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Review article

Optimizing energy consumption using new energies within residential buildings toward objectives of sustainable development

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ABSTRACT

Aim of this study is to provide solutions as to optimizing energy consumption using new energies within residential buildings toward purposes of sustainable development. Using fossil fuels causes increasing pollution and destruction of the environment. Solution to maintaining the environment and designing buildings according to climatic circumstances and sustainable architecture development principles is using new and clean energies and this is a step toward reducing energy waste within buildings. This solution is broadly used in industrial countries and recently in Iran. Such energies are in full interaction with the environment and result in reduction of damage to the environment. Therefore, this study investigate and introduces new energies and solutions as to using new energies including new energy systems encompassing non carbon sources of energy such as solar, wind, geothermal and neutral carbon energy like biomass in order to lower usage of energy within residential buildings as a model for architectural plans toward reduction in energy consumption for economic development and interaction with the environment which are among fundamental objectives of sustainable development.

1. Introduction

Today, energy and optimizing its usage within buildings is among important issues in designing buildings. Preserving non-renewable energies and reserving them for future generation is among the approaches toward optimizing energy consumption. Energy optimization is one of the main and effective means of achieving sustainable development. By energy optimization we mean, choosing correct models well as formation and usage of suitable methods and policies as to production and consumption of energy which along with encompassing continuous economic growth, reduces destruction of energy resources and lowers adverse effects arising from incorrect usage of energy on the environment and society.

Reducing dependence on imported energies, lowering costs of producing and consuming energy, reducing environmental destruction and preserving it for future generation as well as preserving energy for future generation are among benefits of energy optimization. Energy consumption in Iran is three times the average consumption of energy in the world and buildings account for about 40 percent of it. This rate suggests the necessity of considering this issue. To this end, related organizations have made a lot of attempts. Ministry of Housing and Urban Development and Construction Engineering Organization have taken steps toward observing part 19 of national building regulations. Considering high rates of energy consumption in Iran and based on the fact that rate of energy consumption in Iran is about three times the average rate in the world, necessity of paying attention to this issue is of special importance. Using systems to utilize new energies is a solution to lower energy consumption. This approach is common in industrial countries and in recent decades has been used in Iran. Such systems are environment friendly and result in reduction of energy consumption. Protecting the environment is among fundamental goals of sustainable development which covers usage of new energies toward this goal. To this end, first, new energies and definition of sustainable architecture and its development objectives are briefly introduced and then, usage of utilizing some of these energies by systems within residential buildings is offered.

1.1. Sustainable architecture

The best concept of sustainable development for us, the architects, is to build artificial environment toward enhancement of present life quality and satisfying needs of future people. Sustainable architecture is consistent with climate, does not interfere with the environment and respects climate, human, culture and its environment (Ghiasvand, 2006, 24). Indeed, sustainable architecture is a universal matter and does not result in architectural styles like previous trends and although, its main concern is about the environment, takes advantage of all previous trends which had paid attention to lowering rate of material and energy consumption. It can be said that sustainable development is a kind of architecture which uses maximum environmental talents to meet convenience of consumers and uses smart means and solutions in this regard (Ahmadi, 2003, 94).

2. Goals of sustainable development

While sustainable development minimizes unfavorable conditions resulting from construction, It minimizes adverse effects on the environment, production and consumption of energy and material.

Table 1
Sustainable Architecture Principles in View of Jencks (Jencks, 1997).

First principle	**Energy conservation: Building must be built in a way that minimizes need for using fossil fuels.**
Second principle- Coordination with climate	Building must be built to be coordinated with climate and energy resources.
Third principle- Decrease in usage of new resources	Buildings must be designed in a way that minimizes usage of new resources (as fast as possible). They must be used as a new source at the end of their useful life for constructing new buildings.
Fourth principle- Satisfying needs of residents	In sustainable architecture, satisfying mental and physical needs of residents is of special importance.
Fifth principle- Coordination with construction site	Building must be positioned on its site with due care and must be coordinated with the surrounding environment
Sixth Principle- Holism	All principles of sustainable architecture must be embodied in a complete process resulting in formation of a healthy environment.

In an ideal world, sustainable plan can be formed according to natural materials available in the region, obtains its required energy from natural renewable resources and controls waste material produced (Ghiabaklou, 2011, 2).

