Asl, Mahdi Ghaemi; Manzoor, Davoud; Mousavi Barrodi, Mahdi

Article

On-grid simulation of distributed generation (DG) of renewable electricity in urban lighting in the context of sustainable urban management (case : Mashhad)

Journal of urban economics and management

Journal of Urban Economics and Management

To cite this document: Ghaemi Asl, M., Manzoor, D., & Mousavi Barrodi, S.M. (2019). On-Grid Simulation of Distributed Generation (DG) of Renewable Electricity in Urban Lighting in the Context of Sustainable Urban Management (Case: Mashhad). *Urban Economics and Management, 7*(2(26)), 85-98.
www.iueam.ir
Indexed in: ISC, EconLit, Econbiz, SID, EZB, GateWay-Bayern, RICeST, Magiran, Civilica, Google Scholar, Noormags, Ensani
ISSN: 2345-2870

On-Grid Simulation of Distributed Generation (DG) of Renewable Electricity in Urban Lighting in the Context of Sustainable Urban Management (Case: Mashhad)

Mahdi Ghaemi Asl*

Assistant Professor, Department of Economics and Islamic Banking, Faculty of Economic, Kharazmi University, Tehran, Iran

Davoud Manzoor

Associate Professor, Department of Energy Economy, Faculty of Islamic Studies & Economics, Imam Sadiq University (I.S.U.), Tehran, Iran

Seyyed Mahdi Mousavi Barrodi

Ph.D. Student of Economic Sciences, Faculty of Islamic Studies & Economics, Imam Sadiq University (I.S.U.), Tehran, Iran

Received: 2016/11/29 **Accepted: 2017/07/08**

Abstract: Lighting passages is done for citizens' welfare simultaneously with the peak of the consumption of the network, from sunset to sunrise. The present study aimed at designing a model of sustainable urban management in the field of lighting, with simulation of the use of photovoltaic LEDs instead of sodium and halogen lamps. Accordingly, in a system simulation of the network, the scenarios for adjusting the input of various photovoltaic capacities to the electricity supply system of the city of Mashhad have been investigated. The results of on-grid analysis by using this decentralized production pattern shows, taking into account the 200 watts capacity and the 20% utilization factor for each photovoltaic LEDs and installing a photovoltaic LED instead of sodium and halogen lamps, all the power needed to lighting of city streets is provided by photovoltaic solar technology. Moreover, by reducing the potential between fossil and renewable production, emissions of pollutants are reduced by 104,000 tons. Therefore, this method can be used to manage clean and sustainable energy in urban scale consumption, and, while helping the environment and reducing air pollution, it prevents losses caused by the transfer of electrical energy from the plant to the place of consumption.

Keywords: On-Grid Simulation, Sustainable Urban Management, Photovoltaic Technology

JEL Classification: O18, P25, Q2

* Corresponding author: m.ghaemi@khu.ac.ir

1- Introduction

Energy has attracted the attention of many planners and policymakers for many years, so that the development and progress of many of the existing communities, especially developing countries, are significantly will be affected by it (Saeidkhani et al., 2016). Energy, as a driving force for productive activities, is the basis of every country's economic and social activities. The limitation of fossil fuels and their prediction of rising prices, environmental problems and air pollution, global warming, population growth and insecurity in their supply of political and economic crises are all issues that, with all its breadth, have attracted the attention and aim of planners and policymakers in finding appropriate solutions to solve energy problems in the world, especially environmental crises. It also encourages researchers to develop resources that are less polluting and renewable, which has the potential to substitute for fossil fuels and energy (Tahamipoor et al., 2016).

One of the main pillars of development in each country is how the energy sector, the environment and the economy interact. The electricity industry generates many environmental consequences from the production stage to final consumption. However, on the other hand, since this sector is the underlying pillar of all economic and social activities, these impacts and pollution have caused the environment and humanity to face threats (Asgharizadeh et al, 2017).

In recent decades, pollution has become one of the main administrative challenges facing countries, so that countries, in addition to policies and actions within their borders, also pursue pollution control in the international arena. Among the examples of contamination, greenhouse gas pollution is one of the serious threats facing many countries, which, according to its nature, is wider and more pronounced in most parts of the world. Accordingly, it can be said that reducing carbon dioxide emissions plays an important role in protecting the environment and sustainable development (Kohansal & Shayanmehr, 2016).

One of the key pillars of sustainable development is the achievement of sustainable city life. Several studies and plans have been developed to find the principles and guidelines for urban development programs, and the concept of sustainable urban development and management extensively reviewed nationally (Kazemiyan et al., 2017).

