and ideas are provided by the scientific community, institutions and organizations, including the idea of a compact city, smart city, green city, a new tradition city, echo city and so on (Pour Mohammad Reza, 2007) In the meantime, the idea of a green city with green buildings in cities is possible and this article will study on this subject. Today, one of the architects

responsible is to emphasize on important role of design in order to maintain the urban environment with green space and maximum use of clean energy sources.

### **Method**

Despite the fact that in the philosophical and theoretical framework, some issues such as sustainability, energy efficiency and sustainable buildings are focused a lot but to the way of achieving and strategies for sustainability improvement in buildings is less studied. In this study, after the theoretical debates, different methods of green buildings in the cities are stated and then by investigating specific characteristics of some examples of sustainable green buildings, sustainable improvement and realization strategies in city are offered. The methodology of the research is descriptive-analytic.

### **Need to create green buildings in cities**

Cities and citizens can be the main causes of global warming, since a large number of world population are living in cities in which consumers are a large share of natural resources (Shojae, 2012). Studies show that more than 75% of the world's energy consumed in cities and 80% of global greenhouse gas emissions spread in the metropolitan area. Given the key role of cities in the production of pollutants, one of the ways to deal with environmental crises is to achieve sustainability in cities. Some experts, by general understanding of the word and the definition of sustainability argue that cities cannot be sustainable, and some say this is only an imaginary idea. other groups also believe that cities should be sustainable (Tabibian, 2008) Sustainable city is a city that is not only has the least adverse impact on the environment, but also is effective in restoration and improvement of its quality (Bani Massoud, 2009) In general, two types of urban sustainability arise: first, urban sustainability after the environmental disaster with the aim of empowering communities to climate change so that these conditions have minimal impact on the inhabitants of Earth. Acropolis would be an example of sustainable city that is a city floating on the water with salty sea water treatment facilities and planting crops, and designed to accommodate residents of coastal areas after the area is under the sea and buried. Second, urban sustainability is used to maintain the current situation and reduce the destruction or decrease greenhouse gas emissions (Shojae , 2012). This is the goal that can be approached by creating green buildings in the city . Design buildings in cities and their relationship with nature in every corner of the world can cause to destroy or improve the environmental situation on earth. For this reason, building design having optimized energy use and conservation of environment features, are among the most important architects tasks (Bani Massoud, 2009). Due to the pollution caused by dust and dust that enter the country's southwest, as well as pollution from fossil fuels that endanger human health and due to the numerous benefits of green buildings in energy efficiency, the need for such buildings in Iran is essential (Mahmoudi, Pakari, & Bahrami (2012). Sustainable development, the principles of green architecture and green building effects on energy efficiency and theory of urban sustainable development are the result of environmental issues of fans discussions. The overall objectives of sustainable architecture are utilization of energy resources and prevent air pollution (Ziyari, 2001) The stability approach considers three economic, social and environmental issue. Several strategies have been proposed to achieve sustainable development. Green architecture is one of the trends and new approaches to architecture and sustainable development in recent years that have attracted the attention of many contemporary designers and architects in the world. This architecture is derived from the concept of sustainable development is in consistency with the environment. Six general principles constitute green architecture. The first principle is energy conservation, in fact each building must be constructed in such a way to minimize the use of fossil fuels and best use the renewable energy. The second principle is to work with the climate, the buildings should be

designed in harmony with the climate, the shape and placement of buildings can enhance the comfort level. The third principle is to reduce the use of resources, each building should be designed to minimize the use of resources and finally their useful life should be a resource for other structures. The fourth principle is to respect the users, the aim is to meet users' needs and increase their satisfaction. The fifth principle is respect for the site, this principle study proper interaction between the project site and architecture. The sixth principle is holism, in which green building is more than a single building and should consider its neighborhood and show a stable form of the urban environment. In general, we can say that green building is a construction, compatible with environment and energy conservation in the lifetime of building and cover a wide range of environmental, economic and social benefits.

**Table 1. Benefits of sustainable development and green buildings of the environmental, economic, social perspective**

Dimensions of sustainable development		
Social dimension	Economical dimension	Environmental dimension
Creating vitality of citizens -Upgrading Physical and mental health of citizens - Beautify the environment	Increased level of green space - The protection of the building structure With the creation of thermal insulation would save energy and reduce costs and energy consumption Creating new job opportunities	Reducing energy consumption Reducing noise pollution Reducing the temperature of the surrounding environment Decreasing air pollution Reducing greenhouse gases

