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Feasibility Study on Biogas Production Potential from Iran's Rural Biomass Sources

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Abstract

Rising fossil energy prices and waste disposal costs, coupled with an increased sense of environmental responsibility, is driving a market for renewable energy. The use of waste products as an energy source will reduce dependence on traditional source of energy and reduce or eliminate environmental concerns associated with waste management. In rural areas anaerobic digestion is a potential way in which the Rural Management Organization (Dehyari) can work together with agricultural sector to address broad issues such as waste management, pollution control, energy self-sufficiency and climate change. The purpose of present paper is the feasibility study on biogas production potential from Iran's rural Biomass sources. The potential for biogas production from animal manure in Iran's rural areas is 11195 million cubic meter from 63446021 animals annually. Another biomass source is organic part of solid waste. The findings indicate that the potential for biogas production from organic wastes is 487 million cubic meter from 1249 thousand tons per year.

Keywords: Biogas, Biomass, Feasibility Study, Animal Manure, Solid Waste, Energy.

1 Introduction

Energy is one of the essential needs of today's society. The world population is growing, and so is the demand for energy [1]. The most available and affordable sources of energy in today's world are fossil fuels- about 85 % of all commercial energy is derived from them. The most important thing related to fossil fuels is that they are non renewable. A good substitution energy source for fossil fuels is biomass, which is an example of sustainable (renewable) energy [2].

Biomass is defined as all living plant matter as well as organic wastes derived from humans, animals, and plants. Animal waste, garbage, sewage, and trees are a few examples of biomass [3].

Biomass is a versatile source of energy which can be converted to modern forms such as liquid or gaseous fuels, electricity and process heat. Biomass energy also permits operation at varying scales to suit the needs of communities. These varieties of scales are useful for power generation for decentralized applications, especially at the village level. One of the mechanisms by which biomass can be applied is a biomass digestion in anaerobic phase for biogas production [4].

Biogas production from anaerobic digester presents the following advantages [5]:

1. Production of energy: Due to the half liter of diesel oil, biogas fuel such as Methane considered as valuable component, has the calorific value of 6 kWh/m^3 [6]. However, the efficiency of the users (burners/appliances) the net calorific value of biogas can be calculated. Biogas is a proper replacement of conventional fuels like kerosene or firewood, which the consequence would be the least environmental damage and conservation. Moreover, it increments its own value by the value of increasing planted area. Biogas also leads to decrease the consumption of firewood in rural households which is a significant chance to completely omit the firewood's consumption.

2. Change of biodegradable wastes into sanitary fertilizer: One of the most important results of developing biogas plant is high quality and sanitary organic fertilizer achievemnt. This fertilizer is very valuable, especially in the rural areas where the agriculture is important and farmers need to buy chemical fertilizers frequently. Furthermore, Bio-fertilizers can be considered as sustainable, cost effective and eco-friendly resources of chemical fertilizers for nutrients and healthy soils.

3. Natural resources conservation: Developing biogas plants have direct relation to reducing the natural resource conservation. Due to some studies about 65% reduction of firewood demand after installation of biogas plant was indicated. For instance, biogas development leads to complete stop of households to collecting firewood from the forest due to change from traditional stoves to biogas.

Another change occurs by installation of biogas is livestock rearing practice. Farmers instead of grazing in pasture are converting to livestock. For this reason, propagation of biogas production can conserve pastures.

4. Prevention of global warming: The increase of greenhouse gases which include CO_2, CH_4, NO_x, etc. results a problem of rising earth's temperature. According to the World Bank report, the sea levels, would raise up to 50 cm by the year 2050 which causes flooding, coasts erosion, ground water salinization and loss of land [3, 7].

Based on the 20% effect contribution, the second most important greenhouse gas is Methane while carbon dioxide as the first gas causes 62%. In addition, in a time

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horizon of 100 years Methane has a 25 times higher global warming potential compared with carbon dioxide [8].

With biogas plant, a renewable source of energy is captured, which has an important climatic twin effect:

1. The use of biogas reduces the greenhouse gases emissions through a reduction of the demand for fossil fuels.

2. Anaerobic digestion leads to capture the uncontrolled methane emissions [9].

China and India are the countries with a long history of biomass use for biogas production with the earliest records dating back to the late 1800s. By the 2005, about 16 million digesters had been installed in India. With the assumption of 4 m^3 gas production for each digester and 300 working days, the gas and muck production is estimated to be equivalent to approximately 13.4 million tons of kerosene and 4.4 million tons respectively [10, 11]. In china, about 20 million digesters had been installed by the 2000. These digesters could provide 80 million people with gas [10].

