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Simulation of Low-Carbon Eco-City by Using Urban Waste and Photovoltaic Technology: Sustainable Energy Planning of Urban Sector in Holy Mashhad

Mahdi Ghaemi Asl*
Assistant Professor, Economics and Islamic Banking, Faculty of Economics, Kharazmi University Tehran, Iran
Mostafa Salimifar
Professor of Economics, Faculty of Administrative & Economic Sciences, Ferdowsi University of Mashhad, Mashhad, Iran
Mohammad Hossien Mahdavi Adeli
Professor of Economics, Faculty of Administrative & Economic Sciences, Ferdowsi University of Mashhad, Mashhad, Iran
Mostafa Rajabi Mashhadi
Assistant Professor, Faculty of Electrical and Biomedical Engineering, Sajjad Industrial University, Mashhad, Iran

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Abstract: Zero-energy city, sustainable City and zero-carbon city are new terms in cities' energy management. In this study, a framework of designing a Low-Carbon Eco-City (LCEC) in urban sector of Mashhad with focus on sustainable supply of electrical energy has been simulated. For this purpose, the maximum potential of biomass renewable electricity and expansion of photovoltaic capacity- required to cover remaining electricity demand in urban sector of Mashhad has been entered in Hybrid Power Generation System by using an analytical programming approach. The results indicated that biomass technology is superior technology for designing LCEC with less volatility and lower cost of production and it enters into the fossil-renewable hybrid production system with high penetration. Despite increasing capacity of photovoltaic technology up to 8GW, because of high investment cost problem, photovoltaic power generation cannot utilize in competition with the production of biomass technology. Hence it is suggested that biomass technology of sustainable development energy in the urban sector of Mashhad to be regarded as a city on the path LCEC. On the other hand, supportive policies should be adopted to reduce the cost of photovoltaic technology in order to provide the competitiveness of this technology in high capacities.

Keywords: Low-Carbon Eco-City, Analytical Planning, Biomass Technology, Photovoltaic Technology
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* Corresponding author: m.ghaemi84@gmail.com

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1- Introduction

Economic development is fundamental pillar of any country's policies and energy is essential factor for economic development in any society. Rapid growth of population, dependence on energy and consequently growing consumption of fossil fuels lead to increase environmental problems (Amadeh & Rezaei, 2011). Currently, unnecessary use of renewable energies such as coal, gas and oil, has resulted in serious environmental problems including climate change and air pollution; therefore, it is necessary to take a new approach toward new energy resources compatible with the environment (Amiliyan et.al, 2013). Human being has faced two big crises because of current trend of energy consumption increase in the world. Firstly, environmental pollution because of burning fossil fuels, and secondly, acceleration to finish these resources (Fetres & Barati, 2011). In recent years, because of environmental reasons, revealing the harms caused by the combustion of fossil fuels and their negative impacts on ecological cycles, and finishing fossil fuels, motivation to use renewable and clean energy resources has been increased. Today, the use of renewable energy resources are of great importance in energy planning (Saffariyan & Mohammdi Ardehali, 2008).

Energy consumption is one of the appropriate criteria to determine progress level and quality of life in a country. Continuity of energy supply and long-term access to resources require comprehensive energy planning (Safariyan & Mohammadi ardehali, 2008). Energy policy-making in the third millennium can be summarized in three topics: first, moving toward using renewable and clean energies compatible with the environment, second, restructuring in the energy sector and its competition, and the third, increase efficiency in energy consumption (Shakibayi, et.al, 2009).

Given the first subject, renewable energies are more compatible with the nature and environment, producing and supplying them have less environmental pollution. Since they are renewable, they will not be terminated; thus, renewable energies will obtain more shares in the world energy supply increasingly (Fetres & Barati, 2011).

