The Role of Biogas power plant in Generating Electric Energy and its Environmental effects

Farhad Zishan¹, Reza Alayi²

Abstract—Nowadays, generating energy is discussed as a paramount option in wastes management, because the share of energy from producing waste is increasing annually. Biogas is one of these renewable energies, which besides generating energy is one of the major resources of supplying electric energy and in generating electricity. The ever-increasing need to energy and limitations of using fossil resources, and also the increase in environment pollution from consuming these resources have made the use of renewable energies of especial importance. Although limiting or suspending industries like power plant is not practical, but applying environmental policies and concerns about depletion of fossil fuel resources have led to taking serious measures in prevention and control of pollutants and improving the efficiency of power plants. Due to the fact that most of consumed fuel in Iran’s power plants is biogas, and the use of biogas for generating electricity is quite economical, in this paper we study the role and importance of biogas power plant in supplying the required energy, and present some strategies in this regard.

Keywords — biogas, biogas power plant, garbage, electricity, environment.

I. INTRODUCTION

Today wastes are well-known environment pollutant, and if we do not find any solution to decrease the burden of pollutants and wastes, we will face with a lot of disorders and difficulties. Biogas is one of the most suitable resources of renewable energy, which besides its renewability it is also environment-friendly. It is one of the best and highly utilized kinds of energy, which have been used from the remote past by human being. Biogas resources, in the form of energy like electricity or energy carriers such as liquid and gas fuels can meet the requirements of different parts of the society [1], and this characteristic distinguish it from other new energies. In addition to generating energy, biogas causes the creation of fertilizers, increases public health level of the society, controls diseases, and is a suitable method for the disposal of solid wastes. Some factors like energy crisis, limited resources of fossil fuels and pollutions from their combustion have made many countries and energy experts to broadly investigate the ways for accessing to new resources of energy, i.e. renewable energies [2]. Among these resources we can name solar, wind, thermal, water and finally biogas energies. Through gaining access to and controlling dissoluble resources we can produce biogas, which is used as a fuel; it can be converted to different forms of energy and is of widespread use.

II. BIOGAS

In the process of anaerobic digestion of organic compounds, molecules break into smaller and simpler molecules. The end result of this process is a combustible gas known as biogas [3]. Biogas resources are generally substances with animal and plant origin. This energy is renewable energy with least and sometimes negative value. The use of biogas resources in the far lands for generating electric energy is economical both in electric industry and fossil fuel. Biogas is the most flexible non-oil resource, which is used to generate electric energy both directly and indirectly through its conversion into liquid or gas fuel [4]. This energy as the 4th major source of energy and as the biggest source of renewable energy in the world had accounted for generating 14% of electricity and 17% of total primary energy of the world in 1998. Biogas can be imagined as a kind of solar energy, because it is considered as the result of photosynthesis and plant growth. Figure 1 shows how biogas energy is consumed in different parts.

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III. BIOGAS COMPOUNDS

Biogas is a compound of some gases such as methane, carbon dioxide, hydrogen sulfide, nitrogen and oxygen, which is the result of anaerobic digestion and biomass fermentation by methanogen bacteria [5]. The combustible part of biogas is methane, which constitutes the major volume of this gas; one cubic foot of this gas produces 252 kilo calorie (1052.3 Kilo joule) of thermal energy, which is remarkable in comparison to other fuels. Table 1 shows the percentage each gas in the biogas.

<table>
<thead>
<tr>
<th>Gas name</th>
<th>Formula</th>
<th>Percentage in the biogas compound</th>
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</thead>
<tbody>
<tr>
<td>Methane</td>
<td>CH4</td>
<td>55 – 65%</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>CO2</td>
<td>35 – 45%</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>H2</td>
<td>0 – 1%</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>N2</td>
<td>0 – 3%</td>
</tr>
<tr>
<td>Oxygen</td>
<td>O2</td>
<td>0 – 1%</td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>H2S</td>
<td>0 – 1 %</td>
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IV. BIOGAS COLLECTION SYSTEM

Biogas collection is done in two ways: active and passive. In active collection system we make use of mechanical blowers or compressors to create an enforced pressure gradient as a force to transmit the gas. In this system (active) the size of the system blower or compressor depends on total rate of gas flow, pressure loss and amount of the required vacuum. While in passive collective systems there is a natural pressure gradient between produced gas and environment pressure, which leads to gas transfer and extraction [6].

