COST AND POTENTIAL ANALYSIS OF BIOGAS IN ESKISEHIR

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Abstract: In this study, cost analyses were prepared for biogas production in Eskisehir considering the cattle potential. Beside this, solution methods were investigated for returning the biogas product wastes as a fertilizer to the farmers in the area. Energy is accepted as an indicator of development. Development is defined with the amount of energy per man. In Turkey, 50% consumed energy is imported from different countries. Large amount of energy consumption requires new raw materials to produce energy. Due to the sources of unrenewable energy are running out rapidly and environmental pollution are very hazardous, countries were tend to renewable energy. So, the importance of biogas production was increased day by day. As a basis, biogas is obtained in air-free medium by fermentation with plant and animal wastes. It is a burnable gas mixture. Biofertilizer is more efficient than the normal one.

Key Words: Biogas, Energy Potential, Animal Waste, Fertilizer, Biogas Production, Cost Analysis, Biogas Cost.

Eskişehir İlinde Biyogaz Potansiyeli ve Maliyetinin Analizi

Özet: Bu çalışmada Eskişehir ilinin büyük baş hayvan potansiyeli dikkate alınarak biyogaz üretim olanakları araştırılmış ve maliyet analizi yapılmıştır. Ayrıca Biyogaz üretim atıklarının çiftçiye gübre olarak geri verilmesi için çözüm yolları araştırılmıştır. Günümüzde enerji, ilerleyen endüstrinin bir göstergesi olarak kabul edilmekte ve ülkelerin gelişmişliği, kişi başına düşen enerji miktarıyla tanımlanmaktadır. Ülkemizde tüketilen enerjinin yaklaşık %50'si yurt dışından ithal edilmektedir. Büyük çapta enerji ithalatı enerji üretebilecek hammaddelere yönelmeyi gerektirmektedir. Yenilenemeyen enerji kaynaklarının hızla tükenmesi ve yarattığı çevre kirliliği ülkeleri yenilenebilen enerji kaynaklarına yöneltmiştir. Bu konuda yeni ve önemli enerji kaynaklarından biri olan biyogaz dikkati çekmektedir. Biyogaz temel olarak bitki ve hayvan atıkları gibi organik maddelerin, havasız ortamda fermentasyonuyla oluşan enerji değeri yüksek yanıcı bir gaz karışımıdır. Fermentasyon sonucunda elde edilen biyogübre, normal gübreden çok daha verimli bir kaynaktır.

Anahtar Kelimeler: Biyogaz, Enerji Potansiyeli, Hayvan Atıkları, Gübre, Biyogaz Üretimi, Maliyet Analizi, Biyogaz Maliyeti.

1. INTRODUCTION

Biogas is a burnable gas mixture fermented in oxygen free-medium of various organic wastes (herbal wastes see and black moss, and specially groved plants) and animal wastes. Organic wastes and residues are fundamental energy source for his kind of production method. Since these are used in mentioned way, reactions and burnable gas mixture will be revealed. Such organic original materials are defined as converted energy. In general, they can be called as biomass and biomass energy (Nesteren, 2003). Bio and mass means alive and bulk respectively. In other words, it also means storing of materials into the plant.

This energy source is very economical as an example; fermentation of 1 tone biomass material in air-free medium is equivalent to energy of 1.2 barrel petrol. On the other hand, burnable gas mixture is consisted of 40%–70% methane gas, 30% –55% CO_2, N, H and H_2S per cubic meter. Energy consumption is very high in China and India. Therefore, biogas energy as an alternative energy source are being used for 50 years and satisfies the certain amount of energy. It is known that, $1m^3$ biogas is approximately equivalent to 4.7 kWh electrical energy.

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In general animal manure is directly used in eastern part of Turkey for plants and also used as a fuel for heating. And we may say that, usage is not efficient for Turkish economy. In this situation, the most part of the energy is wasted irrelevantly. Also, low efficiency is owing to poisonous unprocessed substance. Above mentioned losses are common problem for agriculture and animal breeding that must be solved in a very short time. So, biogas is produced for either heating or fertilizing from animals.

From the cattle point of view, eastern cities, from the agriculturing point of view, intern cities have more potential but, Eskisehir has really big potential for cattle sheep and goats. In this study, potential of Eskisehir was considered and then by predicting the amount of biogas, cost analysis was fulfilled (Nesteren,2003; Biogas Digest, -; TÜBİTAK, 2009).

2. BIOGAS POTENTIAL IN ESKISEHIR

Before the prediction of biogas potential in Eskişehir, number of cattle, sheep and goats were determined. Values for these were taken from The Ministry of Agriculture and Forestry, Eskişehir Directorate. Distribution of cattle for towns in Eskisehir is given in Figure 1.