In this research, by using obtained energy of biomass technology and photovoltaic energy, Low-Carbon Eco-City (LCEC) model has been simulated in urban part of Holy Mashhad based on sustainable energy supply. For this purpose, maximum potential for biomass renewable electricity along with creating necessary photovoltaic capacity to cover remaining electricity demand of Mashhad have been inserted in the hybrid power generation system by using analytical planning approach.

2- Literature Review

a) Foreign Researches

Regarding plan and design to create LCEC, there have been many applied studies.

Min and Cheng Guo Dong (2001) dealt with production and consumption models guarantying LCEC with environmental method. They introduced and simulated indicators related to LCEC in Zhangye based on patterns related to ecotourism and environmental climates.

Baoxing (2009) studied design principles and creating indicators related to domestic sector in a LCEC by using designing indicators of a green building.

Cao and Li (2011) designed LCEC model and simulated operational practice

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of this model in Tianjin, China by focusing on reforming industrial products, transport system, and energy consumption in metropolises.

Yan (2010) investigated creating LCEC by considering hypothesis of climate change because of greenhouse gas emissions and presented global strategic production and consumption choices to prevent negative climate changes.

Xie et.al, (2010) determined the importance of any economic, industrial, and consumption indicators to create LCEC by regarding MCDM[1] model. They allotted particular importance and main function to energy sector and electric energy consumption and production model.

b) Iranian Researches

Movahed et.al, (2014) dealt with spatial classification and analysis of sustainability and unsustainability rate of Makoo neighborhoods in terms of having development measures. The results indicated that consolidated indices of consistency coefficient are different among the neighborhoods. This means that 14 ones are ideally sustainable, 4 ones strongly sustainable, 3 ones semi-sustainable, 3 ones weakly sustainable, and 2 ones are unsustainable.

Taqvayi & Safarabadi (2013) investigated the role of some factors, particularly managerial system in urban sustainability with descriptive-analytic method. For this purpose, 82 urban sustainability indicators were identified in Kermanshah and main effective managerial factors on sustainable development of Kermanshah were evaluated by using factor analysis. Urban health has the most important role in urban sustainability with indicators such as education, social health, safety, and social discipline.

Majdzadeh Tabatabaei & Ostadzadeh (2015) studied pollution control policies by using comparative static analysis in the framework of an endogenous growth model in economy of Iran to design a macro-economic system having environmental sustainability through moving toward low-carbon economic development. The results indicated that government could adjust economic agents' performance toward choosing optimal solution in allocation of resources to access sustainable economic growth by choosing appropriate policies.

Lotfi et.al, (2016) formulated urban design criteria based on low-carbon neighborhoods. The criteria that are sub-set of sustainable urban design solutions can be used in different levels. Among different scales, neighborhood can be named as an appropriate one including city construction unit to apply low-carbon urban design solutions and principles. Generally, these solutions are based on creating a neighborhood that has low energy consumption, provides a desirable environment for local life, and has more resilience.

3- Theoretical Principles

The scarcity of energy is one of the world today's problems. Electric energy is one of the major and cleanest energies used in daily life. Since discovery of electricity, the energy has affected different aspects of human life. Exclusive features of electricity have made its increasing use inevitable. Advantages such as no pollution, ease of use, variety of production methods, production capability, and large-scale distribution made use of electric energy economical (Manzoor et.al, 2011).

1- Multi-Criteria Decision Making

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Given new approach created in current world about how to produce electrical energy, two sources of solar energy and biomass can be regarded as new sources of electrical energy. Today, the use of other energies including energy recovery of waste as alternative fuel has been put on agenda since it is cheap, available, and it changes to required energy faster (Zare & Deylami, 2013).

