INVESTIGATION OF ENERGIES COMPATIBLE WITH SUSTAINABLE ARCHITECTURE IN SUSTAINABLE DESIGN

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ABSTRACT
Region and land, as a field for formation of architecture has long been providing space required for construction on one hand and balance of consumption level and production of resources. However, after industrial revolution, human overused earth energy resources. Utilization of non-sustainable energy resources not only has unsuitable effect on environment, but also causes our facing with accelerating rate of reduction of these resources. This is while renewable energy resources unlimitedly support us in producing required energy by least adverse effects on environment contrary to fossil fuels. In this paper, after an evaluation, renewable energy resources and its relevant forms are represented which include water, wind, sun, geothermal and similar resources all around the country and finally, we briefly imply to clean energies.

Keywords: Solar Energy, Sustainable Energy, Consumption Optimization

INTRODUCTION
Problem Statement
World faces a great challenge; world population and its demands which are continuously increasing. This issue is along with increasing demand for energy. In general, 40% of goals energy consumption is allocated to buildings. Most of the energy is consumed for light, heating, cooling and air conditioning. Moreover, using energy systems based on fossil fuels leads to emission of greenhouse gases, warming up the earth and climate changes. Buildings are the second source of emission of CO2 in the world.

One of the goals of sustainable architecture is to provide sustainable energy resources. This issue can be accomplished through utilization of renewable resources and optimal usage of energy whose substantiation leads to great development in sustainable development. Renewable energy, have a great potential and according to estimations, they can produce the energy required for more than thousands of times of world’s population.

However, these energies are not the only appropriate factors for securing a sustainable energy source for the world. A high percent of energy produced is lost in production and consumption cycle. Here, a significant potential for protection of energy and its protection will be produced. Since supplying heating and cooling demands using renewable energies is one of the aims of sustainable architecture, securing and optimization of consumption in building leads to more stability of energy in this section. Evaluation of sustainability is an important issue and motivation for discussion about extension of sustainability. According to this, criterion of evaluating sustainability of energy system must reflect four aspects: resources, environmental, social and economic aspects. Sin energizes our planet and enables us to survive. Moreover, besides intelligent technology, it can produce heat and electricity. On the other hand, as the driver of wind force, it can play a vital role in energy production. Wind produces waves, sun enables the cycle of water evaporation to produce power by means of water plans. Using sunlight, plants photosynthesize and produce an extensive range of products; namely biomass. Interactions with moon, produces tidal waves which can be used for electricity production. On the other hand, extraordinary heat of the earth can be used for heating and electricity production.
In indigenous investigations, optimal usage of renewable energies such as wind, sunlight and so on, has been taken into account by manufacturers and today, architects pursue novel plans so that they can reduce energy consumed in buildings as much as possible to achieve sustainable architecture. Therefore, tips such as optimal energy consumption, clean technology and using renewable energy and static and dynamic systems in building must be taken into consideration so that it can have a pivotal role in energy consumption pattern in the future.

**Importance and Necessity**
In recent studies, scientists concluded that each change occurring in environment, results from natural and human factor. Average temperature of urban zones has increased more compared to other zones in global scale. Climatic changes are the most significant problem which is experienced by global environment and scientists agree on this problem which is the result of human activities. If the main factor of this glow is assumed to be accumulation of greenhouse gases in the atmosphere, majority of these gases are produced and emitted in the world as a result of fossil fuels for energy supply (Soltau, 2009). According to statistics of energy balance sheet of the year 2010, building sector of Iran accounted for 37% of overall energy consumption and ranked first among all sector including industry, agriculture and transportation. Therefore, using renewable energies, we can save and protect environment.

**Goals**
This work intends to review energies compatible with environment as well as sustainability problems as one of the solutions for saving energy in design in Iran regions in order to reduce energy consumption and pollutants as a new tradition in construction. Moreover, it is expected that considering these issues leads to improvement of architectural design and energy protection strategies and extension of parameters of design details as well as correct comfort strategies in understanding which can help designers in their work, facilitate their job and enables flexibility in trends and makes selection and decision making possible.

