A Review on the Design Approaches Using Renewable Energies in Urban Parks

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Abstract-Urban parks has recently been a focus of interest for environmental engineers. Diversifying the energy sources and the creation of energy security along with the environmental problems with respect to the consumption of fossil fuels in one hand, and the clean and renewable nature of novel energies in another draw tremendous attention of the world to develop the use of renewables and to increase its contribution in the energy basket. The purpose of this study is to collect information on equipment and technologies of renewable energy that can be used in urban parks which leads to the underlying implementation of sustainable development in cities. Using descriptive method and current implementations, this paper addressed the necessity of applying these methods in the parks in Tehran. The results showed that the use of renewable energies and related technologies in urban parks provides services including lighting, charging small electronics, production of hot water and space heating and cooling in the park. Still, the sustainability of the urban environment is enhanced apart from the beauty of the environment, promoting public education and reduction in fossil fuel consumption.

Keywords: Renewable energies, park design, urban parks, Tehran.

1. Introduction

That urban parks and open green spaces are important strategies in urbanized society. It is argued that the presence of natural assets such as green belts and natural components such as trees and water can effectively increase the quality of life through various ways. The environmental contributions of green urban parks include air and water purification, wind and noise filtering, or microclimate stabilization [1].In Iran, due to the abundance of fossil resources, subsidized energy consumption and low price of energy carriers, utilization of renewable energies are not considered properly. This issue led to the incremental air pollution in major metropolises [2,3]. In recent years, Tehran, as the metropolis and capital of Iran, commenced to find alternatives to fossil resources along with the expeditious exploiting of available renewable resources [4,5]. In the field of environmental engineering, environmental design and landscape design, urban Parks, developing of renewable energy technologies in the design of the urban parks is proposed as one of the major solutions.

The main questions relate to the renewable energy technologies which can be implemented in an urban park? What services do they provide to the parks? And finally, how do they contribute in the sustainability of parks and, in more general case, sustainability in the cities?

Documents and experiences are categorized in four groups: in the first part, the theoretical fundamentals of

renewable energy field (solar and wind) are introduced focuses on two types of renewable energy technologies is investigated. Then, other renewable energy technologies and their applications are studied. In the third part, international experiences in the application of these technologies in urban parks are presented and finally, the role of the renewables in the design of the urban parks in Tehran is described.

Current research aims to identify some of the most important experiences in the field of renewable energy technologies in urban parks and, especially, to note the necessity of applying this approach to the potential places in Tehran. The methodology used in this study is descriptive based on textual studies, and site observations of the parks in Tehran.

Today, more than 80 percent of world energy production derives from combustion of fossil resources which are exhaustible and non-renewable resources [6]. Due to the growing demand for energy resources, reduction of fossil fuel resources, necessity to conserve the environment, controlling the climate change and reduction of greenhouse gases, researchers have proposed many methods including the energy efficiency and the use of renewable energy sources [7-19]. Using renewables and promoting the concerning policies leads to a green world.

2. Overview of modern renewable

All Until the 1990s, a few countries promoted policies for the use of renewable energies where the number of these countries was raise to at least 73 in the early 2009s[20-22]. Among the renewables, solar energy, wind energy, geothermal energy, biomass energy, hydroelectric power, energy from the fuel cell and hybrid systems can be mentioned [6] where wind, solar, geothermal and biomass energies are the most important resources used in Iran [23]. In fact, these indigenous technologies are able to provide services with zero or minimum greenhouse gas emission or air pollutant. Near 14% of the world energy demand is supplied by renewable energies [24] while their contribution to energy production in Iran is less than one percent [25-26]. It should be noted that by 2030, renewable energy provides 29% of electricity generation and 7% of the transportation fuel. [27-29].

