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Assessing the Potential of Biomass Resources for Extraction of Biogas from Livestock Manure and Agricultural Waste

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ABSTRACT
Despite enormous benefits, excessive consumption of fossil resources causes serious environmental threats and increased air pollution, on the other hand, the resources are exhaustible. Thus, there is an obvious need for new renewable and environmentally friendly resources of energy and we'll have to think of a good alternative. Biomass energy can be one of the good options to replace fossil fuels, because in addition to the lower adverse effects on the environment, it can be considered as an inexhaustible source of energy. One of the innovations of biotechnology is to help processes in which waste that can be used as a huge source of energy. Studies indicated that annually a large amount of agricultural waste and livestock manure remains that is not used for any specific purpose, so gradual replacement of fossil (renewable and unsustainable) resources with biomass and establishment and development of bio-refineries, which entails expanding agriculture, seems necessary. In this paper resources of biomass and energy that can be extracted from livestock manure and agricultural waste are studied.
Keywords: *renewable energy, biomass resources, bio-refineries, livestock waste, agricultural waste*

INTRODUCTION

Iran is rich in renewable and non-renewable energy resources whose exploitation is in line with sustainable development and maintaining environment. Significant renewable energy that can be utilized in the country is biomass energy. Biomass is a group of renewable raw organic materials which is annually produced over 400 thousand million tons on the earth and natural polymers constitute the major part of it [1]. Today, biomass energy is one of the best energies while being environmentally friendly, due to renewability and availability, is of great importance. Because it can replace and supply chemicals required industries and in the near future, biomass will be cheaper than petrochemical products made from petroleum and natural gas.

In recent years, the use of existing potentials of biomass resources (livestock manure) in rural areas have been extensively considered by researchers. However, several factors have led to the fact that the use of them in rural areas has been spread in an undeserved manner and they have not found an appropriate position among variety of energies. In our country, biomass and its extractable energy is in Khorasan Razavi Province as one of the major poles of agriculture, livestock and poultry [2].

Figure (1) shows biomass resources of agriculture, livestock and poultry in the province of Khorasan Razavi as an example of the potential of this type of energy in the country [2].

What is biomass?

Biomass is an important resource of renewable energy. Animal biomass includes the remains of animals in nature and also processing of livestock, poultry and fish. In other words, the term biomass includes cellulosic material such as agricultural waste, household waste (cellulose origin), waste paper and waste wood. These materials have the potential to save energy. In fact, during the process of photosynthesis, carbon dioxide from the air, soil and water is stored in plants by solar energy, causing them to grow. The solar energy at the time of application has the ability to convert into energy.

Biomass can be known as the combination of living and non-living organic matter (except oil, gas and coal) or the combination of renewable organic materials. Biological material or biomass refers to total biological materials produced or in an ecological system having an organic base and the ability to direct conversion to energy or energy carriers as a recoverable source of energy. Biomass is a renewable energy source that

provides about 3 to 35% of primary energy needs in industrialized and developing countries, respectively [3].
Biomass is capable of producing electricity, heat, liquid fuels, and gaseous fuels and has various useful chemical applications.
Annually, 400 thousand million tons of biomass is produced on Earth. The energy stored in the dry biomass is over 25,000 Exajoules (25000 × 1018 joules). This is despite the fact that all forms of energy used by human are only about 400 Exajoules a year. These figures point out the greatness of biomass amounts and the energy lies in it [4].
With increasing demand for energy and increasing loss of natural resources for biomass production, methods to increase the energy efficiency from this source that is decreasing, seems necessary. Producing energy, such as bio-ethanol can be an effective way to optimize the use of agricultural waste. The ethanol produced by biological methods and using raw materials of natural origin, rather than oil and gas (fossil fuels) is called "bio-ethanol". Straw of rice, wheat and corn and sugarcane bagasse are discussed as major agricultural waste with high biomass for energy production. Since the agricultural products mentioned are planted in many areas of Iran, therefore, optimal utilization of their waste to provide energy and reduce environmental pollution is efficient.
Biomass can be converted into energy and various essential ingredients (including food, livestock and poultry feed, fuel, etc) with the help of bio-refinery operations. During this process, the carbon dioxide is also produced and returns as a feed back into the green leaves, the plant of photosynthesis, and the renewability and the sustainability of the resource of energy and substance are guaranteed.