Industrial revolution and technological advances lead to oblivion of indigenous architecture. 1970s can be considered as the period of awareness of economic disasters. Sustainability is one of the reactions to these disasters which initially appeared as a mental idea and became comprehensive in the middle of 20th century in theoretical fields such as environmental, social and economic contexts. But at the same time, this idea was introduced as an instruction and regulation in international societies and official organizations (Bahreini, 2006). Due to enormous and dangerous effect of human of environment, sustainability is a solution demand to which in increasing. Moreover, since architects form the individual and social life of humans, they have a vital responsibility for habitats of humans and other creatures. The beginning of 1970s, was the onset of energy recession which addressed the issue of urgent attention to energy protection issue and it was at this time that efforts and expenditures were allocated to researches for right usage of energy and this trend continued for several years. Some of the efforts performed for saving energy led to serious controls over buildings regardless of human needs to natural light, ventilation and temperature control which resulted in creation of unhealthy interior spaces without taking other climatic conditions including sunlight and photovoltaic technologies into account. They solely focused on higher efficiency of energy in buildings regardless of its environmental consequences.

**Questions and Hypotheses**
1. It seems that using renewable energies leads to more coordination of plan with environment and its context.
2. It seems that utilization of renewable energies in architecture can guide us to ways of building design with least energy consumption and environmental pollutants.
3. How architectural design can lead to more compatibility of building with environment?
4. Where is the highest energy consumption in available buildings?
5. What is the best method of energy saving in available buildings?

**Research Methodology**
Obviously, each research needs a methodology compatible with its topic. Selection of the right method and its persistence throughout all processes and research path is one of the fundamentals of a scientific
research. Method of facing am problem and research is in close and mutual relationship with the structure and identity of research. Therefore, for making a consolidating foundation for this research, descriptive and analytical methods are selected. Data collection through library materials including books, thesis, papers and websites is performed and finally, it is attempted to analyze and complement the obtained data and make a final conclusion.

**Theoretical Basics**

All human activities demand energy which must be supplied from various ways (Abdollahi, 2013). According to increasing population growth, necessity of energy supply has been more attended by human. Based on needs, values and goals, human changes surrounding natural environment for utilization (Daneshpour et al., 2009). Incompatibility with production speed and consumption of natural resources and human activities, as a result of industrialization of cities and pollutants made by these activities led to threats for world and cities by serious environmental disasters (Feizi and Banaei, 2009). Due to environmental problems and non-renewability of fossil fuels, it is necessary that – more than ever – scientific utilization of renewable energies be taken into consideration and we seek their optimized usage.

**Energy**

The main source of energies available in earth is sun. Energy resources of the earth are supplied from various ways. Energy of these resources can be classified into two categories:

1. Renewable
2. Non-renewable

**Non-renewable Energies**

These energies are those energy carriers whose resources are limited and they end up by consumption. The most important of them are:

3. Wood and firewood for domestic uses are mainly used for heating and cooking.
4. Fossil fuel: including oil and its derivatives, gas and coal
5. Nuclear energy: reactions which occur in atom, having considerable energy exchange and are classified into fusion and fission.

**Usage of Non-renewable Energies and their Consequences**

From the beginning of industrial revolution onwards, world’s population reached from hundreds of million people to 7 billion ones. Simple and economic lifestyle of human in 200 years ago transformed into ambitious life of 21st century. Population growth on one hand and improved social welfare on the other hand, require more energy. Increasing need to energy resulted in more utilization of fossil fuels (Razzaghi, 2011). Fossil energy which composes main part of our current energy consumption seems to be the cheapest option for supplying energy, regardless of their limitedness and make energy crises and environmental problems (Philips, 2004). Uncontrolled utilization of resources and incompatibility of consumption and production speed on one hand, and waste production and incompatibility of production and decomposition speed in nature, has led to environmental problems in international level (Sassi, 2006). The most significant environmental problems are: imbalance of gases in atmosphere, heat increase, and pollution resulted from greenhouse gases, Ozone layer destruction, acidic rains and oxidizers.

Concerns about environment damage led to initiation of some supporting activities for environment. An example of such activities was introduced in June 2007 whose purpose was to decrease CO$_2$ pollution level as much as 50% up to 2050.