Green buildings despite functions such as beautifying the environment, removing urban pollution and reducing mental stress, are very effective in optimizing energy consumption. This technology has many benefits including reducing noise, reducing the heat island effect, cooling the environment, reducing pollution and air purification, reducing carbon dioxide and reducing the burden of heating and cooling buildings, is an effort to sustain the cities that in following each items listed are studied. 1-soundproofed: the inconvenience caused by noise in the street, is a major problem in urban areas. Insulation of facades covered with plants significantly help in the audio load balancing, the reduction in sound pressure level from outside to inside the building. 2. Reducing heat island effect: large cities because of extensive hard and impervious surfaces and lack of vegetation absorb the sun's radiant heat rapidly and act as a source of thermal energy emitter. This case is so-called heat island phenomenon (Urban Heat Island). The air handling units and cooling increases, which in turn increases energy consumption and greenhouse gas emissions that is the most important thing in ozone destruction are intensified. Research results have shown a significant temperature difference between the areas without vegetation and with areas of vegetation. 3-cooling environment: cooling the environment and the protection of buildings against heat is the other benefits of green buildings in the cities, because the herb, protect the building against sun rays and control temperature and humidity inside the building. . 4-the reduction of air pollution: plants absorb air pollutants through their stomata; in addition they reduce air pollution indirectly through coolant secretions. 5-reduction of carbon dioxide: Burning fossil fuels releases carbon dioxide as a byproduct of combustion. Because of the carbon dioxide gas, the gas that prevents the transfer of thermal energy near ground level to a higher level increases the greenhouse effect and ambient temperature as a confounding factor. Carbon is the main component of plants and decomposes in the soil naturally in plant tissues through photosynthesis. 6. Reducing heat transfer through energy saving of building: Green buildings protect exposure to sunlight. Green buildings by reducing thermal fluctuations on the outer surface of the roof and by increasing the heat

capacity of the cooling layer of roof will help to cool space under the roof in the summer and stay warm in the winter. Cases which reduce heat transfer in the green buildings include increasing the heat capacity of the roof, water retention, and reducing the absorption of the sun. This means there is less energy loss in winter and in summer there is less heat transition from outside to inside (Mahmoudi, Pakari, & Bahrami (2012)

**Table 2. Environmental performance green buildings and its impact on energy efficiency**

Benefits of creating Green Buildings	The operation	Impact on energy consumption
Soundproof	- Green roof with 20 cm thick layer of soil, reduces noise up to 46 dB.	-Acoustic load balancing - Reducing the level of noise from outside buildings
Reducing heat island effects	- Disposal of harmful rays and heat of solar radiation - Absorbing its heat and cold by evaporating	Reducing the use of air conditioning and cooling devices
Cooling environment	- Controlling inside temperature and humidity - buildings protection against the sun's rays	Reducing the need for cooling buildings in summer
Reducing air pollution	- Absorbing air pollutants through the pores of plants - Reducing air pollution through leakage of cooling	Reducing air pollution and the need for air conditioners
Reducing carbon dioxide	Carbon Decomposes through photosynthesis. plants	Reducing the greenhouse effect
Reducing heat transfer through energy saving of building	- Reducing thermal fluctuations on the outer surfaces and increase the heat capacity of the building layer - Retaining moisture and reduce the absorption of the sun	Cooling the Space under the roof in summer and stay warm in winter

### **Designing methods and the creation of green buildings in cities**

In general, to create green buildings in the city, green surfaces should be used including green vertical and horizontal surfaces. Green vertical surfaces or green wall including green facades, indoor and outdoor living and green walls and green horizontal surface including roof gardens or green roofs .

#### ***Vertical green surfaces or green wall***

Green wall is a new technology that is now finding itself slowly in contemporary cities of the world. Green wall is an independent or part of a building structure, covered with vegetation. Types of Green walls from the perspective of implementation, including green facades (Green Facades) and indoor and outdoor living walls (Living Walls) and the green walls and green walls are classified into two types of the air purification: active and passive.

#### ***Green facades***

Green facades, a green wall in which plants can be planted in the ground or in pots brought in height. In traditional green facades or direct climbing, plants are connected directly and without retaining to the wall and go up. Two shells green facades are indirectly attached to the wall by means of a support structures. Scaffold structure of this type can be made of different sorts, such as wood, metal or mesh network (Wirth, 2007).



**Figure 1: Left: the direct system, plants are attached directly to the wall, left indirect systems, connecting green facade by support structures**

Green features could be designed and implemented by three Modular Trellis Panel system (Modular Trellis Panel system)), cable (Cable System) and Wire-Rope Net System (Wire-Rope Net System). Network Systems Modular panels, is lightweight and made of galvanized steel grid and is designed in such a way that holds the distance from the wall surface with green façade. Mesh panels, are assembled together as Modular and can cover a large surface, the panels can also be curved (Wirth, 2007)



**Figure 2. Network modular panel system in the green facade ([www.greenscreen.com](http://www.greenscreen.com))**

A cable system is used for the maintenance of plants and fast-growing trends of embellished. The system consists of a ball, often made of stainless steel and is capable of passing cables and traction through each other to the formation of the network. Balls With the help of screw by passing through its center are installed on walls. Placement and the distance between the ball and the wall is selected in accordance with a specific plan. Net system, is often for the maintenance of plants that grow slowly and need more support. Mesh network system is more Flexible than cable systems and has more varied design capability.



