Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. VI, 2017
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

EVALUATING OF ELECTRIC ENERGY GENERATING POTENTIAL USING BIOGAS FROM ANIMAL BIOMASSES IN BURDUR CITY

Recep KULCU, Cihannur CIHANALP

Suleyman Demirel University, Isparta, Turkey

Corresponding author email: recepkulcu@sdu.edu.tr

Abstract

Today, with population increasing, industry growing up, technology advancing and getting involved with our lives ever so largely, the need for energy naturally increases. As current resources are failing to meet the requirements, search for alternative sources begins. Studies are rapidly increasing on a search for energy resources that are renewable, environment friendly, harmless to living beings and are not reliant on outside sources. Renewable energy resources are sustainable as they exist in the nature and do not have limited reserves. They also have strategic importance on the principle of sustainability as they do not produce greenhouse gas emissions upon usage. Today, renewable energy resources like the sun, wind, biomass, geothermal, hydraulics, hydrogen and wave energies are used in various ways, mainly for electricity. One of the renewable resources, biogas is a gas mixture emerging during oxygen-free fermentation of organic waste, and it is classified among biomass resources. In this study, we have determined the current animal quantity in Burdur city and calculated the amount of fertilizers obtained annually from these animals. Then the amounts of biogas, methane, electricity and thermal energy that can be produced out of these fertilizers is discovered should they be processed in biogas facilities. Figures show that based on 2015 statistics, 3.1mil tons of fertilizers is acquired annually from the animals in Burdur. Processing these fertilizers in biogas facilities can produce 79 million m^3 of methane in a year. Burning this amount of methane in cogeneration systems can produce 275,740,415.72 kWh electricity and 315,131,903.68 kWh thermal energy annually.

Key words*: biogas, Burdur's potential of electric and thermal energy, renewable energy*

INTRODUCTION

Developing technology, increasing population and growing economy demand an increase in the need for energy, resources as fossil fuels meeting these requirements are consumed ever so rapidly. The greenhouse gas emissions produced from using fossil fuels cause increase in world's average temperature, which results in serious environmental issues such as melting glaciers, disruption in rain regime, climate changes and warm streams changing directions. Beside from those problems, dependence in foreign resources caused more issues, and along with unstable prices, the last quarter of the century has naturally seen much more interest in renewable energy resources and their studies.

Approximately 86% of the energy consumed around the world is supplied from fossil resources such as oil, natural gas and coal. Annual consumption rates of energy resources are as follows, 2015: 32.8% oil, 29.0% coal, 24.2% natural gas, 6.8% hydraulic, 4.5% nuclear, 2.7% renewable (MENRa, 2016). These rates show that a large quantity of world's energy need is met by fossil energy resources.

RENEWABLE ENERGY POTENTIAL OF TURKEY

Growth of economy, population and technology increases the need for energy resources in Turkey, as it does for the rest of the world. Even though Turkey is advantageous in renewable resources for its geographical position, most of the energy need is supplied through fossil resources, most of which is imported from other countries.

Ministry of Energy and Natural Resources in Turkey defines the country's energy policy as "provision of energy resources in a manner to help economic growth and social projects and to accomplish this sufficiently, reliably and timely, considering economic and environmental conditions". Over the increasing requests, the ministry 2015-2019 Strategic Plan

consisting of 62 objectives on energy and natural resources (MENRb, 2016).

Turkey's primary energy demand in the year 2014, equal to 123.9 million tons of oil (tpe) (867.3 million barrels) is distributed as: 32.50% natural gas, 29.20% coal, 28.50% oil, 6.70% renewable, 2.80% hydraulic and 0.30% others. Looking at the energy demand distribution on industries, 30% of the consumption is done in the circuit industry (producing electricity), 24% in housing and service, 23% in industry and 19% in transportation. Domestic supply rates of primary energy resources were figured as 25%, for the year of 2014. Imported energy supply rates have reached 75%, the highest point in the last ten years (MENRa, 2016). Values for 2016 are shown in Table 1.

Table 1. Electricty production in Turkey in 2016 distributed on resources (EA, 2016)

Production from	Generation (mWh)	Rate (%)
Natural gas	85,678.193	32.97
Hydraulic	62,744.539	24.14
Imported Coal	43,945.821	16.91
Coal and Lignite	40,554.857	15.61
Wind	14,296.496	5.50
Geothermal	3,962.961	1.52
Other Thermal	2,265.807	0.87
Biogas	1,875.019	0.72
Imports	4,543.829	1.75

Of all the renewable energy resources, biomass energy holds significant importance. Biomass stands for organic forms based on plants and animals.

