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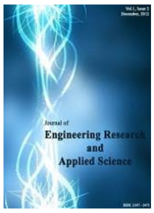

Determination of biogas resources and performance criteria's in Amasya

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Abstract
Biogas energy which is one of the renewable energy types is an important alternative energy source both in terms of its usage advantages and potential values in our country. However, there is a big difference in the biogas production potential values of our country in terms of utilization of biogas energy. In Amasya province, there are 210.199 cattle, 210.160 sheep and 1.502.750 poultry. Annually, 2.3 million tons fresh animal waste are obtained in Amasya province. With the 2018 data of Amasya province, the amount of biogas that can be produced from animal wastes was calculated as 35.9 million m^3 /year. Suluova and central town had the greatest potential among other districts with 11.6 and 10.5 million m^3, respectively. The energy equivalent of biogas produced in Amaya province was calculated as 814.275 GJ and electrical energy equivalent was calculated as 90.474.000 kWh [1]. Researches show that the integrated concept for producing energy and fertilizer from agricultural wastes in Suluova can be realized in an extremely economical way. This is because the highly used chicken manure has very high gas efficiency with low transportation costs. The high nutrient content of the fermentation residue can be widely used instead of chemical fertilizers. As a result of the 8-month storage period, it is possible to apply according to the needs of the plants. By carrying out the integrated concept of producing energy and fertilizer from biomass (especially liquid cattle manure and chicken manure), environmental pollution caused by cattle breeding has been eliminated and the long-term agricultural potential in Suluova has been eliminated and its sustainable development will be accelerated significantly.

Keywords: Renewable energy, biogas potential, biogas production, Amasya.

1. Introduction

The International Energy Agency, Renewable Energy Working Group, defined renewable energy as energy that is constantly renewed and derived from natural processes.

Since ancient times, renewable energy sources have been used for drying products and heating water. Depending on the energy supply and demand conditions, the demand for Renewable Energy has been pushed into the background in some periods.

"As the energy production and consumption of fossil resources in the 1990s negatively affected our natural resources, directly or indirectly, renewable energy resources were supported again." "Law no. 5346; It includes the procedures and principles regarding the protection of renewable energy resources and how these resources are used.

Among OECD (Economic Cooperation and Development Organization) countries, the increase in energy demand has been the highest in Turkey in the past ten years.
According to the results of the studies of the Ministry of Energy and Natural Resources, almost all of the oil and natural gas and 20% of the coal are imported.

Biogas is an important gaseous which can be produced from several organic resources and waste. Anaerobic digestion is a guaranteed alternative for treating biodegradable waste as it produces valuable gas and subsequently a reduced volume of waste is disposed. Biogas production has a very important role in waste management.

Biogas is not 100% greenhouse-gas-free, nevertheless, it does not contribute to global warming but it helps to fight it. The CH_4 can be combusted more cleanly than fossil coal and can provide the desired energy with limited levels of carbon dioxide emission in the atmosphere. The carbon released from biogas can be absorbed by photosynthetic plants adding less total atmospheric carbon than the burning of fossil fuels. As an alternative source of

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both heat and electricity, biomethane helps preserve forests and biodiversity by providing reduced levels of harmful greenhouse gas. Additionally, the use of biomethane does not increase the concentration of greenhouse gases in the atmosphere because carbon dioxide and other gases that create the greenhouse effect are released into the atmosphere during the decomposition process of organic matter [2].

Biogas primarily consists of methane (CH_4) and carbon dioxide (CO_2) with small amounts of hydrogen (H_2), nitrogen (N_2), hydrogen sulphide (H_2S), oxygen (O_2), water (H_2O) and saturated hydrocarbons. Composition of biogas in general given at Table 1.