V. TECHNOLOGIES OF USING BIOGAS IN ELECTRIC POWER PLANTS

In addition to collecting and controlling environment pollutants and improving society’s health by biogas power plants, we can also provide some parts of the required electric and thermal energies. Technologies of using biogas can be divided into four classes:

A. Power plants merely with biogas fuel (biomass)

B. Double-fuel (hybrid) power plants, which use biogas (as a secondary fuel) along with coal. This is the simplest way to increase biogas power plant efficiency in generating electricity.

C. Gas power plants, which convert biogas into a fuel with low or medium thermal value and generally utilize it as a combustive element in gas turbines.

D. Biological process like digestion and fermentation.

VI. DIFFERENT UNITS OF BIOGAS POWER PLANT

1) Separating garbage and supplying organic wastes

In this unit the collected garbage from the city is separated semi-mechanically and by hand; then the separated degradable substances along with organic wastes are sent to anaerobic reactors for the use in generating electric energy. Separation and compost are done near each other in an enclosed environment with bio-filtering.

2) Anaerobic digestion and gas production: In this part or unit, organic wastes with controlled quantity and quality are sent to suitable digestives in which under the effects of environment (microorganisms) break into simpler compounds.

3) Generating electricity and heat: This unit produces electricity and heat. Different technologies such as micro-turbines, gas turbines and biogas motors are utilized in this unit.

4) Other units: Along with the aforementioned units, a biogas power plant equipped with the units for condensing, drying...
and packaging organic fertilizers from fermented substances. The exited water from the condensing unit (condenser) can be used for irrigating green spaces or with designing suitable system can be consumed for preparing input food to the digestive.

**VII. THE AMOUNT OF EXTRACTED GAS AND ELECTRICITY FROM GARBAGE**

Anaerobic digestion is among the suitable technologies for generating energy (electricity and heat) and stabilizing different degradable organic wastes. The suitable efficiency of this process has led to ever-increasing use of different kinds of biogas power plant in the world. Studies have showed that the physical and chemical properties of produced organic wastes in Iran like urban wastes and sewages is very suitable for using as a fuel in biogas power plants. Studies and investigations on wastes by experts show that through decomposing the main wastes in a 15-20 years period we can retrieve and collect about 150-200 cubic meters of gas from 1 ton of wastes, in a way that up to first 10 years we can generate 10 cubic meters of gas annually. Other studies show that from every cubic meter gas, which is collected from waste, about 5.22 kilowatt of electricity can be generated [7].

The amount of obtained energy from biogas will be rationally different in different regions according to the condition of the related region. Daily production of urban wastes in Iran is about 45 to 50 thousand tons. Hence, about 841 petazul energy can be generated each day from urban wastes of Iran. Table 2 indicates the potential of gas production in Iran with regard to some common source of biomass. The main source of biomass include wood; dry leaves of trees; wastes from forest, agriculture, gardening, and food industries; animal excrements; solid, urban and industrial wastes; urban sewages; and sewages from landfills and industrial wastes [8].

<table>
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<tr>
<th><strong>Table 2- Annual production potential of biomass resources and production of biogas in Iran [8]</strong></th>
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<tbody>
<tr>
<td><strong>Biomass resources</strong></td>
</tr>
<tr>
<td>Urban garbage</td>
</tr>
<tr>
<td>Urban sewages</td>
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<tr>
<td>Animal excrements</td>
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<tr>
<td>Industrial sewages</td>
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<tr>
<td>Agriculture wastes</td>
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**IX. THE DEGREE OF POLLUTION EMISSION**

Biogas power plants fueled with biomass have very little emissions even less than renewable energies such as wind and solar. It can be used for generating thermal and electric energies and it is not an unknown technology in Iran. It can be retrieved in the form of thermal and electric energy with a relatively good efficiency; and the degree of emission by biomass combustion is generally less than that of fossil fuels.