Fuel production based on biomass is made by processing these forms.

These processes include physical, chemical and biological practices. In processing biomass biologically to produce energy, the most common practice is biogas production.

Biogas in Turkey

Biogas is a colorless and flammable gas mixture that is produced through decomposing organic waste in an oxygen-free environment. In its main composition it consist of 60-70% methane (CH_4), 30-40% carbon dioxide (CO_2), 0-2% hydrogen sulfur (H_2S), very little of nitrogen (N_2) and hydrogen (H_2).

Biogas usability for energy is based firstly upon the methane rate. Produced biogas is usually converted into electricity in thermal and energy stations (cogeneration) to be directly distributed in a local manner or electricity network.

Table 2. Fundamental waste characteristics (BT, 2016).

Type of raw materials	Fertilizer per unit (kg/ animal/ day)	DS (%)	VDS (%)	Methane production/ raw material (m^3 CH_4/ kg VDS)
Dairy Cattle	43	12	10	0.175
Beef Cattle	29	8.5	7.2	0.325
Calf	2.48	5.2	2.3	0.175
Pig	5.88	11	8.5	0.4
Sheep	2,4	11	9.2	0.3
Goat	2.05	13	9.5	0.3
Horse	20.4	15	10	0.3
Meat Chicken	0.187	22	17	0.35
Egg Hen	0.128	16	12	0.35
Turkey	0.376	12	9.1	0.35
Duck	0.33	31	19	0.35
Beetroot		18	79	0.46
Potato		25	79	0.28
Corn		85	72	0.41
Wheat		87	87	0.39
Rape		88	93	0.34
Grass		18	88	0.35
Clover		20	80	0.35
Pumpkin		22	82	0.26
Sugar Beet		15	80	0.23
Rye		85	87	0.37
Barley		93	86	0.44
Brewery		83	85	0.48
Slaughterhouse Wastewater		10	81	0.90

DS - Dry Substance; VDS - Volatile Dry Substance

The thermal energy produced by burning the biogas can be used in heating the buildings and greenhouses nearby, drying hay, cooling milk or conditioning barns. For business profitability, it is crucial to benefit widely from both products (thermal energy and electricity).

In Table 2, fertilizer production per animal unit, dry substance and volatile dry substance percentages and methane production per raw material are given based on each raw material. These parameters are used to get a hold on how much biogas and methane would be produced

in a biogas facility. In this study, calculations are referred from these numbers.

Turkey has a great potential for biogas production, which is not utilized yet in a wide manner. Based on a study prepared by Germany Biogas Research Center and Turkish experts cooperation, which takes part in Turkish-German Biogas Project, 12% of Turkey's electricity demand can be met by biogas (TGBPa, 2016). Considering this number along with the rate of biogas on Turkey's electricity production distribution in table1, which was 0.72%, it can be seen that only 6% of the country's biogas potential is utilized.