2.1. Types of energies

Source of all available energies on the earth is sun. Energy reserves of the earth come from different sources. Energy of such sources can be divided into two groups: renewable energies, non-renewable energies. Renewable energies are a sort of energy obtained from natural and permanent sources available in the nature and therefore, using them does not cause penetration of pollution to the environment. These energy sources are unlimited and can be used based on environmental conditions (Rahimi, 2011, 1).

Non-renewable energies (mortal) are those energies which have limited reserve and if consumed, are depleted. Among such energy sources are fossil fuel, atomic energy, etc. Such energies cause irreparable damage to environment (Ghiabaklou, 2011, 30).

2.2. New energies (renewable)

renewable energies are those energies with unlimited usage including solar energy, biomass, geothermal, marine and water energy (Ghiasvand, 2006, 23). This type of energies do not have disadvantages of fossil fuels such as increase in concentration of carbon dioxide and as a result, increase in the temperature of the earth and climatic changes as well as environmental pollution. Moreover, resources of production are unlimited and do not come to an end.

Table 2
New Energies.

New Energies	Description
Solar energy	Including active technologies of the sun, photovoltaic solar panels, solar rooftop tiles and solar heater (Fiona, 2011: 14).
Wind energy	Wind is a renewable source of energy which is obtained from heat of sun. solar energy makes earth warm, brings about differences of temperature in different parts of the earth and forms air flow or wind(Ghiyasvand, 2006, 20).
Geothermal energy	The word, geothermal is derived from a Greek root (geo means the earth and thermal means heat). In fact, geothermal energy is a sort of energy obtained from hot water fluid or vapor of hot water available in depths of the earth(Ghiasvand, 2006, 16).
Water energy	One way of obtaining clean energies is making water sources from sea tide as well as using energy of waves in order to produce electricity. There are four main methods of using energy of water: Energy of waves, sea tide energy, differences of temperature and hydraulic energy (Ghiasvand, 2006, 20).
Biomass	Biomass is a renewable source of energy obtained from bio materials. Bio materials include living creatures or remains of them. Every year through photosynthesis, several times the yearly consumption of energy in the world, solar energy is saved in leaves, caber and branches of trees. Therefore, among different types of renewable sources of energy, biomass is unique regarding conserving solar energy (Ghiasvand, 2006, 26). Biomass technology produces electricity with the least disposal and without moving part. Therefore, it is almost less dangerous than photovoltaic. Biomass technology produces energy through synthesis or anaerobic fuel (Tehrani, 2011, 73).

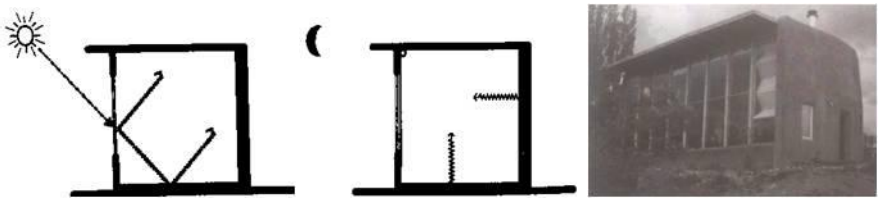
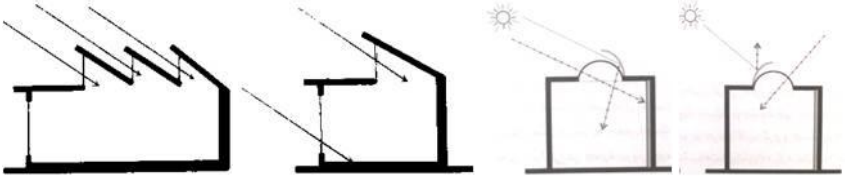
Table 3
Advantages of New Energies (Renewable).

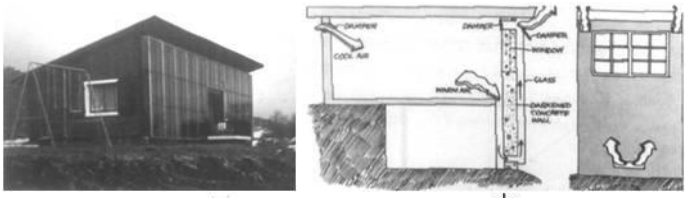
Environmental advantages	Renewable energies do not produce other pollutant and harmful gases for the atmosphere. Renewable energy does not produce waste and problematic waste. Such energies are unlimited. But non-renewable energies (fossil fuels) have limited sources.
Strategic advantages	Renewable energy can be produced regionally and locally but sources of fossil energies are only found in some specific areas. Renewable energy results in independence.
Social and economic	Renewable energies enhance level of small communities because their equipment is mostly set up in rural areas. Such energies provide a nation with the opportunity of forming and developing national technologies.

