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Conversion to biogas energy of animal wastesand expectations for the future (TR 21 region case in Turkey)

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ABSTRACT

Ever-increasing population of Turkey increases energy consumption per capita in Turkey. It is of significant to bring out various renewable energy resources due to the increased energy consumption and inevitable depletion of resources in future. Aim of the study, the biogas that one of renewable energy resources is found out average number of fertilizer and amount of biogas energy to be obtained by using waste of the bovine and ovine animals in Turkey in 2020, along with its contribution to the economy. The research period included 1996-2012 years. As method, quadratic trend analysis was used in order to determine average number of fertilizer and amount of biogas energy and contribution to the economy. As result, it has been found out that 6.6% saving from electric energy will be achieved in case the animal waste is converted to biogas and, in turn, to electric energy in 2020. Furthermore, average quantity of fertilizer from the waste of the bovine and ovine animals and amount of energy to be obtained by its conversion to biogas energy has been calculated for the TR 21 region. To find out current status of the animals in the TR 21 region, index values have been calculated by a variety of criteria. And trend analysis was conducted to determine orientation.

KEYWORDS

Biogas;
Livestock sector;
Türkiye;
TR21;
Trend analysis.

INTRODUCTION

Energy consumption per capita soars as a result of an ever-improving technology as well as world population increasing every day. One of the important reasons of the increased energy consumption is the development rate of Turkey. Recent research shows that oil will deplete within 41, natural gas 62 and coal 218 years, respectively[1]. As it is, renewable energy resources turn out to be is important. According to the definition made by Renewable Energy Working Group, International Energy Agency (IEC), renewable energy is energy renewable continuously and obtained from natural process[21].

A renewable resource, obtained from fermentation of organic waste under anaerobic conditions, biogas has an important place among alternative energy resources. Biogas is produced from livestock

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manure, plant waste, waste water and industrial waste[22]. Although biogas can be produced from any kind of organic substances, only the animal manure is taken into account for calculation of biogas potential in our country[4].

Animal wastes, called 'non-point' sources of pollution, reach to the surface waters and, by way of infiltration, to the lower strata of the soil and groundwater surfaces, thus deteriorating quality of water resources making them unusable[18, 15] and causing a veriety of epidemic diseases. Uncontrolled disposal of animal waste from cattle, pigs, chickens, etc. without being subject to any method leads serious environmental problems. By use of biogas technology, animal waste is converted to less harmful final products[9].

In Turkey, research and development projects related to biogas were first performed in 1960s. Universities, national research institutes, companies and international organizations conduct studies on use of biogas[13].

Oil sources of Turkey are foreign dependant and quantity of nonrenewable energy is limited. And already limited energy amount increasingly depletes. And renewable energy resources are important in this respect. A renewable energy resource, biogas is produced from animal waste. Because of high stock of animals in Turkey, energy generation by conversion of the animal waste to biogas energy is important.

This study aims to show average fertilizer to be obtained from animal waste in Turkey and the resulting contribution to the economy as well as the average quantity of bovine and ovine waste in the TR 21 region and the energy amount to be obtained when it is converted to biogas energy.

A great number of studies were made on biogas;[6, 17, 24, 16, 12, 5, 10, 11, 23]

MATERIALS AND METHODS

Materials of the study are consisted of secondary data. They include data from Tüik, web pages, studies and publications related to the subject as well as books, periodicals, statistics and reports published by various organizations and agencies.

In this study, index calculations have been conducted with respect to the number of animals in the TR 21 region in the course of time. And trend analysis was applied to determine orientation of the changes occurred. And, as a result, biogas and electric energy that can be generated from the bovine and ovine waste in Turkey and TR21 region has been put out.

In determining the trends, particular care has been shown to select the formula which represents the said trend best and has the highest determination coefficient (R2). As a result, linear and exponential trend equation with highest regression coefficients as appropriate for the trend has been used[7].

