

## Potential of Production of Biogas from Animal Origin Waste in Turkey (Tokat Provincial Example)

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**Abstract:** Energy consumption in Turkey increases rapidly. Therefore, non-renewable energy resources are expected to be run out in the future. In this study, importance of usage of animal origin waste, which is one of the non-renewable energy resources, average fertilizer and biogas quantity which can be gained by animal origin waste and their economic contribution are discussed. Energy amount was calculated in case of transferring of animal waste of bovines and ovines in Tokat to average fertilizer and biogas energy quantity. Total consumed energy amount at Tokat in 2007 is 552319150 Kwh. Also, electrical energy quantity, which can be gained by transferring the total biogas amount obtained from animal origin waste is 177964359 Kwh. In this situation, an income of 32% can be achieved at the quantity of electricity consumed in one year in case of using animal origin waste.

**Key words:** Biogas, energy, animal husbandry sector, Tokat, Turkey

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### INTRODUCTION

Energy consumption increases rapidly due to improvement of technology and increasing rate of world population (Kizilaslan, 2009). About 80% of energy need in the world is supplied with fossil fuels such as coal, petrol and natural gas. Known reserve distribution of fossil fuels in the world, equivalent to petrol is 68% coal, 18% petrol and 14% natural gas (Vogel, 1999). Energy need of Turkey will be doubled between 2000-2010 and five times bigger between 2000-2015. This rapid increase in demand is because of high economic development speed rate of Turkey. Government takes some precautions for attracting new domestic and foreign private sector investments and for revision of these establishments and working effectively. Furthermore, government gives the rights of employment of current units to private sector (Hilkiah *et al.*, 2008). Usage of renewable alternative energy resources is needed to be used due to increase energy need with each passing day; climate and temperature changes resulted in damage on nature balance; exhausting of fossil fuels in future. Biogas, which is one of the renewable energy resources is produced by fertilizers of animals, plant wastes, home-waste water and industrial wastes (Vassiliou, 1997). Moreover, fuel is gained by fermentation of plants, animal fertilizers, home water water and product wastes in an anaerobic media (GEMET, 2000). So, not also there prevents the damages to nature but also an alternative energy resource is

obtained. Biogas is especially helpful at preventing air pollution because of using primary energy resources. At the same time, damaging of nature can be also prevented by processing organic wastes with aim of protecting underground and aboveground resources. Research and development studies about biogas were firstly carried out in 1960s in Turkey. Universities, national research institutes, enterprises and international organizations perform studies regarding biogas (Kaygusuz and Turker, 2002). Utilization from this energy resource seems to be very important when compared with animal quantity in Turkey even though, Turkey is dependant on foreign petrol resources. Use of plant-origin and animal origin wastes as eco-friendly and renewable energy sources have been researched for long years and some outcomes could be implemented. First time scientists detected that a combustible gas could be obtained by anaerobic fermentation of organic substances in 1630. The direct connection between combustible gas and organic substances was determined in 1776. In 1808, it was also determined that the combustible gas formed at anaerobic fermentation of cattle fertilizer was methane. In Turkey, in a year, almost 20 million tones of animal fertilizers are used as dried cow dung, which causes big economic losses. If these burned dried cow dungs are converted to biogas energy, villagers can provide their energy costs such as electricity, gas, diesel etc. and because it is not used as dried cow dung, those will be used as fertilizers at farm. If

use of those is raised for biogas system, it brings a huge profit economically. After biogas production wastes are not vanished and also becoming more valuable organic fertilizers. Nutritional value of manure for plants has been increasing at a rate at least 15%. By the researches made, it has been revealed that 1 ton of farm manure contains 4.5 kg of potassium, 4.5 kg of pure nitrogen and 2.3 kg of pure phosphorus. For this reason with wheat, the head of Turkey's agriculture product, 1.5 million ha of fields can be fertilized theoretically.

