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DETERMINATION OF BIOGAS POTENTIAL OF AYDIN PROVINCE

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Abstract

A fast increase has been seen in the use of energy acquired from fossil based and renewable resources along with the increasing population in the world and Turkey. It leads the studies to find new energy resources that fossil resources have been depleting day after day.
Aydın Province that is located on 800.700 ha area over the lowlands irrigated by Büyük Menderes River is among the biggest cities of Turkey due to both animal number and area at which agricultural production is done. 363.215 ha cultivated area which is 45.3% of the total land is irrigable land. There are 70.884 units agricultural enterprises in the city and these enterprises are small and medium scale enterprises. 36% of these agricultural enterprises are the enterprises that make animal and vegetative production together, 35% of them are the enterprises that make only vegetative production and 29% of them are the enterprises that make only animal production. The unused wastes occurred after the production at these enterprises that makes animal and plant production pose a big problem for the enterprises and biogas that is a gas type having a high energy potential due to the methane gas inside it may be produced after they are fermented.
In this paper, animal and vegetative production data of Aydın province will be reviewed and biogas potential of the province will be determined by calculating the waste amount occurred due to the production.

Key words: *Turkey, Aydın, animal waste, vegetative waste, biogas, agricultural production.*

INTRODUCTION

Today, energy has become main need of all communities. For economic and social development, clean energy demand at cheap, reliable and sustainable price is to be met. Along with that, structure of global energy sector and whole supply demand chain has started to take shape with the environmental factors. The climate change draws new route of the world in the energy such in the all policies.
Nowadays, energy demand world-wide is mainly supplied from fossil fuel resources such as coal, oil, natural gas, etc. But these resources are fast depleting depending on their use due to that they are limited. Contrary to these, natural resources such wind energy, solar energy, hydroenergy and biomass are called as never ending in other words renewable energy resources due to that they renew themselves. Advantages of renewable energy resources are helping protection of the environment by decreasing the carbon dioxide emission, decreasing the foreign source dependency in the energy due to that they are domestic resources and making contribution to increase of the employment. Thanks to these properties, renewable energy resources receive support of the public.
Turkey is a lucky country in terms of its biomass potential. The biomass technology among the renewable energy resources have been increasingly demanded in the recent years due to the incentives. The biomass may be used in the energy technology by being directly burned or acquired alternative biofuels (easy transportable, storable and usable fuels) having equal properties to available fuels after their fuel qualities are increased through various processes. The waste biomass (scats, forest and agricultural wastes, municipality wastes, etc.) is traditionally used for cooking or heating in various places of the world. As well as that the biomass resources may be directly used as fuel, they are the products that are very convenient for biogas, biocarbon and biodiesel and have a high potential.

MATERIALS AND METHODS

Within the scope of this study, plant production and capacities of the wastes occurred due to the production will be revealed out as well as properties of the animal enterprises in the Aydın province, animal amounts and their capacities. Within this frame, official data of Ministry of Agriculture Provincial Directorate of Agriculture were used.

Aydın Province was established on 800.700 ha land on the B. Menderes lowland and has total 368.338 ha agricultural land according to 2013 data. 151.681 ha of this land is cultivated land and 216.657 ha is long-termed plant land. In other words, approximately 45% of total surface area is formed from agricultural land. The agricultural enterprises in Aydın are small scale and multipartite enterprises. There are 70.884 agricultural enterprises in the city. These agricultural enterprises generally make animal and plant production together and rate of these enterprises is 36%. The enterprises that make only vegetative production with the rate of 35% and the enterprises that make only animal production with the rate of 29% follow these enterprises, respectively. The distribution of the agricultural enterprises in Aydın by their scales is given at Table 1.

Table 1. Distribution of agricultural enterprises in Aydın by their scales (TUIK 2014)

Scale of the Enterprises (da)	% of the Enterprises
0 - 10	29.1%
11 - 50	51.45%
51 - 100	12.31%
101 - 200	5.57%
201 - 500	1.48%
501 - +	0.09%

The bovine dairy stockbreeding enterprise number in Aydın by scale of the enterprises is Table 2, the bovine stockbreeding enterprise number is given at Table 3 and ovine stockbreeding enterprise number is given at Table 4 (TUIK 2014).