In Iran rural areas, traditional methods of agriculture and municipal waste disposal, such as open dumping, lagooning and land application of untreated wastes are not always efficient and can lead to the pollution of air and water resources. Waste that is digested an aerobically will provide an opportunity for gas and biofertilizer production and reduced risk of contamination to soil and water resources. The environmental concerns, too many agricultural and rural waste productions and the general lack of development in rural areas largely attributed to lack of energy are factors that have made government of Iran to consider agricultural and rural wastes for biogas and biofertilizer production [12].

2 Materials and Methods

The study focuses on data collection for two distinct biomass sources include agricultural waste and rural solid wastes. The common input for biogas plants are animal livestock, straws, degradable agricultural wastes [13], and organic solid wastes. However, major portion of rural solid waste in Iran (about 70%) consists of organic materials.

The first data collection aimed to gain information on issues related to the animal livestock waste. Comprehensive rural animal data were obtained from 2006 Iranian general agricultural census. Calculations are evaluated using animal livestock wastes in rural areas of the country to determine how much biogas will be produced by mentioning biomass source. Farm animals of all types including goat and Capricorn, sheep, naturalize cow, hybrid cow, pure cow and bison were considered. The rate of secretion of manure, Accessible Manure Coefficient and total secretion of manure for each of the animals for biogas production potential of various livestock were used.

The second biomass source is rural solid wastes. The quantities and composition of the rural waste are obtained by previous studies which carried out by the Ministry of Interior (MoI) of Iran [14]. It serves to be aware that the numbers shown in Table 1 as Accessible Manure Coefficient are for the difficulty of collection of all manure for biogas production. For the sake of determining the amount of biogas production from rural solid waste, rural population (from 2009 Iranian statistical year book), [15] Average solid waste residential generation rate, percentage of organic matter in rural waste stream and accessible organic matter were obtained.

3 Results and Discussion

The ability of various biomass sources to successfully predict ultimate biogas production was evaluated. A summary of the results for livestock waste is presented in Table 1. For livestock waste, it is shown that the biogas production potential from a total of 63456 thousands animals was 15678 thousand m^3/y. It serves to be aware that the numbers shown in Table 1 as Accessible Manure Coefficient are for the difficulty of collection of all manure for biogas production. In our study, the biogas production potential varied from 357 to 5542 thousand m^3/y. It should be mentioned that although the secretion of manure and the accessible manure coefficient of pure cow are high but its biogas potential because of pure cow population is low.

Table 1: Biogas Production Potential from Iran's Rural Livestock Waste

Animal	Population (*1000)	Secretion of Manure (Ton/ca.y)	Accessible Manure Coefficient	Total Secretion of Manure (1000*Ton/y)	Biogas Production Coefficient	Biogas Potential (1000*m^3/y)
Goat & Capricorn	20166.90	0.945	0.2	3811.54	0.25	952.89
Sheep	37137.31	1.44	0.2	10695.54	0.25	2673.89
Naturalize Cow	3127.28	9	0.5	14072.75	0.25	3518.19
Hybrid Cow	2345.98	13.5	0.7	22169.48	0.25	5542.37
Pure Cow	520.33	20.25	1	10536.68	0.25	2634.17
Bison	158.57	18	0.5	1427.09	0.25	356.77
Total	63456.36	-	-	62713.09	-	15678.27

This study also evaluated the potential of the biogas production potential from Iran's rural solid waste. The results of about 320 villages on 30 different provinces showed in Table 2. Table 2 presents the average of rural waste generation rate, percentages of the organic component of waste stream, accessible organic matter coefficient, total organic matter and biogas potential. According to the data of Table 2, Average solid waste residential generation rate in rural areas of Iran is estimated 457.73 gr/ca.day.

In the most of studies the average solid waste generation rate is 800 grams per capita/day which similarly was estimated for Iran municipal solid waste. [16] As mentioned above, average solid waste generation rate for Iran municipal areas is about two times more than rural one. The latter matter is because of climate condition; living culture, income level and waste reuse and recycle. A kilogram of organic matter in waste stream will yield 390 liters of biogas. Based on the mentioned assumption, we obtained 486941/60 m3/y for Iran's rural solid waste biogas production potential, as reported in Table 2.