In this research, with the goal of designing a sustainable urban management model in the field of passage lighting, a simulation of the use of photovoltaic LEDs instead of sodium and halogen lamps has been used. Based on research modeling, in system simulation network, the scenarios for adjusting the various photovoltaic capacities to the power supply system of the city of Mashhad have been investigated. These various adjustments and the increasing trend of photovoltaic inputs to the production system are carried out with the aim of identifying the starting point of the sustainable nature of renewable solar power to a stable and secure nature, and operating solar energy system enter electricity network of Mashhad and the urban street lighting will be provided with this clean energy. Based on the findings of this study, all the power needed to provide lighting for urban highways with photovoltaic solar technology is provided, and by creating a resilient capacity between fossil and renewable production, emissions of environmental pollutants will decrease by 104,000 tons.

2- Literature Review

a) Foreign Researches

Wu et al., (2009) designed an LED solar system and evaluated the cost of implementing the project for a 10-km two-way highway. The cost of implementing the project with a $ 22 million LED light bulb, and $ 26 million LED bulb with an $ 18 million mercury lamp. This means that the energy saving by the photolytic system reaches about 1168000 KWh/ year and reduces carbon dioxide production by 770,880 kg/ year. So, according to the group's calculations, the time needed to compensate for the extra costs of the LED system with a power supply of 2.2 years and 3.3-LED photovoltaic system is considered. In addition, the useful life of LED systems is about 10 years. Therefore, given the useful life and cost of time, the use of LED systems, both urban and solar, is economically feasible.

Mokhtar Ali et al., (2011) in a study entitled "Design and construction of LED lighting systems for free-energy solar arrays" examined the changes in energy consumption in the Egyptian streets. This system includes a PV panel, energy storage system, LED lamp, power conditioning and controller. The benefits of this system include low energy consumption, low costs, carbon dioxide emissions and environmental compatibility. According to the group, in 2008/2009, road lighting in Egypt was about 6.2%, or 6982 GWh of total energy consumption. In order to reduce energy consumption, two solutions were considered: the first suggestion was to use LEDs (80 W) instead of HPS lamps (150 W). In this method, energy consumption decreases up to 3724 GWh for street lighting per year. The second proposal is to use a PV system designed to compensate for a total consumption of 6.2% and energy consumption with this system to zero.

In 2013, the International Agency for the Study of Renewable Energy (IAEA) reviewed the energy consumption and greenhouse gas emissions in different lighting methods in two cities of Sydney, Australia and Nagpur -India. In Sydney, the replacement of LED bulbs rather than high-end bulbs has led to an annual reduction of $ 830000 in energy consumption (a 51% reduction in street lighting consumption) and a production of 2185 tons of carbon dioxide produced. These bulbs have a lower energy consumption and longer lifespan. For a variety of reasons, including high costs, PV was not implemented in this city compared to other existing systems in the city. According to the statistics for 2009, Nagpur has 30% of the energy consumption of street lighting. Compared to other cities in India, Nagpur receives a lot of solar radiation; about 300 days of sunlight per year. Therefore, using a solar system for street lighting in 2006-2007, it reduced about 7827 kWh of energy and generated 6.34 tons of carbon dioxide - as a result. Following the success of the project in Nagpur, this city was selected by the Ministry of New and Renewable Energy as the solar city of India (Smith et al., 2013).

In a study on cost-benefit analysis of the use of photovoltaic lighting systems in comparison with the classical lighting systems using the HOMER software to analyze the data of the country of India and has been concluded. Using LED lamps in addition to providing lighting better in outer environments - the higher lighting angle and higher precision in turning a particular environment-have lower cost, higher energy efficiency, and longer durability and brightness, and predicts that future energy use through photovoltaic systems will be greater (Das et al., 2015).

In a study on energy efficient systems for intelligent cities in the European Union, Galvao et al, have come to the conclusion that given the ever-increasing costs of electricity and natural gas, the need to use alternative systems in future smart cities is felt more and more, as shown in this study. General lighting with LED technology can significantly help to save energy and maintain brilliance and increase the brightness of the way to use HPS. The results of this study indicate that even in the worst months of the year for the battery-winter charge-LED technology can be used in street lighting (Gavlio et al., 2015).

b) Iranian Researches

Mehrabi et al., (2018) evaluated photovoltaic systems in power supply of a commercial tower with an average consumption of 32000 KWH of electricity per day in Kerman using a cost cycle method economically and environmentally. In the first scenario of this study, all system costs are paid by the consumer, and in the second scenario, it is assumed that 50% of the initial investment cost was paid by the government and the rest would be repayable at a rate of 2% is being provided. The results showed that the use of photovoltaic systems for generating electricity under the first scenario does not have economic justification, but with government support, this scheme has economic justification. In addition, the results of this study, based on the assumptions made in the study, indicate that over the past 100 years, the price of electricity, taking into account social pollution costs, will reach 30,000 Rials per kilowatt-hour.

Ghaemi-asl et al., (2016) developed a model to create a low carbon city in the urban sector of the Mashhad city focusing on providing sustainable electrical energy. The results of the study showed that biomass technology with less volatility and low production cost is the best technology for designing a low carbon city.