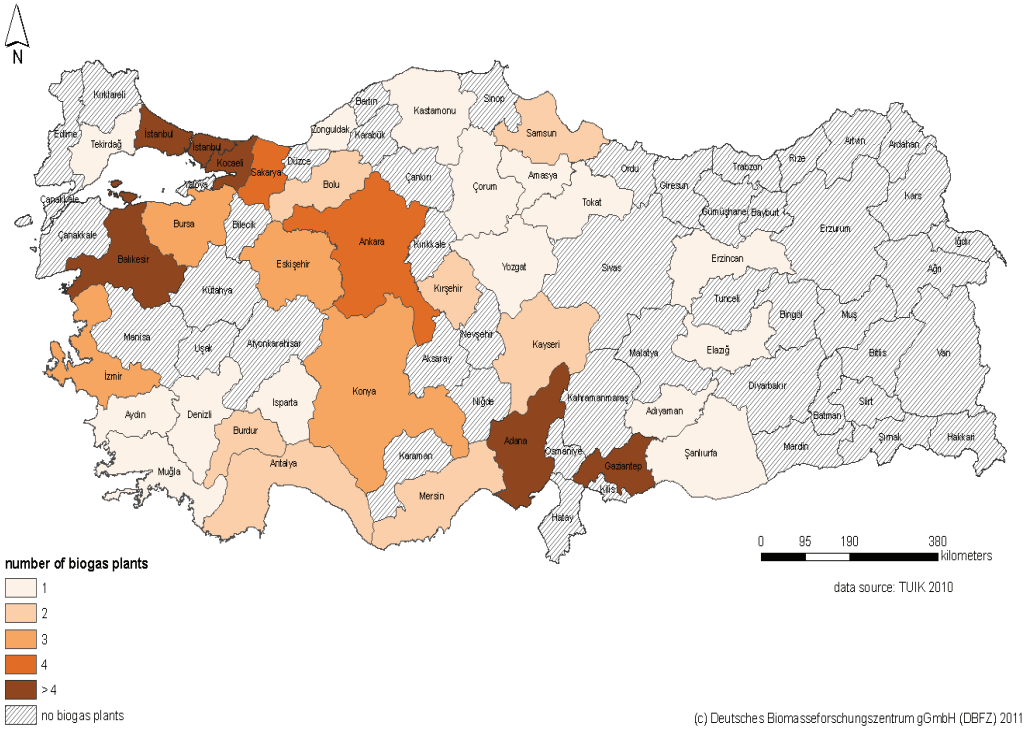

Figure 1.Biogas Facilities' Distribution in Turkey (TGBPb, 2016).

In Figure 1, biogas facilities based on locations in Turkey are given on the map.

Looking at the number of facilities in Turkey, it can be seen that while some cities have biogas facilities established and working, some cities have not started such activities. Considering that those cities have animal husbandry activities, it is supposed that biogas facilities will spread through the country in time.

Biogas systems have numeral advantages. They are clean, cheap, environmental friendly and have high technicity in thermal value resources of energy and fertilizers production. After biogas production, germination of grass seeds that can be found in animal fertilizers are lost. Production transforms waste into valuable organic fertilizer, enabling the soil to benefit from waste. Biogas also affects positively human health in the countryside as it eliminates the smell of animal manure.

With the RER (Renewable Energy Resources) law signed in May 10th 2015, electricity produced from biogas was included under purchase guarantee in Turkey. With the18/04/2007 dated code 5627, act 17, the 2005 dated 6th act made it so the electricity produced by RER would be priced between 5-5.5 euro cents per kWh, as determined by EPDK. In 2010 however, the 6th act was completely changed; legal entities working in

production on RER Support Mechanisms would make use of newly determined prices, terms and payment principles (Kulcu et al., 2011).

Signed by the parliament in December 29th 2010, the new law encouraging for renewable energy production also had the state accepting to give additional support for equipment in domestic production activities.

Accordingly, the biogas facilities (including waste gas) producing electricity out of RER on RER Support Mechanisms would purchase electricity at 13.3 dollar cents per kWh. Though that number may increases up to 18.9 dollar cents per kWh depending on the level of domestic technology used in the facility.

Livestock and biogas potential of Burdur

The city of Burdur is located around the central area of the Mediterranean region, in the proximity of an area called Lakes Region, in the passage from the Mediterranean to Aegean and Middle Anatolia regions, between 29°-24' and 30°-53' eastern longitudes and between 36°-53' and 37°-50' northern latitudes (Figure 2).

The economy of Burdur is mostly based on animal husbandry and agriculture (BGI, 2016). Animal husbandry has great importance in the region and many kinds of the practice can be spotted. So we can say that animal husbandry holds significance in Burdur's economy.

It is advantageous for facilities producing and processing breed stock, meat and milk.

The most important factors for efficiency are maintenance and protection of animal shelters.

Figure 2. Location of Burdur on the map of Turkey (LBMP, 2016).

Table 3.Burdur's fertilizer potential for each animal type (Turkstat, 2016)

Animal	Adult	Young-newborn	Total number of grown animals*	Amount of waste (tons/year)
Cattle	149110	55913	177,066.5	2,779,050.87
Sheep	178649	67779	212,538.5	186,183.28
Goat	156613	48153	180,689.5	135,200.54
Egg Hen	155900	-	155,900.0	7,283.64
			Total	3,107,718.33

*number calculated by adding half of young animals to adult animals.

Biogas production potential of Burdur out of animal fertilizers

Based on waste characteristics on Table 2 and waste obtained from various animal types on Table 3, quantity of methane that can be produced in Burdur is shown on Table 4.

Table 4. Potential methane to be produced in Burdur for each animal type

Animal	Emerging waste (tons/year)	Methane production (m^3/year)
Cattle	2,779,050.87	56,534,054.68
Sheep	186,183.28	12,847,205.42
Goat	135,200.54	9,399,277.58
Egg Hen	7,283.64	477,989.40
Total	3,107,718.33	79,258,527.08

Potential output of biogas in Burdur

In Burdur, 3,107,718.33 tons of waste emerges from animal husbandry each year. Using this waste in biogas production would produce 79,258,527.08 m^3 of methane in a year. Annual production from burning this quantity of methane in a cogeneration unit would be 315,131,903.68 kWh of thermal energy and 275,740,415.72 kWh of electric energy.

