Avrupa Bilim ve Teknoloji Dergisi
Cilt. 2, No. 4, S. 106-111, Haziran 2015

Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
Vol. 2, No. 4, pp. 106-111, June 2015

Research Article

Determination of Biogas Potential from Animal Waste in Turkey: A Case Study for Yozgat Province

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(First received 2 December 2014 and in final form 29 May 2015)

Abstract

The constantly rising energy prices, decreasing fossil resources and the consequent environmental problems, have led to an increased interest towards alternative energy resources. It is both eco-friendly and cheaper when compared to other energy resources, therefore biogas energy is among the top alternative energy resources to be chosen. Biogas is highly important in rural areas, because it is being used as an energy resource as well as a fertilizer resource. In this research, the production potential of biogas from animal waste in Yozgat province and its districts has been defined. Biogas from animal waste has become one of the important renewable energy resources. In addition, the production potential of biogas from animal waste in Central Anatolia Region and Turkey in general has also been determined and comparisons have been made. When 2012 data are taken into account, the province of Yozgat has a potential of 45.070 million m^3 biogas potential from animal waste. With 6.546 million m^3 biogas, the Central district is placed first, while with 6.521 million m^3, Akdagmadeni district is in second, and with 5.166 million m^3, Sorgun district is in third place. Yozgat's animal waste biogas energy potential makes up 7.024% of Central Anatolia Region, and 1.266% of Turkey.

Key Words: Biogas, Central Anatolia Region, Yozgat, Turkey.

Türkiye Hayvansal Atık Kaynaklı Biyogaz Potansiyelinin Belirlenmesi: Yozgat İli için Örnek Çalışma

Özet

Sürekli artan enerji fiyatları, azalan fosil kaynaklar ve bunların gerçekleştirdiği çevresel sorunlar nedeniyle dünyada alternatif enerji kaynaklarına olan ilgi her geçen gün artmaktadır. Biyogaz enerjisi hem çevreci hem de diğer enerji kaynaklarına göre daha ucuz olması nedeniyle tercih edilmesi gereken alternatif enerji kaynakları arasındadır. Kırsal alanlarda biyogaz, hem enerji kaynağı hem de gübre kaynağı olarak kullanımından dolayı önem taşımaktadır. Bu çalışmada günümüzde önemli yenilenebilir enerji kaynaklarından biri olan hayvansal atık kaynaklı biyogazın Yozgat ili ve ilçelerindeki üretim potansiyeli belirlenmiştir. Ayrıca; İç Anadolu Bölgesi ve Türkiye genelindeki hayvansal atık kaynaklı biyogaz üretim potansiyeli de belirlenerek karşılaştırmalar yapılmıştır. 2012 verileri dikkate alındığında Yozgat ili 45.070 milyon m^3 değerinde hayvansal atık kaynaklı biyogaz potansiyeline sahiptir. 6.546 milyon m^3 biyogaz ile Merkez ilçe ilk sırayı alırken 6.521 milyon m^3 ile Akdağmadeni ilçesi ikinci, 5,166 milyon m^3 ile Sorgun ilçesi üçüncü sırayı almaktadır. Yozgat ilinin hayvansal atık kaynaklı biyogaz enerjisi potansiyeli İç Anadolu bölgesinin %7.024'ünü, Türkiye'nin ise %1.266'sını oluşturmaktadır.

Key Words: Biyogaz, İç Anadolu Bölgesi, Yozgat, Türkiye.

1. Introduction

With the world population growing fast, the existing resources are constantly decreasing. Most of these resources are limited, and in order to keep them at the service of humanity for a longer period of time, these need to be used appropriately, renewed, or replaced by new resources [1]. In recent years, the usage of hydraulic, solar, geo-thermal and wind based energy production became common and energy production by direct burning from bio-mass has become widespread [2, 3]. However, resources biogas production in an oxygen-free environment from vegetative and animal resources, which are defined as bio-mass renewable energy, is almost non-existent [2]. Biogas is methane gas which is formed after fermentation of energy plants, organic wastes in an airless (anaerobic) environment. Biogas is a color-free, odorless, and lighter than air gas with a density rate of 0.83 against air and has an octane rating of 110. It burns with a bright blue colored flame, and consists of 40-70% methane (CH_4), 30-60% carbon-dioxide (CO_2), 0-3% hydrogen sulphur and low amounts of nitrogen and hydrogen [3-5]. Being an eco-friendly gas, biogas can replace natural gas, one of the fossil fuels, contributes to the reduction of greenhouse gas in atmosphere. In Table 1, natural gas and biogas compounds have been given. As it can be understood from Table 1, methane and carbon-dioxide are the main components of biogas. Methane content within natural gas is 92% in volume, while in biogas; it is 55-70%. However, carbon-dioxide amount within natural gas is 0.61% in volume (almost non-existent), but within biogas, it is about 35-45% [6].

