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The Use of Photovoltaic Energy for Sustainable Urban Development Emphasizing economic and Environmental Considerations

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ABSTRACT: Solar energy is one of the pure and non-detrimental resources for environment which has long been utilized by humans. Therefore, in order to move toward sustainable development, it is required to pay attention to practical and scientific use of renewable energies such as solar energy even more seriously than before. Hence, one of the main objectives of sustainable architecture is to move toward designing solar buildings and supplying heating and cooling needs of buildings by renewable energies. Among the important characteristics of benefiting from renewable energies such as solar energy, one could refer to their purity and nonpolluting features which lead to removing greenhouse gas emissions, free costs and availability, safety and finally reducing fossil fuel consumption. The present research is a descriptive and analytic study and it should be noted that the advantages of using solar energy in an administrative building is examined. Given the utilization of solar photovoltaic panels in the building of Ministry of Economic Affairs and Finance, the method for selection and the advantages of utilizing the aforementioned technology for sustainable urban development with respect to economics and environment will be investigated.

Keywords: photovoltaic energy (solar electricity), sustainable development, administrative building.

INTRODUCTION

Today, the issue of utilizing fossil fuels has turned into a social crisis and problem. The issue is deeply discussed regarding different aspects including environmental problems, the running out of the fuels and economic problems. The fuels are among concentrated chemical energies and can definitely have better uses than combustion. One the other hand, according to the recorded statistics during the last 42 years, the global energy need has dramatically increased. Hence, the world in the contemporary era is experiencing years of common effort by human community in order to control carbon emission, control environment and continue the survival of human beings on the earth. Thus, human community is looking for alternative energies amiable with the environment, infinite and secure. Hence among the renewable energies, one could refer to resources such as the energy

*Corresponding Author Email: bagheinee@yahoo.com Tel. +98 912 607 19 40 Fax: +98 897 79 793 of wind, wave, biogas, the earth and the sun. Solar energy is the largest energy resource in the world as it is the origin of energies on the globe in the sense that the energy taken from the sun in an hour by the earth is more than all of the consuming energy on the earth during one year. Given the increasing air pollution in large cities and greenhouse gases and the detrimental effects of environment due to fossil fuel consumption, it is undeniable to see the movement toward renewable energy and expanding new energy technology such as solar energy in Iran. Given the characteristics and advantages of using photovoltaic systems for sunny country of Iran, using cooling and heating systems, ovens and refining water devices, heating water, water saving resources and even selling energy to the over-consuming network of governmental organizations need to be more highlighted. Accordingly, in order to create the culture and the importance of pure energies, the overall plan for public organization and institutes' use of solar energy was approved by the Energy Commission of Islamic Council. In similar vein, The Ministry of Economic Affairs and Finance located in 12 districts of Tehran as the executer of photovoltaic systems and in cooperation with Tehran Electricity Distribution Company started using the system. Therefore, the study with two objectives, the first one the ideal purpose for determining the best and most suitable way for using the energy in buildings for sustainable urban development and the specific objective which is applying photovoltaic systems in administrative buildings of The Ministry of Economic Affairs and Finance in order to have economical use of fossil fuels. By using analytic-descriptive method, the research investigated the principal concepts and theories in photovoltaic energy in order to make a large step for identifying the informational needs and collection references for photovoltaic energy by scholars, scientists and international organizations and executors of photovoltaic energy system in The Ministry of Economic Affairs and Finance in the way that the subsets of each title were examined as much as it was possible. In addition, the research is retrospective, contextual, temporal and a case study. Accordingly, it seems that given the reports for technical-economic implementation of plans related to photovoltaic system and the obtained energy from the system (around 30 % of the total electrical producing energy through among the developed countries is obtained from solar electricity), in addition to moving toward gaining an international standard, there is a significant relationship between the serious decision for environmental and developmental movement and reconstructing other administrative buildings and optimized use of consuming energy.

MATERIALS AND METHODS

The literature suggests that fossil energy resources will decrease in the future and there is a desperate need for alternatively pure energies as the researchers are looking for. In so doing, solar energy and applying solar energy is suggested to be the most cost-effective method for using renewable energies in the modern world. That is why most of the developed and developing countries are largely investing on this issue. Given the fact that in Iran, the sun irradiance annual average is around 5 KW per day, the number of cloudy days in a row is less than five in a year, hood transparency in most parts of Iran is more than 60 percent and the sun irradiance is higher in highly-elevated areas and our country is mountainous and most of the areas are more than 1000 meter high, it is simply argues that applying solar energy in Iran will be definitely cost-effective. 6 methods for producing electricity from the solar energy have been recorded so far: 1. solar mirror, 2.central sharing receiver, 3. concave mirrors (plate-string) 4. Solar chimney, 5. Solar pool, 6. Optic silicones (photovoltaic) (Romi *et al*, 2013).