With rise in urbanization and population growth, one of the most important issues that allotted a major part of local management activity to itself is optimal management of production wastes. Today, with rapid socio-economic growth in countries, in addition to increase in quantity of waste, change in consumption model led to increase in the quality of produced waste (Rahnama & Kazemi Kheybari, 2012). Biomass is one of renewable energy resources that provides nearly 3 to 35 percent of human primary needs in industrial and countries respectively. Biological material or biomass refer to total produced or available biological materials in an ecological system based on organic materials able to change directly to energy or energy carrier materials as renewable energy sources (Amiliyan et.al, 2013). Fuel derived from waste refers to a material that is obtained after conducting various recycling processes. In addition to energy production, it has influential role in the environment beauty, land use planning (spatial planning), public health, no pollution, and economic considerations (Zare & Deylami, 2013).

However, among mentioned renewable energies, solar energy can be cited as an endless source of energy solving many energy and environment problems. The energy is thousands of times more than the amount that man needs and consumes. Solar energy efficiently and importantly can be used as clean and available source.

On the other hand, huge change in energy generation and transportation systems came into existence in most of the developed countries in the field of power industry that meet all needs and advantages required for production and transfer in technical, academic, and commercial issues. The new system of energy industry production is named Distributed Generation (DG). This method improves validity and reliability of electricity supply led to considerable investment to apply DG units.

DG increase requires change in required technology to manage electricity transmission and distribution. In this case, there would be increasing need to network operators to manage networks actively. With active management increase, additional merits will be created for consumers. These advantages will be introduction with more choices than energy supply services and more competition, but moving toward active management can be problematic. Main indicators in decision-making and DG application are (Noorollahi & Noroozi, 2010):

1. The use of available capacities
2. Design possibility, and domestic construction, if possible
3. The use of more appropriate primary energy with less pollution (like renewable energies)
4. Economical than other sources

Both aspects of particular attention to renewable energies and electrical energy DG can be investigated and implemented in the subset of sustainable development and city.

Sustainable development, as one of the main issues discussed in development

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and planning communities, is the output of different development notions. The concept was used in conference on sustainable development in Stockholm, Sweden in 1972. In 1872, in UN World Conference on Environment and Development, in Brandtland report titled our common future, sustainable development defined as a process that current needs can be met without destroying future generations' ability (Mousavi, 2012). Sustainable Development Goals mean providing basic needs, improving living standards for all; better protection and management of ecosystems are implemented in all spatial organization levels, including local, national, regional, and global ones, but urban level has attracted more attention because of continuous growing concentration of population, particularly in less-developed countries (MoosaKazemi Mohammadi, 2011).

Sustainable city is one that can keep living because of economic use of resources, avoiding excessive production of waste, and accepting useful and long-term policies. Sustainable city planners should focus their goals to create cities with less energy input, and less material, waste, and pollution output (MoosaKazemi Mohammadi, 2001).

LCEC is created in a process in which consumption and production pattern guarantees maximum use of urban sustainable potential. Such process would not be achieved in short-term and it requires considerable changes in managerial and economic models (Yu, 2014).

Yu (2014) studied different criteria for LCEC including different economic, social, and environmental aspects. Based on these criteria, a city can be named as LCEC that has following pre-requisites:

1. Having an economy relied on regional-local resources
2. Applying renewable and low-carbon energies in energy production pattern in urban and regional levels
3. Enjoying modern transport system facilitating walking, cycling, and public transport processes
4. Having purposeful management pattern of urban waste and preventing energy waste with increase in technology efficiency
5. Water resources management and designing recycling natural resources and industrial-artificial products
6. Recovery of environmental damage caused by incorrect production and energy consumption patterns
7. Guarantying civil rights for all ethnic groups and sections of society to promote sense of responsibility in urban society

According to the designed model for LCEC, practical-operational model related to energy sustainable planning of holy Mashhad urban sector has been designed and simulated in this research that include indexes 2 and 4 of a LCEC.