Table 2. Distribution of bovine dairy stockbreeding enterprises in Aydın by their scales (TUIK 2014)

Scale of the Enterprise (per unit)	Number of the enterprises (Unit)	% of the enterprises
1 – 5	24421	52.73%
6 – 10	9644	20.81%
11 – 25	9299	20.1%
26 – 50	2185	4.71%
51 – 100	617	1.33%
101 – 200	122	0.26%
201 < per unit	27	0.06%
Total	46315	100%

Table 3. Distribution of bovine stockbreeding enterprises in Aydın by their scales (TUIK 2014)

Scale of the Enterprise (per unit)	Number of the enterprises (Unit)	% of the enterprises
1 – 5	622	50.12%
6 – 10	287	23.13%
11 – 50	302	24.33%
51 < per unit	30	2.42%
Total	1241	100%

Approximately 44% of the ovine enterprises in Aydın raise 1-25 animals and 19% of these enterprises raise 26-50 animals.

Table 4. Distribution of ovine enterprises in Aydın by their scales (TUIK 2014)

Scale of the Enterprise (per unit)	Number of the enterprises (Unit)	% of the enterprises	Number of the animals (per unit)
1 – 25	1951	43.7%	27495
26 – 50	857	19.2%	29048
51 – 100	810	18.15%	54631
101 – 250	572	12.82%	83157
251 – 500	104	2.33%	36129
501 < per unit	170	3.8%	29088
Total	4464	100%	259548

It is seen in Table 5 that fruit, beverage and spice plants form the biggest part of distribution of agricultural lands in Aydın province.

Table 5. Distribution of use of the agricultural lands in Aydın (TUIK 2014)

Use type of agricultural lands	Land sizes (da)
Cereals and other plant products	1330001
Fallow area	35569
Vegetable gardens	111290
Fruit, beverage and spice plants	2155207
Ornament plants	79
Total	3632146

In the method; the literature data concerning to waste amounts depending on the animal numbers and types and plant product range and waste amounts depending on plant product range will be taken into consideration in order to reveal out biogas potential of the province and rural area.

There are so many factors that are effective on the waste amount occurred at the animal and agricultural enterprises and biogas amount to be acquired. These are animal type, live weights, total additive ratio, plant range, volatile solid ratio, usability of the waste and biogas efficiency.

At the calculation of animal waste amount; 5-6% of the alive weight may be taken as basis for daily waste amount as well as that 10-20 kg/day (age) waste efficiency may be accepted for bovine animals. In the same way, 2 kg age/day or 4-5% of the live weight may be accepted as daily waste production for sheep and goat (Yokuş, 2011).

At the calculation of animal waste amount; the wastes occurred due to the production in proportion to acquired agricultural products cover 90-160% of the total production (ITEP, 2010). The waste amounts of some croplands and garden products in Aydın are seen at Table 6.

It is suitable for biogas production that nutrition material is between 8% and 13% TS (Total Solid). When the solid material is too low, precipitation of the material inside the solid is a matter.

Table 6. Waste amounts of some field crops and garden products in Aydın (TUIK 2014)

Products	Product amount (ton/year)	Wastes	Usable waste amount (ton/year)
Wheat	76557	Fodder	11988
Barley	30336	Fodder	4853
Rye	1848	Fodder	388
Oat	2881	Fodder	428
Corn	174575	Sap	235676
		Grainless corncob	90779
Cotton	316856	Stem	209125
		Carding waste	80798
Olive	274985	Residue Oil	137492
		Pruning	40585
Sunflower	1212	Stem	1957

When this ratio is too high, prevention of gas outlet is seen. The solid matter rates; 5-25% of the cattle manure, 10-90% of chicken manure, approximately 30% of the sheep manure.

In case too much water is used during collection of animal wastes, TS ratio may be decreased to 2-5%. This decreases the system efficiency due to that too much energy is used for heating the water.

