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Investigation of Biogas Potential from Animal Waste in Bingöl Province

Üsame Demir[1], Perihan ÇULUN*[2]

[1]Bilecek Şeyh Edebali University, Engineering Faculty, Mechanical Engineering Department, Bilecik, Turkey
[2]Bingöl University, Engineering and Architecture Faculty, Department of Mechanical Engineering, Bingöl, Turkey
Üsame Demir ORCID No: 0000-0001-7383-1428
Perihan ÇULUN ORCID No: 0000-0021-7979-9695

**Corresponding author: pculun@bingol.edu.tr*

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Abstract: In this study, biogas and energy potential of animal wastes belonging to Bingöl province was investigated. The study in question was based on data from the Bingöl Governorship Provincial Directorate of Agriculture and Forestry for the years 2002-2020. In the light of 18 years of data, it has been determined that annualy 741.452 tons of manure can be obtained from an average of 948.144 animals, and 34.225.934 m^3 of biogas can be obtained from this manure, also 161GWh of energy per year can be obtained from this biogas. If these animal wastes were evaluated in the said years, a total of 2898 GWh energy would have been obtained. In addition the evalueting data for 2020 it is understood that the biogas potential installation power of Bingöl province is 25.6 MW. Considering the distribution of biogas energy by districts, it is understood that Karlıova district plays an important role with a share of 31% in total power potantial. According to 2020 datas only it is seen that 73.8% of the 303.7 GWh electricity consumed can be met by biogas energy. In addition, according to turkey statistics institute data of 2020 total potential power of Bingöl and its neighboring provinces Diyarbakır, Elazığ, Erzurum, Erzincan, Muş and Tunceli is calculated as 298MW. However, it is understood that only 2.6% of this power (Equal to 7.63MW) is used currently.So it is obvious that the establishment of biogas facilities in related regions will decrease country's dependency on foreign energy.

Bingöl İli Hayvansal Atık Kaynaklı Biyogaz Potansiyelinin Araştırılması

Anahtar kelimeler Enerji, Biyogaz, Hayvansal atık, Bingöl

Öz: Bu çalışmada Bingöl iline ait hayvansal atıkların biyogaz ve enerji potansiyeli araştırılmıştır. Söz konusu çalışma, Bingöl Valiliği İl Tarım ve Orman Müdürlüğü'nün 2002-2020 yıllarına ait verilerine dayanmaktadır. 18 yıllık veriler ışığında, ortalama 948.144 hayvandan yıllık 741.452 ton gübre elde edilebileceği ve bu gübreden 34.225.934 m^3 biyogaz elde edilebileceği, ayrıca yıllık 161 GWh enerji üretilebileceği belirlenmiştir. Söz konusu yıllarda bu hayvan atıkları değerlendirilseydi toplam 2898 GWh enerji elde edilecekti. Ayrıca 2020 yılı verileri değerlendirildiğinde Bingöl ilinin biyogaz potansiyel kurulum gücünün 25.6 MW olduğu tespit edilmiştir. Biyogaz enerjisinin ilçelere göre dağılımına bakıldığında Karlıova ilçesinin% 31'lik pay ile önemli bir rol oynadığı anlaşılmıştır. Sadece 2020 verilerine göre tüketilen 303.7 GWh elektriğin %73.8'inin biyogaz enerjisi ile karşılanabileceği görülmektedir. Ayrıca türkiye istatistik enstitüsü verilerine göre 2020 yılı Bingöl ve komşu illeri Diyarbakır, Elazığ, Erzurum, Erzincan, Muş ve Tunceli'nin toplam potansiyel gücü 298 MW olarak hesaplanmıştır. Ancak şu anda bu gücün sadece %2.6'sının (7.63 MW'a eşit) kullanıldığı anlaşılmaktadır. Dolayısıyla ilgili bölgelerde biyogaz tesislerinin kurulmasının ülkenin dışa bağımlılığını azaltacağı aşikardır.