Hatami et al., (2014) evaluated independent network photovoltaic system economically for the villages of Tehran instead of the expansion of the national electricity grid. The results showed that the use of a photovoltaic system instead of a nationwide power grid for electricity supply to the villages is well suited. In the worst case, the greatest cost of the photovoltaic system, the 18% discount rate and the household size of 50 and the number of cloudy days 3 times within 76 km of the village from the electricity distribution network, is the use of the photovoltaic system from the development of a more economical national grid. Therefore, for villages under 50 households, when the distance from the distribution network is more than 76 kilometers, the photovoltaic power is more economical than the national distribution network.

MahdaviAdeli et al., (2014) studied feasibility on the use of a photovoltaic system in order to provide the required electrical charge of a residential complex in Mashhad as a case of household use by using the actual data of a residential unit equipped with a photovoltaic system called Green House in Mashhad in 2012. The results indicate that the use of these systems in residential complexes of three units is justified. With the initial investment of 200 million Rials, the domestic rate of return in a residential complex with an average consumption of 400 KWH per month for each unit is equal to 22.83%, and the return period is 13 years, as well as the net present value of 3,696,000,000 Rials.

3- Theoretical Background

The theoretical foundations of this research are twofold: 1. Energy management framework required for urban passages with photovoltaic LED technology. 2. Theoretical basis of sustainable urban management

The energy Management Framework Required for Urban Roads with LED Technology

In the lighting section of the streets, the goal is to provide appropriate lighting, reduce losses, and reduce traffic and improve the consumption curve of the network. The purpose of this section is the use of appropriate lights and the use of fewer and less efficient lamps, and avoiding transmission losses with decentralized electric energy production. Executable activities such as correcting the disadvantages of the lighting system of the streets (troubleshooting of photocells, lamps, feeding network, photocell installation, etc.), implementation of high potential saving technologies, implementation of standardized lighting system in newly established pedestrians, implementation of several automation protocols. Road lighting is one of the goals to be used to assess its performance (Tavanir Distribution Coordination Deputy, 2011).

Against the limitation of energy resources and the growth of human needs, attention has been focused on finding new solutions for energy saving. Despite some of the benefits of current lighting sources, the disadvantages of producing harmful ultraviolet rays, bubble bubbles, the inability to smoke them, the toxicity of mercury found in tubes have led to the emergence of a new technology for the global lighting industry. Photovoltaic LED bulbs have a significant potential for optimizing energy consumption and do not have the following disadvantages (Abbasivardeh et al, 2008).

LEDs are semiconductors that convert light energy into electrical energy. Photons and heat are generated when certain elements in a particular configuration are combined with each other and flow through them. The main part of the LED, called the chip, consists of a semiconductor dual layer: the n-type layer (for electrons) and the p-type layer (for holes), so that the electrons are inserted into the holes. The real binding of the layers (called the p-n connection) lies in the space where the electrons and cavities encounter each other in the middle of the active region. When the electrons and holes recombine together, photons are produced. The important characteristics of LEDs are (Rajabi Mashhadi, 2010):

LEDs have superb power in creating light that accurately displays the natural color of objects. In addition, LEDs do not have any filaments or tubes to damage or break (if they fall).

LEDs have great optical control benefits because of their small size and even the choice of packaging. Given the high potential for energy savings, the use of LEDs with defined radiation angles will be desirable and reasonable.

The packaging of LEDs provides the ability to focus and provide superior light guidance, while light and fluorescent light sources require external reflectors to collect light and direct it in the desired state.

LED manufacturers claim that LEDs have a life span of over 50,000 hours. Because the LEDs have no filament, the light output of a LED decreases over time. This effect, which reduces the light flux of the LED, without noticeable, occurs over thousands of years. In fact, the complete burning of a LED (like other lighting devices) is meaningless. Therefore, the lifetime of the lamp in such a way is the time required to reach the LED flux to a certain percentage of the initial light flux, which is usually 70%.

LEDs are considered as cold light sources due to their low heat production and no diminishing color is obtained when using dimmer, unlike yellow-tinted lamp luminaires.

LEDs are ideally suited for use in places where light needs are needed, while the high frequency of switching on/off has a lot of effect on the early burning of fluorescent lamps. In the case of HID lamps, it is also time consuming to light the lamp.

LEDs quickly reach their maximum fluorescence, unlike compact fluorescent lamps; they do not need mercury, resulting in a reduction in CO2 emissions, which has a profound effect on greenhouse gas emissions. In addition, unlike fluorescent lamps and strings, exterior shocks do not damage the LED.