BIOGAS ENERGY PRODUCED FROM ANIMAL WASTE IN TURKEY

Geographical and political position of Turkey in the world is very important. Our country is like an energy bridge between Europe and Asian and Middle Eastern countries. In addition to the increased energy requirement in Turkey, according to the projection for the year 2010, the total energy consumption rate is 37% locally, with the cost of energy requirement corresponding to USD55 billion[8].

Biogas production is considered to significantly contribute to meet energy requirement and fertilizer deficit for the population living in the rural sites and, mostly, dealing with agricultural production and, consequently, it is deemed appropriate for use as an alternative energy potential[13, 14].

Daily and annual quantity of muck to be produced by animal weight is given below[2].

- 5-6% of the bovine animal live weight, kg-muck/day
- 4-5% of the Sheep-Goat live weight, kg-muck/day
- 3-4% of Chicken live weight, kg-muck/day

In other words.

- 1 bovine 3,6 ton/yearmuck
- 1 ovine 0,7 ton/year muck
- 1 fowl 0,022 ton/year muck.

Basing on these values:

- 1 ton cattle manure corresponds to 33 m3/yearbiogas
- 1 ton fowl manure corresponds to 78 m3/year biogas

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- 1 ton sheep manure corresponds to 58 m3/year biogas.

HEAT AMOUNT GENERATED BY 1 m3 of BIOGAS (4700-5700 kcal/m3).

• Equals to 0.62 liter gasoil, 1.46 kg charcoal, 3.47 kg wood, 0.43 kg butane gas, 12.3 kg dung, and 4.70 kWh electric energy.

FUEL QUANTITY EQUIVALENT TO 1 m3BIOGAS: 0.66 liter diesel oil, 0.75 litergasoline.

In the study, total quantity of biogas produced in Turkey from the bovine and ovine waste in 2012, TABLE 1, is calculated as 3.10 billion m^3/year. If, in Turkey, the bovine and ovine waste was converted to biogas energy in 2012, it would generate electric energy of 14 597 550 427(Kwh/Year) and diesel oil of 2 049 868 784 (l/year). In Turkey, total electric energy consumed in 2012 was 194 923 349 000 (Kwh/Year) in total. If Turkey used bovine and ovine waste in 2012, 7.5% would be saved from the electric energy consumed in one year. Biogas energy to be produced from the bovine and ovine waste in 2020 is projected as 4 156 213 266 m^3/year. If this biogas energy is converted to electric energy, electric energy of 19 534 202 350 (Kwh/Year) is estimated to be produced

According to the trend analysis conducted, the electric energy to be consumed by Turkey in 2010 is estimated to be 294 256 000 000 (Kwh/Year). According to projections for the year 2020, in case the animal waste is converted to biogas energy, it will result in 6.6% saving en the electric energy consumption.

The study uses Trend Analysis to find total number of cattle in 2012. According to the result of the analysis, quadratic has been found the most appropriate equation. In Figure 1, On basis of the equation Yt = 9770252 - 184241*t + 22399*t**2, total number of cattle is estimated to be 19 163 556 in 2020. Additionally, estimated quantity of muck will be 68 988 802(ton/year) and estimated amount of biogas 2 276 630 466 (m^3/year) for 2020.

In the study, according to the result of the Trend Analysis, ın Figure 2, the quadratic equation of Yt = 34247879 - 1589180*t + 63225*t**2 was used to

TABLE 1 : Equivalent quantity of biogas and diesel oil that can be produced on basis of animal waste potential of Turkey in 2012

Kind of Animal	*Number of Animal (Piece)	Quantity of wet fertilizer (ton/year)	Quantity of Biogas(m^3/year)	Electric Energy (Kwh/year)	Diesel Oil (lt/year)
Cattle	13 914 912	50 093 683	1 653 091 539	7 769 530 233	1 091 040 416
Sheep	27 425 233	19 197 663	1 113 464 454	5 233 282 934	734 886 540
Goat	8 357 286	5 850 100	339 305 800	1 594 737 260	223 941 828
Total	49 697 431	80 991 546	3 105 861 793	14 597 550 427	2 049 868 784

Source: *[19].http://tuikapp.tuik.gov.tr/hayvancilikapp/hayvancilik.zul (number of animal/piece). Other data give has been calculated by using a variety of values.