The sun as an energy source is the origin of life and the beginning of another alternative energies. The sun, which is about 333 thousand times the weight of the earth, can be taken into account as a great source of energy up to five billion years. Solar energy reaches the earth through radiation, conduction (conductivity) and convection mechanisms. The parameters which affect energy intake include: time, latitude, climate and the location [30]. Due to its dry and hot weather and with a minimum of 2800 hours of sunshine throughout a year, solar energy is regarded as a great potential source [31-33].

In the present era, solar energy systems are used for different purposes, which are classified as follows:

• The use of solar thermal energy for domestic, industrial and power generation,

• The direct conversion of sunlight into electricity by photovoltaic devices [34].

A system in which the solar energy is converted into electrical energy without any chemical reactions or moving parts is called a photovoltaic device. A solar cell element is used in this process. Solar cells are capable of direct conversion of solar energy into electricity with an efficiency in the range to 5% to 20% [35]. Due to the improved efficiency of solar cells, solar energy is now more popular than ever before [36-37].

The extraction of power from the wind with modern turbines and energy conversion systems is an established industry. Machines are manufactured with a capacity from tens of watts to several megawatts, and diameters of about 1m to more than 100 m. Traditional mechanical-only machines have been further developed for water pumping, but the overriding commerce today is for electricity generation. Such wind turbine generators have become accepted as main stream generation for utility grid networks in many countries with wind power potential, e.g. in Europe, the USA and parts of India and China; other countries are steadily increasing their wind power capacity. Smaller wind turbine generators are common for isolated and autonomous power production. Since about 2002, much additional generation capacity is being installed at sea in offshore wind farms where the depth is moderate.

One of the best methods of using wind power is to produce electrical energy. This means that by placing a wind turbine in the wind path, the mechanical power is transferred to the turbine and generator, thus producing electrical energy. In an operational approach, the kinetic energy of the wind is transferred into mechanical energy and then into electrical energy [38]. This turbines are categorized according to the rotational axis which is vertical or horizontal. The amount of electricity produced by wind in a location depends on the speed and the frequency. Generally, harnessing wind energy instead of the electricity generated from the fossil fuels contributes to the reduced greenhouse gas emissions. The natural beauty and landscape of wind energy systems are considered as a symbol of clean energy for the people [24].

3. Application of renewable energy technologies in the design of urban parks

Renewable energy technologies are used in electricity generation, thermal energy and heat production and liquid fuels. Seventy percent of the world's energy is consumed in cities that are considered to be one of the world's contaminated sites [39]. Parks are considered as one of the elements which shape the cities which has various public applications such as recreation, education, research and improving the health for people owing to their considerable amount of green space. In addition to the environmental impact, due to its green landscapes, they contribute to the beauty of cities [1]. One of the goals of sustainable urban parks plans with the use of clean and renewable energies is to install a large number of the renewable equipment to harvest renewable energies in the park and make this place an exhibition of sustainable energy for the future generations.

Implementation of this program, the use of renewable energies leads to improve parks, establishes the energy efficiency measures, as well as the positive environmental impacts on the global climate change. Modern technologies like solar and wind energies provide services by smart utilization of energy carriers in a location. These services are summarized for urban parks in Table 1 [40].

Table 1. Energy technology and services in designing of urban parks

Energy source	Energy technology	Energy service
Solar energy	Solar water heater	Hot water
	Solar thermal collector	Space heating
	Photovoltaic panels	Lightning Space cooling Other applications (water pumping, charging small electric devices)
Wind energy	Wind turbine and generator	Lightning Space cooling Other applications (water pumping, charging small electric devices)

In the following parts, the application of renewable energies in the design of furniture and lighting different places (i.e. walking paths, buildings, and parking lots) and other equipment will be mentioned in urban parks.

3.1 Urban furniture

Here, solar energy technology is added as a novel and innovative furniture in the urban parks. The renewable energy technologies are designed in such a way that, in addition to beautiful shape, provides maximum efficiency.

A) As figure (1) illustrates, Black Tree is a public solar charger for cell phones introduced by the Strawberry Tree. This company was the first which devised public solar charger for mobile phones. The completely novel design system has been installed since 2012in Tašmajdan Park in Belgrade. This system is developed as an artificial tree which is able to convert the solar radiated energy into the useful electrical energy.