Theoretical Foundations of Sustainable Urban Management

After the energy crisis in the 1970s, the United States, Germany, Denmark and Japan, the world's leading energy fossil fuel consumers, are considering reducing dependence on fossil fuels and, consequently, the concerns about its pricing changes towards the development of renewable energy technology (Razdan, 1385, p. 69). Furthermore, considering the high consumption of fossil fuels such as coal, oil, gas, etc. during the past two centuries, and the limited resources of this type of fuels, consideration of the replacement of renewable energies is inevitable (Fatras et al., 2012). Accordingly, the latest attraction of investments from renewable energy, solar energy is 28%, biofuels 14%, biomass and waste technology account for 7% of funding (Zinelzade et al., 2012). The high cost of using renewable energy in relation to other energy sources makes it necessary to use energy savings in industries to have specific policies and long-term plans (Razdan, 2006).

On the other hand, in most advanced economies in the electricity industry, there has been a huge transformation in energy production and transmission systems that meet all the needs and benefits of the base of production and transmission in technical, academic and commercial fields. This new system of energy production generates a dispersed energy generation (DG). This method also greatly improves the credibility and reliability of electricity supply and has led to significant investment in the use of dispersed production units. Increased generation of production requires a change in the technology needed to manage transmission and distribution of electricity. In this case, there will be a growing need for network operators to actively deploy networks rather than to deactivate them. By increasing active management, there will be additional benefits to consumers that these benefits will be introduced with more choices than energy services and more competition. However, going to more active management can be difficult. The main indices for decomposing and using distributed production are:

1. Utilization of existing capacities
2. It is possible to design and, if possible, build inside the country
3. Using more suitable primary energy with less pollution (e.g. renewable energy)
4. Having economical cost than other resources

Both aspects of “special attention to renewable energies” and “dispersed electrical energy production” can be verified and implemented in the context of the concept of “sustainable development” and “sustainable city.” (GhaemiAsl et al., 2016).

Sustainable development and sustainable urban development have gradually become a new and dominant paradigm in the most popular theoretical and scientific literature on urban development and planning. This pattern, although observing different interpretations, but in general, emphasizes the sustainability and continuity of development for all and future generations over time and on all aspects of the complex economic, social and environmental dimensions of the development process at the level A country or city is emphasized. The Brundtland Commission in 1987 described the concept of sustainable development as Sustainable Development is a development that can meet the needs of the present generation without compromising the needs of future generations and consistent with their interests (Navabakhsh & Sabeti, 2015). Sustainable urban development has been at the heart of many urban movements in recent decades, such as UNODC 21 (Rio Conference on Sustainable Development, the United Nations Human Development Report 2003, and the New Urbanism Charter in Industrial and Developing Societies). Sustainable urban development pursues macroeconomic metropolitan areas, such as reducing pollution, preserving natural resources, using alternative and natural energy, recycling waste and increasing urban access. Modern urban design patterns, such as the ecological city, the compact city and the city without cars, are known as the practical effects of this view (Hosseini et al., 2009). In line with the first and third components of sustainable urban development for the protection of the environment, in particular the urban environment and the use of renewable energy (photovoltaic energy), in this study, the applied-operational model associated with sustainable urban energy planning in Mashhad was designed and simulated.

4- Research Methodology

Given the volatile nature of renewable electricity, network planning must be done taking into account the oscillatory nature of renewable electricity generation and the instantaneous distribution of electricity generation and consumption so that, if necessary, the fossil capacity can support the network needs to be provided. In this research, a descriptive-prescriptive approach analysis method has been used to simulate the production of fossil-hybrid hybrid systems. Analytical planning is one of the new numerical optimization methods that was first proposed by Zelenka (2001, 2002a and b). The main reliance of analytical planning is the data-driven approach to the bottom-up modeling of the hybrid production system, which is designed to simulate energy hybrid systems based on the advanced Energy PLAN 11/11 version. In addition, since there is the possibility of creating an open source exchange in common models, the software communication and exchange, and the outputs of the above models, have been performed using the OSEMOSYS software, and the simulation of the hourly data with the frequency of 8784 hours per year (such as demand, price or segregation of power plants) has been done in this software. Costs of production include operating costs (variable and fixed) and investment costs. References for obtaining information for system simulation, Budget Office, Deputy Director of Planning and Research of Khorasan Regional Electric Company, Electricity Market Office, Technical Supervision Bureau, Production Department of Khorasan Regional Power Company, Information and Statistics Office Khorasan Regional Electric Company and Khorasan Electric Power Production Management Company (power plants).

In this study, analytical programming of power generation system analysis, which is designed according to the Lund model (2014), firstly, moment-hour electricity demand was calculated accurately by the Electricity Market Office and the Office of Information and Statistics of the Regional Electricity Company of Khorasan. As given to the production system of the plants in the city of Mashhad, is introduced.

After the requirements and minimum and maximum production limits for fossil fuels have been determined, based on the Lund analytical planning model (2014), available power plants, based on the priority of the lowest final cost is used to cover the instantaneous-hourly demand, but the price will be determined at any moment-hour based on the long-term final cost of the power plant used to cover the demand of each instant-hour.