Photovoltaic energy

A phenomenon by means of which and without using mechanical mechanisms of irradiance energy that are turned into electrical energy. In fact, the phenomenon is based on the granulations of irradiance energy hypothesis and any system that uses this characteristic is called a photovoltaic system. The system directly changes the available energy in the sun into DC type electricity by solar cells. By using the obtained electricity and electrical and electronic equipment, it is possible to supply the electrical energy of AC and DC loads. Photovoltaic system consists of three major parts including:

- 1. Module or solar panels which are the convertor of solar energy into electrical energy.
- 2. The medium or the desired power manages or inspires the obtained electrical energy from photovoltaic system based on the predetermined design in concordance with the consumer needs. The equipment mainly uses control charge, battery, invertor, etc. It is designed according to the needs of the consumer.
- 3. The consumer or the electrical load: including all of the electrical consumers such as AC. DC.

The main reasons for the growing interest to photovoltaic industry (solar electricity) in Iran and annual growth are as follows:

- 1. Lack of need to fossil fuel and supplying fuel problems
- 2. The potential for production in the consumption place, reducing the costs for transportation and distribution of electrical energy and lack of the need for having thorough electricity network in the country.
- 3. The possibility for installing and implementing in different powers suitable for consumer needs.
- 4. Appropriate lifetime and easy utilization.
- 5. The possibility for installing on the façade.
- 6. The possibility for installing on the façade, ceiling and roof and the ability to store the energy in the battery.

Photovoltaic photonic cells

In order to obtain the solar energy, it is essential to have solar photovoltaic collection which is done by interconnected parts called panel in the sense that the solar photovoltaic thermal collector is a combination of photovoltaic panels and thermal solar cells' parts producing electricity and heat simultaneously in an interconnected system. Therefore, photovoltaic panels and thermal solar panels work with each other. In fact, the structure of solar cell is similar to a Diode consisted of pion with two conductive halves of n and p. As a result of this bond and the movement of the added load between the two, in the place of two conductive halves' bond, there is a bending in energy band that the formal energy of the two halves becomes equal. As a result of this bending, the electrical field between the two conductive halves is created from n conductive half to p conductive half. When the sun is irradiance on this bond, the photons with higher energy than semi-conductor energy gaf excite the conductive half causing electron pair production and hollow. After the electron pair production, the electrons and hollows are separated from each other by the field existing in the bond and the electrons move toward n semiconductor while the hollows go toward p semiconductor. By the semiconductors, the load carriers move toward external circuit and we will have electrical current. In this way, solar energy is absorbed by solar cells and changed into electrical energy (Chin, et al., 2015). As mentioned above, the performance of the solar cell is schematically shown in (1). Solar cell technology could be divided into three generations: first generation solar cells which are crystal silicon and are today highly mature and are based on two crystal silicon of n and p bonds. Pure silicon which is an inherent semiconductor with direct energy gaf of 1.1eV could be changed into semiconductor of p and n by making it impure. The record for these cells' feedback is 20.6% obtained in 2014. The technology for creating crystal silicon cells is too costly due to having large crystals in high heating structures. Given the fact that the technology has reached its final maturity, it is not expected to have price reduction for these types of cells. That is why in early 1980, the ideas for the technology of thin film solar cells emerge. Some of the factors for increasing the cost of a solar cell are as follows:

High cost of the used materials in creating the cell.
Costly methods for producing the cell.

In order to reduce the cost of primary materials for creating cells, some materials should be developed that are not based on single crystal and not made of costly materials. In addition, the volume of consuming materials for creating cells should be reduced as much as possible. The emergence of second generation solar cells or thin film solar cells was seeking for solving this problem. The solar cells are based on thin films generally made of low cost materials such as amorphous silicon, silicon Nano-crystal, cadmium telluride, indium de selenite copper, etc. and the amount of used material is little due to the thinness of the cell films. Costly methods for producing cells which generally low speed production, is another factor for increasing production costs. High temperature processes (more than 573 K) an in vacuum are the first methods which are costly with low speed and small production dimensions (Bailie, et al., 2015). This problem is to a large extent solved in thin film solar cells based on solvent. In order to deposit these types of cells, printing and spraying methods were introduced which are cost-effective, speedy and large producing dimensions (100 times larger). Despite the advantages noted for the second generation solar cells, they have short life with lower feedback than first generation cells (Aguas, et al., 2015). The design of third generation solar cells is based on new concepts such as quantum and new materials such as nanoparticles. Indeed, now there is no distinctive dichotomy between different generations of solar cells since scholars try to achieve highly effective cells by integrating the concepts of three generations (Lamb, et al., 2015).