Table1. Composition of natural gas and biogas [6]

Parameters	Units	Natural-gas	Biogas
Methane	% in vol.	92	55-70
Ethane	"	5.1	0
Propane	"	1.8	0
Butane	"	0.9	0
Pentane	"	0.3	0
CO_2	"	0.61	35-45
Nitrogen gas	"	0.32	0-2
H_2S	mg m^{-3}	1	0-15.000
NH_3	"	0	0-450
Water dew point	^oC	Dew point at -5	Saturated
Net Comb. Heat	MJ kg^{-1}	48.4	20.2
Density	kg Nm^{-3}	0.809	1.16
Rel. Density	(-)	0.625	0.863
Wobbe Index (W)	MJ Nm^{-3}	54.8	27.3

As it is known, being released to the atmosphere by the burning of fossil fuels, CO_2 is one of the most important elements effecting global warming (global climate change). Producing biogas also releases CO_2 into the atmosphere. However, this amount is only as much as the CO_2 amount absorbed by the plants from the atmosphere [7, 8]. The remaining products following biogas production are named fertilizers. Nitrogen, phosphorus and potassium, which are found within organic matters and needed by plants, are preserved inside the fertilizer and this product can be used as agricultural fertilizer [9]. When the remaining organic matters, following biogas production are used as fertilizer, serious increases will be observed in product fertility, thus, biogas production must be considered not only for energy value, but also for its contribution to the environment. During this production, many harmful microorganisms are terminated by fermentation, and also, the fertilizer odor is also eliminated [10].

In this study, the production potential of biogas from animal waste in Yozgat province and districts has been defined, as this form of energy has become one of the important renewable energy resources. In addition; the production potential of biogas from animal waste in Central Anatolia Region and in Turkey in general has also been defined and comparisons have been made.

2. Materials and Methods

Within the scope of this study, Turkish Statistical Institute's (TUIK) [11] 2012 animal statistic data has been used as material. The amount of fertilizer acquired from the animals can vary, depending on the type of the animal. In order to determine the animal waste potential, 3.6 ton/year has been taken as a basis for a bovine, 0.7 ton/year for an ovine and 0.022 ton/year for a poultry animal [1, 12]. The biogas amount produced from a ton of usable fertilizer is deemed to be 33 m^3 for bovine, 58 m^3 for ovine and 78 m^3 for poultry [1, 13, 14]. In addition to these, the heat amount produced by 1 m^3 of biogas is equal to 0.63 liter of gas oil, 3.47 kg wood, 0.43 kg LPG, 4.7 kWh electric and 0.8 liter gasoline [15].

The land area of Yozgat is 1412300 hectares and in terms of land size, the province is ranked 15th in Turkey. Yozgat covers 1.82% of the total land area of Turkey [16]. Looking at Table 2, we see that in the province of Yozgat, there are a total of 1361535 animals. These animals consist of 57% poultry, 25% ovine and the remaining 18% is bovine animal. When we look at it on the basis of districts, the total animal existence is distributed by 24% in Sorgun district, 20% in Central district and 14% in Akdagmadeni (Figure 1).