Biogas energy extraction from biomass resources

Biogas can be achieved by the anaerobic fermentation of biomass. The main resources for biogas production include livestock manure, municipal and industrial wastewater, waste and agricultural waste.
According to the needs of today's world, it seems necessary to use biogas. Developed countries have carried out great plans in this regard, in countries such as China, India and Spain biogas is significantly used and the Scandinavian countries have launched large industrial projects using biogas. During processes of planting and harvesting crops, horticulture and forestry in addition to the main product, some materials are obtained which are known by the name of agricultural waste, such as leaves, stems, bark, pods and branches, etc. In addition, during the processing and conversion, which may be performed on main product, other useless materials are also obtained called product waste such as pomace fruits including olive, bran, seeds, bark and wood chips, sawdust, etc. all the materials are obtained by the process of photosynthesis and have organic matter containing large amounts of potential energy this energy can be converted into other energies such as heat, chemical energy, electricity or mechanical energy.
The use of renewable energy in addition to savings of fossil fuels will be as an alternative to natural gas consumption, particularly for remote villages of the national gas network, because it will be created from the fermentation of livestock waste collected in the farms and villages. In addition to the use of biogas as an energy resource, the use of this technology is of great importance in environmental and agricultural dimensions.

Potential for biogas production

Biogas obtained by applying a set of physical, chemical and environmental processes such as decomposition, fermentation and etc. on various resources of biomass in a container, contains 40-70-% (usually 55-65) of methane, carbon dioxide, and a few other gases. When fermentation is used, biogas is obtained from resources such as livestock manure in a fermentation chamber. After applying a series of filtering processes on the gas, it can be considered as an energy carrier. In the process of biogas production to energy amounts of organic matter are obtained that the thermal energy will reduce the resultant energy and the materials shall be removed from the biogas.
For removal of organic materials, it is important to select a suitable biological method and it depends on a variety of factors including type and concentration of input materials, the removal rates of interest, environmental factors, existing facilities, economic factors, and so on.
Generally, there are two ways to remove organic materials: aerobic and anaerobic. In the aerobic treatment, organic matter converts to carbon dioxide and water in an anaerobic reactor, whereas in anaerobic treatment, the materials convert to methane and carbon dioxide in the absence of soluble oxygen. In anaerobic method, energy resulting from conversion is little and the energy is actually stored in methane. Therefore, the growth of bacteria in these systems is low and consequently the costs related to the disposal of excess sludge are reduced [5].

Biogas units

Biogas units have different models. In a general classification, biogas units may be categorized as follows:

1) Balloon units 2) fixed gas tank units 3) moving gas tank units

All of these models include the entry pool, anaerobic fermentation chamber, outlet pool, biogas collection tank and system for transmission and use of biogas. In all units, raw materials (animal manure) are mixed with water and through entry pool built on the upper surface of the ground, are transmitted to the bottom of the fermentation chamber. Fermentation chamber, creating the appropriate conditions of temperature, humidity and lack of air, maximizes methane production rate from anaerobic decomposition. These materials after fermentation and gas production, according to the law of communicating vessels, are transmitted to the outlet pool or the compost pool through an especial canal. Gas chamber is generally located above the fermentation chamber and collects and stores the natural gas. After starting the machine, the biogas produced is sent to the consumption place daily by a special gas valve at the top of the tank and is used.

A biogas unit is actually a simple fermentation tank (or anaerobic digester). Fermentation is performed on organic matter inputs such as agricultural waste and animal manure shown in Figure 4, and on the other hand the resulting methane gas and residual sludge rich in soil fertilizing substances such as potassium, nitrogen and phosphorus are removed.

Various aspects of biogas technology is important, first, the biogas due to its high heating value, can be used as fuel and is a good alternative to natural gas. Secondly, the use of this technology has significant social impacts in the field of environment and human health and third, the sludge discharged from the biogas unit, will be enriched fertilizer, which can greatly increase the efficiency of agricultural products.

Using the study of Adl, the potential of biogas production in Iran can be summarized as [6]:

A) The available animal manure in Iran has been 74,946 thousand tons per year of which the amount of 8668 million cubic meters of biogas can be produced.

B) Agricultural and forest waste mass in Iran has been 23147.5 thousand tons per year of which 5475.8 million cubic meters of biogas can be produced.

A review of past work

The history of biogas production dated back to the early nineteenth century when a person named Divi produced 3.0 of liters methane gas in 1808 by the fermentation of cow manure and vacuum distillation [7].