Photovoltaic system

Photovoltaic phenomenon is defined as a phenomenon creating electricity as a result of irradiance without using stimulus mechanism has showed in Fig. 1. The system using this phenomenon is also called photovoltaic system. The system is one of the most used new energies. Up to now, there have been many systems with different capacities (50W to many megawatts) in the world. Given the reliability and the performance of the systems, there is an increasing number of applicants for these systems. It is possible to have acceptable current and voltage by parallelizing solar cells. Photovoltaic collector changes some of the solar energy into heat and others into electricity. Applying photovoltaic systems for using sun is so common. Using photovoltaic panels is increasing in developed countries. A major part of photovoltaic system is pill photovoltaic. Photovoltaic panels exposed to sun are made of photovoltaic cells. The cells consist of semi conductive silicon materials. Other parts of the photovoltaic systems after panels are: medium part, consumer (electrical load).



Fig. 1: Photovoltaic panel performance

Medium part: The obtained electrical energy from photovoltaic systems and according to conducted design appropriate to the needs of consumer. The equipment usually includes control charge, battery, invertor etc.

Consumer: all of the electrical consumers including direct electricity consumption and in correspondence with the amount of consumption (Raghuwanshi, 2015). Different methods for using photovoltaic systems

- 1. System connected to the overall electricity network
- Systems independent of the network: A) system of feeding for a residential building, B) water pump system by solar pomp. C) Seismology station feeding system, D) photovoltaic power station (Salas, *et al*, 2015).

Changing a photovoltaic power station to a photovoltaic sub-network

Changing a photovoltaic power station to a photovoltaic sub-network requires two stages of designing and utilizing the system. In designing stage, the required equipment should be identified and for each of the appropriate capacity should be assigned. The most important issue in designing stage is determining optimized capacity of the battery for adding to the photovoltaic power station. After determining the capacity of battery bank system, utilization stage starts. Utilization of solar subnetworks includes two major parts of higher control or energy management and sub-network convertor control (Kobayakawa, *et al*, 2015).

Photovoltaic sub-network designing stage

In order to design a solar system for an administrative building, there are certain phases for a design that should be taken into account. The first phase is to obtain accurate information about the given environment and climate. Hourly information about the climate and environment in an area during two years is used. Instead of hourly information, it is possible to use average daily or monthly information and the data were used for systemic design in Greece (Good C, *et al*, 2015).

In order to examine the accuracy of information in solar system by using hourly and daily information, the results were compared. The second stage in solar system designing is to analyze consuming load model and similar to climatic information, it is possible to use medium or hourly information. The next task is to gain statistical information about electricity network breakage (Tse, et al., 2016). Here, the potential features of electricity breakage are obtained based on statistical information during 5 years. Since the reliability of city electricity network is not enough for load supply, installing photovoltaic system was proposed. In order to achieve appropriate capacity of photovoltaic system, the optimized probability for loss of load probability (LOLP) should be calculated. In a sense, the optimized LOLP belongs to the systemic capacity which has the least total cost by considering the costs of electricity breakage. Hence, the loss of electricity breakage should be considered among the costs. The losses imposed on the consumer due to electricity breakage could be evaluated by a parameter called ICDF. Measuring ICDF was significant issue of reliability. There are many studies conducted for measuring ICDF by different proposed methods. To the researcher's best knowledge, no study has been conducted on designing photovoltaic systems considering ICDF parameter. The next stage in designing photovoltaic system is to identify the used technology in Modules and the type of mechanism for solar Module movements for tracking the sun. The most important used technologies incorpo-