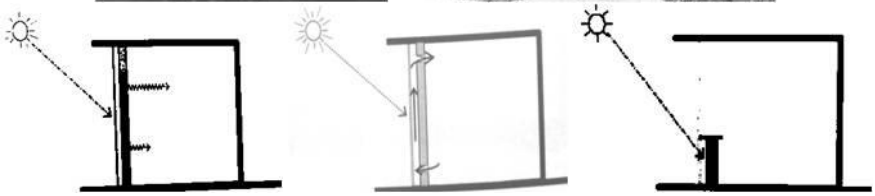
2.3. Usage of new energies within buildings to reduce energy consumption

Solar systems: Today, thermal uses of solar energy in buildings have gained a special position. First type of solar system is inactive or static systems. In this method, radiative energy of sun makes interior space of building warmer through some elements and components of building by means of big south-faced windows.

Table 4
Applications of New Energies.

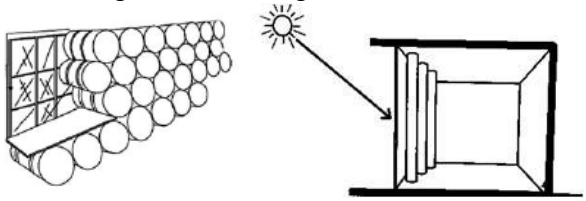
Direct Absorption	Buildings with direct absorption which are dependent on south-faced windows called solar windows. 
Skylight	Sky lights are an appropriate method for places of high depth, where solar light does not reach all the space through southern walls or for whatever reason, receiving light through southern window is not possible. 
Indirect absorption	In indirect absorption, savers are barrier between sun rays and interior space. They can be divided into two groups: Trombe wall, water roof.
Trombe Wall	This wall is located near windows and is made of materials with high density such as stone, brick, clay or gallons full of water and their outer layer is in dark paint. Trombe wall makes efficient use of sun possible and its efficiency depends on material, thickness and paint of the wall.





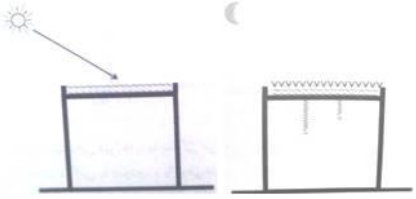
Water Wall

This wall was first made in 1972 by Steve Beer in his house in new Mexico. He used 250 liter barrels horizontally in shelves designed for this purpose. In this system, parts facing glass are in black and interior parts are white. In order to prevent energy waste, over nights, glasses are coved with thermal insulator and during day, this insulator is laid on the ground like a hinge and serves as reflector.



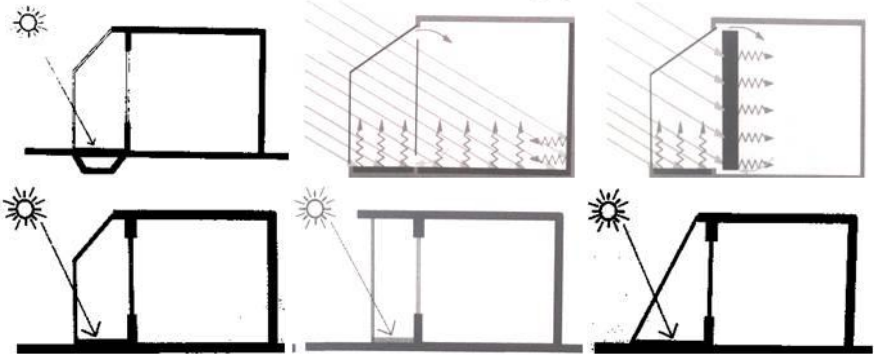
Rooftop Pool

In this system, rooftop pool absorbs heat of sun during winter days and, roof is coved by thermal insulator at night to conserve heat obtained. This way, heat of water inside pool gradually keeps air inside building warm through conduction and radiation.