The waste amounts at the animal wastes vary according feeding regimes of the animals, their sizes and climate conditions. The obtainable waste amount also varies depending on the breeding types. If animals are tied only at nights, obtainable waste is to be calculated as 50% of the total waste. When they are kept in a shed of which base is soil, collecting the waste is getting harder. If a base plate is used, the fodder is to be maximum 2-3 cm and unfermented sawdust is not to be used. The collected waste amount and therefore biogas production decreases at summer months when animals kept untied are brought to the pasture in the summer.

Period of staying in the shed of the animals is 65% for dairy cattle, 25% for beef cattle, 99% for poultry and 13% for ovine animals.

The energy sustainability is basis at all enterprises for making production. If energy of the enterprise is bound to biogas production, it is required to continuously buy gas from biogas facilities. Otherwise, the enterprise may not maintain its activity.

Table 7. Waste properties and biogas efficiencies by animal species (Yokuş, 2011)

Animal Species	Alive Weight (kg)	Fresh Waste Amount		TS (%)	UK (Volatile Solid) (%)	Usability Period of Staying in the Shed (%)	Biogas Efficiency l/kgUK
		Percentage of the Weight	Kg/day				
Bovine	135-800	5-6	10-20	5-25	75-85	Milk 65 Meat 25	200-350
Ovine	30-75	4-5	2	30	20	13	100-310
Coop **Egg** **Et**	1,5-2,0	3-4	0,08- 1,00	10-35 50-90	70-75 60-80	99	310-620 550-650

RESULTS AND DISCUSSIONS

The waste amounts that may be acquired from various animals are given at Table 8. The values stated at Table 7 are get benefit at the calculations. 450 kg was taken as basis for alive weight of the bovine animals, 50 kg for ovine animals and 2 g was taken as basis for chicken.

As percentage of alive weight, the daily fresh waste amount was calculated as 6% for bovine animal, 5% for ovine animal and 4% for poultry. By taking the period of staying the shed, usability of the waste was selected as 50% for bovine animal, 13% for ovine animal and 99% for poultry.

Table 8. The waste amounts that may be acquired depending of the animal species (Yokuş, 2011)

Animal species	Fresh waste production (kg/ day.animal)	Solid matter ratio (%)	Solid matter waste production (kgKM/day.animal)	Total TS waste amount that may be acquired (kg/ day.animal)
Bovine	27.00	15	4.050	2.0250
Ovine	2.50	30	0.750	0.0975
Poultry	0.08	35	0.028	0.0277

Table 9. Biogas potential of Aydın province from animal wastes

Animal species	Animal Number	Fresh waste amount (ton/year)	Waste amount (tonKM/year)	Obtainable solid manure amount (ton/year)	Obtainable biogas (m^3/year)	Calorific value (GJ/year)
Bovine	343465	3384847	507727	253863	50772600	1152612
Ovine	259548	236707	71012	9222	1844400	41870
Poultry	2960594	86419	30246	29946	5989200	135963
Total	3563607	3707973	608985	293031	58606200	1330445

Table 10. Calorific value of Aydın province field crops

Products	Wastes	Production (ton)	Area (ha)	Usable wastes (ton)	Availability (%)	Unit calorific value (Mj/kg)	Total calorific value (Gj)
Wheat	Fodder	76557	22100	11988	15	17.9	214585
Barley	Fodder	30336	10221	4853	15	17.5	84927
Rye	Fodder	1848	921	388	15	17.5	6790
Oat	Fodder	2881	1030	428	15	17.4	7447
Corn (Grain)	Stem	174575	15933	235676	60	18.5	4360006
	Grainless corncob			90779	60	18.4	1670333
Cotton	Stem	316856	58880	209125	60	18.02	3768432
	Carding waste			80798	80	15.65	1264488
Sunflower	Stem	1212	404	1957	60	14.2	27789

By getting benefit from solid matter ratios, the solid waste amount that may be acquired from an animal per day was calculated as 2,02 kg for bovine animal, 0.098 kg for ovine animal and 0.028 kg for poultry. By getting benefit from these values, values of biogas potential from animal wastes calculated from Aydın province is given at Schedule 9. At the calculations, the biogas amount acquired from 1 ton solid animal waste was accepted as 200 m^3 and calorific value of the biogas was accepted as 22.7 MJ/m^3.