**Diagram 1: Energy consumption in various sectors (Energy Balance Sheet, 2010)**

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Research Article

Renewable Energy

Renewable energies are those which are available from earth to sun and include:

Geothermal

This is the only renewable resource which is not dependent upon solar energy. The source of this energy is the internal heat of the earth originating from molten materials or magma. This energy is made from decomposition of radioactive isotope of Potassium as well as high pressure resulted from gravity forces (Razzaghi, 2011). Other source of this energy is the molten core of the earth which can be seen in regions such as Sabalan, Maku, Salmas and Damavand. Geothermal belts are at the vicinity of volcanoes (Ghaiabalko, 2011).

Figure 1: A schematic of a geothermal system (Razzaghi, 2011)

Geothermal energy can be used for: 1. electricity generation, 2. heating of buildings.

Wind Energy

Wind energy is in fact a part of solar energy which approaches the earth. Solar energy results in earth heating and temperature changes in various points of it leading to formation of air flow or wind. Wind turbines transform the kinetic energy of winds into mechanical one (Ghiabalko, 2011).

Water Energy

Water energy is that part of energy which is obtained by transforming kinetic energy of water into electricity in the vicinity of water resources or far from them. Four main methods of utilizing water energy are as follows:

Energy of waves, tidal energy, water temperature change, hydraulic energy (Ghiabalko, 2011).

Biomass Energy

In photosynthesis process, solar energy will be stored for future usage. This saved energy can be transformed into heat or electricity or change into methane, alcohol or hydrogen (Lanker, 2006). Biomass resources are forest, animal, agriculture, urban and industrial wastes (Ghiabalko, 2011).

Solar Energy

Sun is a burning sphere which by means of its nuclear reaction and transforming 700 million tons of hydrogen into 695 million tons of helium per second releases 5 million tons of energy in the form of gamma rays, is the source of life and heating of earth (Soltandoust, 2011). Solar energy is the energy released from fusion within the sun. This energy is of the other forms available in earth, except nuclear and geothermal energy. The amount of solar irradiation received in each point differs according to climatic conditions and other characteristics of the region. Potentially, Iran is one of the best places for exploiting solar energy. Simple technology, being non-pollutant and most importantly, storing fossil fuel for future generations or transforming them into valuable materials using petrochemical technique are some of the reasons why using solar energy is necessary for country.

At present, solar energy is used for various systems and goals the most important of which are as follows: a. photo-biologic systems: changes made in life of plants and animals through sunlight and photosynthesis, b. photochemical systems: chemical changes made by sunlight, optical electrolysis, electrochemical photovoltaic cells, hydrogen production equipment, c. photovoltaic systems: transformation of solar energy into electricity, pure water production, transfer and pumping systems,
systems of green space and solar driers and ovens, cooling systems, power towers, solar driers and power plants.

**Sustainability Concepts**

**Sustainable Development**

Concept of sustainable development was introduced for ensuring life and welfare of people all around the world although the development itself can be a threat if resources are not appropriately protected. Investigations led to dissemination of a report entitled “joint future” in 1987 simultaneous with initiation of cold war, discovery of Ozone layer cavity in 1985 and a year after Chernobyl disaster. This report emphasized on a main axis: most of today’s development trends makes people poorer and vulnerable, damage environment and intensify the trend of ending up resources. Therefore, we need a development path which leads to progress and growth of human not only in some places, but also throughout the world and for far futures (Simon, 62). So, one of the most widely accepted definitions for sustainable development was presented: Sustainable development is one which meets current needs without endangering future generations’ ability to meet their requirements.

**Sustainable Energy**

Energy can be considered as the most fundamental base for development. Energy and methods of its supply are one of the most important challenges of the society, availability of a lot of cheap energy resources with least environmental threats corresponding to its production and consumption is one of the most significant factors in optimization of lives and one of the most fundamental goals of sustainable development especially in developing countries. If the energy is produced and consumed such that it can meet human development in all social, economic and environmental aspects in long-term, the concept of sustainable energy will be substantiated (Aslani, 2003).