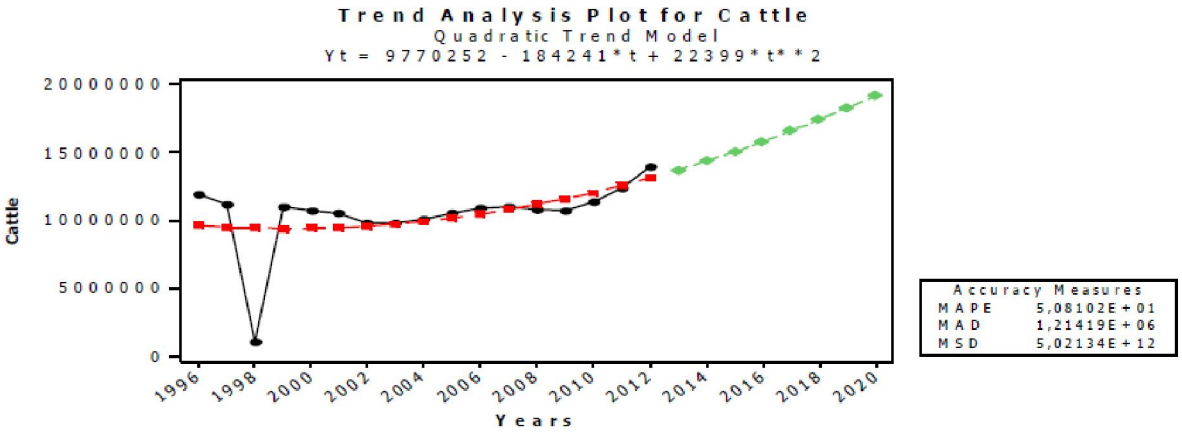

Figure 1 : Future projections about number of cattle in Turkey

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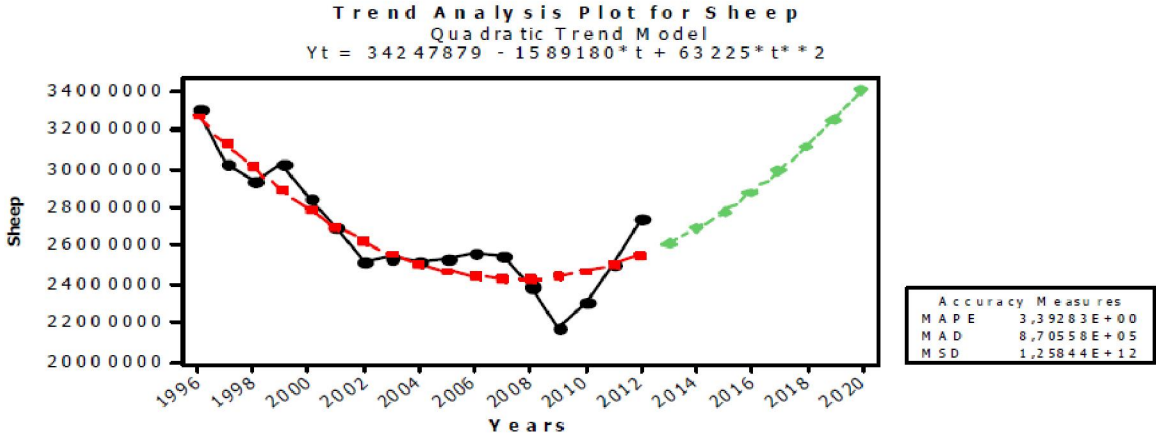