Greenhouse

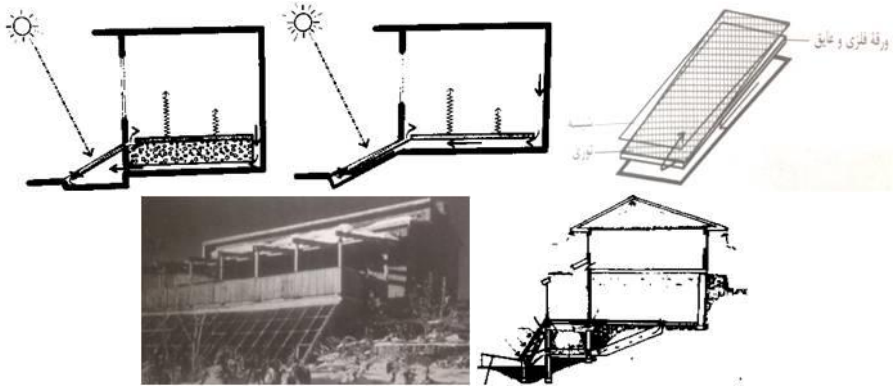
Greenhouses also called solar spaces serve as solar collectors to obtain thermal energy of the sun and are built in southern part of buildings. Function of greenhouses is based on greenhouse property of glass and using materials with high heat capacity. Materials with high heat capacity can be used on the floor, in wall between greenhouse and interior space and even on the ground of interior space.



Thermosiphon

Convection current of a fluid which occurs in a closed system, where cold fluid is replaced with warm fluid in the same system is called thermosiphone. Such system is in fact a natural replacement cycle. It should be noted that distribution of heat in Trombe wall (with gate) and greenhouse is conducted by thermosiphone. In this

system, stage of energy absorption can be undertaken in connection with the building or in a completely new environment. Also, heat absorbed through channel can be directed and saved in a suitable place such as concrete slab or stone storage which usually is above surface of absorbent.



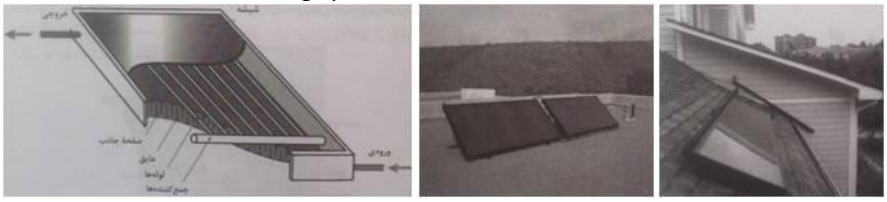
Solar Collector

This is a system used for collecting thermal energy of sun as well as transference and saving that in utilization site.

Flat Collector

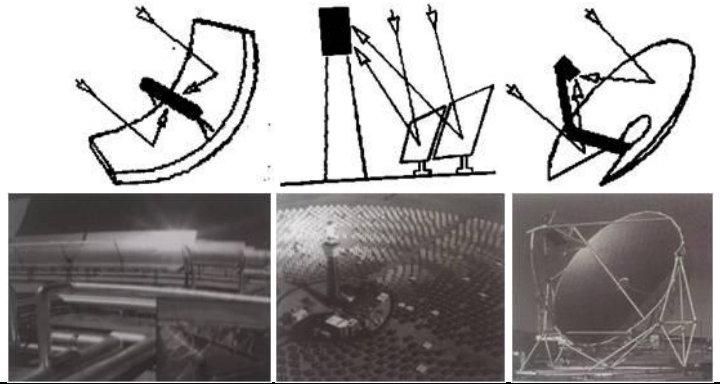
The most economic method of collecting solar energy is using flat collectors. These collectors are made and used in different types and designs in different countries around the world. The most common usage of flat collectors is warming water and space of houses, using them in air conditioning and finally, in warning water or air needed in industrial process.

Flat collector is usually set up fixed and therefore, does not have problems regarding sun tracking systems used in localizer collectors.



Localizer Collector

Such collectors are used due to their very high production of energy in solar power plants or solar furnaces. There are Three types of localizer collectors: Localizer collector with sagittal dish, Localizer collector with central tower, Localizer collector with sagittal line.