**Figure 3. Right cable systems left: mesh network systems**

### Interior and exterior living wall

Living walls are a combination of panels with vegetation and those are mounted vertically by a structural lightweight system, narrowly to the building facades and are self supporting. Living wall can be used in interior and exterior of building. The walls depending on the type of pages, type of exterior and interior, have different implementation details. Living wall compared to green facade, is a more costly system and needs more maintenance in terms of irrigation and supply of additives for plants. Living walls include modular systems and industrial felt. The modular system is a chamber filled with growing medium attached to the wall that different types of it are box and the envelope system. Box systems, are modules that are placed as place of plant growth in metal support frame and has the ability to separate from the wall or replaced to change the model. Each module contains a bag of soil in which the lightweight plants have already been planted in the greenhouse and irrigation system is drip. Envelope systems including gardening container, having a moisture barrier is flexible.



**Figure 4. Modular system of living wall top system box below: Envelope systems**

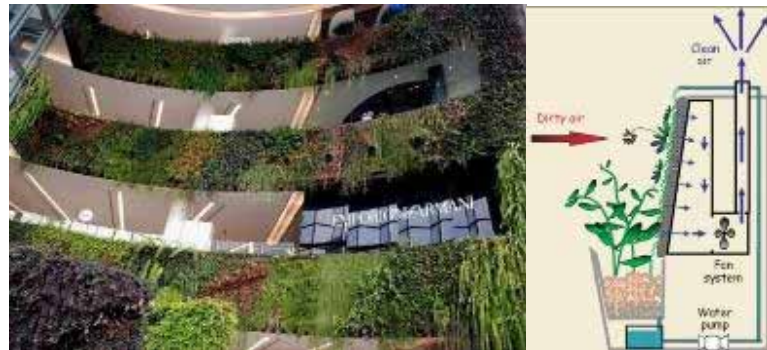
In the system of industrial felt roots are placed between the fiber and food and water go through woven layers of plants. The system is suitable for dry weather.



**Figure 5. Industrial felt living wall systems**

Living walls in terms of air purification is divided into two types of active and passive. Passive Living walls (Passive Living Wall) are made from square or rectangular modular panels that provide vertically growing medium and maintain plant and is attached to building facades or structure the lightweight construction system, with the distance. Implementation details of panels are different and are made of different materials such as plastic, polystyrene, polypropylene, ceramics, metals (steel, aluminum), textiles industry (a felt) and concrete. In order to have Lighter

walls of the living system, in the most cases seedbed is as plant maintenance and, food is available for plants by the irrigation system. Planting bed depending on the type of plant and details on system performance in relation with depth is different and irrigation system of living walls is usually dripped. Active living wall (Active Living Wall), is one of the newest types of green walls with integration is used in heating, cooling and ventilation of the building. The system purifies indoor air and also acts as a thermal regulator. The herb absorb monoxide and carbon dioxide and can remove particulate matter in the air and natural processes of plants produce, fresh air that is drawn into the system through a vent and then led into the building



**Figure 6. Active living walls**

### **Green walls of Landscape (Walls Landscape)**

Green walls of Landscape compared to vertical surfaces are designed with a slope greater and their main use them is to reduce noise pollution and soil stabilization on slopes. This type of wall is used on the wall of the bridge, highway or long vertical walls and will improve the urban landscape. Traditional campus green walls are made of concrete blocks, nowadays with the advancement of technology polypropylene geotextile bags containing planting bed is used.



**Figure 7. Green walls of landscape and their slope [14]**

### **Horizontal green surfaces**

#### ***Green roof***

Green Roof Systems began when plans for a green space on the roof of the structure was carried out, the roof of a building where all or part of it is covered with soil and plants. In other words, medium on the roof of a waterproof layer is, called green roof. Green roofs are also called as ecological roofs or vegetative life. Green Roof depends on how to use is divided into three types of private, semi-private and public divided. Private Green roof is about one that has been constructed in private building and is used only by its owner. Semi-private Green roof is roofing of communal properties and apartment complexes and is used only by residents of the complex and public green roof, is the roof of the property and government agencies and is used by all citizens. Green roofs based on shape of roof are classified into sloping green roof and, flat roof. In the slope Green Roof to prevent medium erosion, special measures such as the use of mesh networks is considered. For

