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Biogas production potential from livestock manure in Iran

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ABSTRACT

Population growth and technological advancement mean that human activities now consume increasingly higher levels of energy. This causes major problems such as depletion of fossil fuel resources and environmental pollution. Energy managers and planners are therefore trying to develop options to meet these increasing demands for energy while maintaining low environmental impact. Application of advanced energy saving techniques and renewable energy resources and technologies present a good solution to these problems. Bio-energy is a widely available resource so it presents an attractive type of renewable energy. Biomass is abundant and easily accessible, making it a low cost resource with great flexibility in terms of potential application.

This paper reports on biogas production from livestock manure and considers evaluations made for the different provinces in Iran. Data for calculations were sourced from available databases relating to Iranian cattle farms. This study reports on calculations made using statistical data on number of cows, amount of manure produced and volume of created biogas per kilogram of animal waste. The total amount of biogas production from livestock waste was calculated for each province using theoretical and experimental methods. Outcomes showed that production of biogas from livestock waste could potentially supply a proportion of the country's natural gas demand. The outcomes were tabulated and a GIS database was generated. Volumes of produced biogas from livestock manure were compared with those of natural gas consumption and outcomes were plotted on a classified map showing data for natural gas consumption and biogas energy. Outcomes revealed that the provinces of Sistan-Baluchestan and Ilam had the highest priority in production of biogas from livestock waste with annual gas consumption levels of 33.3% and 9% respectively.

Contents

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1. Introduction

Energy is the driving force for economic development and industrialization around the world. Fossil fuels are currently the main resources that are used for fuel, as such they are an important consideration in terms of finding solutions to the world's increasing demand for energy [1]. However fossil fuels are limited, and burning fossil fuels has a strongly negative impact on the environment [2]. Ever since the first oil crisis, renewable energy has attracted much by its renewability, sustainability and as a result of increased environmental awareness [3]. So, the role of renewable energy resources in electricity production is improving and it is currently receiving much research attention for its potential to replace with fossil fuel consumption in power plants. This has been brought about by increased public awareness of the negative environmental impact of conventional methods of generating power, especially from coal and petroleum power plants [4].

The main purpose of investigating potential sources of renewable energy is to identify localities that have a suitable supply of renewable energy resources. In the past, biomass energy has been a major source of fuel and it is now an important part of research in the field of renewable energy. According to historical accounts, people in the past relied mostly on dried leaves and wood for fuel [5]. Biomass, as a derivative of biological materials is a renewable resource. Any biological material including organisms or the remains of organisms such as wood and any other organic matter such as forest debris from trees and material from pruning plants and fragments of wood can be used as a source of biomass. Biomass resources include long chain organic compounds that are converted into simpler molecules by the process of digestion [6]. The first step in the digestion process is hydrolysis of polymers that converts polymers to monomers such as glucose and amino acids. In the next step the materials generated by microorganisms are converted to volatile fatty acids, hydrogen and acetic acid. By continuation of this process, active fatty acids (butyric acid and propionic acid) are converted to hydrogen and carbon dioxide by acidogenic bacteria and in the final step hydrogen, carbon dioxide and acetate are converted to carbon dioxide and methane by methanogenic bacteria. The biogas produced in this process consists of two components, methane and carbon dioxide with a small amount of other gases. Biogas usually contains about 55–65% methane, 30–35% carbon dioxide, and some hydrogen, nitrogen and other impurities. Its heating value is around 5300 kcal m^{-3} (600 BTU per cubic foot) and natural gas contains about 80% methane, with a heating value of around 9800 kcal m^{-3} (1000 BTU per cubic foot) [7].

In terms of an overall classification, the final products of biomass are biogas, biodiesel and bioethanol and the analysis in this current study relates to biogas and the potential of biogas production from livestock manure in Iran.

The first report on biomass by the Russian Pillini was on the production of biomass from landfill waste, and incomplete combustion was reported [1]. Von Helmond in 1630 was the first scientist to identify and formally report biogass flammability [3]. There is a wide range of material suitable for application as a biomass resource for bioenergy generation and these are categorized to 6 classes as listed:

- Forest
- agricultural and crop waste
- food industry waste
- municipal solid waste (MSW)
- livestock waste
- municipal sewage and industrial organic waste

Table 1
The share of the biogas production resources in the world [1].

#	Resource	Share (%)
1	Municipal sewage and industrial organic wastes	2
2	Municipal organic wastes	11
3	Livestock wastes	28
4	Agricultural wastes	59

The Food and Agricultural Organization (FAO) reported that 3,339,000 ha of forest exist in the region of the Middle East, of which 1,658,000 ha are located to Iran. It was also reported that each hectare has the potential to produce 80 m^3 of biomass [2]. Thus, the output of Iranian forests has the potential of 133 million cubic meters or 331 million tons of biomass, annually. Efficient use of this resource could generate 218 TWh electricity [1]. As mentioned earlier, livestock waste is one of the main resources available for biogas production in Iran. It is obvious that varied climate conditions are an important consideration for keeping domestic livestock and Iran has suitable climate conditions, therefore good potential for significant amounts of biomass production. Therefore planning for production of biogas from livestock manure is an attractive option that needs to be highlighted in planning and policy development agendas for renewable energies.

The contribution of different biomass resources for biogas production in the world is shown in Table 1 which demonstrated that the agricultural solid waste and livestock manure most important ones with higher values. Preliminary investigations revealed that the Iran's biomass potential is equal to 15 million tons or 140 million barrels of crude oil equivalent, and that is equal to 13% of Iran's total crude oil production in the year 2010 [1]. According to variety and diversity of biomass resources, different methods for resource assessment (calculations of available and accessible resources) are applicable. These methods can be applied for analysis and assessment of biogas production from Livestock manure in Iran.

Firstly, livestock resources in Iran were analyzed and amounts of animal manure produced in each province were estimated using different methods. Secondly, calculations were made using volume of biogas produced and fractions of methane gas from computed livestock resources. According to annual volumes of natural gas consumption and calculated volumes of biogas production from livestock waste in each province, evaluations were made for the portion of natural gas consumption that could potentially be replaced by biogas from livestock waste.

Application and utilization of biogas in Iran has a long history. Sheikh Bahai (1530–1622) was the first to use biogas in a bathhouse in Esfahan. In recent years, the first biogas production digester was built in 1975, Niazabad village, Lorestan western Iran. This digester has a volume of 5 m^3 that used the livestock waste of the village to produce biogas for providing hot water for bath [1]. The livestock waste resources are under the attention of industrialized countries to produce biogas. The produced biogas can be used as an energy carrier after performing some refinement processes matching with global and environmental standards such as ISO: TC 255. Using biogas in industry can make a big saving in consumption of valuable fossil resources (Oil and Natural gas) [2].

This gas can be directly applied to a wide range of industries and existing heating systems, which can save natural gas and oil consumption as an exportable and valuable fossil fuel resource which reduces the environmental air pollutions. In most countries, general use of this gas is for cooking and lighting [3]. There are different types of reactors for the production of biogas and two types are most commonly used in Iran, Chinese and Indian models without any major modification in structures and digestion method. Comparisons of these two conventional biogas reactors are presented in Table 2 [4] and also shown in Fig. 1.