1. INTRODUCTION

With the increasing population and the development of technology, the need of energy increases day by day. At the same time with the population increase, environmental pollution increases, and it is generally known that fossil fuels are exhausted. In this sense, researches on alternative energy sources are increasing day by day. According to 2010 data, fuel and alternative energy sources used in the distribution of electricity generation in

the world are 28% nuclear, 25% solid fuels, 24% natural gas, 17% renewable energy sources excluding biomass, 4% biomass, 3% liquid fuel. By 2020, 23% of electricity production was met from nuclear, 23% ıf them from solid fuels, 17% of them from natural gas, 30% of them from renewable energy sources excluding biomass, 6% of them from biomass and 1% of them from liquid fuels. In the distribution of electricity generation, it is seen that there is a tendency towards renewable energy by abandoning fossil resources. A study is expected that by 2050 it will have a very high share of 92% of renewable energy including biomass in electrical energy production [1]. In Turkey according to 2010 sources 46.47% of electricity generation was obtained from natural gas, 26.22% of them from renewable energy sources excluding biomass, 18.05% of them from liquid fuels, 9.05% of them from solid fuels[2]. In 2020 26.8% of electricity generation was obtained from natural gas, 50.2% of them from renewable energy excluding biomass, 12.1% of them from liquid fuels, 9.4% of them from solid fuels, 1.5 of them from biomass [3]. Therefore, according to the sources of energy production it is seen that there is a high rate of turn to renewable energy in Turkey. On average 24% of the world's energy needs are met from nuclear energy and therefore, it is seen that investments are made in nuclear energy in our country too. By 2050 it is predicted that nuclear energy will not remain and 92% of energy will be met from renewable energy worldwide. In addition while 36% of energy in the world is met from renewable energy this rate is aproximately 51.7% in Turkey in 2020. This ratio shows that Turkey is above the world average in terms of transition to renewable energy. While energy production from biomass increased 1.5 times in the world from 2010 to 2020, it increased approximately 7 times in Turkey. There is a high tendency towards alternative energy sources in our country, especially to reduce foreign dependency. Biogas production from animal wastes should be prioritized as an alternative energy source considering the existence of animals in our country. When evaluated in terms of animal assets, it is known that there are 72 million 271 thousand total animals, including 18 million 158 thousand cattle and 54 million 113 thousand small cattle as of 2020 [4]. If this potential animal waste is evaluated, it is understood that the energy amount of 4.385.371 TEP/year can be met and it will make a great contribution to the country's economy, especially in terms of foreign dependency of energy [5]. Many studies have been carried out in terms of the biogas potential of Turkey. Biogas potential of Elazig province has been studied and an analysis of return figures of biogas to be produced in the biogas plant has also been conducted [6]. The amount of fertilizer that can be obtained from the wastes of all animal assets of Turkey and the maximum biogas production that can be produced depending on these fertilizer amounts have been evaluated. It has been understood that when this biogas is used for electricity generation, there will be a great decrease in the amount of electrical energy that we depend on. In this respect, it was emphasized that especially agricultural, domestic and animal wastes should be used for energy production [7]. Biomass potential of Eastern Anatolia Region was examined in another study. The amount of dry biomass in cultivated areas in all provinces in the Eastern Anatolia Region has been calculated. Average thermal values were calculated according to the amount of dry biomass and the amount of energy obtained from it. According to the values obtained, they suggested that necessary researches should be made especially in provinces for the utilization of biomass wastes or forest wastes and that necessary facility should be established and research centers should be established to close our energy deficit on a provincial basis [8]. In the study conducted to evaluate animal wastes in Tokat province, animal assets according to Tokat city center and districts were examined. According to these animal beings, the potential biogas production and the electrical energy to be obtained from it have been revealed. According to the data obtained, the amount of electrical energy produced from animal waste will meet approximately 32% of the electricity consumption of Tokat province in 2007 [9]. In the study carried out for Sivas province, the electrical energy that could potentially be produced according to the general animal number of the province was evaluated. In addition, in the study suggestions were given about the size of the biogas facility that they can establish on a small scale according to the number of animals for cattle, ovine and poultry breeders. In the data presented, the appropriate size of the facility for livestock holdings is suggested as 14, 21, 28 m^3 for 20, 30, 40 animals respectively; for 30 000, 40 000 cattles 356, 474 m^3 respectively. It was emphasized that for small ruminants it should be 16 m^3 for 500 animals and it is more important to establish small-scale biogas plants instead of a single large biogas plant [10]. In the study conducted for the province of Iğdır, the biogas potential from animal waste was evaluated according to the city center and districts. It has been determined that the district with the highest biogas potential is Tuzluca. In addition, they revealed that the biogas potential of Iğdır province constitutes 3.76% of the Eastern Anatolia Region and 0.679% of Turkey in general [11]. In the study conducted for the province of Ardahan, the amount of biogas that can be obtained from animal wastes and the amount of electrical energy that can be produced were determined for the city center and districts. According to the density of animal clusters, locations of the city center and districts to establish a biogas plant have been revealed. In addition, a guide has been prepared for the investments to be made for the biogas plant [12]. In the study conducted for the province of Malatya, the biogas potential that can be obtained from animal wastes was evaluated and the biogas potential of the province was revealed by comparing it with animal assets throughout Turkey [13]. In a statistical study conducted in Turkey, it was calculated that according to the number of chickens, the biogas potential that could be produced in Turkey in 2009 was 390 million m^3, which is equivalent to an energy of 8.853 million GJ. In addition, the provinces where more than 10 million m^3 of biogas will be obtained annually from chicken waste in Turkey are listed as Bolu, Balıkesir, Sakarya, Manisa, Afyon, Konya, İzmir, Ankara, Çorum and Bursa [14]. In the study conducted for Kahramanmaraş province, biogas production potentials from animal and plant wastes were determined. In this sense, it is predicted that the majority of production will consist of animal wastes. In addition, a mapping was made according to the production potential