Table 2. Yozgat province and districts' animal existence (Pcs) [11]

Districts	Bovine	Ovine	Poultry	Total
Central	35468	49420	190180	275068
Akdagmadeni	45912	21180	120950	188042
Aydincik	8000	6510	8060	22570
Bogazliyan	10785	87100	37256	135141
Candır	1148	5744	2323	9215
Cayıralan	9070	14540	6079	29689
Cekerek	35155	17898	4200	57253
Kadısehri	19843	10918	19280	50041
Saraykent	13797	4910	15523	34230
Sarikaya	19840	21214	20020	61074
Sorgun	32662	20316	269122	322100
Sefaatli	8008	21290	12096	41394
Yenifakili	2965	14680	10162	27807
Yerkoy	10264	41724	55923	107911
Total	252917	337444	771174	1361535

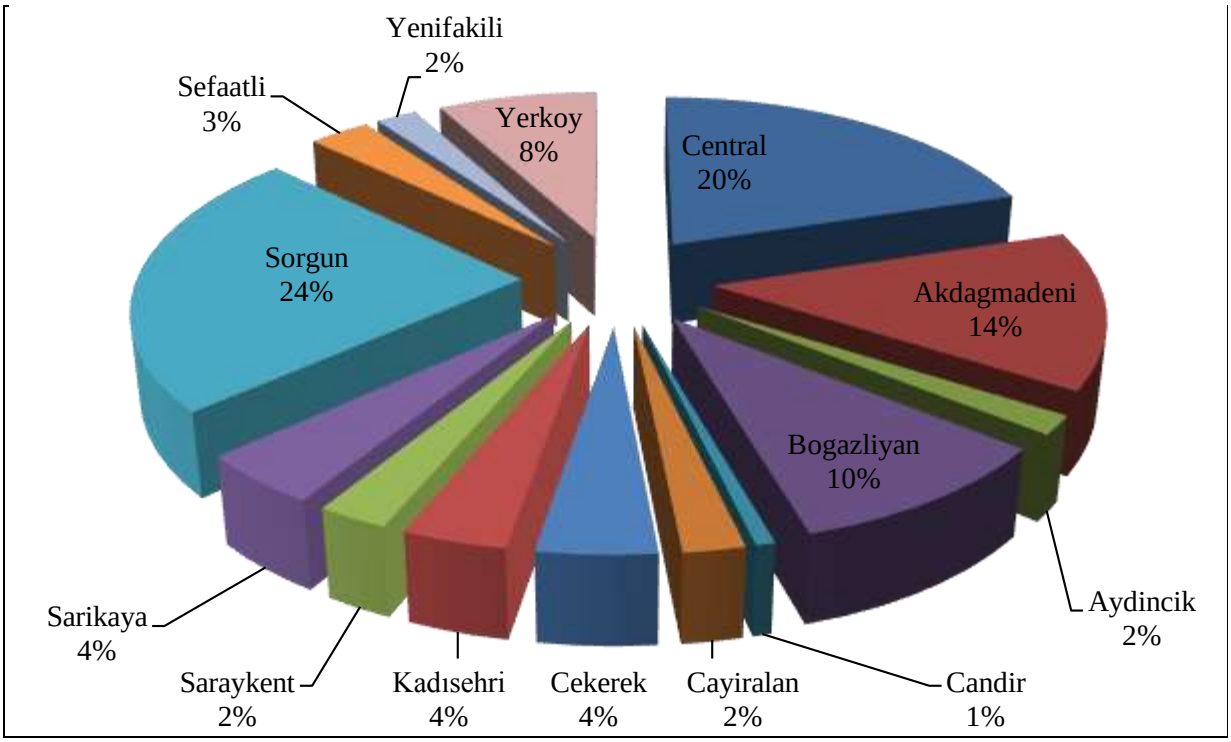

Figure 1. Animal existence distribution per district

Taking the animal existence amounts into consideration, Yozgat's animal waste potential and producible biogas amount have been given in Table 3. As it can also be seen in Table 3, animal waste potential in Yozgat is 1.163 million ton/year, and the total biogas amount that can be produced is 45.070 million m^3 / year. If we were to evaluate it per district, the Central district is first with 15%, Akdagmadeni is second with 14%, and Bogazliyan, Cekerek and Sorgun are third with 11%.