Economic value of electricity production

Purchase prices of electricity produced in biogas facilities under RER laws depend on the domestic technology used in the facilities. As calculated for Burdur, Table 5 shows differing prices for domestic and foreign technology units to be used in a facility that would be established there.

Table 5. Price equivalents of units to be used

Technologic unit type	Price of an unit (USD/kWh)	Price of produced electricity (USD/year)
All Imports	0.133	36,673,475.29
All Domestic	0.189	52,114,938.57

Economic value of fermented fertilizers

Processed and watered fertilizers obtained in producing biogas also have trading value in the fertilizer market.

In biogas production, the waste processed in separators becomes 20% watered fertilizer in a quantity of 970,562.55 tons per year. With these fertilizers being equivalent to 50 USD per ton, 48,528,127.50 USD of income would be generated.

Economic value of thermal energy production

Based on the calculations on biogas production potential, biogas to be burnt in cogeneration units would produce 315,131,903.68 kWh/year of thermal energy. Pricing for this energy would be 0.0185 USD/kWh (referred from natural gas), resulting in an income of 5,829,940.218 USD/year.

CO_2 decrease

Biogas is considered in the category of renewable energy resources. So emissions emerging from burning biogas are considered a part of nature's cycle. Then, producing biogas and burning it in cogeneration units in Burdur would cause CO_2 diminish of 278,025.12 tons/year, as the energy is produced solely out of fossil resources.

CONCLUSION

Growth of economy, technology and population causes an increase in the demand for energy resources.

As the need for energy rises and fossil resources decline rapidly, production and usage of new, renewable and harmless resources are to be spread quickly.

To meet the needs with renewable resources, current investments must be supported, new investors must be encouraged and studies should be augmented. Known as the fuel of the future, biogas should be invested into and supported in both business and scientific studies, as it is a cheap and harmless resource for energy and fertilizers.

In this study, usage and production of biogas, a resource holding strategic importance for Turkey, were analyses in the scale of Burdur and economic benefits of processing animal waste were given in numbers.

Results show that Burdur has the potential of producing 79,258,527.08 m^3 of methane. Burning this quantity of methane in cogeneration units holds the potential for producing 315,131,903.68 kWh of thermal and 275,740,415.72 of electric energy in a year.

Another benefit of biogas facilities is fermented fertilizers, and Burdur has the potential of producing 970,562.55 tons of fertilizers annually. All this output from potential biogas facilities in Burdur is equivalent to 48.53 million USD (fermented fertilizers), 52.11 million USD (domestic technology electricity production) and 5.83 million USD (thermal energy), added up to 106.47 million USD of total gain.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Suleyman Demirel University Department of Scientific Research Project with project number 4780 YL1-16.

REFERENCES

Biogas Turkey (BT), 2016. Fundamental Waste Characteristics. Retrieved from http://biyogaz.org.tr/silaj_depolama.asp.

Burdur General Information (BGI), 2016. Retrieved from http://www.burdurkultur.gov.tr.

Energy Atlas(EA) 2016. Electricity Production in Turkey. Retrieved from www.enerjiatlasi.com >elektrik-uretimi.

Kulcu, R., Süslü, A., Ekinci, K. &Yaldız, O., 2011. *Biogas Option for Animal Waste Management in Turkey and RER Law*. TRNC: Ukay.

Location of Burdur on the Map of Turkey(LBMP), 2016. Retrieved from http://www.lafsozluk.com/2012/01/burdur-ilinin-turkiye-haritasindaki-yeri.html.

MENRa, 2016. Ministry of Energy and Natural Resources, Crude Oil and Natural Gas Sector Report.

Retrieved from www.enerji.gov.tr>File> TP_HAM_PLTROL

MENRb. 2016. Ministry of Energy and Natural Resources. 2015-2019 Strategic Plan. Retrieved from www.sp.enerji.gov.tr/ETKB_2015_2019_Stratejik_Plani.

Turkish-German Biogas Project (TGBPa), 2016. What is Biogas? Retrieved from www.biyogaz.web.tr/tr/biyogaz-nedir.

Turkish-German Biogas Project (TGBPb), 2016. Biogas Potential Report of Turkey. Retrieved from http://www.biyogaz.web.tr>files>docs.

TurkStat, 2016. *Database*. Retrieved from https://biruni.tuik.gov.tr/hayvancilikapp/hayvancilik.zul.