Fig. 1. Setting up solar panels in the benches in designing urban parks

In this way, it contributes with the surrounding trees in a common struggle for the oxygen-richer earth. The length of the steel construction is more than 3.5meters and its height is 4.5meters which resembles the line of a real tree [41].

B) Typically, the park benches are designed to have stuck to be very simple. Figure (2) shows a park bench that seems to be unconfident at first, taken that it looks just great and seems more like an art sculpture than a piece of park furniture. The bench is called the Fresh Chair which is exposed in the sun's radiation from the enormous disk on its top which protects people from the sun's direct rays. The converted energy is then utilized to power up some ambient LED lighting at night. Moreover, the bench is able to produce a cooling mist during summer [42].

Fig. 2. The fresh-chair installed in the Seoul Park

C) Petal Benchresembles a gigantic flower open to provide the average fanciful fairy a place to rest. At night, the flower can be closed to follow the nature of flowers that also follow this timely ritual. Also, because during the day the Petal Bench collects solar energy, at night it lights up. Figure (3) depicts the Petal Bench [43].

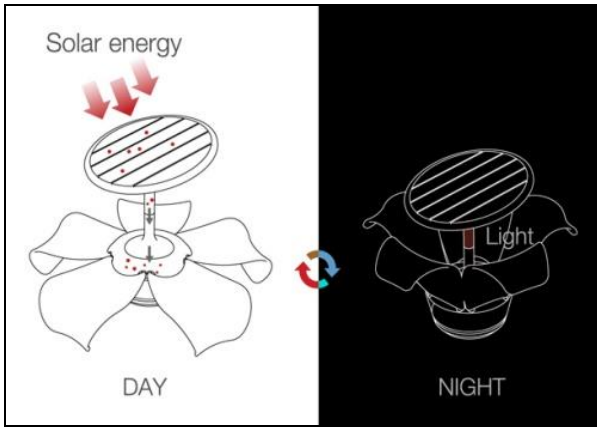

Fig. 3. The Petal bench

It is concluded that the renewable energy applications, especially photovoltaic cells, in urban parks furniture aims to form a beautiful canopy during the day and provide lighting later at night.

3.2 Equipment

A) At Bryant Park, as figure (4) depicts, City Charge fits right into any public space and works well with the current chairs and tables. The system has five wheels on swivel casters with brakes and its position can be easily change to make room for other activities such as programming, or maintenance activities. The solar panel is rotated manually to point due South. All the electronic components may be remotely controlled and monitored through proprietary software. These features along with other ones make this product an ideal selection for any public space. The idea is integrated to the street furniture so that it may be left outdoors for long time without the need of protection during rain or snow. Most parts are made of carbon steel with an electro-coated and polyester powder-coated finish. Other features include its end result to provide great rust and UV protection and the easiness to clean with residential grade cleaning products [44].

Fig. 4. The City Charge in Bryant Park

B) Other similar devices which work with solar energy and can be used in urban parks (Street Charge Station) is installed in Central Park in New York and Union Square. Figure (5) illustrates this project [45].

Fig. 5. Street Charge Station in New York Central Park

C) Whirlers is a large cluster of colorful wind turbines at Fresh Kills Park in Staten Island. The project is part of the Land Art Generator Initiative exhibition. The Whirlers design is based on the Darrieus, a popular vertical-axis wind turbine. The designers conceived of the project as a sort of whirling artificial forest of 10,000 colorful turbines that would give visitors the experience of walking amidst a spinning forest. Figure (6) illustrates this project [46].

Fig. 6. The Whirlers project in Fresh Kill

It is concluded from the aforementioned discussion that application of renewable energies in the urban park equipment is presented as a part of a public services such as charging electric vehicles for small devices that work with delivered energy from renewables.