of the districts and the places with the highest biogas potential were determined [15]. In the study conducted for Çanakkale province, situations related to electricity generation from biogas in the world and in Turkey have been presented. A comparison of biogas potential with Çanakkale province and other provinces has been made [16]. In the study conducted for Denizli province, biogas production potential from animal wastes and the amount of electrical energy that can be obtained from biogas were revealed according to their districts. In this sense, it is stated that it is important to have a facility made of animal wastes in Çivril district. In addition due to the high number of chickens in Honaz district, it was observed that a biogas production facility was suggested to be established here [17]. In the study conducted for the Thrace region, potential biogas production amounts from animal waste in all provinces and districts were evaluated. In this sense studies were carried out for the whole region with the numerical mapping method. It was stated that Edirne could be the province with the highest potential biogas production from animal wastes in the Thrace region [18]. Potential biogas production that can be obtained from animal wastes in Erzincan province has been determined. The use of potential biogas as an alternative to electricity generation and natural gas has been evaluated. In addition, it has been shown how

Erzincan province will benefit economically in the use of biogas to be produced annually [19]. Again, a study conducted for Erzincan determined where a biogas plant should be established in provincial and district centers [20]. In the study conducted for Kırşehir province, the amount of biogas obtained from animal wastes was determined and where the biogas facility should be established in the province [21]. In the study conducted for Bitlis, biogas production potential from animal wastes in the city center and districts was examined. In this sense, the amount of earning that can be obtained in case of utilizing this potential throughout the province has been presented [22]. In a study, the number of biogas facilities and production amounts in Turkey were examined. In 2017 it was determined that there are 122 licensed Renewable Waste Power Plants with 634.2MW power. It was emphasized that these facilities should increase as the demand for energy increases day by day [23].