4- Research Method

To simulate production system, analytical programming method with descriptive-prescriptive has been used in this research. Analytical programming is one of the numerical optimization methods present by Zelinka (2001, 2002) for the first time. In analytical programming, a set of functions, operators and closures are defined and all variables may be mutable or fixed over time. By using available functions, operators, and closures, an analytical programming can be defined as a set of problems that researcher looks for finding a suitable

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solution for them. Due to the changing nature of problems, General Functional Set (GFS) is used for it. In analytical programming, appropriate solutions will be recognized that the mapping of GFS would be a set of possible and operational programs. Moreover, there are subsets that each of them includes some functions in general function. The number of available functions in each subset is smaller than or equal to the number of sub-components. Obtaining the mapping of GFS follows a two-part process. The first part is Discrete Set Handling (DSH) and the second one is designing guaranteeing processes. DSH was used by Zelinka (2002) and Zelinka et.al, (2005) to create a discrete index that can present a suitable solution in evolutionary process like evaluating alternative individuals in Nested structure well. Thus, analytical programming can be used in exact mathematical problems, systematic simulations, and energy planning.

Power, production, demand and cost data of power plants of Mashhad were inserted in simulation system based on statistics of 2012.According to detailed statistics of Iran electricity industry of 2012, consumed electrical energy of Mashhad urban sector was totaled 4888 GWh in 2012. Data used in simulation system in the first scenario have been represented in tables 1, 2, and 3. To calculate the cost of production (that is calculated based on total cost of production in t moment), alignment costs of production method was used. Production cost items include operational costs (fixed and variable, and investment costs. References to obtain necessary information to simulate system are budget office of deputy of planning and research of Khorasan regional electricity company, department of electricity market, technical department of monitoring production-deputy of operation of Khorasan Regional Electricity Company, Office of Information and Statistics of Khorasan Regional Electricity Company, Khorasan Electric Energy Production Management (Power Plants), and Office technical support and production planning of TAVANIR.

Data on emissions and taxes on emissions were extracted from Danish Energy Agency (2012). Accordingly, environmental emissions tax has been calculated at 493027.2 Rials. In this research, for indexing the spread of environmental pollution, CO_2 was used.

According to Taherifard & Shahab (2010) and Rostami et.al, (2013), and feasibility studies of deputy of planning and researches of Khorasan regional electricity company, the annual discount rate of capital has been considered 10 percent on average.

According to the official exchange market, dollar and euro exchange rates were issued in the summary of Iran economic changes (2012) 24752 and 32436 Rials respectively. Moreover, the information of deputy of planning and researches of Khorasan Regional Electricity Company were used for the cost of wind and solar renewable power generation. Accordingly, solar and wind power investment costs per kilowatt power are 104.5 and 39.75 million Rials respectively, and fixed and variable costs of operation and maintenance of solar and wind power per MWh are 636 and 156897 Rials respectively. It is worth mention that these statistics were calculated based on available equipment for Khorasan Regional Electricity Company with its climatic-commercial conditions.

Yet, because of fluctuating nature of renewable power generation, particularly electricity in photovoltaic system, a sustainable and reliable system of electricity generation cannot be planned and designed only by relying on renewable energies. For this purpose, it is necessary to insert fossil sector in simulation of hybrid system. One of the main constraints in renewable and non-renewable hybrid systems of power generation is to provide reliable generation system. Based on that, a certain percentage of total generation of network electrical energy should be provided from sustainable generation units. In most studies, it has been determined 30 percent. Fossil power plants i.e. gas, steam and combined cycle, are generation technology along with geothermal and nuclear power plants that are able to make network sustainable (Lund, 2014). Thus, minimum share of sustainable generation units in production network has been determined 30 percent in this research.

Regarding the use of renewable energies in Khorasan Regional Electricity Company, preliminary studies have been done to familiarize with the use of renewables, challenges of its use, and solutions in top countries. In the second step, energy profile of Khorasan Regional Electricity Company was prepared based on views and forecasts by experts. Finally, according to these studies, it has been agreed to provide 8 percent of required power in the area by renewables.