the construction of the green roof, the building must be structurally stronger than conventional and must have capability for installing the required facilities. In general, green roofs consist of the following components: (1) vegetation cover: plants that are compatible with the climatic conditions of the region are selected according to weather conditions and the type of plants and irrigation system will be installed, (2) planting media: depth of medium depends on the type of plant chosen. Often a lighter medium is used to reduce the load on the construct, (3) drainage layer: to remove excess water from the planting media and is a layer of sand, gravel or porous polymer, (4)insulation: to filter the water that comes out from the medium prevents the obstruction of the drainage layer, (5) protective layer: is a layer that prevents penetration of plant roots and prevents damage to the membrane-embedded on roof which may be a chemical barrier in membrane or a physical such as pvc, polyester or polyethylene, (6) Roof membrane. and Roof structures.



**Figure 8. The various layers forming the green roof**

Green roof based on average depth of planting and its facilities is divided into both centralized and extensive green roof. Centralized or intensive green roof (intensive), due to the lack of restrictions on planting depth layer covers a variety of plant species that can be considered as a recreational space, this type of roof gardens require watering, fertilizing, pruning and other care.



**Figure 9. Types of extensive green roof, from left to right: modular trays, interlocking modular system, weakened.**

Planting depth layers varies between 20 and 60 cm and because of the trees; they have the ability to load 300 to 970 kg of excess live and dead loads of the building. Extensive green roof (extensive), which is also known as performance-oriented brand, needs the minimum maintenance facilities and can be the very thin layer of soil that contains one or two short roots plant species.



Planting depth should be between 41 to 102 mm and weighs when the wet is between 49 to 98 kilograms per square meter. Extensive green roof types include The modular tray system: the plants in modules and trays are inserted, the continuous modular system: growth medium is installed for plants as rolls to desired location, the weakened system, including green roofs with development environments with different depths.

### **A Case Study of green buildings and their impact on energy efficiency** ***California Academy of Sciences***

The Academy is designed in 2008 by the famous Piano Italian architect Renzo and constructed from recycled materials. The index features is respecting the environment and the site and the application of solar cells. Its basic design has reduced energy consumption by 30 to 35 percent. Green roofs are one of the most fundamental parts of the construction that have placed 9 native plant species in California. Plants on the roof are equipped with a thermal insulation layer. Roof has played the role of insulation and makes building warm in winter and cool in summer and prevents more than 405 million pounds of greenhouse gas emissions in a year.



**Figure 10. Green Roof in the California Academy of Sciences and its infrastructure**

### ***Brownell Museum in Paris (Quai Branly Museum)***

This museum is museum of arts and civilizations of Africa, Asia, Oceania and America, and is designed and built in the vicinity of the Seine in the heart of Paris shortly after the Eiffel Tower and the Louvre, in an area of two and a half hectares. Jean Nouvel with designing creative project has used ideas such as considering the technology, green architecture and the use of cover plants in the museum's walls. Building four semi-detached buildings have been formed. Interestingly, in the interior design of the museum, is the plant cover walls with an area of 800 square meters in which 15,000 plants of 150 different species covered walls that by changing seasons, covering walls and color change. The building's green roof also collects rainwater and after treatment, re-uses it again (Talebian, Atashi, and Nabi Zadeh, 2009)



**Figure 11. Green Roof of Brownell Museum in Paris**

### Conclusion

By creating green buildings, we can take a big step towards urban sustainability and optimizing energy consumption. Design and construction of these buildings is possible with four overall method green views, indoor and outdoor living walls, green walls and green roofs area. In the planning of most cities in the developed world to create green spaces in the building have been implemented as a recipe in the building and in Iran by using various methods trying to increase green space on the existing building and build them on buildings under construction. In general, the creation of such building has an important impact on energy efficiency of buildings that are listed in Table 3.

**Table 3. The necessity and methods of green buildings creation in energy efficiency**

Need for creating green buildings	Methods of creating green buildings in cities	Its impact on energy efficiency
-Achieving urban sustainability to improve the situation - Reducing the degradation process - Helping optimize energy consumption - Reducing pollution from dust imported from south-western countries to Iran -Environmental Protection	Green vertical surface <ul style="list-style-type: none"> <li>- Green facades</li> <li>- Interior and exterior living wall</li> <li>- Green walls</li> <li>Landscaping</li> </ul>	-Sound insulation and sound load balancing -Reducing heat island effects Cooling Environment -Space under the roof will stay cool in summer and warm in winter stay -Reducing the use of air conditioning and cooling devices -Reducing air pollution and the need for air conditioners -Reduce heat transfer through energy saving buildings -Reducing the need for cooling buildings in summer
	Green horizontal surface <ul style="list-style-type: none"> <li>Green roof</li> </ul>	

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