Previous studies on biogas energy have been meticulously examined. Among the mentioned studies, there is no study on the biogas energy potential for the province of Bingöl. In this respect, this study will be both an original study and a guide for biogas studies to be carried out in Bingöl Province. And also it is aim to encourage the establishment of biogas facilities in the province of Bingöl and reduce foreign dependency by providing local energy production. Based on literature studies, the biogas potential and related energy data obtained from animal wastes were investigated for the province of Bingöl, which has a high livestock potential. So Animal waste data obtained from Governorship Provincial Directorate of Agriculture and Forestry for the years 2002-2020. Biogas potentials of province and districts were revealed separately. Electrical energy consumed by the region were compared with the electrical energy produced from biogas. In addition, the data of the provinces neighboring Bingöl for the year of 2020 were evaluated in terms of current installed power.

2. MATERIAL AND METHOD

Bingöl province is located in the Upper Euphrates Section of the Eastern Anatolia Region between 41º 20 ′ and 39º 56 ′ east longitudes and 39º 31 ′ and 36º 28 northern latitudes. The land within the provincial borders is quite hilly, and the city center was established on a plain bordered by mountains on all four sides. The majority of rural settlements are located in mountainous areas. In this respect, both bovine and ovine breeding constitute important sources of income in this city. Bingöl is adjacent to Erzincan and Erzurum in the north; Muş in the east; Tunceli and Elazig in the west and Diyarbakır in the south. There are 7 Districts of Bingöl, Yayladere, Kiğı, Yedisu, Adaklı, Karlıova Solhan and Genç. In the study in question, data belonging to the years 2002-2020 obtained from the Bingöl Governorship Provincial Directorate of Agriculture and Forestry were used. Within the scope of this study, Livestock data for the year 2020 published by Turkish Statistical Institute (TSI) was used [4]. Bovine, ovine and poultry data were used in biogas and energy calculations.

Table 1. Animal Presence of Bingöl Province in 2020 [4]

Districts	Bovines	Ovines	Poultry	Total
Adaklı	10.386	48.920	6.800	66.106
Genç	19.357	39.079	6.495	64.931
Karlıova	20.986	348.375	11.760	381.121
Kiğı	3.670	9.976	6.811	20.457
Merkez	60.050	101.398	723.600	885.048
Solhan	19.984	147.291	5.000	172.275
Yayladere	1.783	4.386	382	6.551
Yedisu	8.297	21.427	1.650	31.374
Total	144.513	720.852	762.498	1.627.863

According to 2020 data 60.050 of 144.513 cattle in Bingöl province belong to Bingöl center. The highest number of cattle belongs to Karlıova after the central district, followed by Solhan, Genç, Adaklı, Yedisu and Kiğı. The fertilizer used in the calculations was taken as 3,6 tons year-1 for cattle, 0.7 tons year^{-1} for small cattle and 0.022 tons year^{-1} for poultry [24]. The amount of biogas taken from the fertilizer on a ton basis is 33, 58, 78 m3 ton^{-1} for bovine, ovine and poultry respectively [24]. The electrical energy obtained from 1 m^3 of biogas is the same for all three animal species and is 4.7 kWh [25].

3. RESULTS

In this study, biogas and energy potential of animal wastes belonging to Bingöl province was investigated. In the study datas belonging to the years between 2002-2020 obtained from the Bingöl Governorship Provincial Directorate of Agriculture and Forestry were used. The land is quite hilly within the province of Bingöl and the city center was established on a plain bordered by mountains on four sides. The majority of rural settlements are located in mountainous areas. In this respect, both bovine and ovine breeding constitute important sources of

income in this city. Expecially small cattle breeding is the most common in the region. In Figure 1, the numbers of bovine, ovine and poultry animals belonging to the province of Bingol and theoretical biogas of them are given for 2002-2020 years. As seen in related figure the annual average bovine number is below 200000, while the average number of sheep and goats is around 500000. It is understood that potential of manure obtained from ovine animals is higher than that of bovine animals. As a matter of fact, while the potential biogas multiplier for ovines is 58, it is 33 for bovines. So the biogas potential of manure obtained from ovine animals is of higher quality than that of bovine animals. Considering ovines livestock has an important place due to its location, the importance of researching and evaluating potential biogas production can be better understood. In addition as seen from same figure (**Figure 1**) a significant increase is seen in the number of poultry animals in the last three years.