rate mono-crystal silicon, multi-crystal silicon and thin film silicon or a combination of technologies. In many cases, solar modules are used along with multi-crystal silicon technology since this type of module is common in Iran. In addition, the installed arrays on the two-axis engine are used for taking the maximized solar energy. The mechanisms for tracking sun movement for arrays are arrays with constant angle, arrays with single-axis engine and arrays with two-axis mechanism are used for taking the highest amount of energy. Adding battery and invertor is the last stage in designing photovoltaic system. There are two methods in order to achieve suitable battery capacity. The first way is a sensing or estimating process. This method is used for achieving suitable battery capacity. The advantage of this method is that is does not need accurate climatic information and does not have calculations. However, the capacity of the battery may not be precise and it may be too large. Another method for determining battery capacity is to use numerical simulation. In this method, the battery charge status and load supply by photovoltaic system is for a time interval of hour or day. By considering the accurate information, battery model include charge status, battery lifetime, load and climate information and battery capacity. Nevertheless, in this method, electricity breakage is not taken into consideration. Ignoring electricity breakage means that the system is always connected to the system and the emergency situation never occurs which is not an appropriate hypothesis. Electricity breakage should be taken into account and the battery capacity for a system with commercial building load is achieved by considering the minimum reliability. This is done for different capacities of solar arrays and among which the most cost-effective one will be chosen. The important point is that for any capacity, solar array of battery present reliability. However, essentially, since solar array is not the most costeffective option, here, a battery system with certain capacity should be designed for a set of solar array of 110Kwat along with an administrative building (Han, et al., 2016).

The stage of utilizing photovoltaic sub-network As mentioned above, utilizing photovoltaic subnetwork includes two main parts of higher control and converter control. Different methods for higher control of photovoltaic system are presented. By using status machine method, higher control decides based on system status to present a certain point for battery convertor. By using battery charge status and DC, higher control decides for determining the point. In a sense, the conditions of the system change based on the fact that DC or battery charge trespass its range. By providing some simple conditions, higher control will be possible. Although the method is simple, it is not necessarily optimized since in this method the major resource supply is the array power and if the consuming power is more than that of producing array, the battery will start to de-charge. Another important issue is controlling photovoltaic system convertors. Photovoltaic system is formed of invertor, network direction, bidirectional battery convertor and array convertor. The most important challenge for array convertor is significant changes of the points. The reason is that array convertor should maximize Maximum power point tracking (MPPT) according to higher control order. Hence, the point changes in a wider interval. Array convertor controller should be characterized as being able to have appropriate response to significant changes of the point. Using compatible controller control method is designed and the results are presented for a practical case. The issue is also examined with controller design (PID) and the practical results are presented. However, no reference was made to setting controller parameters. Yola parameter determination method was used for designing array convertor controller. Another important challenge is in controlling converters in photovoltaic system about invertors since photovoltaic system load significantly changes and the changes in the convertor are manifested as changes in the load. However, the issue is solved by presenting the method of using feed-forward. However, using feed forward has its own problems while the most important one is worsening stable status of the system. Moreover, generally, the challenge for practical applications is that usually there is not accurate converter model and many of the parameters are not exactly identified (Yang, et al., 2015).

In order to cope with the proposed challenges, Active Disturbance Rejection Control method (ADRC) is suggested in many cases. Although nonlinear control methods such as feedback linearization, liapanov, compatible control etc. have had many advances in the theory, in practice, PID is the most effective one in industry. The most important weak point about available nonlinear controls is their high reliance on the accurate system model. In industry, uncertainty of many parameters is undeniably common. Hence, the presented controllers could not be the alternative for PID in industries due to reliance on system model.

Module modeling and solar array

Photovoltaic cell produces low voltage and high current. Hence, usually a set of photovoltaic cells are connected to each other. The set of cells are called a panel or a photovoltaic module (Gu, et al, 2015). By connecting numerous cells in a series, the photovoltaic module voltage increases. Therefore, the loss of conductivity in the cables will decrease. Module is known as the building block of a large photovoltaic power station. Many modules are connected to each other in a series and form a module string. Thus, the voltage will increase. By connecting many strings in parallel way, array will be formed. In order to make an array work correctly, there should not be a shadow over the modules. Otherwise, the incorrect performance of the system will lead to heating which could damage photovoltaic cells. By-pass diodes are used for preventing damage to solar cells. However, it should be noted that it will result in increasing primary price of the system. The power of a string is usually from hundreds of W to many Kwts. The range of power for arrays starts with hundreds of w to hundreds of megawatt for large solar power stations (Teo, et al, 2015).