As seen at Table 9, annual wet waste potential from the animals brought in Aydın is 3,707,973 tons. The obtainable solid waste amount according to the dry matter ratios and fattening environment is 293,032 tons/year. In Aydın province, annual biogas amount that is obtainable from bovine, ovine and poultry animals is 58,606,200 m^3 and energy is equal to 1,330,445 GJ. The biggest share among the animal waste amounts belongs to bovine animal. The share of bovine animals among the total wet waste amount is 86% and its share among the obtainable solid waste amount is 86%. Therefore, bovine livestock raising has the biggest share with the rate of 86% among the biogas potential of the animal wastes in Aydın.

Obtainable wet waste amount was determined by multiplying daily fresh waste amount and period of staying in the shed. The specific mass was taken as 975 kg/m^3 at calculation of volumetric amount of the waste. The water amount that is necessary for transforming the waste of which solid matter rate is accepted as 15% into 9% solid matter ratio was calculated. By adding daily wet waste and waster amount to be added, material amount to be fed to the enterprise daily was determined.

If we review the calorific value equivalents of different agricultural wastes in Aydın in Table 10, we see that corn gives 235,676 tons usable waste acquired from its stem against 15933 ha land when cultivated are and waste amounts are compared. If we proportion cultivation to usable waste amounts, cotton gives approximately 3.5 times waste while corn gives approximately 14.8 times waste. The product waste of which usability is the highest one among the field crops is carding waste of cotton plant with the rate of 80% and then corn stem and corncob with 60% and sunflower stem and cotton stem follows. Total calorific value of annual waste amount of the field crops is approximately 11.5 PJ.

CONCLUSIONS

According to estimated calculations, it is observed that there is 13 PJ annual energy potential of animal and vegetative wastes in Aydın where animal and vegetative production is done. Provided that convenience of biogas production from wastes is revealed out with the assessment of its environmental, economic and sociocultural effects in detail, it is an important way of supply of regional energy need. The biogas energy that is acquired in indirect ways may be get benefit in heat and power production as well as that it may be used in obtaining hot water and air by directly being burned, cooking in the bakeries and lighting.

The basis material obtained from biogas enterprise output is organic substance containing manure. This fermented manure is purified from pathogens and may be used for organic substance at the vegetative production.

Obtaining biogas and fermented manure by assessing the animal waste after being anaerobic fermentation will allow for decreasing the environmentally hazardous waste amounts and waste management cost as well as that it will allow for production and use of renewable energy.

When it is taken into hand economically, it shows biogas systems as an expensive alternative energy resource that first investment cost is high. It is estimated that small scaled biogas enterprises may amortize themselves within approximately 8-10 months when they are operated with full efficiency. But at the first stage, there is a financing need for establishment of the enterprise. This financing may be supplied with state funded credit or may be met by private individuals who have users. In so many countries, programs are started by the state by considering benefits of the biogas technology in terms of environment and health. The biogas systems are tried to be popularized by decreasing the cost with applied incentives and credits.

Designing high efficiency biogas systems of which investment costs are low and installation,

use and maintenance is easy will allow for development of biogas technology in our country by taking climate conditions and production opportunities into consideration.

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REFERENCES

Ergür H., Okumuş F., 2010. Cost and Potential Analysis Of Biogas in Eskisehir

ITEP, 2010. Advanced Technology Projects (ITEP) Support Program Report. Turkish Foundation for Technology Development.

The German Solar Energy Society (DGS). 2005. Planning and Installing Bioenergy Systems, Ecofys.

TUIK, 2013. Aydın with Selected Indicators.

TUIK, 2014. Turkish Statistic Institution, http://www.tuik.gov.tr/Start.do

Yokuş I., 2011. Biogas Potential of Animal Wastes in Sivas Province. Ankara University, Institute of Science and Technology. Department of Agricultural Machinery, Postgraduate Thesis, Ankara.