According to these studies, among renewables, Khorasan enjoys suitable potential of wind and sunlight. On the other hand, the existence of large cities such as Mashhad, daily production of garbage heaps, and agricultural land in the area have prepared a suitable ground for development of biomass power plants. Therefore, 1410 roadmap has been targeted to focus on three types of energies; wind, solar, and biomass., 6 percent wind power, 1.5 percent solar power generation and 0.5 percent biomass will form 8% renewable power generation. To provide this amount of power, and taking into account the utilization factor of 25% for wind turbines, 20 percent for solar generators, and 80 percent for biomass power plants, the capacity of wind turbines in vision horizon will be reached 822 MW, the capacity of solar generators to 257 MW, and the capacity of biomass power plants to 22 MW. Implementation of these policies will be followed by creating 5 thousand jobs (Khorasan Regional Electricity Company, 2012).

Given the nature of sustainable energy planning in the scale of Mashhad, it is not possible to use wind turbines in urban space. According to the studies and conducted satellite potential surveys by Khorasan Regional Electricity Company (2012 a), Khorasan has 14 million hectares of land with suitable wind intensity located mainly in Khaf region placed in a 120-day winds of Sistan with intense wind. Regarding the use of capacity of biomass and photovoltaic power, designed plan is based on maximum potential of biomass power generation, as priority of renewable generation of Mashhad, to be entered to generation system and remaining demand on production to be provided with different scenarios of using photovoltaic system.

Fossil power plants providing Mashhad electricity are Toos power plant (4 unit heater with a nominal capacity of

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600 MW), Mashhad (3 unit heater with a nominal capacity of 129 MW and 4 unit gas with nominal capacity of 195.5 MW), Shariati (6 unit gas with a nominal capacity of 150 MW, 2 cycle gas units with a nominal capacity of 246 MW, 1 unit with a nominal capacity of 100 MW steam cycle), and Ferdowsi (6 cycle gas units with a nominal capacity of 954 MW). The details of generations and technical features of these power plants were reported in tables 1and 2.

According to locating studies and potentiometric of building biomass power plants by Renewable Energy and Energy Efficiency Organization (2007), city of Mashhad is the best place to build biomass power plant and to use municipal solid waste entering the landfill in Khorasan. Using the estimated potential not only help considerably to obtain energy, but also to remove a major part of problems related to environmental pollution and problems caused by waste management.

In this regard, if maximum potential of Mashhad biomass is used in four forms of power plants incinerators of waste entering the landfill, gas from waste to landfill, anaerobic digestion of waste entering the landfill, and landfill from input waste to landfill, 61.35 MW will be generated. With an average utilization rate of 80%, the capacity will generate 429.87 GWH to network. Given the consumption of 4888.61 GWH Mashhad municipal powers, 8 percent demand of municipal electricity will be provided.[1]

With entering 429.87072 GWH annual biomass energy potential to generation system, uncovered 4458.74 GWH energy will be remained. It is necessary to design an analytical programming to use solar energy and biomass power plant beside Toos, Mashhad, Shariati, and Ferdowsi power plants.

According to the obtained information of METEONORM model calculations (version7) on weather station in Mashhad, and considering horizontal radiation, diffuse radiation, horizontal diffuse radiation in each 1000 square meters, 1.355 GWH electrical energy is generated while regarding utilization factor of 20%, 2.5237989 GW solar power is required to meet remained energy (4458.74 GWH. In this regard, Mashhad power generation system, as a low-carbon environmental city, based on using the potential of 61.35 MW biomasses and photovoltaic equipment of 2.537989 GW beside fossil power plants of Mashhad, Toos, Ferdowsi, and Shariati were simulated.