Irradiance atlas analysis

According to the measurement, the annual average of sunny hours in the country stations were 2954 hours shows in Fig. 2, while the central and south eastern had the highest value (maximum in Saravan station: 3408 hours) and northern shores had the minimum values (the minimum in Ramsar station: 1587 hours). The average for annual sunny hours is confirmed by verified reports of the ministry of Energy to be more than 2900 hours. The average for annual changeability of sunny hours of the country is 5.3% that it has the minimum changes (2.4% in Biabanak) and in northern shores the least sunny hours are there. The highest changeability is in Rasht (10.1% in Rasht station). The distribution of seasonal averages of sunny hours is similar to annual average. Increase in sunny hours toward the south and the east could be attributed to becoming closer to the areas of highly pressured and hot and not having enough humidity to the area. The only exception is reduction of sunny hours toward southern and south eastern shores especially during summer which somehow shows itself in the annually situation. The reason is increase in the humidity of shores and summer seasonal system influences on these areas. Decreasing sunny hours toward the north is not unexpected due to short waves and western silicones during winter, its reduction in the Caspian Sea shores seem natural due to the density of humidity in this narrow plain. The summer sunny hours of the country are a less than the twice as much as winter sunny hours as shown in Table 1. Mojarad and Moradi (2014) concluded that temporal trends of sunny hours by using linear regression equations in more than half of the area of the country (56%) show that 16.6 hours annually have significant increase. The trends are observed in western, eastern, south eastern and southern parts of the country. The highest increasing trend is in Jask station in the marginal coasts of the country with 32.5 hours in a year while the lowest one was in Shahrjord with 7.1 hours in a year. In 44 percent of the rest of areas, there is no significant trend (although the values of the trend are positive, no station in the country showed a significant reducing trend). The same story is true for the season trends and generally in four seasons, the same areas show significant trends (Mojarad and Moradi, 2014).

Although electricity production by photovoltaic does not depend on the seasons, during the whole day from the early hours of the dawn to the sunset, they can produce electricity. The peak of their production is during the noon. Photovoltaic units could produce electricity if the weather is cloudy although their output will decrease. In a cloudy day with low light, the photovoltaic system may receive 5 to 10 percent of solar irradiance and the output correspondingly reduces. Solar panels produce more electricity in lower temperatures. The equipment such as other electrical devices works better if the weather is not too hot. Photovoltaic systems produce energy in winter days less than summer ones and the reason is not only the cold weather but the reduction of day hours and lower solar irradiance angle. Usually, panels are installed with 30 degree angle toward the earth in the south and the angle for each season needs to have some trivial changes. In winter it should be 25 angles while in summer



Fig. 2: General annual irradiance atlas in Iran over the horizon

it must be 45 angles which is averagely installed as 30 degrees. Photovoltaic systems produced in industrial ways nowadays, are classified into two broad groups of crystal silicon as the first generation technology and film thin as the second generation technology.

The international market for producing the photovoltaic cells is increasing. The growth has been around 50% since 2003.In 2006, it was 2megawat and in 2007 it went more than 3.4 Gigawatts. The installed photovoltaic capacity in the world is increasing. The value will go more than 67.4 Gigawatts by the end of 2011 which is half percent of the world demand for electricity. Large photovoltaic markets in the world consist of: 1. Germany with 26% hare, 2. China with 16% share, 3. Northern America with 12% share, 4. Italy with 11% share, 5. Japan with 7% share, 6. France with 4% share, 7. Greece with 3% share, 8. Australia with 3% share, 9. India with 2% share and Britain with 2% share and other countries with 14% share (Lewis, 2016).

Economic considerations in utilizing energy

There is a consensus in European Union on the law explaining that energy consumption must be equal to house production. The law could be the model. Houses and cars both have detrimental effect on the atmosphere. Vehicles using fossil fuel and the energies used in the houses play the most important role in producing greenhouse gases. According to the law agreed by the EU, in near future, houses, offices and restaurants will be built in a way that they will not hurt the atmosphere since they should produce as much as energy they use. The law could be a model for other countries. In order to achieve agreements, representatives from European parliament, council and EU commission were discussing the issue for months. The law is not still approved by the parliament and minister council. There seems to be no problem. The law will be enforced in 2021. It was already decided to consider 2018 as the deadline. The law will not include the past (Jalali and Moti Birjandi, 2010).