Table 1: Composition of biogas

Constituent	Formula	Concentration (v/v)	
Methane	CH_4	40–75%	Combustible
Carbon dioxide	CO_2	15–60%	Non-combustible
Moisture	H_2O	1–5%	Non-combustible
Nitrogen	N_2	0–5%	Non-combustible
Hydrogen	H_2	Traces 0–5000 ppm	Combustible
Hydrogen sulfide	H_2S		Combustible
Oxygen	O_2	< 2%	Non-combustible
Trace gases	–	< 2%	
Ammonia		**0–500 ppm**	

Figure 1: Flow chart of biogas production [3].

Today, organic components of animal, vegetable, domestic and industrial wastes are used for biogas production. These wastes are converted into biogas in an oxygen-free environment, under certain conditions, with the help of different groups of microorganisms, the remainder is evaluated as an efficient fertilizer source.

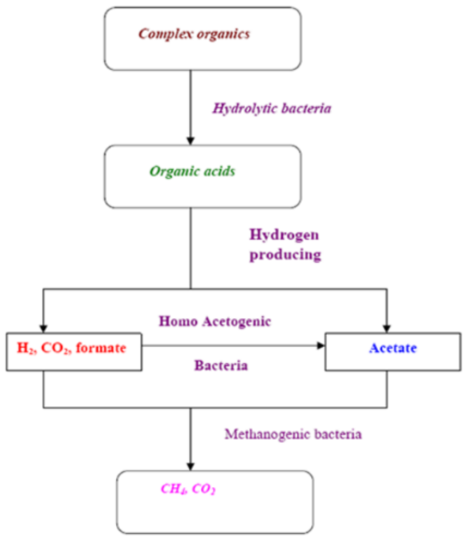

Figure 1: Flow chart of biogas production [3].

Anaerobic fermentation varies according to the way the fermenter is fed with the new material. In this respect, it is possible to examine anaerobic fermentation in three groups. In the form of continuous fermentation, the organic matter is given to the fermenter in a certain amount every day and the fermented material at the same rates is taken from the fermenter daily. In this type of fermentation, gas production is continuous. In the discrete fermentation with feed, the fermenting is initially filled with a certain amount of organic material and the remaining volume is divided into the fermentation time, the fermenter is completely emptied and refilled.

2. Material and method

The amount and composition of animal wastes (feces and urine) excreted per unit of time also vary widely. These depend on several criteria's such as the "total live weight" of the animal (TLW), animal species, animal size and age, feed and water intake, climate, and management practices, etc. For design of facilities for animal waste collection and treatment, measurements and samples should be taken at similar farm fields. For planning the powerplant purpose, Taiganides (1978) suggests that the general guideline values given in Table 2 may be used. Young animals excrete more waste per unit of TLW than mature animals. The quantities of waste-water or wastes to be handled would, in general, be larger than those given in Table 2 due to the addition of dilution water, wash-water, moisture absorbing materials and litter, etc. [4]. Table 3 shows the approximate weights of animals, the quantity of waste produced and their BOD5 values.

Table 2: General characteristics of animal waste [4].

Parameters	Symbol	Units	Pork pigs	Laying hens	Feedlot beef	Feedlot sheep	Dairy cattle
Wet waste	TWW	%TLW/day	5.1	6.6	4.6	3.6	9.4
Total solids	TS	%TWW	13.5	25.3	17.2	29.7	9.3
		%TLW/day	0.69	1.68	0.7	1.07	0.89
Volatile solids	TVS	%TS	82.4	72.8	82.8	84.7	80.3
		%TLW/day	0.57	1.22	0.65	0.91	0.72
Biochemical oxygen demand	BOD_5	%TS	31.8	21.4	16.2	8.8	20.4
		%TVS	38.6	29.4	19.6	10.4	25.4
		%TLW/day	0.22	0.36	0.13	0.09	0.18
COD/BOD_5 ratio	COD/BOD_5	ratio	3.3	4.3	5.7	12.8	7.2
Total nitrogen	N	%TS	5.6	5.9	7.8	4.0	4.0
		%TLW/day	0.039	0.099	0.055	0.043	0.043
Phosphate	P_2O_5	%TS	2.5	4.6	1.2	1.4	1.1
		%TLW/day	0.017	0.077	0.008	0.015	0.010
Potash	K_2O	%TS	1.4	2.1	1.8	2.9	1.7
		%TLW/day	0.01	0.035	0.013	0.031	0.015