Table 2: Biogas Production Potential from Iran's Rural Solid Waste

Row	Province	Average Solid Waste Residential Generation Rate (gr/ca.d)	Percentage of Organic Matter	Accessible Organic Matter Coefficient	Total Organic Matter (ton/d)	Biogas Potential (1000*m^3/y)
1	East Azerbaijan	269.92	72.66	0.7	153.78	21.89
2	West Azerbaijan	350.8	72.49	0.7	195.59	27.84
3	Ardebil	329.58	60.28	0.7	64.20	9.14
4	Esfahan	501.92	48.2	0.7	101.21	14.41
5	Ilam	312.3	47.69	0.7	21.14	3.01
6	Boushehr	637.62	42.75	0.7	52.02	7.41
7	Tehran	439.76	46.65	0.7	131.00	18.65
8	Chahar mahal va bakhtiari	521.46	35.86	0.7	53.03	7.55
9	South Khorasan	461.06	41.81	0.7	39.72	5.65
10	Razavi Khorasan	468.74	41.04	0.7	228.19	32.48
11	North Khorasan	489.11	36.52	0.7	49.96	7.11
12	Khoozestan	330.14	70.8	0.7	223.67	31.84
13	Zanjan	518.82	37.22	0.7	49.18	7.00
14	Semnan	423.42	53.48	0.7	22.06	3.14
15	Sistan	290.21	44.33	0.7	119.97	17.08
16	Fars	368.08	66.24	0.7	285.45	40.63
17	Qazvin	472.36	39.47	0.7	44.91	6.39
18	Qom	655.44	37.65	0.7	10.03	1.43
19	Kordestan	386.12	51.96	0.7	79.42	11.31
20	Kerman	433.48	49.65	0.7	168.93	24.05
21	Kermanshah	292.89	49.65	0.7	61.66	8.78
22	Kohkilooye	310.35	35.76	0.7	25.43	3.62
23	Golestan	540.02	56.24	0.7	171.65	24.43
24	Gilan	819.97	54.7	0.7	338.78	48.22
25	Lorestan	444.49	41.93	0.7	88.81	12.64
26	Mazandaran	691.67	50.44	0.7	327.75	46.66
27	Markazi	635.46	42.33	0.7	72.56	10.33
28	Hormozgan	580.17	39.63	0.7	122.87	17.49
29	Hamedan	432.67	45.91	0.7	95.07	13.53
30	Yazd	323.96	52.35	0.7	22.70	3.23
Total	21325783	-	-	-	3420.73	486.94
Average	-	457.73	-	-	-	-

As can be seen in Table2, Iran has a high biogas production potential from rural waste resources. Anaerobic digestion method is found to be greenhouse gases and competitive compared with alternative biomass utilization strategies. Thus, the propagation of biogas in rural areas is in line with the national objectives of a "Global warming prevention" and "sustainable development." Moreover, the reductions in greenhouse gases emissions will finance the project; as an example, Certified Emission Reductions (CERs) are often oversubscribed on the emissions mercantilism market by taking part in CDM programs. Therefore, further revenue is often gained to complete for the high biogas Establishment price. The government ought to additionally take measures like giving tax incentives to support the event of CDM programs for operation of anaerobic digestion projects.

In step with the results of economic analysis in regard to high potential of biogas production from rural waste in Iran and also multiple uses of biogas plant (as a energy and fertilizer), anaerobic digestion promotion is economically profitable, with a high economic come back on the investment quantitative relation [17].

4 Conclusion

Manure co-digestion is a method that increases the buffering capacity of substrate mixtures and adds essential nutrients that can substantially improve biogas and fertilizer quality. The results of this research show that 16165214 m3/y of biogas can be derived from Iran's rural Solid and livestock waste. The biogas plant can effectively reduces the amount of methane (one of the most important greenhouse gases) directly released into the atmosphere, by trapping it and facilitating its use as a green fuel. After burning, methane only releases harmless gases in air.

Most part of Iran is a vast in agricultural that's produces biomass resources. The 4R strategies (reduction, recycling, reuse and recovery) of wastes through biogas technologies have attracted widespread attention. Currently, Iran is making an attempt to popularize rural biogas technologies, accomplish integration of technologies and facilities, and accelerate the pace for biogas promotion.

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