Turkey's dependence on imported oil is at high a level such as rate of 73%. In addition, today the price of oil per barrel that is up to \$120 makes this problem even more complex. Turkey allocates a large portion of the imports budget to purchase oil and natural gas and spent 11.8 billion dollars in 2007 for 23.5 million tons of oil. Biogas production will reduce the dependence on foreign Turkey's energy field and as well as will also contribute to the solution of some problems common in the agricultural sector. Although, energy dependence on foreign energy can be reduced to some extent by the efficient use of the basic measures such as use of more efficient, large size of solar energy and the elimination of energy loss and all natural resources, the sustainable biogas production option for closing the energy gap has to be considered as an important alternative by all countries having the appropriate conditions for the possibility including Turkey.

Biogas is seen as an important value particularly for small towns and farms to meet the electricity needs. With this method, costs arising from transmission lines that transmit electricity to small settlements and the transformers can be eliminated dramatically. Economic development in rural areas is one of the most important benefits of biogas. Each year, billions of Turkey Lira oil is spent. Biogas fuels can reduce oil imports in half in the near future. Change potential with billions Lira in the rural areas of Turkey is an incredibly effect. It will be important to create many jobs (production, harvesting and use) and in industrial development (in plant development for fuel conversion and energy). By ensuring regular income and power in different products, farmers will participate in society.

All of them come to the importance for Turkey of biogas; Turkey has production potential coal of 2.5 million tons per year or production potential biogas of 20-25 billion Kwh electric energy. In this study, the average amount of fertilizer and biogas obtained from animal wastes in Turkey and their economic contribution, an average of the amount of fertilizer of cattle and small ruminant animal waste in Tokat and biogas energy conversion in the case to be obtained in the amount of energy intended to put forth.

## MATERIALS AND METHODS

### The study material is constituted of secondary data:

Tokat Provincial Directorate of Agriculture records, web pages, previously related to research and publications about the subject, various organizations with published books, journals, statistics and reports have been benefited. Average amount of fertilizer to be obtained from waste of cattle and small ruminant animals in Tokat and biogas energy conversion in case the amount of energy were calculated.

## RESULTS AND DISCUSSION

### Average amount of fertilizer and biogas of Turkey that can be obtain from animal waste

**The amount of fertilizer per day:** According to the different types of animals there may be various amounts of fertilizer efficiency. Account the amount of fertilizer, 10-20 kg for cattle day<sup>-1</sup> (age) fertilizer efficiency can be considered as 5-6% of body weight per day may be based on the amount of fertilizer. Sheep and goats in the same way for 2 kg (wt.) day<sup>-1</sup> or 4-5% of body weight per day can be regarded as a fertilizer. Chicken manure production per day is 0.08-0.1 kg (wt.) day<sup>-1</sup> or 3-4% of body weight. The daily and annual production amounts of fertilizer based on animal weight are given:

- About 5-6% of live weight cattle animal manure kg-age day<sup>-1</sup>
- Sheep-goat 4-5% of body weight-age fertilizer kg day<sup>-1</sup>

### Another approach:

- One cattle 3.6 tons year's<sup>-1</sup> fertilizer
- One small ruminant animals, 0.7 tons year's<sup>-1</sup> fertilizer

### Based on these values:

- One ton of cattle manure, biogas 33 m<sup>3</sup> year<sup>-1</sup> biogas
- One ton sheep manure biogas 58 m<sup>3</sup> year<sup>-1</sup> biogas
- One ton of poultry manure biogas 78 m<sup>3</sup> year<sup>-1</sup> biogas

As shown in Table 1, fuels as equivalent to an effective temperature of biogas are given. In Table 2, size,

Table 1: Fuels as equivalent to an effective temperature of 1m<sup>3</sup> biogas

Fuel	Values
Wood coal (kg)	1.46
Wood (kg)	3.47
Butane gas (kg)	0.43
Dried cow dung (kg)	12.30
Electricity Kwh	4.70
Diesel (L)	0.66
Gas (L)	0.75
Propane (m <sup>3</sup> )	0.25
Butane (m <sup>3</sup> )	0.20
Coal (kg)	0.85

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**Table 2: Biogas production quantities according to the business assets in the animal**