Figure 2 : Future projections about number of sheep in Turkey

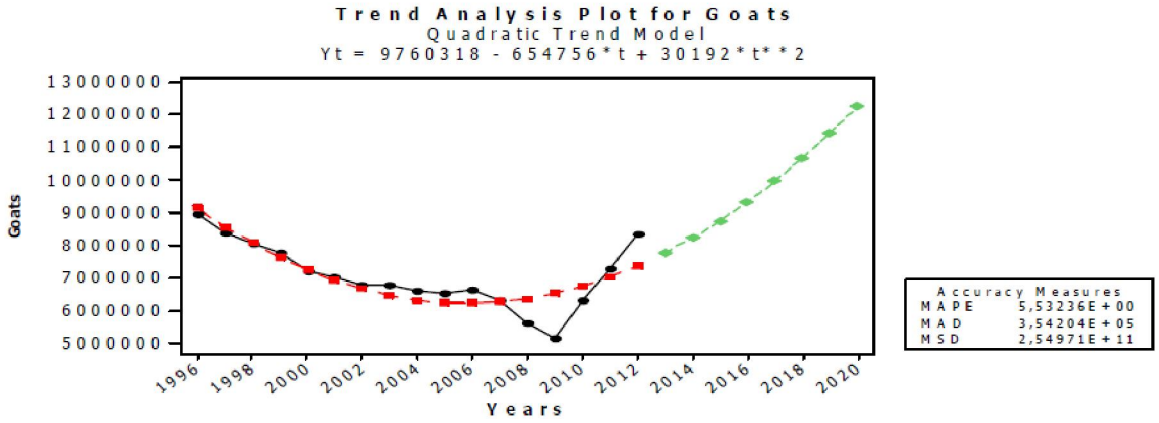
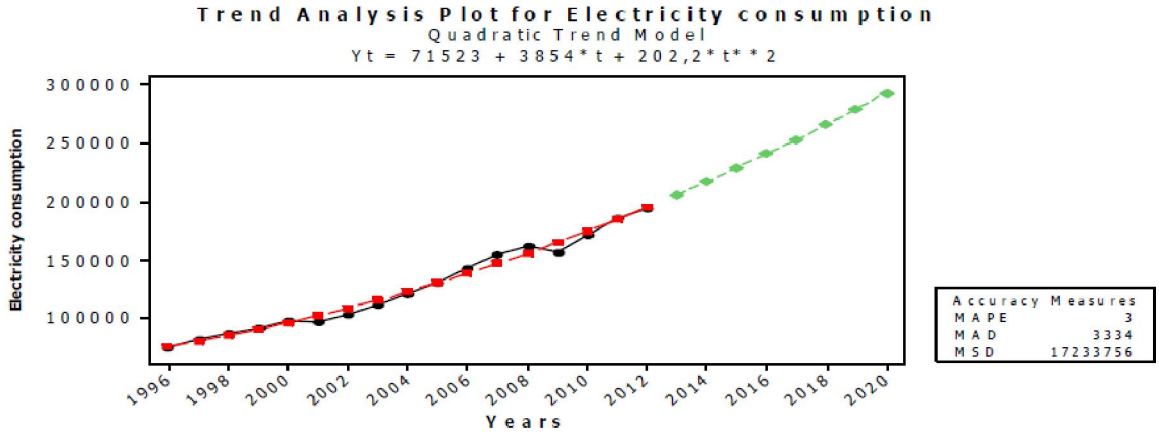


Figure 3 : Future projections about number of goat in Turkey



Source:[20]. (Data for the period of 1996-2012 sourced from Tüik)

Figure 4 : Future oriented projections about electric consumption in Turkey

estimate number of sheep in 2020 and, as a result, total number of sheep is estimated to be 34 033 834 in 2020. Furthermore, quantity of muck to be obtained in 2020 is estimated to be 23 823 684(ton/year) and amount of biogas 1 381 773 672(m^3/year)