Houses with zero energy

Houses with zero energy is a term considered for the new generation of green buildings since all of the required energies are produced in the building and is supplied by the systems producing green energy. Zero production is also true for building complexes since in these complexes, fossil fuel is not used. Therefore, production of carbonic gas will be zero. The complexes have a comprehensive system for minimizing the waste, water consumption, energy use and the need to importing energy since the whole required energy is produced inside the complex. There are some plans for constructing the first zero energy houses in San Francisco and building this house will be a model from an effective green plan for constructing similar houses in the world since the building will be constructed in an archeological city. One of the remarkable points about the city is the design of the buildings for optimized use of energy. The buildings are self-sufficient with regard to electricity production in the sense that the required electricity is produced by the photovoltaic device installed on the roof of the building. The 8 kilowat device is able to supply the required electricity for the building. Effective house electrical appliances and low consumption lamps minimize the required electricity. The building is from the north to the south and solar panels have angles so that they could be used as the maximum solar irradiance during the morning and the afternoon (Jalali and moti Birjandi, 2010).

RESULTS AND DISCUSSION

Examining the use of photovoltaic energy in the building of the Ministry of Economic Affairs and Finance

The building was constructed around 70 years ago with the area of 95000 square meters in Tehran

Naser Khosro Street. The skeleton of the building is concrete in six floors and the ceilings are made of bars. The external and internal walls of the building are pressured bricks in 11 and 22 centimeters and the facade is 3 centimeter Travaton stone and the internal walls are made of plaster. As mentioned above, given the advantages of using photovoltaic system such as the purity of solar energy, the infinite, available, free, and secure resource in the ministry, the device was used and by the end of 1393 in two phases, the plan for using photovoltaic energy with the capacity of 70 kw including 21 invertor and 144 solar panel was conducted. The geographical length of the site is 51.420981 and the altitude is 35.681624. The used panels in the project are solar world and their feedback is 17 percent. It should be noted that for any kilowatt of the electrical energy obtained from a photovoltaic system 10 to 12 square meter space is needed for installing solar panels which were installed on the roof of the building. Moreover, the price for the equipment and the solar panels, battery and convertors for each kw, energy equals 4 million Tomans.Some parts of photovoltaic energy in the building of the Ministry of Economic Affairs and Finance show in Fig.3, Fig4. Fig.5.

Economic justification and the advantages of solar energy

Photovoltaic energy has many advantages more than energy supplying some of which are:

- no need to fossil fuel
- Intangible difference between producing energy in the best and the worst place with regard to solar irradiance
- reducing the environmental pollutions
- infinite access to solar energy for changing into electricity
- high lifetime



Fig. 3: Solar panels used in the Ministry of Economic Affairs and Finance for photovoltaic system

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Fig. 4: Inventor used in The Ministry of Economic Affairs and Finance for using photovoltaic system



Fig. 5: Three phase electricity used in The Ministry of Economic Affairs and Finance for using photovoltaic system.

- easy installation and implementation and no need to complex equipment or human force
- low probability for risky incidents such as explosion or fire
- Reducing energy waste (transfer and distribution of energy from the production point to high consumption)

By using photovoltaic energy panels in the point, the production reaches consumption and energy waste will decrease. On the other hand, while paying heavy electrical bills in summer is one of the people concerns, solar energy has high economic justification for high consuming users. Moreover, the guarantee for returning the investment on solar electricity power station is between 10 to 15 years and it should be noted that although the solar electricity production method is costly at the beginning, it will show its economic justification after the time mentioned. Given the increase demand for electricity and limitations of fossil resources and increase in the pollution from the resources, using the solar energy has some economic justifications. Fig. 6, is an example.

As shown in the Fig. 7, energy reduction is significant and this is achieved by solar energy.

The effect of photovoltaic energy on environmental Kuznet curve in Iran

According to the theory of Environmental Kuznet curve (EKC) in the early stages of economic development, economic growth leads to environment pollution. But from a threshold level onward, the economic growth has some reduction in environmental consequences. In fact, the relationship between the two variables is similar to upside-down U. EKC is one of the instruments and methods for examining the environmental effects of economic growth and many studies examined it by using national and international data.

The studies related to EKC examined the relation between different variables of economic and environmental growth in a desirable way. To simply put the hypothesis of EKC, there is a U-like relation between some pollution indexes and one of the economic growth indexes. In other words, by increasing economic power of the society, environmental loss is primarily increase. But finally after reaching the threshold of economic growth, due to some reasons such as people awareness of damaging the environment or moving toward making the economics more service-based, the descending trend of the



Fig. 6: The electricity consumption during 2009-2015



Fig. 7: The rate of electricity consumption reduction by using solar energy

curve starts. The climax for this curve is non-polluting growth status. EKC is based on LAD and LS by using genetic algorithm. In the following, first LAD method is examined and then theoretical and mathematical structure of the EKC in dynamic and static status is discussed and finally, genetic algorithm and the optimizing parameters are discussed.