<table>
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<th><strong>Table 3- Emissions (of different pollutions) [9]</strong></th>
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<tr>
<td><strong>CO2</strong></td>
</tr>
<tr>
<td>Biogas</td>
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<tr>
<td>Fossil fuel</td>
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</table>
The environmental effects of using renewable energies, producing fuel from biomass require processes with complex organic compounds, which may produce some solid, liquid or gaseous wastes. The processes may cause a lot of pollutions or may convert some kind of pollution to a totally different pollution.

X. THE ADVANTAGE OF USING BIOGAS POWER PLANT AND SOME STRATEGIES FOR INCREASING EFFICIENCY

Biogas as a local and renewable source of energy is of importance in improving domestic and industrial security condition, decreasing emissions of greenhouse and pollutant gasses that destroy ozone layer, economical growth and estimating energy sources; its technology is acceptable economically. Controlling, optimizing, and exploiting this gas require expending money. The low prices of fossil fuels in Iran, the increase in energy demand, environment pollutions and some other factors have made biogas as economically suitable option. With the construction of biogas power plant in addition to supplying some portion of the required energy in the country, we can take an effective step forward in response to crisis resulting from wastes and decreasing pollutant emissions and this would be of remarkable impacts on economy and society. Lack of geographical and time limitations and simplicity of technical equipment have made biogas more suitable than other renewable energies. For increasing power plant’s efficiency we can use an absorbent chiller to cool down input air. Through using thermal retriever in the direction of outputs, we can use the exited warm air from the turbine to retrieve absorbent chiller. Moreover, we can use the said warm air to heat anaerobic products in the digestive. In the presence of heat, anaerobic substances produce more biogas. For increasing efficiency and decreasing the costs of generating electricity some fuels like wood is utilized.

XI. CONCLUSION AND PRESENTING STRATEGIES

With regard to annual increase of energy use and the decrease of fossil energy resources, it can be said that, this energy resource will never satisfy the ever-increasing need of human being for survival and development. On the other hand, the increase in the amount of solid wastes, animal excrements, and agriculture wastes in the world are among the main factors in increasing greenhouse gases in the world, which is a threat to human life. Hence, beside having an exact and efficient planning and correct management, and replacing fossil fuels with renewable energies, in particular biogas technology, which is very effective in generating power plants’ energy and decreasing emissions we must also follow some rules to optimize using of this energy to prevent environmental hazards.

The high efficiency of this technology in generating electricity and heat shows that the concurrent generation of electricity and heat will lead to significant decrease in the amount of carbon dioxide emissions; moreover it increases fuel efficiency. According to studies, it is possible to collect significant amount of biogas from wastes and garbage of different cities of Iran, and it is possible to increase the volume of produced gas from landfills through utilizing some optimized methods. With regard to the quantity and quality of the urban waste we can determine the potential for generating biogas electricity in the country. Despite the high potential of utilizing this technology, simplicity of its use and its secondary advantages in our country (Iran), unfortunately it is of little attention. There are some barriers in utilizing this technology, which we hope to be removed in the near future and we use this simple but valuable technology:

- cheapness in Iran;
- Energy Non- integrity of the related performed studies;
- Lack of publication and culture of using this technology;
- Lack of public presentation of comprehensive data and the results from conducted projects for free access of interested people;
- Tendency to monopolize the obtained results from the performed projects;
- Lack of skilled and experienced people to promote this technology nationally;
- Lack of investment by private sector and hence lack of competition among authorities and companies and also lack of public education.

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