In the analytical planning approach, assuming that the instantaneous-hourly demand for a given time period is certain or predictable, the module for calculating the price of the production system follows the hourly-hourly price pattern, and accordingly, the price is determined on the basis of the following components at each interval:

1. The cost of the manufacturer's fuel for the production of $g_j(t)$ at t $G_{j,F}\lfloor g_j(t)\rfloor$

2. The cost of exploitation, repair and maintenance of the j-th manufacturer at the production level $g_j(t)$ at t $G_{j,M}\lfloor g_j(t)\rfloor$

3. Investment costs and development of the capacity of the j producer at the production level $g_j(t)$ at time t $G_{j,I}\lfloor g_j(t)\rfloor$

4. In some models, investment costs and capacity development in the model are ignored. In the Lund analytical planning model (2014) to simulate the production system, these types of costs are also used to calculate the average price Production system is considered. Given the cost components of the production system, the total cost of fuel, utilization, repair, maintenance, and investment cost and capacity development for the manufacturer j at the time t will be as equation 1:

$$G_{j,FMI}\lfloor g_j(t)\rfloor = G_{j,F}\lfloor g_j(t)\rfloor + G_{j,M}\lfloor g_j(t)\rfloor + G_{j,I}\lfloor g_j(t)\rfloor \qquad (١)$$

The total "total cost of fuel", "total operating cost, maintenance", and "total investment cost and capacity development" at t for producing g (t), will be in the form of equation (2-4), which indicates the total cost (TC) is produced:

$$G_{FMI}\lfloor g(t)\rfloor = \sum_j G_{j,F}[g_j(t)] + \sum_j G_{j,M}[g_j(t)] + \sum_j G_{j,I}[g_j(t)]$$

$$G_{FMI}[g_j(t)] = G_F[g(t)] + G_M[g(t)] + G_I[g(t)] \qquad (2)$$

Therefore, the moment-hourly price for a k-th consumer in such a production system will be equal to:

$$P_k(t) = \frac{\partial(TC)}{\partial d_k(T)} \quad (٣)$$

Given that in planning the analysis of this research, the demand is cumulative and distributed by the time-and-hour distribution of all network subscribers per hour in the model, the total cost of the system of production will be as equation (4):

$$P(t) = \frac{\partial(TC)}{\partial d(T)} \quad (۴)$$

Now, taking into account the same time intervals and one hour, we can rewrite the relation (4) as equation (5):

$$P(t) = \frac{\partial G_{FMI}[g(t)]}{\partial d(t)} \quad (۵)$$

The constraint affecting the model is the supply and demand balance, according to which the total energy supplied at t hour should be equal to the total demand at time t. If the demand is suddenly lower than predicted, then the necessary storage space for the supply of electrical energy in the production system will be provided.

The moment-hourly price of the production system at t is calculated as the sum of the fuel component $\gamma_F(t)$, the operating component, the maintenance $\gamma_M(t)$ and the investment component and the capacity development $\gamma_I(t)$

$$P(t) = \gamma_F(t) + \gamma_M(t) + \gamma_I(t) \quad (۶)$$

With regard to the definition of the instantaneous hourly price components of the production system, equation (6) can be written as equation (7):

$$P(t) = \frac{\partial G_F[g(t)]}{\partial g(t)} + \frac{\partial G_M[g(t)]}{\partial g(t)} + \frac{\partial G_I[g(t)]}{\partial g(t)} \quad (٧)$$

The sum of these three terms in the term is called the system lambda (Ibid, 365):

$$(t) = \frac{\partial G_{FMI}[g(t)]}{\partial g(t)} = \gamma_F(t) + \gamma_M(t) + \gamma_I(t) \quad (٨)$$

The emission figures and emission tax data from the Danish Energy Agency (2012) have been extracted and, accordingly, the environmental pollution tax is calculated to be 493027 Rls per ton .In this study, carbon dioxide (CO2) emissions have been used to measure the variation in environmental emissions. Regarding the cost of generating solar power, the information provided by the Khorasan Regional Electricity Planning and Research Department’s budget office has been used. According to the statistical tables of this office, the cost of investing in photovoltaic LEDs (taking into account the cost of batteries and conversion equipment) per kilowatt, 104 million Rials and the fixed and variable cost of operation and maintenance of solar power in each megawatt at 636 Rials has been calculated. It should be noted that these statistics are calculated based on the availability of equipment for the Khorasan regional power company and in line with the climate-commercial conditions of the Khorasan Regional Electricity Company, and international or national statistics (in other parts of the country) can be different from these statistics. The lighting meters in Mashhad city streets have 3737 subscribers, each of which is one of these meters. In Mashhad, three different capacities are used for street lighting: 140 watts, 265 watts and 415 watts. In total, the amount of energy consumed in the lighting section of urban streets in Mashhad in 1391 is 146 GWh, which indicates the target of energy supply with photovoltaic LEDs and their use instead of sodium and halogen lamps.