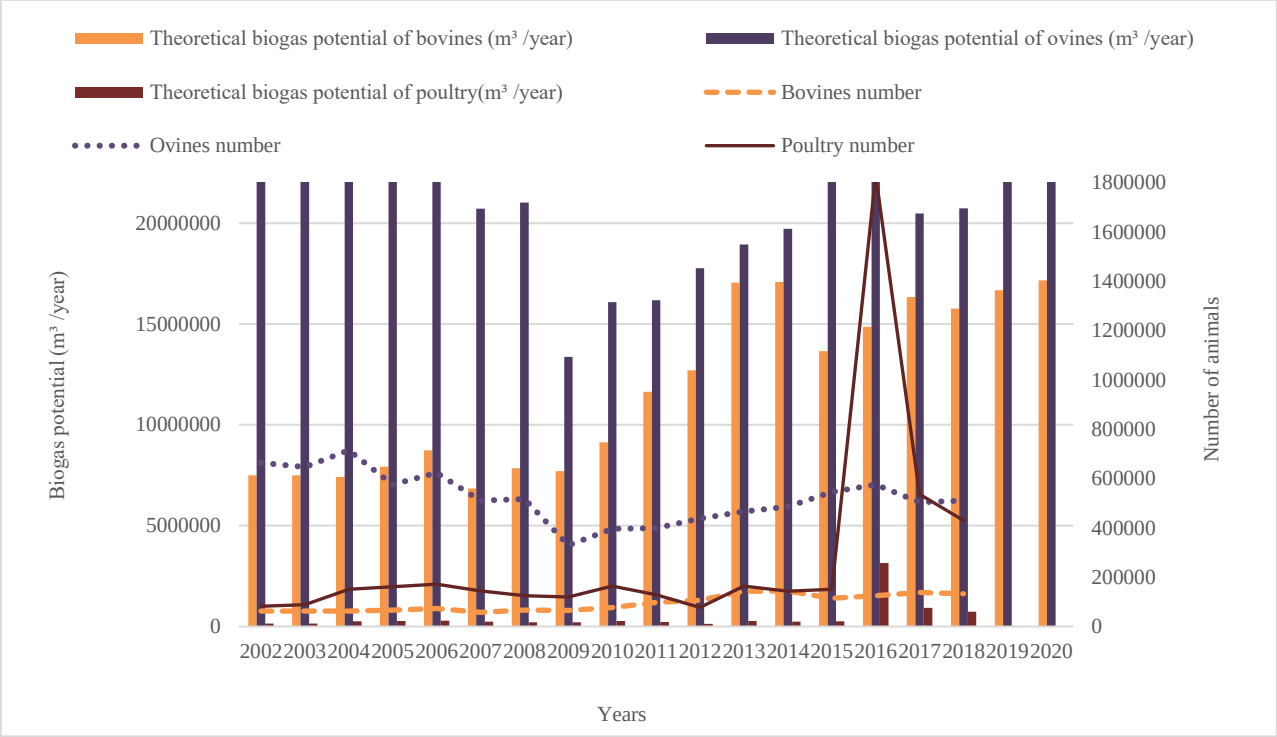

Figure 1. Number of animals and theoretical biogas potential of them for Bingöl province

According to annual average values data from Table 2, there is an annual total of 948.144 animals, including 99.047 bovines, 540.122 ovine, 308.975 poultry. From these animals, in totaly 741.452 tons/year of fertilizer is obtained from all animals, 356.569 tons/year of them obtained from cattles, 378.085 tons/year of them provided from ovine, 6.797 tons/year of them provided from poultry manure. And also 11.766.783 m^3/year of the total biogas produced annually is obtained by small animals, 21.928.953 m^3/year of them produced by cattle and 530.197 m^3/year of them produced by poultry. The relevant energy amounts were determined for bovines, ovines and poultry as 55.35 GWh / year, 103.1 GWh / year, 2.5 GWh / year respectively with an average annual total of 160.9 GWh/year (Table 2). In the light of these values, it was possible to establish a biogas plant with an installed power of 18.4MW in the 18 year period(from 2002 to 2020). If these animal wastes were evaluated in the said years, a total of 2898 GWh energy would have been obtained. But this energy became idle because the existing potential biogas energy was not utilized.