3.3 Lighting sidewalks, passageways and streets

It seems that when the utilization of renewable energies is mentioned, the attentions are typically drawn to the urban park lights and solar photovoltaic cells which are the first practices in the harvesting of renewable energies in the urban landscapes. In fact, according to many studies throughout the world which were performed based on the sustainable development, they put the use of renewable energy in agenda in a way to at least provide minimum portion of lighting of the buildings and ways in the city.

A) City of Dubai in United Arab Emirates, which takes advantage of high solar radiation level due to geographical location and climate condition, recently installed solar-powered LEDs called Mizhar as shown in figure (7). The lifetime of these lamps is seven to ten years and are 80 to 90 percent more efficient than traditional bulb lamps. The lighting the streets and parking lots using Mizhar has saved up to 26 percent of electricity consumption, which also

prevents greenhouse gases from entering the atmosphere as a result [47].

Fig. 7. LED lamps installed in Mizhar

B) In another example, as figure (8) depicts, park Kimnyoung Maze in Seoul, South Korea, used solar-powered LED lighting in its pathways. The aim is to promote energy saving and environmental sustainability [48].

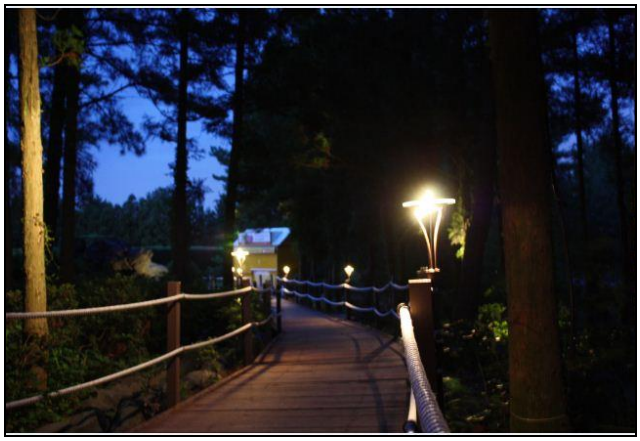

Fig. 8. LED lamps in park Kimnyoung Maze in Seoul

C) Chinook Winds Public Park & Sports area in Airdrie, Canada, took the commitment to sustainability to the next level. UGE's off-grid outdoor lights are used to illuminate the park's pathways as illustrated in figure (9).The system is entirely driven by the renewable energies. The lighting systems are chosen by Chinook Winds for two reasons:(1) goals for high light sustainability, and (2) its most flexibility and cost-effectiveness option as a novel lighting system. UGE outdoor lights cut Chinook Winds' installation costs in half and now provide 80% more reliability than traditional grid-tied streetlights. UGE performed a site analysis to offer a customized solution for Chinook Winds, making sure that the lights harvested the maximum amount of wind and sun to garner energy. Each light system features one of UGE's vertical-axis wind turbines and a solar panel, which work together to generate one kWh a day per streetlight [49].

Fig. 9. Hybrid system installed in Chinook Winds Public Park & Sports

D) Although the application of electric vehicle is increasing dramatically, providing them with a steady supply of renewable energy is an important issue. Figure (10) depicts a new project where the photovoltaic grove are used for two simultaneous functions:(1) acting as a go-to source for renewables, and (2) providing a shady place for cars to park while they are charging. Each of the trees in Neville Mars's solar forest is consisted of a group of photovoltaic leaves installed on an elegantly branching poll. The base of the trunk provides a power outlet which is utilized to juice up your eco ride as you run errands. Design of the trees and leaves wasn't a goal at first but came naturally as they tried to maximize the shaded surface that the structures provide. However, the energy efficiency of the overlapping PV panels raised some concerns at the beginning. The solar forest is definitely an aesthetic stride which serves as a great inspiration for integration of solar thermal technology with natural forms [50].