In Figure 3, Quadratic model Yt = 9760318 - 654756*t + 30192*t**2 is the most appropriate one for the trend analysis equation. According to the trend analysis, total number of good is estimated to be 12 261 308 in 2020. Estimated quantity of manure is 8 582 916(ton/year) and estimated amount of biogas is 497 809 128(m^3/year)

In Figure 4, Quadratic model Yt = 71523 + 3854*t + 202,2*t**2 is the most appropriate one for the trend analysis equation. According to the trend analysis conducted, electric energy consumption is

TABLE 6 : Conversion of the animal waste to biogas energy in TR 21 region for 2012

Kind of Animal	*Number of Animal (Piece)	Quantity of wet fertilizer (ton/year)	Quantity of Biogas(m^3/year)	Electric Energy (Kwh/year)	Diesel Oil (lt/year)
Cattle	474 557	1 708 405	56 377 365	264 973 616	37 209 061
Sheep	622 977	436 084	25 292 872	118 876 498	16 693 296
Goat	173 998	121 799	7 064 342	33 202 407	4 662 466
Total	1 271 532	2 266 288	88 734 585	417 052 521	58 564 823

Kaynak:[19].

TABLE 7 : Index values of total number of bovine and ovine in the TR 21 region

Years	Index Values of Total Number of Bovine and Ovine in the TR 21 Region (Cattle, Goat, Sheep)	Index Values
1996	1 200 030	0
1997	1 093 220	91,09
1998	2 293 250	191,09
1999	933 180	77,76
2000	891 530	74,29
2001	1 824 710	152,05
2002	852 972	71,07
2003	876 732	73,05
2004	1 729 704	144,13
2005	974 200	81,18
2006	1 007 588	83,96
2007	1 981 788	165,14
2008	1 044 665	87,05
2009	991 311	82,60
2010	2 035 976	169,66
2011	1 212 752	101,06
2012	1 271 522	105,95

Kaynak:[19].

estimated to be 294 256 in 2020.

Biogas energy produced from animal waste in the TR 21 region

TR21 Thracian Region plays a special role for the bovine breeding in Turkey. As a result of artificial insemination applied successfully in the region for year, significant progress has occurred in the existence of the bovine in terms of genotype characteristics, and the ratio of the cultural and cultural hybrid animals to the total number of animals is very high[3]. Because of high animal existence in this region, establishment of biogas plants here is significant for conversion of the animal waste to biogas energy.

TABLE 6 shows amount of biogas produced from the animal waste in the TR 21 region as 88 734 585(M^3/Year) and amount of electric energy as 417 052 521 (Kwh/Year). And diesel oil to be produced from biogas is in amount of 58 564 823(lt/year). This rate of diesel oil is significant to meet fuel requirement of the farmers. In the TR21 region, amount of electric consumed in 2012 is 8 791 946 000 (Kwh/Year). If the bovine and ovine waste was converted to biogas in the TR21 region in 2012, 4.7% electric energy would be saved.

Index values given in the TABLE 7 show an increase by 6% in 2012 compared to 1996. The highest increased is in 1998, 91.09%.

In Figure 5, Trend Analysis was conducted to find total number of cattle in the TR21 Region for 2020. According to the analytical result, the most