Table 2. Annual average data of 2002-2020

Animal breed	**Num. of animals per year**	**Theoretical Fertilizer Potential (tons / year)**	**Theoretical Biogas potential (m^3 /year)**	**Produced Energy (GWh /year)**
Bovines	99.047	356.569	11.766.783	55.3
Ovines	540.122	378.085	21.928.953	103.1
Poultry	308.975	6.797	530.197	2.5
Total	948.144	741.452	34.225.934	160.9

Table 3. Datas for 2020

Animal breed	Animal number	Theoretical Fertilizer Potential (tons / year)	Theoretical Biogas potential (m^3 /year)	Produced Energy (MWh /year)	Potantial power plant capacity(MW)
Bovines	144.513	520.247	17.168.144	80.700	9.2
Ovines	720.852	504.596	29.266.591	137.500	15.7
Poultry	762.498	16.775	1.308.447	6.100	0.7
Total	1.627.863	1.041.618	47.743.182	224.300	25.6

Table 3 shows the animal numbers, potential biogas and energy values for 2020 only. According to the result from Table 2 and Table 3 this is a sign that the number of animals will increase gradually for Bingöl. At the same time the increase in the energy produced by biogas in question will observed. The evalueting data of 2020 only it is understood that the biogas potential installation power of Bingöl province is 25.6 MW. In this regard, it is observed that there is an increase of approximately 40% in 2020 compared to the power of the facility that can be established for the other 18 years.

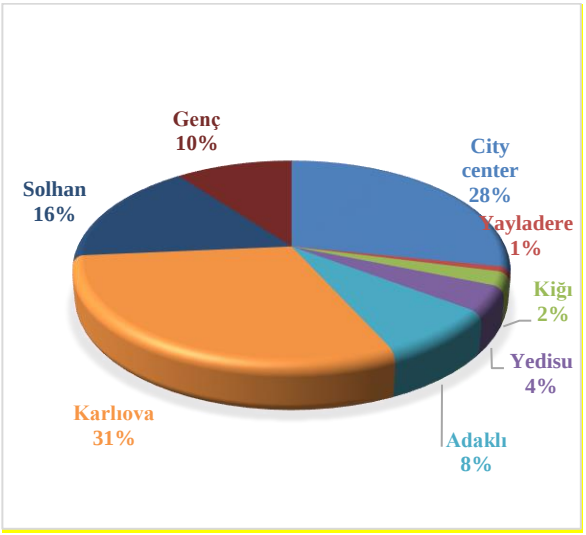

Figure 2. Distribution of biogas energy by districts

In Figure 2, the distribution of biogas energy by districts is shown in the pie chart. From the related graph, the distribution of total biogas energy in Bingöl province as 31% Karlıova, 28% city center, 16% Solhan, 10% Genç, 8% Adaklı, 4% Yedisu, 2% Kiğı, % 1 Yayladere respectively. It is understood that Karlıova has an important place in biogas production in Bingöl province.

Considering the distribution of biogas energy by districts, it is understood that Karlıova district plays an important role with 31% installed power potantial in this matter.

Table 4. Electricity Consumption Values in Bingöl Province by Years and Consumer Type (Obtained from board (EPDK)).

Bingöl	2020	2019	2018	2017
Lighting	16.126	14.633	12.469	10.403
Domicile	129.972	122.600	117.778	111.732
Industry	53.042	49.228	63.114	58.029
Agricultural watering	1.308	781	452	426
Business	103.293	118.748	111.723	114.144
Grand Total (MWh)	303.740	305.989	305.535	294.733

According to the electricity consumption values of Bingöl province obtained from EPDK (Table 4), it is seen that the annual consuption potential was in total approximately 294GWh in 2017; 305 GWh in 2018 and 2019 and 303.74 GWh in 2020. It is understood that by using the 224.3 GWh/year biogas potential energy obtained in 2020, 73.8% of the total consumption value of the relevant year,(Which is 303.7 GWh/year according to Table 4), will be met.