In the simulated model, demand conditions and systematic limitations based on Lund analytical programming (2014), available power plants, are used based on the priority of least total short-term cost to cover moment-hour demand, but the price in any moment-hour is determined based on total long-term cost of power plant that is used to cover moment-hour demand. Given exact calculation of production cost of used power plants in network and other ready power plants to enter into the network, the priority of power plants entrance to market to cover moment-hour demand can be determined in any moment-hour of 2012 by electricity market department and technical department of supervision on production, deputy of operation of Khorasan Regional Electricity Company. To calculate final short-term cost, operation and maintenance cost items,

1- Statistics related to Mashhad municipal consumption in 2012 have been extracted from detailed statistics of Iran Power Industry-distribution sector, pages 112-120.

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fuel cost, and other operational costs such as salaries, wage, and material are used. To calculate final long-term cost, investment cost items including cost of establishing and running, overhaul costs, and optimization or depreciation cost are used. However, total short-term cost is adjusted with the arrival of environmental pollution tax on production cost calculations. It affects directly total short-term cost of fossil power plants. Operational costs (fixed and variable) and investment cost to determine total short-term and long-term cost directly are calculated by using advanced modeling software modules of EnergyPLAN11.4, and EnergyPRO6.3.

In these software modules, fixed and variable operating costs are introduced precisely for moment-hour for all power plants and generation models by using data from department of electricity market and technical supervision department on generation-deputy operation of Khorasan Regional Electricity Company to related module.

In fact, without considering an estimation of total cost, the final calibrated cost will be available for software module in an input-output model. In return, based on useful life of each plant and cost of investment, establishment and launching of each plant during generation and operation, distributed long-term marginal cost would be specified during useful life by software. This cost would be associated with investment cost related to any moment-hour of power generation in system. On the other hand, sustainable supply of network that is considered as basic condition of production system and combination of renewable and fossil power plants, main criterion of analytical programming would be optimal combination of hybrid. Finally, by determining power plants that should be brought, moment-hour price of generation system would be calculated based on total long-term cost of power generation in system.

Table1. Technical-economic features of power plants

Plant / Explanation	Toos	Mashhad	Shariati	Ferdowsi
Nominal power-MW	600	325	496	954
Average operational power-MW	600	300	420	792
Gross product- MWH	3992906	1344579	2184747	2511800
Domestic consumption -MWH	290107	79138	37727	12069
Pure product- MWH	3702799	1265441	2147020	2499731
Maximum production load-MW	574	196	413	819
Load factor-percentage	79.4	78.3	60.4	35
Exploitation rate-percentage	76	52.2	59.4	36.2
Gas- - thousand cubic meters	356166	482522	446623	761253
Fuel oil - thousand liters	722197	0	0	0
Diesel fuel - thousand liters	322	1381	66078	954
Randman- percent	36.4	29.5	44.9	792

Reference: (Khorasan Regional Electricity Company, 2012)

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Table2. Data related to costs of power plants (first part)

Power plant*	Salary, wage, etc. (million Rials)	Chemical material (million Rials)	Non-chemical materials- foreign exchange (million Rials)	Rial Non-chemical materials- (million Rials)
Power plant 1	204,104	6,818	8,019	3,665
Power plant 2	132,983	3,036	3,156	2,255
Power plant 3	103,245	1,877	4,737	828
Power plant 4	14,048	0	1,156	3,246

*In order to maintain the integrity and confidentiality in reporting classified information of private and governmental power plants, power plant names were not mentioned.

Reference: (Khorasan Regional Electricity Company, 2012 and exact calculations)

Table3. Data related to the costs of power plants (second part)

Power plant*	Frequency Control (million Rials)	MVAr Control (million Rials)	Overhaul (million rials)	Optimization / amortization (million rials)
Power plant 1	2,663	1,864	38,500	30,000
Power plant 2	778	544	90,696	34,928
Power plant 3	1,570	1,099	42,500	12,200
Power plant 4	199	139	41,000	5,000

*In order to maintain the integrity and confidentiality in reporting classified information of private and governmental power plants, power plant names were not mentioned.