Animals	Appropriate plant	Fertilizer needed for daily	Biogas amount to produce (m <sup>3</sup> gün <sup>-1</sup> )	Equivalent amount of LPG (kg)
2.500 chickens	15	200	17.0	7
5.000 chickens	30	400	34.0	14
10.000 chickens	60	800	68.0	28
20.000 chickens	120	1600	136.0	56
50.000 chickens	300	4000	340.0	140
5 bovines	5 m <sup>3</sup>	75	2.5	1
10 bovines	10	150	5.0	2
50 bovines	50	750	25.0	10
100 bovines	100	1500	50.0	20

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**Table 3: Equivalent amount of biogas and coal corresponding to animal waste potential in Turkey (\*)**

Animal genus	Livestock (number)	Wet-fertilizer amount (ton year <sup>-1</sup> )	Biogas amount (M <sup>3</sup> year <sup>-1</sup> )	Coal equivalent (ton yıl <sup>-1</sup> )
Cattle	11054000	39794400	1313215200	1181894
Sheep-goat	38030000	26621000	1544018000	1389616
Chicken-Turkey	243510453	5357230	417863937	376078
Total	292594453	71772630	3275097137	2947587

eie.gov.tr, total biogas amount: 3,27 billion m<sup>3</sup> year<sup>-1</sup>, (\*) In the event of interior temperature of Fermenter 18°C

**Table 4: Numbers of cattle and small ruminant in Tokat Province (2007)**

Name of District	Bovine				Ovines		
	Cattle	Calf	Water buffalo	Total	Sheep	Goat	Total
Center	36500	10505	635	47640	45000	1700	46700
Almus	10750	4775	250	15775	13645	1190	14835
Artova	9483	4307	10	13800	12035	126	12161
Basciftlik	2650	1075	25	3750	5200	5	5205
Erbaa	12300	3100	1600	17000	36000	2500	38500
Niksar	18900	8350	1750	29000	25200	2450	27650
Pazar	6400	2500	300	9200	3800	900	4700
Resadiye	11243	4216	316	15775	24519	400	24919
Sulusaray	6000	2500	50	8550	3500	250	3750
Turhal	27000	6000	1750	34750	16210	4960	21170
Yesilyurt	6730	2100	20	8850	2930	150	3080
Zile	28900	7910	700	37510	21000	2000	23000
Grand Total	176856	57338	7406	241600	209039	16631	225670

Tokat Provincial Directorate of Agriculture, Animal Health Branch records

daily production of biogas and LPG gas effectively equivalent amounts of heat are given for biogas plants of chickens and cattle enterprises depending on the number of animals. Feeding animals in open areas or in the barn affects daily manure production. In addition, rate of solid matter in fertilizer also affects the production. Rates of solids in manure: Optimum for the formation of biogas, 7-9% of plant fertilizer-water mixture should be solid. Rates of solid materials is around 15-20% of cattle manure, 30% of chicken manure and 40% of sheep manure (Karacan, 2007).

In Table 3, equivalent amount of biogas and coal corresponding to Animal Waste Potential in Turkey is given. In the case of working in the optimum fermenter temperature to be between 2.2-3.3 billion m<sup>3</sup> year<sup>-1</sup> of this potential seems theoretically possible.

**Tokat Province potential animal existence:** About 13.2% of Tokat Province is composed meadow-land area. Production of feed crops is at 12.6% level in field crops. Conditions appropriate to make fodder crop farming and

due to developments in cattle genotypes, there seems increase in the number of hybrid animals and animal productivity. This situation shows great the potential of animal husbandry in Tokat Province. In Table 4, number of cattle and small ruminant in Tokat Province were given.