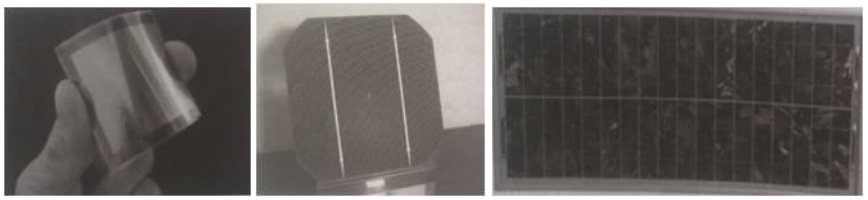
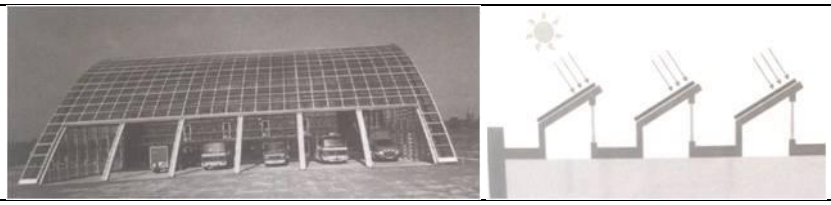
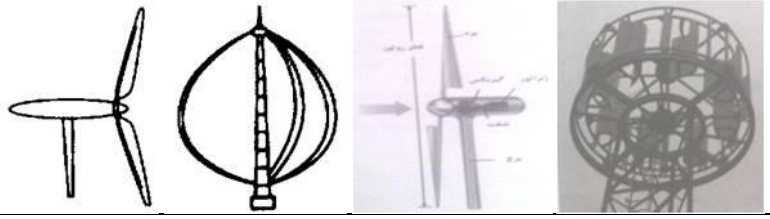
Photovoltaic Systems	A phenomenon which produces electivity from sun rays without using driving mechanisms is photovoltaic and the element causing such process is solar cell. This system directly transforms energy of light into electrical energy. Solar cells are made of semi conductive materials. Such systems can directly transform solar energy into electricity with the efficiency of 5 to 30 percent. Main element of all these cells is silicone. Generally, three kinds of solar cells have been defined: Single crystal, poly crystal, flexible.  

Table 5
Application of Wind Systems.

Systems	Description
Wind turbine	Till now wind turbines have been a source of electricity in gusty cities instead of power plants. Modern Wind turbines are divided into two groups: Turbines with horizontal axis and turbines with vertical axis. Wind energy is produced by constructs of building and natural flow. On higher levels, wind flows with higher speed and wind turbines harness such . energy. 

2.4. Solutions for reducing energy consumption within residential buildings

1- Designing buildings according to climate: Buildings must be adjusted to climate of respected region to have capacity of conserving energy efficiently. In order to achieve such goal within buildings, appropriate orientation, using shape and dimensions adjusted to climate, using materials appropriate for climate and considering occupied and empty spaces in view of design requirement ..... must be considered in designing buildings.

2- Direction of building shape placement: Such direction which is the appropriate orientation of building in view of climate to receive solar energy is more important.

Efficient direction of building placement for collecting heat of sun in winter is along with larger front. Also, direction of building placement for receiving sun's heat in a building is with north/ east or west facade ratio of 1/5 to 1/6 (Azghandi, 2003, 486).

3- Materials and insulators making outer surface: This case is more relevant to thermal resistance rating of layers making outer surface ad thermal transfer factor of such surface. Materials used to reduce heat transfer and

in different combinations to achieve the desired result (thermal comfort) are usually used with reduction in energy consumption (Hart, 2011: 153).

4- Using two layer windows in order to reduce thermal energy waste.

5- Correct designing of building doors.

6- Providing capability of saving energy in buildings.

7- Splitting interior space of buildings.

In cases where just a certain part of architectural building must be warmed, through separating it from other parts, it becomes possible to make that certain part warm and this itself results in energy conservation.

8- Reducing ratio of roof area to useful area of building

9- Reducing ratio of building outer surface to useful space dimension

10- Reducing ratio of surface of openings in outer surface (door and window) to useful surface area of building.

11- Using inactive solar systems such as window or sun wall, horizontal and vertical boxed cornice, tree shades....

12- Reducing leakage of air from seams and openings of outer surface (Gholabchi, 2003, 188).

2.5. Designing residential buildings using new energies

Besides solutions offered as to conserving energy within buildings, using renewable energies in designing buildings can result in formation of a sustainable design in contact with the environment which makes energy saving possible.