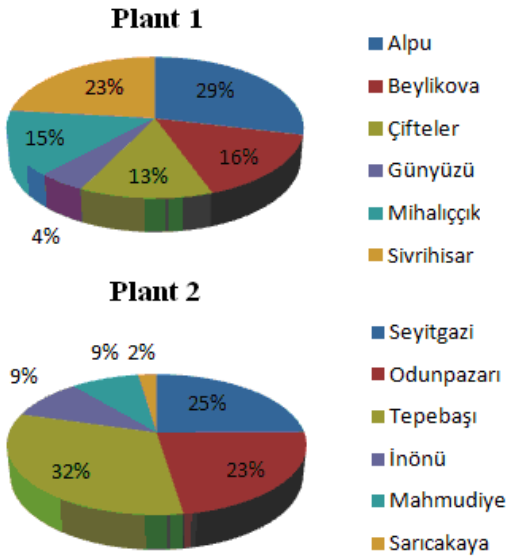

Figure 1:
Distribution of cattle in Eskisehir, 2009 (TÜBİTAK, 2009)

The accurate numbers for cattle is given in Table I. The total number is 118937 in Eskisehir. According to the town locations and the density of population, the wastes will be collected in two steps in order to reduce the cost of transport and biogas. That's why, two plants were considered, one being in Seyitgazi and the other in Alpu. Cattle manure is the most suitable material for biogas plants because of the methane producing bacteria already obtained in the stomach of ruminants. The specific gas production however, is lower and the proportion of methane is around 65% because of prefermentation in the stomach. Its homogenous consistency is favorable for use in continuous plants as long as it is mixed with equal quantities of water.

Table I. The number of cattle in towns of Eskisehir

Cattle				
Plant 1				
Town	Cow	Calf	Buffalo	Total
Alpu	10589	5293	5	15887
Beylikova	6019	2724	0	8743
Çifteler	5580	1537	0	7117
Günyüzü	1459	1056	0	2515
Mihalıççık	5888	2382	0	8270
Sivrihisar	8617	4236	0	12853
Sub-total	38152	17228	5	55385
Plant 2				
Seyitgazi	13920	1872	12	15804
Odunpazarı	10246	4106	66	14418
Tepebaşı	13471	6787	47	20305
İnönü	4080	1800	120	6000
Mahmudiye	4860	672	0	5532
Sarıcakaya	976	517	0	1493
Sub-total	47553	15754	245	63552
Total	85705	32982	250	118937

Conventional methods can be used for production of biogas of 118 173 cattles.

Statistics for animal wastes

- Manure: 5.47 tone/year/one cattle
- 33 m³ biogas/1 tone manure
- 4.7 kWh electrical energy per 1 m^3 biogas.

Production is;

(118 937) x (5.47) = 650 585.39 tone/year manure

(650 585) x (33) = 21 469 317.87 m^3/year biogas

Values are outlined in Table II. Since decision is made for two plants, special care was taken in selection of plant site in order to process the manure more easily. Sometimes, the biogas must be treated/conditioned before utilization. The predominant forms of treatment aim at removing either water, hydrogen sulfide or carbon dioxide from the raw gas. The biogas is usually wholly saturated with water vapor. This involves cooling the gas, e.g. by routing it through an underground pipe, so that the excess water vapor condenses at the lower temperature. When the gas warms up again, its relative vapor content decreases. The "drying" of biogas is especially useful in connection with the use of dry gas meters, otherwise which would eventually fill up with condensed water.

Table II. The amount of fertilizer and biogas in Eskisehir

Plant No	Number of Cattle	Fertilizer (tone/year)	Biogas (m^3/year)
1	553 85	302 955.95	9 997 546.35
2	635 52	347 629.44	11 471 771.52
Total	118 937	650 585.39	21 469 317.87

The equivalence of 1 m^3 biogas as an electrical energy is 4.70 kWh. Similarly the equivalence of 1 m^3 methane as an electrical energy is 10 kWh. Electrical energy for residences 21.376 krş/kwh.

TEDAŞ buys electrical energy at 17.376 krş/kwh from private sector (Akbulut ve Dikici, 2004; Bilir ve Ark., 1983; TEDAŞ, 2009; TÜBİTAK, 2009). Biogas income is 31 572 TL for cattle potential in Eskisehir (Table III).