Table 3. Animal waste potential and producible biogas amounts in Yozgat province and districts [11]

Districts	Animal Waste Potential (ton/year)	Biogas Production Amount (m^3)
Central	166462	6546399
Akdagmadeni	182770	6521803
Aydincik	33534	1228536
Bogazliyan	100615	4881449
Candır	8204	373575
Cayiralan	42963	1678271
Cekerek	139179	4910280
Kadısehri	79501	2833703
Saraykent	53447	1865067
Sarikaya	86714	3252634
Sorgun	137725	5166888
Sefaatli	43997	1836481
Yenifakili	21173	965687
Yerkoy	67387	3009321
Total	1163677	45070100

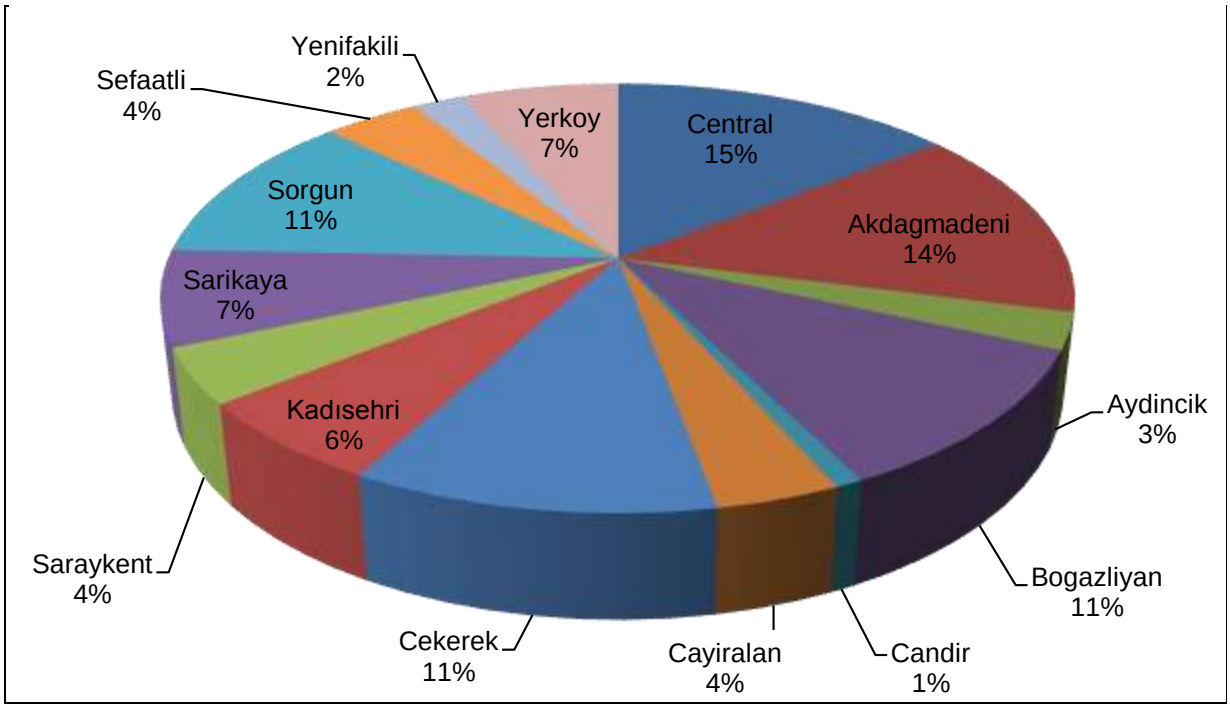

Figure 2. Biogas Production Potential per District in Yozgat Province

In the province of Yozgat, it is possible to produce an annual total of 45.070 million m^3 biogas energy, and the equivalent of this amount in other energy resources has been given in Table 3. As it can be seen from this table, biogas production potential from animal waste in Yozgat in total are approximately equal to 36.056 million litre gasolines, 19.38 million kilogram LPG, and 211.829 million kWh electricity energy. The comparison of the potential biogas in Yozgat province compared to other fuels has been given in Table 4.