In Table 5, the number of animals in Bingöl province and its neighbors, the relevant biogas energy amounts and the current installed power are given for comparison purposes for 2020. The biogas facility established by Sütaş company in Bingöl for cattle manure, chicken manure and vegetable waste has a capacity of 2.1MW, whereas the biogas potential of Bingöl is much higher than this installed power. Similarly It is understood that the biogas potential in Diyarbakır is far above the installed power of 2.15MW.

Table 5 Biogas data of neighboring provinces of Bingöl for 2020 (Obtained from turkey statistics institute 02.12.2021)[4]

Data of 2020	Bingöl	Diyarbakır	Elazıg	Muş	Erzurum	Erzincan	Tunceli	Total
Ovine num.	720.852	2.091.344	854.456	1.235.552	904.587	501.027	432.565	6.740.383
Bovine num.	144.550	656.074	209.142	331.881	869.009	124.125	37.086	2.371.867
Biogas potantial(MWh/year)	218.264	765.396	279.825	421.077	657.833	164.911	103.249	2.610.555
Potantial installed biogas power (MW)	24.9	87.3	31.9	48	75	18.8	11.78	297.68
Installed biogas power(MW)	2.1	2.15	0	0	3.38	0	0	7.63

There are currently two biogas power plants with 3.38MW power in Erzurum named Erzurum and Akşehir biogas power plant. On the other hand, there is currently no biogas facility in Elazig, Erzincan, Muş and Tunceli that uses animal wastes. According to the relevant table, the total installed power potential of Bingöl and neighboring provinces is 297.68 MW, while all installed facilities are only 7.63MW.

4. DISCUSSION

In this study, the biogas potential of Bingöl province was evaluated. For this purpose, annual average results were obtained by using the data on animal waste between the years 2002-2020. Also using the data of 2020, the electricity rates that can be met with the biogas potential were examined. In addition, the data of the provinces

neighboring Bingöl for the year 2020 were evaluated. Considering the average values obtained according to 2020, it is understood that the potential biogas power of the province of Bingöl is approximately 25.6MW. It has been understood that 73.8% of the electricity consumed annually can be met if a 25.6MW biogas power plant is established. According to relevant data, the total installed power potential of Bingöl and neighboring provinces is 297.68 MW, while all installed facilities are only 7.63MW. Therefore, it is understood that only 2.5% of the potential of Bingöl and surrounding provinces is used. On the other hand, considering that approximately 27.4% of the electricity produced in Turkey is obtained from natural gas, 17% from ital coal and 2.2% from biogas [26], it is understood that sufficient attention should be given to biogas studies.

According to the February 2021 biogas production facility pre-feasibility report in Elazig province, although the biogas installed power of companies that have obtained a biogas license within the scope of Turkey increases every year, it is understood that the total installed power is currently 147MW[27]. Considering that the potential power of Bingöl and neighboring provinces is 297MW according to our own study. Therefore, it is understood that Turkey's total installed power corresponds to only 50% of the potential biogas energy of Bingöl and neighboring provinces. In other words, only the biogas potential of Bingöl and neighboring provinces is twice the current total installed power of Turkey. Therefore, when we consider this in terms of the eastern Anatolian region and Turkey, a large proportion of electrical energy can actually be met from these waste energies. Especially considering that biogas energy is not only caused by animal wastes, but also vegetable wastes and all organic wastes can be evaluated. In this sense, we believe that this issue will be even more important[7]. In this respect, it is clear that the evaluation of biogas energy produced both in the province of Bingöl and the other centers of Turkey will close a large energy deficit of country. With the use of this potential, it will be possible to get rid of the 50% energy dependence on abroad[26]. And also we are of the opinion that biogas energy should be re-evaluated not only throughout Bingöl but also in every region of Turkey.

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