Least absolute deviation

LAD was proposed by Koenker and Basset (1978). Similar to OLS method in which the conditional mean estimates the dependent variable (E(y/X)), the LADs are robust method for measuring regression conditional mean. When error sentence distribution has thick tail, LAD will be more efficient than OLD (Dasgopta, 2007).

Furno (2001) showed that if erroneous sentence distribution is abnormal, erroneous sentence test is obtained from LAD method which is stronger than when erroneous sentences are obtained from OLS method. Machado and Silva (2000) indicated that LAD with skewed method in the remained values, the test will be improved for examining the variance of Heteroscedasticity. Hitomi and Kagihara (2001) proposed Nonlinear Smoothed LAD (NSLAD) which is practically measurable.

Hence, in order to estimate the parameters of a nonlinear pattern instead of minimizing RRS in different periods of time, it is possible to minimize the sum of absolute deviation of the expected value from the observed value. In most cases, this type of minimization is called LAD. A large number of studies are conducted showing the expected parameters with the target character function that are better than when it is RSS (Dasgupta and Mishra). Given the proposed characteristics for LAD in this study, LS and LAD methods were used simultaneously for nonlinear EKC (with having renewable energies).

Expanding EKC with renewable energies

By increasing the share of renewable energy for the whole energy, pollution decreases in a certain level. One of the objectives of the research is to find the photovoltaic energy share from the whole energy in non-polluting point of EKC in the current condition of economics. In this section, two pollution functions namely dynamic and static will be defined based on their fossil and renewable energies and the relations are based on nonlinear parameters (1 and 11 equation). Equation 1 is the pollution function show fossil energies and renewable energy based on based on production in a static long term equation. Equation 1 is the expansion of nonlinear relation of pollution in Islamloyan and Ostadzad (2012) with few changes. In the following, the parameters of this equation will be discussed.

1)

Where y_t , p_t , n_t and rt are the income, pollution, fossil energy and renewable energy. All of the variables are considered here. Moreover, Θ , A, α , and variables are the model parameters. Based on the EKC hypothesis, the pollution function based on the income should be concave.

Therefore, by supposing the EKC hypothesis based on Eq1, the following limitation is imposed on α parameter:

2)

On the other hand, pollution changes based on the production is in the form of Eq3 which is possible to estimate the model parameters and put them in the Eq in order to know the descending and ascending process.

3)

In addition, by increasing production and more use of fossil energies, the pollution increases and pollution growth decreases. Therefore, the pollution for fossil energies will be an ascending and concave function. As a result, according to eq4 and 5, the following limitations will be considered: 4,5)

Given the Eq 4 and 5, it is concluded that. On the other hand, by increasing production and more use of renewable energy which is considered as an index for increasing production technology, it is expected from the pollution to decrease. Given eq 1, we will have

6)

In the maximum (no pollutant point) of EKC which is it is possible to measure the share of renewable energies.

7)

Given r definition, it is possible to use eq8 to measure the share of renewable energy to the total energy at the maximum point of EKC.

8)

Now, the pollution function in dynamic situation will be discussed. In the framework of the given model following Iwata *et al* (2010), by few changes in the model, it is presumed that change in environmental pollution is made of three parts. A part of pollution release which happens as a result of production process and is identified as a by-product along with the production and the part of the pollution that is naturally cleaned by the environment. In Eq9, change in the environmental pollution () consists of three parts. The first part shows pollution release as a result of production process and is known as a by-product along with the production. The second part () is the level of nature absorption in each period

9)

Given Eq.9 and simplification process, we will have the following:

10,11)

Given the above Equation, the share of renewable energies in maximum point of EKC is measured as the following:

12)

By taking derivatives from equation 12, we have: 13)

By simplification, the share of renewable energy is measured by using Eq18.