**Biogas and electrical energy amounts corresponding to the potential of animal waste in Tokat:** In 2007, the total energy consumed in Tokat amount is 552, 319, 150 Kwh. As shown in the Table 5, if we convert total amount of biogas into electrical energy that can be obtained from animal waste in Tokat, we will obtain the amount of electrical energy 177, 964, 359 Kwh. The amount of earnings in terms of electricity consumed per year can be achieved by 32% with use of animal waste in Tokat. To increase agricultural production in Tokat, to obtain more output from unit area the fertilizer should be used. Converting animal waste into biogas and then in turn be used as farm fertilizer is of great importance in terms of Tokat economy. In 2007, the total biogas derived from

Table 5: Biogas amount and electrical equivalent of produced corresponding to the potential of animal waste in Tokat (\*)

Animal genus	Livestock total (number)	Wet fertilizer amount (ton year <sup>-1</sup> )	Biogas amount (M <sup>3</sup> year <sup>-1</sup> )	Electricity (Kwh)
<b>Bovines</b>				
Cattle	176856	636682	21010968	98751550
Calf	57338	206417	6811755	32015246
Water buffalo	7406	26612	879833	4135214
<b>Ovines</b>				
Sheep-goat	225,670	157969	9162202	43062349
Total	467270	1027680	37864758	177964359

\*In the event of interior temperature of Fermenter 18°C

animal waste 37, 864, 758 m<sup>3</sup> year<sup>-1</sup>. Fuel which farmers use are expensive. Instead, if biogas, an alternative energy source are produced and used, the costs drop and farmers gain profits from the financial aspect (Republic of Turkey Ministry of Agriculture and Tokat Province Agriculture Directorate, 2007). This amount of biogas, when turned to diesel fuel, 24, 990, 740 L are obtained, which meets a significant proportion of farmers' fuel need.

Study carried out by Ulusoy *et al.* (2009), Bursa Region indicate that 6,000 tonnes of pea waste are obtained per factory. Since, there are about 10 plants in this region, a total of 60,000 tonnes of pea waste is estimated to be generated for this scenario in this region. If the 60,000 tonnes of pea waste were instead processed for biogas production, 4.92 millions m<sup>3</sup> of gasses could be obtained. If this gas was used to generate electricity, it would be possible to obtain 8.61 million kwh of electric energy and 8.26 million kwh of heat energy. Bursa, 15,000 tonnes of tomato waste could be used for biogas production, for a potential yield of 1.35 million m<sup>3</sup> of gas. If this gas were used to generate electricity, it would be possible to obtain 2.36 million kWh of electric energy and 2.27 million kwh of heat energy.

In the study carried out by Prasertsan and Sajjakulnukit (2006), the amount of agricultural residues is about 61 million ton a year of which 41 million ton, which is equivalent to about 426 PJ of energy was unused. The most promising residues are rice husk bagasse, oil palm residue and rubber wood residue, merely due to their availability at the mills, which heat-power cogeneration is feasible. Biogas resources are from industrial wastewater and live stocks manure, which have potential of 7800 and 13,000 TJ year<sup>-1</sup>, respectively.

### CONCLUSION

Biogas is more appropriate for use in rural areas to develop, in very large cities with a population and inadequate infrastructure that system will take time to implement. By establishing the laws supporting entrepreneurs proposing to implement this system in rural areas and by improving farmers and public awareness, energy shortage, which is one of the Turkey's biggest

problems can be eliminated as soon as possible. In the long run, in big cities, an energy source of self-sufficient and protecting the environment can be achieved by issuing a law for implementing the facilities, net customized borders, high sanctions, inspections, which are easy to control and by raising society awareness.

Energy is provided from two main sources. These are non-renewable and renewable sources of energy. Unconsciously consumption of non-renewable energy sources since the start of the industrial revolution until today has led to reduce of energy resources. Non-renewable energy resources (oil, coal, etc.) are estimated to be run out in the near future. In developed countries, per capita energy consumption is increasing. For this reason, it is necessary to tend to new and renewable energy sources and to prevent depletion of non-renewable energy sources.

In Turkey, especially in rural areas wood, manure, LPG and coal are used as fuel for the purpose of cooking and heating. Especially, in recent years low-income people in rural areas are economically disadvantaged in Turkey because of increases in fuel prices. Lack of sufficient fuel for the purpose of warming in rural areas leads to destruction of limited forest areas. To prevent these, as one of the renewable energy sources, studies using animal waste to obtain biogas should be given priority.

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