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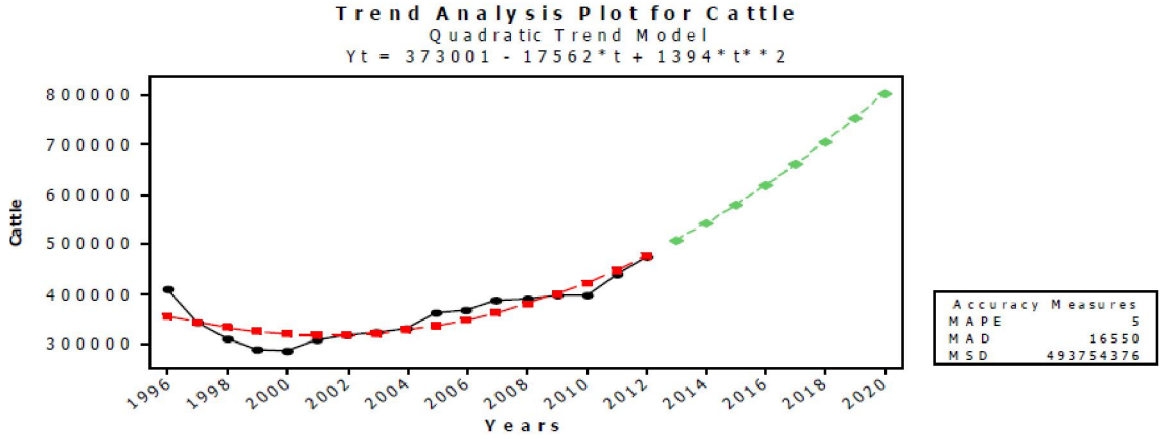