TLW = Total live weight of animal

Table 3: Waste production by various animals

Animal	**Average weight of animal (kg)**	**Total waste, (kg/head per day)**	**BOD5 (kg/head per day)**
Beef cattle	360	18-27	0,45-0,68
Dairy cattle (milk cows, replacement heifers, breeding stock)	590	44	0,91
Swine	45		
Chickens:			
Broilers		0,05	0,0044
Laying hens		0,06	0,0044
Sheep and lambs	-	7	0,16
Turkeys	7	0,41	0,023
Ducks	1,6		0.017
Horses (pleasure, farm racing)	-	37	0,36

The annual production of nutrients from animal wastes is given in Table 4 During storage of animal wastes, a considerable portion of N which exists in the form of ammonia (NH_3) is lost through NH_3 volatilization [4].

Table 4: Nutrient content of raw livestock wastes in kg per 500 kg live animal weight per day, and as influent wastewater to a treatment system (mg/L)

	Raw waste characteristics							
	BOD5		TN		TP		TK	
	(k	(mg/	(k	(mg/	(k	(mg/	(k	(mg/
Cattle	0.	18,8	0.	4,80	0.	500	0.	3,20
Beef	0.	25,4	0.	5,40	0.	1,45	0.	3,30
Pig	1.	27,3	0.	4,60	0.	1,60	0.	2,55
Poultr	**1.**	**43,6**	**0.**	**11,1**	**0.**	**4,00**	**0.**	**4,00**

A significant loss of nitrogen in the form of NH_3 may occur from the manure during deposition. In cases where the fertilizer is stored in deep pits and lagoons with a solid matter content of more than 30%, the N loss takes values in the range of 20-55%. In cases where the fertilizer is stored as more liquid (with less than 12% solid matter content), the N loss in question may vary between 25-80%. P and K are physically and chemically less mobile than nitrogen and retain their initial values. [5].

Table 5: Values accepted for the purpose of calculating the biogas potential

Raw materials		**Production of fertilizer for animal feed per unit**	**Availa bility %**	**KM (Dry substance % fertilizer quantity**	**KM fly Dry matter %KM**	**Methane production ratio m^3 CH, kg)**
Cattle manure	Adult	43,00	50	13,95	83,33	0,18
	Young pup	2,48	50	8,59	44,23	0,33
Ovine fertilizer		2,40	13	27,50	83,64	0,30
Chicken Fertilizer		0,18	99	25,88	77,27	0,35

Since the farmers expressed their desire to operate greenhouses during the examinations made in the region, the residual heat of the combined heat and power plant can be used for heating greenhouses in autumn, winter and spring.

In these seasons, relatively low temperatures are experienced in Suluova, and hard frost periods can be experienced in winter.
Combustion gas generated in the combined heat and power plant can be used to meet the CO_2 need of greenhouses to the extent permitted by Turkish legislation, thereby accelerating the growth of plants.

Another possibility to use the residual heat of the combined heat and power plant is the drying of the solid fermentation residue in a belt dryer followed by the production of high-quality organic fertilizer pellets, which are in great demand in the field of fruit growing and horticulture.

Since very high heat amounts are generated additionally in the second development/dissemination phase of the biogas plant, laying the near-environment remote heating network and heating the residential and commercial enterprises in the centre of Suluova may be economical.

Houses and industrial sites are not in close position. They distributed to small parts and far from each other's. Because of these, these opportunities are very weak.
The continued growth of the agricultural sector will lead to the establishment of food businesses in the region in the future. Large amounts of heat can also

be used for food processing all year round in these establishments.

Biogas Powerplant will supports to also diversity of agricultural production in the region. Rural areas will be able to use for production for biogas sources.
First of all, after determining the biogas production techniques and potential, statistical data specific to Suluova were included. Sample calculations are given for different places. Based on these, inferences were made for Suluova. The biogas values of animal and vegetable wastes were chosen as reference. Cost analysis is presented as a calculation method and may vary according to the current €/₺ rate and electricity prices. Renewable Energy support mechanisms are constantly changing, so the feasibility changes.