14,15,16,17,18)

Pollution change for increasing the use of renewable energy is depicted in Fig. 8. The chart indicates that in the early stages of increasing the use of renewable energy, pollution is dramatically reduced. Given the concave changes of pollution for renewable energies, by increasing the use of renewable energy, the effectiveness of the energies on the pollution will decrease:

24)

CONCLUSION AND SUGGESTIONS

After implementing the photovoltaic system in the building of the Ministry of Economic Affairs and Finance with the capacity of 70 Kw and its delivery by the electricity distribution company in Tehran, it was according to the investigations and was based on the monthly implementation in 7700KW and annually 92400 KW which equals 30000000 Rials per month was saved in electricity consumption which was around 10 percent of electricity costs. Given the trivial maintenance costs (about 1 percent of the total price in the year), and lack of pollution of the environment, it is cost effective. Among other results of the study, one could refer to the creating culture and movement toward pure and renewable energies in Iran, the possibility for saving the obtained energy of injecting the added value to the network and reducing the consumption of fossil energies.

It is observed that how it is possible to prevent fossil energy and by utilizing solar energy, optimize energy consumption. The Fig. 9 shows consumption decrease based on which, the pollution in the environment decreases and in addition to energy supply, it is



Fig. 8: Pollution changes to increasing the use of photovoltaic energy

possible to consider environment protection. Therefore, economically speaking, solar energy is cheaper and more suitable than fossil energy.

According to the Fig. 10, it can be argued that reduction in energy consumption is significantly observed. That is why one could argue that by applying solar energy in governmental buildings in which electricity consumption is remarkably high, it will decrease through photovoltaic energy application and it will have environmental advantages such as reducing the pollutants as well as economic benefits.







Chart 5 shows the consuming electricity in District 12 in Tehran after using photovoltaic energy



Fig. 10: shows the consuming electricity in District 12 in Tehran after using photovoltaic energy



Fig. 11: Comparing before and after applying photovoltaic energy in Districts 12 and 22

According to the Fig. 11, it can easily be argued that the level of energy consumption in two districts is fluctuating. Therefore, given energy supply in a district and achieved success in the considered objectives, it could be developed in other districts. Thus, statistical considerations of the study are generalizable for developing in other districts which were about reducing fossil energy consumption. Since Tehran is one of the large cities of Iran and energy consumption is dramatically increasing, it is vital to present suitable solutions for achieving alternative energies. One of the important solutions is to replace energy in the buildings. In so doing, it is first essential to start with governmental and organizational buildings and then, the replacement will include other administrations, residential complexes, residential settlements, universities, schools and commercial towers. For this purpose, attention must be given to architectural considerations. In order to achieve the objectives, it is necessary for the specialists in the municipal of Tehran province to pay more attention to sustainable and green architecture in constructing architectural buildings and prevent constructions that develop energy consumption. Sustainable architecture paves the way for the building to supply its energy, help the environment in addition to economic savings. It is clear that attention to the environmental culture and achieving sustainable urban development is a difficult but realizable issue. Given the high consumption of electricity provided from fossil energy and the majority of energy consumptions in buildings and urban streets, it is essential to take measures for reducing energy consumption. As indicated in the statistics and results of the study, decrease is energy is tangible. One could use solar energy as much as possible and apply it in other parts of Tehran. Sport buildings, administrative buildings, schools, residential houses, commercial complexes in Tehran have increase electricity consumption in Tehran. By solar energy an attention to sustainable urban architecture, it is possible to move toward optimizing solar energy and move toward pure energy. This will be an effective step in sustainable urban development and means the essential attention to architecture and urban buildings.

Given the annual average irradiance, the place had 5.90 KW to square meters and the sparse irradiance was 1.29 KW hour to square meter. Therefore, if there are 456 panels, the total produced energy by the panels in a day equals 587.88 KW hours and annually it will be measured based on the conditions of the site which is 214.57 MW.

Therefore, it is possible to increase the capacity of the above-mentioned system in the building of Ministry of Economic Affair and Finance up to 200 KW (130 KW increase). The cost for providing the equipment and implementing the system is 6 billion Rials. In this part, if buying the produced energy by the Tehran electricity distribution company is 6750 Rial for each Kw, the income for selling the electricity will be 1.44 billion Rial annually. Given the real conditions for Power station, after 4 years, the gained income from selling the energy will waste the primary investment and is considered as pure profit which is more than 23.17 Rial after 16 years (20 years of power station existence). With respect to using pump system of water by solar systems, it is possible to use feeding station system and protecting photovoltaic energy by gas pipes in the building.

Moreover, the expected parameters and the data in 1391 show that the tendency for pollution to using renewable energy equals -0.07 () that is, by 1 percent increase, using renewable energy given the status quo of Iran, the pollution will decrease 0.0.7 percent per capita.

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