Table III. The equivalence of cattle potential to biogas and electrical energy in Eskisehir

Plant No	Number of Cattle	Fertilizer (tone/year)	Biogas (m^3/year)	Energy (kwh)
1	553 85	302 955.95	9 997 546.35	3 218 388 209
2	635 52	347 629.44	11 471 771.52	3 692 967 544
Total	118 937	650 585.39	21 469 317.87	6 911 355 753

3. EXPENSES FOR BIOGAS PRODUCTION

Trucks with 10 tones capacity will be used in carrying the manure that are bought from the farmers and since the cost of transport is 2.5 TL/ton, total amount for a day is 4456 TL. The cost of collected wastes and transport is shown in Table IV and V respectively. Daily cost of transport approximately 6000 TL.

Table IV. The amount of payment for collecting wastes

Plant No	Manure (ton/day)	Payment (TL)
1	830.016	2075
2	952.40	2381
Total	1782.41	4456

According to the negotiations executed between the farmers and the plants management, certain amount of payment will be done and then after the production of biogas, waste of manure, being dried will be carried back to the farmers which is about 1782.41 ton a day (Table IV).

Table V. Daily cost of transport for towns and Eskisehir

Plant 1		
Town	Cost of transport (TL)	Total cost of transport daily (TL)
Alpu	–	–
Beylikova	75	404.2
Çifteler	150	658.125
Günyüzü	175	271.36
Mihalıççık	100	509.815
Sivrihisar	150	1188.47
Sub-total		3031.97
Plant 2		
Seyitgazi	–	–
Odunpazarı	100	888.75
Tepebaşı	100	1251.69
İnönü	125	462.345
Mahmudiye	75	255.75
Sarıcakaya	125	115.08
Sub-total		2973.615
Total		6005.585

Due to changes in fuel prices, the transporting payments may show changes. But negotiations fulfilled before the transport will solve this problem (Karataş ve Ark., 2003; DGS, 2005). Consumed biogas is 816 009.55 m^3/day for the houses located around the plants. Hence, daily biogas consume is 1107 m^3/day-person (Table VI).

Table VI. Population of towns and daily biogas consume in Eskisehir

Town	Population (2009)	Demand of daily biogas consume[m^3]
Plant 1		
Alpu	13919	15408.33
Beylikova	7154	7919.48
Çifteler	16882	18688.37
Günyüzü	7697	8520.58
Mihalıççık	11186	12382.90
Sivrihisar	24939	27607.47
Sub-total	81777	90527.14
Plant 2		
Seyitgazi	17262	19109.03
Odunpazarı	343371	380111.70
Tepebaşı	272411	301558.98
İnönü	7565	8374.46
Mahmudiye	9225	10212.08
Sarıcakaya	5525	6116.18
Sub-total	655 359	725 482.41
Total	737 136	816 009.55

4. CALCULATIONS

In developing countries, the household energy demand is greatly influenced by eating and cooking habits. Gas demand for cooking is low in regions where the diet consists of vegetables, meat, milk products and small grains. The gas demand is higher in cultures with complicated cuisine and where whole grain maize or beans are part of the daily nourishment. As a rule of thumb, the cooking energy demand is higher for well-to-do families than poor families. Energy demand is also a function of the energy price. Expensive or scarce energy is used more carefully than energy that is effluent and free of charge. The gas consumption for cooking per person ranges between 300 and 900 liter per day, per quin (five members) family for two meals between 1500 and 2400 liters per day. In industrialized countries, biogas almost always replaces existing energy sources as electricity, diesel or other gases. The objective of biogas production may be less to satisfy a certain demand, but to produce biogas as much and as cheap as possible. Whatever surplus is available can be fed as electricity into the grid. The gas demand is market-driven while in developing countries, it is on-demand (Deniz, 1987; Erzincanlı, 2009; Eskişehir Taşıyıcılar Kooperatifi, 2009; Alçiçek ve Demiruluş, 1994). Calculations for Eskisehir are shown in Table VII.