3. Biogas production potential

Once the amounts of agricultural residues and animal waste per site were known, potential biogas production amounts had to be determined. Finally, it was converted to electric potential per site. Table 6 shows the biogas production rates for different types of raw materials. To reach these final values, four basic assumptions were made. The source of agricultural residues showed methanation potential rather than biogas potential. For this reason, it is assumed that the biogas is 50% methane, and the methane production rates are adjusted to obtain biogas. Secondly, all agricultural residues were assumed to be on a 'dry Basis' as no further information was available on the water content. Third, maize silage was assumed to be the residue for the maize crop. Finally, both anaerobic digestion methods (CSTR and plug flow) yield the same biogas for the same input feedstock.[6].

Table 6: Biogas production rate

Biogas Production Rate (m^3 /kg dry mass)	
Animal waste	
Cows	0,2
pigs	0,25
sheep	0,093

Table 7: Projected biogas potentials for 2020

Agricultural Residue	
Barley	0,385
Wheat	0,498
Oat	0,406
Beans and peas	1,382
Fatty Seed	0,48
Corn silage	0,96

Using these values, the total potential for biogas in cubic meters has been determined for each field identified on the defined region. Then this potential was converted into electricity, so it was easily compared to the existing natural gas production. The estimated potential for electrical production is calculated with the assumption that the biogas produced at each site have the same composition and a gas-to-electrical efficiency ratio of 35%. For example, in site 1, by using 2,14 kWh/m3, total electrical potential biogas calculated 1300,5 GWh/year. According to 1,1 of annual population growth rates, 5 years later this value reach to 1375,64 GWh/Year.

4. Preliminary identification and predictions on revenues from fertilizer production organic fertilizer pellets

In the first development/spread phase, about 146,000 tons/year five cattle will be fermented at the liquid fertilizer and approximately 25,000 tons/year chicken feces will be fermented at the biogas facility. The biogas calculation program of the Northern Rhine Vestfalya Agriculture Room and the nutrient and reference values of the biogas fermentation residue have been calculated in Table 8 [7].

In the calculation, the KM ratio in chicken manure was taken as 30%. This value is based on the statement dated 17.01.2017 of the Private enterprise in Suluova. After fermentation, the volume of fermentation residue is 16,382 m³/year and the DM rate is 8.6%. After the separation in the pressure screw separator, a solid phase with a mass of 26,140 tons/year and a DM ratio of 32% is formed. The DM ratio is increased to 88% in the dryer. Table 9 shows investment expenses of the biogas power plant.

Table 8: The mass balance of the substrates

The mass balance of the substrates		Mass %	KM %	Mass Ton	KM Ton
Beef cattle liquid manure	Liquid		11	146,000	16,060
Chicken feces	Thick		30	25,000	7,500
Mixed-raw liquid fertilizer	Liquid		13,78	171,000	23,560
Fermentation residue after Fermenter	Liquid		8,64	161,382	13,942
Separation fermentation residue	Thick	16,2	32	26,140	26,140
Separation fermentation residue	Liquid	83,8	4,12	135,241	5,577

Table 9: Investment expenses of the biogas facilities

Construction costs	€
Earthmoving, road building	300,000
Front tank	150,000
Pump in container	100,000
Fermenter	1 393 195
Fermentation residue tank (Liquid fertilizer lagoon)	2 296 642
Electrical measurement, control and regulation technique	142,000
Wiring	103,000
Combined heat and power plant – CHP	1 430 000
Heat technique	133,000
Other (scale, fence, tree, etc.)	181,500
Unexpected costs, risk of space, etc. (5%)	250,000
Sand separation	250,000
Intermediate total, cost of building a biogas facility, net	6 729 337
Expenses and acceptance of the facility	18,000
Engineering fee	235,000
External report fee	15,000
Subtotal, biogas plant construction side expenses	268,000
Total investment expenses, net	6 997 337

Approximately 70% of investment costs are construction and 10% are machine costs. The rest is the share of the CHP.