1- Using solar cell technology (photovoltaic) in body and facade of building

Besides fundamental benefits as to energy conservation, shape of body and roof of buildings is affected by using solar panels. In buildings using PV combinatory systems, besides energy production, solar panels serve as means of beauty making and protection of facade as well. Such panels serve several functions and compared to independent and in need of accessory construct systems, make cost saving possible. Combinatory photovoltaics can be a substitute for roofs, facades, shutter form walls, and work with glass or special elements such as boxed cornice or parasols.

2- Using wind turbines: Using such turbines in body and façade of buildings provide for about half the electricity need of the buildings and therefore is cost effective.

2.6. Examples of buildings using new energies

East SBIC building: This building was constructed in 1998 near central station of Tokyo. This building produces 2 and 35 kW electrical energy daily through solar cells. Such building is composed of 8 floors over the ground and 2 floors underground of total area of 7663 m2. In initial plan of this building, solar panels were not mounted but when designers were thinking of reducing dead load of wall and provision of shade for southern wall , they were used as vertical and semitransparent elements. Moreover, polycrystalline solar panels (of less transparency and more energy production) were mounted on roof of the building on the roof of its bower in order to enhance capacity of energy production in summer. This building is the first building in Japan which started production of energy out of solar cells in large scale and with the highest capacity (architecture.loxblog.com).

Four Times Tower in New York: This 48 floor tower is the first huge office building constructed in 1990 in New York. The company which was the owner of this tower undertook a range of vast measures resulting in building health and enhancement efficiency in order to meet environmental standards.

- Insulating wall with high thermal resistance
- Windows with high efficiency and appropriate separating of walls which makes maximum penetration of natural light possible.

- Low consumption fluorescent electrical lamps.
- Fans and pumps with variable speeds and high efficiency.
- Natural gasses without cooling/ warming CFC and HCFC
- 1.5 kW integrated photovoltaic panels in curtain walls. Such wall is the most economic photovoltaic system set up in urban spaces.

Utopia Tower: Utopia Tower is a long tower which while having a unique design, have used material Nano technology as well. This tower and its elements are made of materials similar to a living creature and can easily interact with their environment and bring about reviving energy within building. HVAC in this building have provided a part of elevator systems energy and electrical systems through integration of Nano cellular technology and outer surface of building. Also, using Nano cellular technology which is a narrow film attached to phasic cell, glass sensitive to sun light in different positions reacts and controls the heat obtained through glass surfaces (www.design.philips.com).

World Trade Center of Bahrain: Wind turbines which till now had been a source of electricity in gusty cities instead of power plants, has been set up in World Trade Tower in Bahrain with the innovation of significant architecture of Atkins Construction Company to be used as a new method of providing electricity in modern buildings. This tower is located in a part of Bahrain coast with the speediest winds compared to other parts. Three 30 meter propellers which are located between these two towers, produce 1100 megawatt electricity a year for this 42 floor building.

Pearl Tower in China: This tower is one of green towers of the world with 300 meter elevation. This tower has been designed in a way that harvests wind on its length. In the body of this building, wind turbines have been designed to produce energy using wind. From distance this tower is more like a huge wing which passes wind through its 69 floors. This building conserves heat and cold inside itself. Energy consumption of this building is minimized due to maximized usage of light in days along with preventing penetration of unwanted sun rays to spaces with air conditioner and warming water by sun.

3. Conclusion

Today, energy and optimizing its consumption within buildings is among important issues in designing buildings. Considering the fact that a major part of energy consumed around the country is related to construction area, paying attention to usage of new energies in designing buildings especially residential ones can result in optimization of energy consumption and conservation of environment. In view of the fact that such energy does not cause environmental pollution and is unlimited, it is one of the fundamental objectives of designing sustainable development toward interaction with the environment which is using new energies to the purpose of sustainable development objectives. To this end, this study attempts to provide general principles regarding optimization of energy consumption in architecture and introduce usage of new energies within samples of buildings. If modern technologies could be broadly introduced in architecture, it would be possible to turn buildings into high quality constructs with less energy consumption. As a result, using new technologies in buildings and considering changes made to construction industry and using new innovations and architecture consistent with the environment, this can be an effective approach toward reducing consumption of fossil energies within buildings, optimizing energy consumption and finally, reducing pollution. Using new and clean energies within buildings is a solution to increase useful life of buildings, comfort of residents, energy saving and achieving objectives of sustainable development.

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