Reference: (Khorasan Regional Electricity Company, 2012 and exact calculations)

5- Research Finding

Based on generation system simulation based on analytic programming, the results of base generation system simulation and low-carbon city scenarios have been calculated and represented in table4. As mentioned in research method, costs, separated optimal products, sustainability indicators were calculated by using software modules of EnergyPLAN 11.4 and EnergyPRO 6.3.

Table4. The results of base generation system simulation and generation system of low-carbon environmental city

Index / System product	Base model (basic conditions[1] of generation system)	Environmental low-carbon city scenarios
Average price (Rials on KWH)	2053.107	8048.605
Environmental emissions (thousand metric tons)	3293	3173
Optimal production of renewable electricity (million MWH)	0.00	0.33
Optimize solar electricity production (Million MWH)	0.00	0.01
Optimal production of biomass electricity (million MWH)	0.00	0.32
Optimal production of fossil electricity (million MWH)	4.89	4.56
Network sustainability index[2] (percentage)	3633	2909

Reference: (Researchers' calculations)

1- In the base model, only 660 KW capacity of biomass and operational capacity of 43.2 KW of solar power plant of Elahiyeh were considered.

2- To calculate this index, Lund method (2014) -pages 86-88 was used.

According to table4, with entrance of solar and biomass technology, environmental emission will be reduced 120 thousand tons in environmental low-carbon city scenario since penetration rate of renewable energy in this scenario is counted an expected outcome to design hybrid system. In addition, moment-hour planning of biomass and solar renewable energy to generation system has prevented fluctuating influence of clean energy on network sustainability. It is worth mentioning that although biomass technology has fluctuating renewable entity, high biomass potential of Mashhad and exploitation rate of 80 percent in potentiometric of Khorasan Regional Electricity Company (2012 a) prepares the ground for biomass technology not to affect significantly the generation system reliability and network sustainability despite 0.32 TWh entrance to generation system. In other words, maximum generated energy with biomass technology in hybrid system (with clearly defined and non-swinging approach) is 0.4 TWh. According to moment-hour analytical programming generation to keep network sustainability, only 0.08 TWh of the maximum rate of the maximum theoretical production is not entered to the system and the remaining is used really in to cover demand generation system. However, considering exploitation rate of 20 percent for photovoltaic technology, it may generate 4.45 TWh electrical energy, but volatility nature of this technology in analytical programming disturbs network sustainability. Based on generation system planning; only 0.01 TWh solar electrical energy is regarded to enter into generation network. In this regard, biomass energy can be regarded as pioneer and top technology to create sustainable low-carbon city.

Nevertheless, the big problem of low-carbon environmental city scenario is cost increase with a scale of four times than base model i.e. basic conditions of generation system. The reason for the high cost may be for high investment costs for solar power generation since according to budget information of Khorasan Regional Electricity Company for 2012, investment cost to create one MW fossil capacity, is 20310 million Rials on average whereas it is 104500 million Rials for one MW solar capacity. In return, low cost of creating biomass capacity, 15096 million Rials for investment cost in per MW, represent superiority of using this technology to create one environmental low-carbon city. Thus, biomass technology is considered as the best choice to target planning of sustainable low-carbon city.

Given Mashhad potential, biomass technology is counted as top technology to create environmental low-carbon city, but according to Kanase-Patil et.al, (2011), the use of renewable resources in large capacities can solve the problem of solar energy volatility. For this purpose, in addition to the scenarios enjoying photovoltaic equipment of 2.537989 GW, represented in table 4, scenarios 4, 6, and 8 GW to create photovoltaic capacity in generation system were planned and simulated. Its results represent unchanged product of 0.01 TWh solar electric energy. From one hand, fossil-biomass hybrid system can optimally cover electrical energy demand of urban sector. On the other hand, high cost of generating solar renewable power than fossil and biomass products prevents the arrival of this technology to generation system as a priority in analytical programming based on moment-hour cost of generation. It is

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worth mentioning that considerable increase in generation system cost, due to high capacity of solar power generation, is one of the outcomes of using this technology with 4 to 8 GW capacity in generation system.