5. Results

Agriculture and waste constitute two of the four main sectors that cause greenhouse gas emissions in Turkey. Country 35% (27 million ha) of its land is used for agriculture. The total animal stock in Turkey is approximately 10 million cattle, more than 30 million sheep and goats and more than 300 million poultry is around 11 billion tons of solid animal feces are produced annually. In addition, liquid waste or animal wastewater (liquid manure, urine) originating from farms and slaughterhouses. It is solid and inappropriate release or storage of liquid waste materials into the environment is common in many regions of Turkey high level of pollution of ground and surface waters, formation of irritating smells and cause hygiene problems [8].

The feasibility study presented examines the construction and operation of a biogas plant with an electrical power of 2 MW. As a result of the investigations, it was concluded that the production of fertilizer in Suluova was not economic. Because there are large farmland near the biogas facility, the use of non-disparsed liquid fermentation residue is more economically and ecologically advantageous. It is recommended that this liquid phase of the unparsed fermentation residue be stored in a liquid fertilizer lagoon (108.000m³) and used as needed in nearby fields (1,586 tons/year/N, 785 tons/year P_2O_5 1,090 tons/year K_2O). The following economic picture is formed within the scope of the construction and operation of the Suluova biogas plant.

Table 10: Scope of the construction and operation of the Suluova Biogas power plant.

	€/year
Total investment expenses (biogas facility)	7 000 000
Total current expenses (biogas facility)	1 895 000
Total revenues	3 339 000
Electricity sales	1 756 000
Sale of liquid fermentation residue	1 583 000
Non-taxable profit	1 444 000

The return rate in investment is calculated as 5 years.

The economy can be further corrected in the medium term through the sale of the CHP residual beam (e.g. for heating greenhouses).

Research has shown that the integrated concept of producing energy and fertilizer from agricultural waste in Suluova can be carried out in a very economical way. This is achieved by very high gas efficiency with a high proportion of chicken dung, low shipping costs. The high nutrient content of the fermentation residue can be widely used instead of chemical fertilizer. As a result of 8 months of storage time, it is possible to implement according to the needs of plants.

By carrying out the integrated concept of producing energy and fertilizer from the biomass (especially liquid cattle fertilizer and chicken fertilizer), the environmental pollution caused by cattle nutrition has been eliminated and the long-term and sustainable development of agricultural potential in Suluova will be significantly accelerated.

The goals of Biogas Powerplant initially expressed will be achieved:

- A good ecological condition of Suluova Region in accordance with the EU-water Framework Directive
- The production of electrical energy from animal waste from animal farming
- Use of nutrients in liquid cattle fertilizer and chemical fertilizer in agriculture reducing its use
- CO_2 – protecting the climate by reducing emissions
- The environment of liquid fertilizer is a product-producing area used in animal farming and consumption incentives through disposal and evaluation of the producing high quality organic fertilizer for agricultural use

As a result of the use of biomass in the region for energy production, dependence on fossil energy sources imports will be reduced and energy independence will be possible.

In the calculation of investment costs, it was assumed that the construction site would be allocated for free, as agreed with Private Companies [8].

Investigations and estimates made in the Suluova region are affected by current developments and may lead to significant deviations in the results.

Therefore, the estimates and calculations based on the feasibility study must be rechecked, updated and detailed before they are decided or adapted to other regions in Turkey.

In the year 2021, Biogas is very important for energy independency and environmental expectations.

The following substances can be used as raw materials for biogas fermentation in Suluova district:

- Liquid cattle manure/Chicken manure
- Kitchen waste of facilities such as canteens, restaurants, hospitals
- Slaughterhouse (Slaughterhouse) wastes
- Separately collected biowaste
- Wastes generated in the processing of foodstuffs [8].

We have to make diversity of the sources of Biogas such as clover, oat, silage etc.in the region.

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