5- Results

Based on the simulation of the production system based on the analytical planning, the simulation results of the hybrid-fossil-solar hybrid system have been calculated and reported in Table 1.

Table 1- Simulation results of the basic production system and fossil-reactive hybrid production system

Scenario / Index	Base model (Initial conditions of the production system)	Photovoltaic 110 kilowatt modulation	Photovoltaic 220 kilowatt modulation	Photovoltaic 330 kilowatt modulation	Photovoltaic 440 kilowatt modulation	Photovoltaic 550 kilowatt modulation
Average price (Rials per kilowatt-hour)	۱۹۲۰,۲۸۰	۱۹۲۰,۵۳۹	۱۹۲۰,۷۹۸	۱۹۲۱,۰۵۷	۱۹۲۱,۳۱۶	۱۹۲۱,۵۷۵
Release of environmental pollutants (Ton)	۳۲۹۶۰۰۱	۳۲۹۵۸۹۹	۳۲۹۵۷۶۲	۳۲۹۵۶۲۴	۳۲۹۵۴۸۷	۳۲۹۵۳۵۰
Optimal production of photovoltaic power (Gigwatt hours)	۰۰,۰	۰,۱۹	۰,۳۹	۰,۵۸	۰,۷۷	۰,۹۶
Optimal production of fossil fuels (GWh)	۴۸۸۸,۶۱	۴۸۸۸,۴۲۰	۴۸۸۸,۲۳۰	۴۸۸۸,۰۳۰	۴۸۸۷,۸۴۰	۴۸۸۷,۶۵۰

The results presented in Table 1 show that in such capacities, the amount of energy required for urban street lighting cannot be increased in any way, and production capacity needs to be increased to higher values. Various adjustments and the increasing number of photovoltaic inputs to the production system are carried out to achieve the goal of transforming the turning point of the oscillatory nature of renewable electricity into a stable and secure nature, and operating solar system in a Mashhad city electricity network. For this reason, the simulation of the capacity of 20 to 80 megawatts is calculated and presented in Table 2. Due to the 80 MW capacities, production of energy with the required target value is close to each other, all 80 to 85 MW photovoltaic capacities have been calculated by changing the range of 0.5 MW, among which the capacity of 83.5 MW is the closest possible target to target 146 GWh. Hence, in the end column of Table 5, 83.5 MW capacity figures have also been reported.

Table2. Simulation results of the basic production system and fossil-reactive hybrid production system

Scenario / Index	Adjustment of 20 MW photovoltaic	Adjustment of 40 MW photovoltaic	Adjustment of 60 MW photovoltaic	Adjustment of 80 MW photovoltaic	Adjustment of 83.5 MW photovoltaic
Average price (Rials per kilowatt-hour)	۱۹۶۳,۳۵۲	۲۰۱۴,۴۵۳	۲۰۵۷,۳۳۲	۲۱۰۸,۶۲۵	۲۱۱۲,۵۴۵
Release of environmental pollutants (Ton)	۳۲۷۱۰۶۴	۳۲۴۶۰۹۲	۳۲۲۱۱۱۹	۳۱۹۶۱۴۷	۳۱۹۱۷۷۷
Optimal production of photovoltaic power (Gigwatt hours)	۳۵,۰۴	۷۰,۰۷	۱۰۵,۱۱	۱۴۰,۱۵	۱۴۶,۲۸
Optimal production of fossil fuels (GWh)	۴۸۵۳,۵۸۰	۴۸۱۸,۵۴۰	۴۷۸۳,۵۰۰	۴۷۴۸,۴۷۰	۴۷۴۲,۳۴۰

The results of Table 2 show that with the capacity of 83.5 MW, it would be possible to cover the demand for lighting in photovoltaic electricity by using a photovoltaic power supply and the sustainable energy management system of the city in the urban section, at this point completely provided.

6- Conclusion and Discussion

Totally, 415528 LED lights have been used in the city of Mashhad. Considering the capacity of 200 watts for each photovoltaic LEDs and the installation of a photovoltaic LED instead of sodium and halogen lamps, all the power is provided to supply lighting power to urban roads with photovoltaic solar technology, which according to the study The Khorasan Regional Electric Company (2012 A), each 200 watt solar cell, equates to planting 14 10-year-old trees to the environment. However, the utilization rate of photovoltaic LEDs is considered to be 20%, and the cost of each photovoltaic LEDs is considered along with the battery and equipment needed for conversion, and it is possible to store in hours there is high radiation and low consumption. Furthermore, since this simulation is carried out under the network, there is sufficient fossil capacity to provide the necessary requirements when necessary, so that if the coefficient of utilization of the photovoltaic LEDs is zero Considering the maximum electricity demand of the city of Mashhad, which is 4888.61 GWh (based on the study year), the city's electricity fossil power plants can easily support the clean energy production system and covering the entire network. However, only in the Black-Out system of photovoltaic production, there is a need to utilize fossil fuels to support, and the energy management of urban roads will be essentially renewable and sustainable.