**Sustainable Architecture**

By a look at the above concepts, we will find out that the only factor which can accomplish goals of sustainable development by arranging various factors along with sustainability and guaranty our lives and that of future generations is sustainable architecture. Green building has a multivalued composition including environmental aesthetics, social, and energy and so on and all of these principles in a minor scale and a complete process lead to a physically and mentally healthy environment. Green building is in fact a method of design which concentrates on reducing of using non-renewable energy resources and states that human can obtain whatever s/he needs from nature without damaging it. It must be noted that if green building patterns are not dominant over modern constructions, earth planet will soon face serious problems arising from lack of energy resources and environmental pollutions. Finally, sustainability can be stated in following three main principles:

1. Saving energy consumption.
2. Design based on life cycle.
3. Human design.

Which in this research emphasis is on saving energy in sustainability.

**Energy Crisis and Explanation of International Community Path in Reducing Energy Consumption**

Energy crisis, environmental pollution, global warming phenomenon and heat island of big cities are of major problems of current century. Above issue resulted in consumption of a lot of energy for heating and cooling of spaces and this necessitates the sound application of natural resources of energy and appropriate management of construction. One of the applied ways of reducing energy consumption is green building design, since main part of energy in the world, is consumed in building sector. This illustrates that energy loss of buildings must be prevented and by providing solutions, reuse of energy must be made possible. In this way, three principles can be presented as follows:

1. Reducing energy demand by various measures such as insulation, optimal utilization of solar energy, control of air replacement and heat recovery.
2. Utilization of renewable energies including solar, wind, geothermal and biomass energies.
3. Using high efficiency energy conversion methods such as heat exchangers and lighting systems.
Methods of Achieving Sustainable Design

The ultimate goal and challenge of green design is to find temporary solutions whose consequence is quantitative, qualitative, emotional and spiritual benefits for building residents. Triple principles of green design provide an extensive awareness of corresponding environmental problems. Strategies corresponding to each of the principles concentrate on certain and more personal issues. The purpose of each strategy is to provide an appropriate understanding about how building conforms to internal, local and global environment. This section discusses methods for applying green design in architecture.

Saving Energy Resources

Saving energy, water and material provide special design methods which improve sustainable architecture and can be classified into following two groups:

1. Methods of Reducing Inlet Flow

These methods reduce the flow of non-renewable resources to the building. Demand for inlet resources is directly related to utilization of the resource.

2. Methods of Managing Outlet Flow

By lowering the level of outcomes and appropriate management of them, such methods reduce environmental pollutions.

Energy Maintenance

Maintaining energy is one of the methods of reducing inlet flow. The main aim of this strategy is to reduce fossil fuels consumption. Building conditions can prevent undisciplined extension of cities and climatic conditions and specifications affect coordination and arrangement of buildings.

Planning Site by being Aware of Energy Issues

Such planning enables designers to maximize utilization of natural resources available in site. In moderate climate, openings located in the south of buildings increase passive solar heating. Deciduous trees make shadow in summer and in winter, make the absorption of solar energy impossible. By planting evergreen trees in northern side of the building, it can be protected from winter storms and its energy productivity can be improved as well.

Passive Heating and Cooling

Solar irradiation approaching building surface is the most significant energy entering a building. Solar irradiation supplies heat, light and UV required for photosynthesis. Historically, architects tried to utilize forms in buildings which make shadow in summer and receive enough heat in winter. However, in design of modern buildings, this primary necessity is ignored. Passive solar system provides solutions and facilities using structure whereby solar irradiation can be exploited in more suitable times of the day.

Insulation

Windows having large surface area and insulated walls prevent loss of heat. Reducing such exchanges reduces heating and cooling load of the building and consequently its energy consumption.

Energy Alternatives

Solar energy systems, geothermal water and wind which are commercially available, can reduce needs to external energy resources or even eliminate them. Electrical and heating equipment can be exploited by these systems or their combination in all climatic conditions.

Daylight

Design of building and its windows so that it can utilize natural light leads to saving electrical energy required for making light, reduction of electrical loads peak and energy required for cooling. In addition, natural light improves the quality of illumination of interior spaces and consequently, mental health and productivity of residents. These qualitative benefits of natural light are more important than its potential for saving.