Table VII. Calculations of biogas consume in Eskisehir

Plant Specification	Calculation Method	Example	Price	Currency Unit	Currency [TL]
Cost of Plant	Present Capacity (kwh) x cost	6911 x 3000 €	20733000	€	41466000
Expenses					
Purchase Cost	Fertilizer (ton) x 2.5 €	650585.39 x 2.5 €	1626463	€/year	3252926.95
Transport Cost		3002.7925	1096018	€/year	2192036.7
Cost of Employment			151500	€/year	303000
Energy Cost	Total Energy x 0.01		3531.703	€/year	7063.405579
Total Expenses	Cost of Fuel, ilness, maintenance, clothing and amortisation	Installation Cost x 0.12	2487960	€/year	4975920
Annual Total Expenses			5365474	€	10730947.06
Income					
Electricity Sale	Capacity (kwh) x (–20%) operation time x Electricity Price		6192256	€/year	123845512
Carbon Trade	Capacity (kwh) x (–5%) operation time x Green Certificate Payment		1050472	€/year	2100944
Effective Heat	Cogeneration heat (kWh) x operation time x 0.03 (€/kwh)		1200000	€/year	2400000
Organic Fertilizer Sale	Amount of Organic Fertilizer x Fertilizer Unit Price		813231.7	€/year	1626463.475
Annual Total Expenses			9255960	€/year	18511919.48
Outcome					
Annual Profit	(Income–Outcome)/year		3890486	€/year	7780972.419
Back Payment Period (year)	Total Investment Expense / Annual Profit		5.329154	year	

5. RESULTS

Before building a biogas plant, there are different circumstances which should be considered. For instance, the natural and agricultural conditions in specific countries are as important as the social or the economic aspects. To consider the most important factors, we provide a checklist for the planning procedure, a planning guide and a checklist for construction of a biogas plant. Failure or unsatisfactory performance of biogas units occur mostly due to planning mistakes. The consequences of such mistakes may be immediately evident or may only become apparent after several years. Thorough and careful planning is therefore, of outmost importance to eliminate mistakes before they reach irreversible stages. As a biogas unit is an expensive investment, it should not be erected as a temporary set-up. Therefore, determining the siting criteria for the stable and the biogas plant are the important initial steps of planning (DGS, 2005; Ünal ve Gözen, 2007; Pehlivan, 2009).

In this study the biogas potential and its advantage to Eskisehir economy were investigated. According to the statistical data 88000 people live in towns and villages in Eskisehir which leads to 22000 family. Production of biogas is not the solution for the energy problem. Saving can carry out at least in cooking at villages using biogas instead of liquid petrol gas (LPG). The other advantage is enviromental health. Wastes loose the odour when treated at the plants so microbes will be uneffected which will cause illness. Beside energy production at biogas plants, produced inert waste will be used as fertilizer by the farmers. Chemical specifications of inert waste will change in positive way. Fermented waste will decrease the percentage of salt and so the efficiency of soil increases at reasonable rates. If such work is performed thorougly in country, consirable amount of energy will be gained.

Present potential used in production of biogas in Eskisehir will lead to electrical energy equivalent to 740 billion TL and used wastes in agriculture will lead to 1.5 trillion TL once more for agriculture. Besides these, 22000 family can use 12 liters LPG bottle monthly which means approximately 150 billion a year. As a result, if handled animal wastes will add considerable amount of income to Eskişehir.

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REFERENCES

1. Akbulut ve Dikici (2004), Elazığ İlinin Biyogaz Potansiyeli ve Maliyet Analizi.
2. Alçiçek, A. ve Demiruluş, H. (1994), Çiftlik Gübrelerinin Biyogaz Teknolojisinde Kullanılması.
3. Bilir ve Ark. (1983), Elazığ İlinin Biyogaz Potansiyeli ve Maliyet Analizi.
4. Biogas Digest, Volume II, Biogas-Application and Product Development, Information and Advisory Service on Appropriate Technology (ISAT).
5. Deniz, Y. (1987), Türkiye'de Biyogaz Potansiyeli ve Biyogazın Sağlayacağı Yararlar, Ankara.
6. Erzincanlı, H. O. (2009), Türkiye'de Atıklardan Enerji Üretimi ve Biyogaz.
7. Eskişehir Taşıyıcılar Kooperatifi (2009).
8. Karataş ve Ark. (2003), Elazığ İlinin Biyogaz Potansiyeli ve Maliyet Analizi.
9. Nesteren, B. (2003), Tarım ve Köy İşleri Bakanlığı Köy Hizmetleri Genel Müdürlüğü Ankara Enstitüsü, Ankara.
10. Pehlivan R. (2009) Biyogaz ve Biyogaz Uygulamaları, Selçuk Üniversitesi Çevre Mühendisliği Bölümü.
11. TEDAŞ (2009) Yayın Bülteni, Kasım.
12. The German Solar Energy Society (DGS), 2005, Planning and Installing Bioenergy Systems, Ecofys.
13. TÜBİTAK, Bildiriler El Kitabı (2009) Türkiye'nin Hayvansal Atık Kaynaklı Biyogaz Potansiyeli ve Ekonomisi.
14. Ünal, E., Gözen, M. (2007), Elektrik Piyasasında Yeşil Sertifika Uygulamasının Düzenleme Kurumları Açısından İncelenmesi.

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