Table 4. The equivalent of the producible biogas in Yozgat to other fuels [11]

Districts	Gas oil (L)	Wood (Ton)	LPG (Kg)	Gasoline (L)	Electricity (kWh)
Central	4124231	22176005	2814951	5237119	30768076
Akdagmadeni	4108736	22630659	2804375	5217443	30652477
Aydincik	773978	4263023	528270	982829	5774123
Bogazliyan	3075313	16938629	2099023	3905159	22942811
Candir	235352	1296305	160637	298860	1755802
Cayıralan	1057311	5823602	721656	1342617	7887876
Cekerek	3093476	17038671	2111420	3928224	23078316
Kadısehri	1785233	9832951	1218492	2266962	13318407
Saraykent	1174992	6471782	801978	1492053	8765815
Sarikaya	2049159	11286642	1398632	2602107	15287383
Sorgun	3255139	17929103	2221762	4133510	24284376
Sefaatli	1156983	6372589	789686	1469184	8631461
Yenifakili	608383	3350937	415245	772550	4538733
Yerkoy	1895872	10442345	1294008	2407457	14143810
Total	28394163	156393249	19380143	36056080	211829472

The animal waste biogas production potential of Yozgat Province covers 7.024% of Central Anatolia Region. Approximately 18.022% of the production potential of biogas from animal waste in Turkey is covered by the Central Anatolia Region, while the province of Yozgat has a share of 1.266%. Central Anatolia Region's biogas production potential from animal waste has been given in Table 5.

Table 5. Animal waste biogas production potential of central Anatolia region [11]

	Bovine	Ovine	Poultry	Total	Animal	Biogas	%
Ankara	275805	895906	8323864	9495575	1803157	83423168	2.343
Konya	646816	1918662	10662482	13227960	3906175	173036237	4.860
Kirikkale	65762	146467	743121	955350	355618	15034281	0.422
Kayseri	277546	510040	4288270	5075856	1450535	61038760	1.714
Sivas	339843	486575	437855	1264273	1573670	60879652	1.710
Karaman	52127	485035	1280875	1818037	555360	28083090	0.789
Aksaray	172715	379554	329024	881293	894700	36493039	1.025
Nigde	124475	501065	621511	1247051	812528	36197381	1.017
Nevsehir	70347	98869	780905	950121	339637	13711337	0.385
Kirsehir	101642	109957	420485	632084	452131	17260876	0.485
Eskisehir	118881	603963	5621913	6344757	974427	48291163	1.356
Cankiri	134283	110196	1579760	1824239	595310	23137646	0.650
Yozgat	252917	337444	771174	1361535	1163677	45070100	1.266
Central	2633159	6583733	35861239	45078131	14876932	641656735	18.022
Turkey	14022347	35782519	257505341	307310207	81193330	3560504260	100

3. Conclusion

In recent years, biogas technology made it possible to process wastes which cause environmental problems, and make them harmless, while producing energy. This technology is highly important in terms of producing alternative energy. Even though there is an animal waste potential to be utilized in Turkey, it is not being benefited as well as it should be. There is an 81.2 million tonnes of animal waste potential in Turkey. Using this potential is likely to result in a great input in economic terms. In this study, the animal existence figures have been taken as a basis, and an attempt was made to define the production potential of biogas from animal waste in the province of Yozgat, Central Anatolia Region, and Turkey. Within the province of Yozgat, the total amount of animals is 1.361 million, and the total biogas amount that can be produced from the excrement of these animals is 45.070 million m^3. Looking at the districts, we see that the central district is first with 6.546 million m^3. The central district is followed by 6.521 million m^3 in Akdagmadeni, and 5.166 million m^3 in Sorgun districts. In addition, Central Anatolia Region's biogas production amount from animal waste makes up 18.22% of Turkey. Yozgat on the other hand, makes up 7.024% of Central Anatolia Region, and 1.266% of Turkey. When we evaluate these rates, we can see that Yozgat's animal waste sourced biogas production potential is an issue worth examining. The possible amount of biogas that can be produced in Yozgat is approximately equal to 28.394 million liter gas oil, 156393249 kg wood, 19380143 kg LPG, 36056080 liter gasolines and 211829472 kWh electric energy. These values show that biogas is an alternative resource of energy resource which can meet the energy needs of the region and the province of Yozgat, but it is not being used. Another important benefit to be provided by the biogas production in Yozgat province and districts is the positive effect of biogas production on the environment and the fertilizer which is brought into a usable form. The province of Yozgat and the surrounding towns have an economy dependent on agriculture, and this production will meet the fertilizer needs of the region. All these findings need to be analyzed and before it is too late, biogas potential from animal waste in Yozgat province and districts needs to be benefited from.

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