Low Consumption Facilities and Equipment

After expenditures of construction, maximum expenditures are for utilization and maintenance of it. During building life, these expenditures may exceed its construction costs. Therefore, exact selection of heating system and low consumption ventilation system is necessary and mandatory. Costs and initial
expenditures of such equipment may be higher than that of lower quality equipment, but these expenditures will be compensated by future savings.

**Keeping Water**
Methods of keeping water can bring about reduction of inlet or outlet flow or even both, since commonly, water which enters building and what exits it are related to urban purification system. Therefore, reducing consumption will lead to reduction in residuals.

**Water Reuse in Site**
Water which is used in building can be classified into two groups: wastewater and graywater. Graywater is a type of water which is produced by activities such as hand washing. Although its quality is not as drinking water, it can be recycled in building and utilized for irrigation of ornamentals and filling toilet flushing. Utilization of appropriate pipeline with suitable design can be effective in facilitation of this application.

**Reducing Consumption**
Systems and equipment corresponding to water supply can be chosen so that they can reduce loss and consumption. In many parts of US, according to regulations, using low pressure valves and low volume flushing mandatory. Suction toilets and bio-compost reduce water consumption to a great extent. Bio-compost toilets purify their wastewater in site and eliminate the need to urban purification operations.

**Maintaining Materials**
Production and consumption of masonries for building have various consequences and effects of local and global environment. Extraction, process, production and transportation of masonries have to some extent environmental damages. To save and reduce consumption, inlet and outlet flow methods must be used.

**Using Recyclable Materials**
During building design and selection of masonries, we must seek methods for using recyclable materials. This prevents loss of energy in production process.

**Determination of Building Size and Quality of Systems**
If a building is too big for application and purpose, or its dimensions are beyond required ones, materials used in it will be more than is needed.

When a building is too big or small compared to the number of residents or users, its heating, cooling and ventilating systems whose dimensions will be determined according to building area, will be insufficient or inefficient. This method is directly related to planning steps and architectural design. To ensure appropriate dimensions of the designed building and its systems, current and future needs of client must be taken into account.

**Conclusion**
Buildings are the most important energy consuming sector and the second source of CO₂ emission. According to this, in construction of buildings, sustainability must be taken into consideration. Solutions for current issues and environmental crises include reduction of fossil fuel consumption, supplying more environmental friendly energies which lead to utilization of renewable energies. Using sustainable energies is the necessary but not enough condition for development. Moreover, sustainable development requires a sustainable energy source. Another condition for sustainability is optimal energy consumption and improving energy efficiency. Therefore, there is a mutual interaction between sustainable energy and energy optimization.

There is a close relationship between energy consumption optimization and environmental effects. Therefore, using less energy resources and consequently, less pollution through improved energy efficiency steps can be taken toward energy consumption optimization. Therefore, besides protecting resources and environment for future generations, today’s architects seek novel plans to reduce energy consumption as much as possible and improve welfare whereby sustainable and green architecture goals can be achieved. Therefore, implications such as optimal energy consumption, energy efficiency, clean technology and utilization of clean and renewable energies and static and dynamic systems must be taken into consideration so that they can play a pivotal role in energy consumption pattern. Of course, other factors contribute to energy consumption pattern including public organizations support, investment,
planning and energy management, modification of consumption pattern, promotion of knowledge level and development of clean technologies and so on which demand national collaboration. Sustainable development is effective when they are based on real human and moral values. Such moral system must lead to common elements appropriate for each social, cultural and economic position. Therefore, determination of criteria and indices for sustainability can play a more effective role in promoting such goals. Negotiations and collaboration of societies and countries as well as various economic sectors and more efforts in technology and research development are tools for overcoming challenges faced by human and a guaranty for current and future generations. Connections between political energy framework, financial supply and implementation of projects of sustainable energy and energy productivity must be improved so that substantiation of sustainability in economic, social and environmental sectors can be observed and needs of future and current generations’ needs to sustainable goals can be met.

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