6. Conclusion and Suggestions

According to the results of generation system simulation in scenarios of entering different photovoltaic capacities besides entering maximum biomass-renewable power potential, top scenario is to use photovoltaic equipment of 2.53789 GW in addition to create a capacity equal61.35 MW for different types of power plants having biomass technology. Therefore, to create required photovoltaic capacity, it is necessary for each of subscribe of municipal electrical sector of Mashhad in 2012 to create a capacity equal 2.24 KW small-scale photovoltaic power to design LCEC in their urban area including roof or balcony.

Regional solar power plants can be used to provide targeted solar electrical energy in any area, depending on subscriber in similar solutions with this approach. For instance, Elahiyeh solar Power plant started in 2012 with 43.2 KW capacity in central office of Khorasan Regional Electricity Company and completed in 2014 with the capacity of 110 KW can be a suitable model to design other power plants with average scale at urban area level. However, supportive policies to reduce cost of solar renewable generation with photovoltaic technology can play an influential role in declining generation system cost, and create competition and prepare the ground to use clean energy in sustainable energy planning.

Regarding the targeted use of municipal waste in different types of biomass power plants, it is necessary to take advantage of maximum biomass potential and maximize production rate in current condition since actual rate of electrical energy generation from Mashhad municipal solid waste landfill is nearly 456 MWh monthly, based on installed equipment with 660 KW power. However, if one engineering landfill is constructed and equipment installed fully, obtained energy will be increased. It is worth mentioning that 120 thousand tons reduction of environmental pollutant emission is counted as the first step to move toward an ideal model of low-carbon city. Promotion of biomass and biogas generation technology can help to reduce pollution. Thus, different types of biomass power plants can be regarded as pioneer technology in the path of creating LCEC.

An important point that should be mentioned at the end is that analytical programming of LCEC design is done with a comparative realistic approach monitoring technological-climatic potential and except from available tools in urban planning. Therefore, given specific conditions and features of Mashhad, final judgment about biomass and photovoltaic technology has been done. It is obvious that change in the conditions of generation costs and urban-demographic features can bring completely different results for urban planners in other urban areas.

Finally, some of the solutions to achieve ideal situation about environmental low-carbon city can be summarized as follow:

a. The use of different photovoltaic capacities as complementary renewable capacity to provide network demand

b. Maximum use of biomass renewable power potential as renewable power plant enjoying low volatility of low-carbon electricity generation

- Various electricity tariffs for renewable power generation models, and supporting solar and biomass electricity at small and local scales

c. Using legal and institutional capacities to encourage produce and develop solar and biomass renewable energy by using legal articles including:

- Articles 2 and 8 of the implementation of general policies of Article 44 of the Constitution

- Paragraph (b) general policies in energy sector

- Law to regulate a part of government's financial regulations approved on February 16, 2002 (article62)

- Guidelines of article 62 to regulate a part of government's financial regulations (articles 5, 6, 7, 8, 9, 10)

- Law to include provisions to regulate a part of government's financial regulations approved on November 16, 2005 (articles 2, 6, 27, 53)

- Article 5 executive book of regulations article 6 to include provisions to regulate a part of government's financial regulations

- Executive book of regulations article 53 incorporation provisions into law as part of the government's financial regulations (articles 1, 2, and 7)

- Direct Tax Law (articles 132, 141)

- Environment Protection Council Act No. 165 (dated on January 13, 1999)

- Law to prevent air pollution (articles 1, 3, 29, 34)

- An Act to amend the pattern of energy consumption (4, 8, 10, 14, 15, 18, 19, 20, 24, 25, 26, 27, 44, 48, 52, 61, 62, 73, 75)

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