In addition, the decentralized production of renewable energy in the urban lighting section prevents transmission losses due to the long distance between the place of production and consumption, and by creating the ability to substitute between fossil and renewable production, the emission of environmental pollutants is also 104,000 Tons decrease.

It is also possible to increase the cost of the production system per capita from the urban electricity subscriber, which is the main source of street lighting, in which case the increase in the cost of electricity for urban subscribers will be negligible. Because according to the detailed statistics of the power industry in Iran (2012), the distribution company of Mashhad in the urban sector has a total of 113,107 units, of which this subscriber base in the study year consumes 4888611 megawatt hours. The average of each subscriber consumes 3.5 megawatts of electricity per year. In other words, the electricity consumption of each urban municipality of Mashhad in the base year of study was 3660.3 kWh per month. Considering the increase of 190 IR. Rials, the finished product price adjusted to 83.5 MW photovoltaics resulted in an increase of 68433 IR. Rials are the monthly cost of electricity for urban customers. In fact, this figure reflects the optimal municipalities' complications to reach the sustainable energy management point of urban roads in the city of Mashhad. Subsidies of various governmental and international organizations are also available to sustainable urban energy management in such a situation, and these rates can also be based on the amount of assistance and assistance provided to the less varied ones reduced.

7- References

Abasivardeh, M.A., Hanifi, M.F., & Fakhari, A. (2008). Field Study of LED Lighting with LED Lighting. *23rd International Conference on Power*. (In Persian).

Ali, M., Orabi, M., Abdelkarim, E., Qahouq, J. A. A., & El Aroudi, A. (2011, December). Design and development of energy-free solar street LED light system. In *2011 IEEE PES Conference on Innovative Smart Grid Technologies-Middle East* (pp. 1-7). IEEE.

Asgharizadeh, E., Mehregan, M., Shakoori, h., ModaresYazdi, M., & TaghizadehYazdi, M. (2017). Providing a mathematical model for the development of power plants by considering dispersed generation units aimed at controlling carbon dioxide. *Quarterly Journal of Industrial Management*, *4*(9), 587-608. (In Persian).

Bohn, R. E., Caramanis, M. C., & Schweppe, F. C. (1984). Optimal pricing in electrical networks over space and time. *The Rand Journal of Economics*, 360-376.

Danish Energy Agency .(2012) .Assumptions for socio-economic analysis on energy . Danish Energy Agency.

Das, N., Pal, N., & Pradip, S. K. (2015). Economic cost analysis of LED over HPS flood lights for an efficient exterior lighting design using solar PV. *Building and Environment*, *89*, 380-392.

Detailed statistics of Iran's power industry. (2012). Power Distribution, Ministry of Energy, Tavanir Mother Specialist Co., Tehran. (In Persian).

Fatres, M.H., Aghazadeh, A., & Jebraeili, S. (2012). Investigating the Effect of Renewable and Non-renewable Energy Consumption on the Economic Growth of Selected Countries in Development (including Iran), the period from 2009 to 1980. *Journal of Energy Economics Studies*, *9*(32), 51-72. (In Persian).

Galvão, J. R., Moreira, L. M., Ascenso, R. M., & Leitão, S. A. (2015). Energy systems models for efficiency towards Smart Cities. In *IEEE EUROCON 2015-International Conference on Computer as a Tool (EUROCON)* (pp. 1-6). IEEE.

GhaemiAsl, M., Salimifar, M., & MahdaviAdeli, M.H. (2016). Simulation of the creation of a low carbon city with the use of urban waste and photovoltaic technology: Sustainable energy planning in the urban sector of Mashhad. *Journal of Urban Economics and Management*, *5*(17), 67-81. (In Persian).

Hatami, M., Nazemi, Al. Dolatabadi, A., & Mostafapoor, M. (2014). Economic Evaluation Using a Network-independent Photovoltaic System in Villages with Monte Carlo Simulation (Case Study: Tehran). *Journal of Rural Development Strategies*, *1*(2), 19-33. (In Persian).

Hosseini, S.B., Rezazadeh, R., Bagheri, N., Azimati, H., & Ghanbaran, A. (2009). Environmental sustainability in urban open spaces: Quality assessment of residential neighborhoods in Abargar. *Journal of Environmental Science and Technology*, *4* (11), 173-184. (In Persian).

Kazemian, Gh., Rasooli, A., & Khazayi, M.M. (2017). The Place of New and Renewable Energies on the City's Sustainability, A Case Study of Tehran. *Quarterly journal of urban planning and research*, *8* (29), 99-118. (In Persian).

Khorasan Regional Electric Company. (2012 A). Report of measures of Khorasan Regional Electricity Company in the field of renewable energy development, Mashhad. (In Persian).