Fig. 10. The solar forest

E) Figure (11) illustrates the Quiet Revolution's QR5 is its VAWT design, aka Vertical Axis Wind Turbine. The VAWT enables the QR5 to harvest power from the wind energy near around buildings that change directions at a constant rate. It is also quieter than other typical wind harvesters since the tip speed is slower (owing to the triple-helix design) which in turn allows it to be situated closer to buildings and also on the towers. The QR5 is currently produced with 5m high and 3.1m in diameter. Two more sizes are currently being developed, the OR2.5 (2.5m x

2.5m) and the QR12 (12m x 6m). The QR5 currently costs about £25,000, which includes the purchase of the wind turbine, integrated control electronics, peak power tracking, auto shutdown and generator. Considering the placement and the local wind speeds, the QR5 will pay for itself within 15 years or less [51].

Fig. 11. Quiet Revolution Turbine

Using wide ranges of renewable energy technologies, the designers and engineers in different fields presented art lighting in urban areas and parks in an effort to create a more sustainable future. It is aimed to save power consumption and offset costs of energy as an innovative and environmentally friendly solution. Furthermore, the benefits for using renewable energies in lighting includes: this method does not need to install any heavy construction, has long life and different heights are available (tall and short standing lamps), they can be used inside and outside of buildings in parks, parking lots, streets, sidewalks and pathways.

4. Investigation of the role of renewable energy in urban parks Tehran

The Pardisan Park covers an area of over 300 acres including campuses for academic education, research and entertainment and located in west of Tehran. In line with environmental and educational perspective, much of the lighting in the park pathways and sidewalks is energized by solar energy (photovoltaic system) to exhibit the unity of man and nature (figure 12).

Fig. 12. Lighting part of the Pardisan Park using PV systems

Among other parks which take advantage of renewable energies is the Niloufar Park with an area of about four acres located in north of Tehran. The park has an educational center for energy conservation and energy efficiency to inform people of efficient methods of energy consumption and sustainable development. Moreover, classes held in the park for school activities and ordinary people. Energy efficiency center or in other words, the energy building is a place where the practical methods, presented and explained to the public and visitors. Important parts of solar water heaters, photovoltaic panels are exhibited and methods for insulation of buildings are presented as well.

In addition, in some cases, the manufacturers of vehicles with lower energy consumption are also invited to offer their products. Energy building in Niloufar Park takes advantage of both passive and active solar energy harvesting (figure 13). The east-west axis part of the building has large south-facing windows and this part was separated from the interior of the building, gaining solar thermal energy in a passive way. Using photovoltaic cells on the roof and solar water heaters (providing lighting and fraction of heating and cooling demand) may be considered as an active technique of solar energy utilization [52-54].

The park also has also the wind energy potential due to its topographical conditions, so a 1.5kW micro turbine energy harvester is installed on top of the roof.

Fig. 13. The energy building in Niloufar Park

The use of new technologies that work with renewable energies is seen in different parts of the park such as: heat supply to the park buildings, space cooling [55], lighting parking lot, pathways and streets, exploiting maximum energy efficiency and generating electricity through photovoltaic cells [56]. These are the means implemented in the case of some of the parks in Tehran to achieve sustainable economic growth, thereby reducing the adverse effects resulting from the incorrect use of energy on the environment and society. The proper utilization of resources is promoted as well as the improvement of landscape for the environment which all leads to the sustainable development in the city.

5. Conclusion

The urban parks in developed areas usually aim to minimize energy consumption in buildings and infrastructure systems, using modern technologies such as photovoltaic cells, wind turbines, thermal cells for heating water, principles applied in green buildings and indigenous renewable energies. In general, two main goals pursued for

renewable services: first, avoiding waste of energy efficiency and use of renewable energies in the proper position; second, providing educational opportunities for park visitors to train them energy efficiency methods towards the development of renewable and sustainable energies. At the end, it is stated that use of renewable energies, which are considered as a necessity in developed countries, is a great investment. Owing to the climatic conditions and possibility of using high-level solar and wind potential in almost all year round, Iran has the opportunity to pay more attention to the use of this technologies and services in its urban parks.

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