In Iran, the bath of Sheikh Bahai (eleventh century AD) was probably the first bath which was heated by methane gas. But the first digester producing methane in Iran was newly built in 1975 in Niazabad, Lorestan. In 1982, a 3-m^3 unit was studied at Sharif University of Technology. During the years 1982-1966, Renewable Energy Research Centre of the Atomic Energy Organization conducted specialized research in this field including the construction of 10 biogas units in Sistan and Baluchestan, Ilam and Kurdistan provinces. In 1981, the Ministry of Jihad-of-Construction also took some measures in this regard: first, in 1984 a plot was built in Hyderabad, Karaj, then in 1985, a real unit was constructed in Chin-Sib-Ly village located in Aq-qala in Gorgan region. The Ministry constructed 40 other digesters in different regions of the country of which 18 units reached the stage of gas production. The academic and research centers have taken some steps in this regard. Including the unit established by the Jihad-e-Agricultural of Agriculture Faculty of Karaj University in years 1984-1986 and the unit constructed by Mr. Khalil Sheikh Qassimi (Expert of Water and Sewage Company) in Shahin Dej, Azerbaijan in 1993. Also a biogas unit for digesting human waste in Kish Island and a livestock manure fermentation unit Mahdasht, Karaj were established that both designed and built by AEOI in the years 1998-1999 [8, 9, and 10].

Adl et al (2003) examined thermo-chemical conversion of wood and agricultural waste to gas. Their results showed that the gas rate in this technology is between 1 2.5 cubic meters per kilogram of biomass and energy efficiency is between 70 and 80% [11]. Taleghani and Shabani Kia (2005) assessed biogas plants in Saveh technically and economically [12]. Omrani, Safa, and Golbabaei (2006) designed a biogas plant in the Chinese model in Islamic Azad University, Science and Research Branch in Hisarak Tehran [13]. Dahvari, Theqat al-Eslami and Razavi Tousi (2008) designed a biogas unit for a village in Sistan and Blouchestan province [14]. Adeli Gilani and Souri (2010) designed biogas units for the village Galesh located on the eastern plains of Gilan. In this study, they considered one single biogas unit for every 3 rural households [15]. Alidadi, Kouhi Fayegh dehkordi, Ebrahimian, and Aghaei (2010) evaluated the potential of biogas production in the village Samsami, Koohrang [16]. Sheikh al-Eslami (2010) analyzed economically a pilot biogas located in Mahdasht, Karaj [17].

On sludge digesters and anaerobic wastewater treatment reactors in Iran, it must be said that unfortunately biogas from sludge digesters are not currently being used by municipal wastewater treatment plants.

Studies have also been conducted for many countries, some of which will be mentioned later.

Singh and Sooch (2004) compared economically the different models of individual biogas units for Indian households [18]. M. Virgi, Mackenzie, and Akla (2009) examined the barriers to the use of biogas technology by farmers in Kenya [19]. Pipat Manomay, KaolaAn and Vitidsant (2009) assessed

economically the production of electricity from biogas in pig farms in Thailand [20]. Karlas et al (2010) in a study assessed economically the construction of plants producing both electricity and heat by farmers in Greece [21]. Jouri, Bento, Custer, Schmidt, and Wolfring (2010) examined the production of biogas as an alternative to natural gas in the country of Luxembourg, to prevent the country's natural gas imports [22]. Esm et al (2011) in a laboratory research, explored the ways to increase methane from biogas by adding substances such as corn forage and so on to raw materials, in Denmark [23]. Peterson, Estavis, Dansdal and Givi (2011) and Lau, Alan, Tesolakis, Glanski, and Viszinski (2012) in a research for the UK concluded that the by applying some changes to biogas and converting it into Bio-methane, biogas can be used for vehicle fuel [24, 25]. Anzyla et al (2012) examined the economic, technical and environmental effects of construction of biogas units in Kenya [26]. Iglinski et al (2012) have calculated the potential of biogas production in Poland [27]. Ownerbus and Tarker (2012) have calculated the potential of biogas production from livestock manure in Turkey [28].

CONCLUSION

Gradual replacement of fossil resources (renewable and unsustainable) with biomass seems a strategic necessity rather than a choice. With the arrival of livestock manure into biogas plants, their unpleasant odor and pathogens shared between humans and animals are largely destroyed. The use of biogas technology leads to reduce methane emissions, since the arrival of livestock manure into biogas units prevents the spontaneous fermentation of livestock manure and the entry of the resulting methane into the atmosphere and consequently the warming of the planet. Iran is among the countries with vast resources to produce biogas. Applying the usual amounts of biogas efficiency from livestock manure, agricultural waste, municipal waste and urban wastewater and food industries, the resulting biogas will have plenty of energy. Unfortunately, despite having the potential, the resources are utilized as much. Low cost of energy and lack of public awareness of this type of energy can be considered as deterrents to this type of energy in the country.

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