Figure 5 : Future oriented projections of number of cattle in the TR 21 region

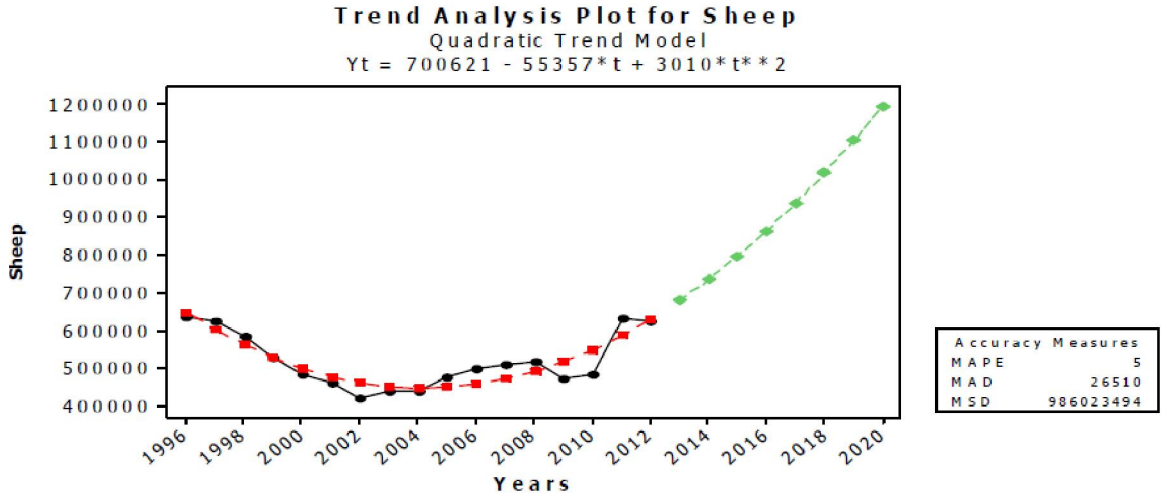

Figure 6 : Future oriented projections of number of sheep in the TR 21 region

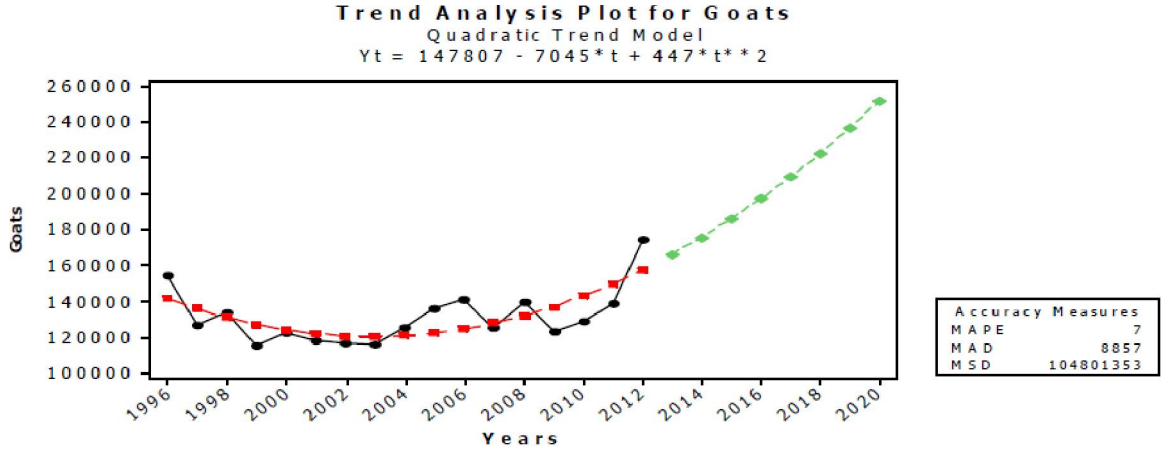

Figure 7 : Future oriented projections of number of goatin the TR 21 region

appropriate equation was found quadratic in form.

According to the equation Yt = 373001 - 17562*t + 1394*t**2, total number of cattle is estimated to be 805 137 in the TR21 Region for 2020. And it is also estimated that quantity of muck will be 2 898 493(ton/year) and amount of biogas 95 650 269(m^3/ year) for 2020.

In the trend analysis conducted, the most appropriate model was found quadratic in form. In Figure 6, the equation Yt = 700621 - 55357*t + 3010*t**2 was used. According to the trend analysis conducted, total number of sheep is estimated to be 1 198 172 for 2020. And it is also estimated that quantity of manure will be 838 720(ton/year) and amount of

biogas 48 645 760(m^3/year).

In Figure 7, Quadratic model Yt = 147807 - 7045*t + 447*t** is the most appropriate one for the trend analysis equation. According to the trend analysis conducted, total number of goat is estimated to be 251 050 for 2020. And it is also estimated that quantity of manure will be 175 735(ton/year) and amount of biogas 10 192 630 (m^3/year).

CONCLUSIONS

With industrialization and urbanization, energy use is constantly increasing in Turkey. And along with the increased energy consumption, our energy resources decreases. For this reason, production of biogas as a renewable source of energy is important.

Besides its contribution to the economy by energy, biogas has also valuable contribution for the environmental health. Conversion of the manure to biogas eliminates offensive odors and destroys and consequently prevents microbes from infesting the environment. While animal waste converted to biogas is used as biogas, it is also used as richer fertilizer for the agricultural fields.

Bush, dung and coal are used for cooking and heating purpose in Turkey, particularly in the rural areas. In Turkey, the increased prices of fuel and energy in recent years considerably affect the rural people with lower income. For this reason, the animal waste should be converted to biogas, a renewable energy resource.

In Turkey, amount of total biogas produced from the bovine and ovine waste is calculated as 3,10 billion m^3/year for 2012. If Turkey used bovine and ovine waste in 2012, 7.5% would be saved from the electric energy consumed in one year. According to the trend analysis made, amount of biogas to be produced from the animal waste is estimated to be 4,1 billion m^3/year for 2020 and if this amount of biogas is converted to electric energy, than an estimated electric energy saving of 6.6% would be achieved. And considering the amount of energy we consume, it is a significant rate.

If the bovine and ovine waste in the TR21 region was converted to biogas energy in 2012, electric energy will be saved by 4.7. According to the trend analysis conducted, amount of biogas to be produced from the bovine and ovine waste in 2020 is calculated to be 154 488 659 m^3/year.

Trend analysis shows tat animal potential will increase in future years both in Turkey and TR21 Region. For this reason, biogas plants should be established to convert the animal waste to energy. And government should encourage establishment of the biogas plants.

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