Khorasan Regional Electric Company. (2012 B). Budget approved in 2012, Planning and Research, Budget Office and Economic Studies. (In Persian).

Kohansal, M., & ShayanMehr, S. (2016). Interaction of Energy Consumption, Economic Growth and Environmental Pollution: Application of the Simultaneous Spatial Equation Modeling of Panel

Data. *Journal of Energy Economics, 5* (19), 179-216. (In Persian).

Lund, H. (2014) *Advanced Energy Systems Analysis Computer Model*, Documentation Version 11.4, Aalborg University, Denmar.

MahdaviAdeli, M.H., Salimifar, M., & Ghezelbash, A. (2014). Economic Evaluation of Using Solar Energy (Photovoltaics) and Fossil Power in Household Use (A Case Study of Three Units in Mashhad, *Journal of Economic Policies, 6* (11), 123-147. (In Persian).

Mehrabi, h., Sadeghi, Z., & shojadini, H. (2018). Economic and environmental assessment of photovoltaic systems in commercial use and dynamic energy simulation. *Journal of Iranian Energy Economics, 7*(27), 159-201. (In Persian).

Navabakhsh, M. & Sabeti, M. (2015). Design and presentation of a model to measure the impact of cultural capital on the dimensions of sustainable urban development with an emphasis on clean energies. *Journal of Social Development Studies, 8* (1), 37-50. (In Persian).

New Energy Organization of Iran (SANA) (2007) Potential of Bio-Resource Resources in Iran, Ministry of Energy, Deputy Head of Energy Affairs. (In Persian).

RajabiMashhadi, H. (2010). *Evaluating the effectiveness of consumption management activities in different sectors after the realization of electricity prices.* Report of Internship Project, Khorasan Regional Power Company, Mashhad. (In Persian).

Razdan, M. (2006). Policies for the use of non-renewable energy in selected countries and the status of Iran. *Journal of Energy Economics Studies,* No. 10, 68-115. (In Persian).

Rostami, S., Haghparast, A., & Lari, H. (2013). Study and estimate the price of electricity produced from wind, solar and biogas plants. *The first national conference of the Iranian Energy Society*, Tehran. (In Persian).

Saeidkhani, M., Falahi, E., & Baneshi, M. (2016). Providing a model for energy management in Iran based on technical, economic and environmental criteria. *Journal of Energy Economics, 5*(18), 29-60. (In Persian).

Smith, E., Simpson, R., & Nicola, S. (2013). Lighting up the streets, The cases of Sydney, Australia, and Nagpur, India, ICLEI-Local Governments for Sustainability and IRENA- International Renewable Energy Agency

Summary of Economic Developments in the Country. (2012). Central Bank of the Islamic Republic of Iran, Tehran. (In Persian).

Tahamipoor, M., Abedi, S., BabaAhmadi, R., Ebrahimizadeh, M. (2016). Investigating the Effect of Renewable Energy on Per Capita of Iran’s Real Economic Growth, *Iranian Journal of Energy Economics, 5* (19), 53-77. (In Persian).

Taherifard, A., & Shahab, S. (2010). Investigating the Technical and Economic Aspects of Electricity Production. *Journal of Energy Economics,* No. 125 and 126, 31-39. (In Persian).

Tavanir Distribution Coordination Deputy. (2011). Electricity Consumers Management Regulations Available online at: https://www.tavanir.org.ir/dm/dmmodiryatmasarf/doc/2.pdf. (In Persian).

Wu, M. S., Huang, H. H., Huang, B. J., Tang, C. W., & Cheng, C. W. (2009). Economic feasibility of solar-powered led roadway lighting. *Renewable energy*, *34*(8), 1934-1938.

Zelinka, I. (2001). Analytic programming by means of new evolutionary algorithms. In *Proceedings of 1st International Conference on New Trends in Physics* (Vol. 1, pp. 210-214).

Zelinka, I. (2002 a). Analytic programming by means of soma algorithm. In *Proceedings of the 8th International Conference on Soft Computing, Mendel* (Vol. 2, pp. 93-101).

Zelinka, I. (2002b). Analytic programming by means of soma algorithm, Proc. 8th International Conference on Soft Computing, VUT Brno, Mendel'02 Czech Republic, 93–101.

Zelinka, I., Oplatkova, Z., & Nolle, L. (2005). Analytic programming- symbolic regression by means of arbitrary evolutionary algorithms, In: Special Issue on Inteligent Systems of International *Journal of Simulation, Systems, Science and Technology, 6*(9), 44–55.

Zeynalzadeh, R., Sadeghi, Z., Dehghanpoor, M., Ghaedi, M. (2012). Economic and Environmental Assessment of Photovoltaic Systems: A Case Study of Southeast Iran. *Journal of Energy Economics Studies, 9* (33), 115-149. (In Persian).