Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676, p-ISSN: 2320-3331, Volume 20, Issue 1 Ser. 1 (Jan. – Feb. 2025), PP 23-29
www.iosrjournals.org

Determination Of The Potential Of Biogas Energy Production Due To Animal Presence For Rural Areas And Investigation Of Their Effects On CO_2 Emissions

Mustafa İRİŞİK
Lecturer, Kütahya Dumlupınar University Dumlupınar Vocational School Department Of Electricity And Energy, Kütahya, Türkiye,

Abstract
The main aim of this study is to determine the biomass energy production potential of Dumlupınar district and analyze its impact on greenhouse gas emissions. At the same time, it is aimed to contribute to making agriculture and livestock activities in rural areas more efficient. Key benefits of the study include increasing rural employment, increasing the income level in the region, expanding the use of technology, reducing migration rates and promoting healthy living conditions. These elements will contribute to the sustainable development of the region, both economically and environmentally. Within the scope of the research, it was calculated that 833.624,6 m³ of biogas could be produced annually by considering the animal presence in Dumlupınar. The amount of electrical energy that can be obtained from this biogas is estimated at 3.918.035 kWh. When the investment costs of the biomass plant are calculated, the return period of the investment is determined as 4,7 years. In addition, the plant is expected to prevent around 3.330,33 tons of CO_2 emissions per year upon operation. This will make a significant contribution to environmental sustainability and play an important role in combating climate change by reducing carbon emissions. Biomass energy offers a cleaner and more sustainable alternative to fossil fuels. The results of this study provide important data for the effective evaluation of renewable energy sources and the promotion of economic development in rural areas. In addition, revealing the regional biomass potential will contribute to planning similar projects in the future.
Keywords: *Electric Power Generation, Biogas, Carbon Emission*

Date of Submission: 27-01-2025 Date of acceptance: 07-02-2025

I. Introduction

Today, population growth and the rapid advancement of technology increase the need for energy in many areas. For the last 10 to 15 years, energy needs have been heavily derived from fossil sources. This situation gradually increases the usage of fossil fuels and exacerbates their environmental impacts. Increasing energy needs and negative environmental impacts disrupt the balance of the life cycle on earth(Olcay, Giray Tunca, & Arif Ozgur, 2024) . Although the capacities of raw materials and energy sources are limited, the need for these resources is constantly increasing and rapidly. The limited reserves of primary energy sources are leading humanity to seek out new sources of unusual energy and to increase energy efficiency. In a study aimed at increasing energy efficiency, it was calculated that the energy saving in the use of waste heat in rotary kilns is 15.07%(Tunca, 2025). The increase in fuel prices, the proliferation of populations, industrialization, the necessity of effective use of national resources, the damage of existing fuels to the environment and the problems of climate change, it makes the use of renewable energy sources necessary within the scope of innovative energy technologies. One of these clean and renewable energy sources is biogas energy.

Biogas can be used in all machines running on natural gas or LPG by making small revisions. This reduces the amount of CO_2 emissions from these devices. In addition, while the smell and fly formation caused by animal waste in rural areas is another advantage of using in the production of biogas without waiting for animal waste, when the remaining weed from the biogas plant is spread in agricultural lands in a way that is free from the seeds of harmful grass, it also ensures higher yields. Another benefit of biogas is its employment and economic contribution to rural areas, which reduces external dependence because it meets the need for heat, electricity and fuel. With anaerobic biotechnology, biogas production is one of the methods of extracting energy from biomass, which has an important place in renewable energy sources. In recent times, anaerobic decomposition processes have been applied to a large proportion of industrial and agricultural wastes. This clean energy is obtained by converting organic waste into methane gas in an oxygen-free environment. The rest is used as a rich source of fertilizer.

When the literature on biomass is investigated, it is emphasized that in the study of agricultural energy potential of the European Union, understanding the specific characteristics of the agricultural sector of each country in the union is vital to using the full potential of biomass. In addition, the theoretical potentials of agricultural biomass of selected European Union countries were analyzed as an average of 10.411,18 Ktoe (Kilotonne of oil equivalent) (Weremczuk, 2023).In a study on the potential and future of agricultural biomass for energy purposes for the country of Poland, in 2010 and 2030, biomass energy use will increase from 6,3% to 16,1% in electricity generation, from 10,4% to 11,6 % biofuel production will increase, but biomass energy will decrease from 83,3% to 72,3% in heat production. In addition, due to the European Union's energy economy policies, it was foreseen that in 2020, 80% of renewable energy will be obtained from biomass sources (Baum, Wajszczuk, Pepliński, & Wawrzynowicz, 2013). In the study of the analysis of the energy potential and feasibility of biogas production from agricultural raw materials in Lithuania, the best opportunities for biogas production are Siauliai (179 GWh), Kaunas (163 GWh), In the cities of Panevezys (128 GWh) and Marijampole (120 GWh), it was determined that large livestock and poultry farms were quite dense and that environmental conditions were suitable for growing energy plants suitable for biogas production (Navickas, Venslauskas, & Zuperka, 2009). In the Czech Republic, the study conducted to determine the potential for electricity and thermal generation of biomass energy from forest sources from renewable energy types shows that the total annual volume of dendromas dating back to 2036 is 13.473 million tons (Šafařík, Hlaváčková, & Michal, 2022).

In a four-way study of potential biomass energy production forecasting in China, agricultural crop from bioenergy raw material cultivation, food and feed production provides materials derived from forestry, both from residues and from industrial wood waste, biomass sources from energy crops and woody crops were calculated in 2030 to provide 18.833 PJ/year and in 2050 to 24.901 PJ/year (Zhao, 2018). Another study identified biomass potential from agricultural residues for energy use in the Indonesian city of West Nusa Tenggara (WNT) which is growing extensively in this city, post-product residues from corn, cocoa and paddy, plants accounted for about 85,47% of total biomass. The total heating value of these residues is calculated as 42,4 PJ (Fitri, Gürdil, Demirel, Cevher, & Roubík, 2023). In another study, a multistage and multi-object model was developed, including the anaerobic digestion process, to ensure the sustainability of the supply chain of bioenergy production. This model was used in a case study for the Golestan province and results have been shown to support the potential of three biogas power plants in Gonbad-e-Kavoos (Bijarchiyan, Sahebi, & Mirzamohammadi, 2020).

In a study for the Mediterranean region in Türkiye, it is estimated that 39% of the current plant remains and 9% of the animal remains are in this region according to the information obtained from the official institution. These residues show 6,9% of the region's energy demand, which means it has a production capacity of about 8,3 PJ/year. It is also estimated that thanks to the electrical energy obtained from these wastes, it can reduce CO_2 by 2.644.302 tons/year. The amount of biogusts that can be obtained after the production of biogas is calculated as 1.184.049 tons/year (Bilgili, 2022). Seyitoglu S. and his friend's study revealed the potential of the city of Corum and its districts for biogas production and electricity generation (Seyitoğlu & Avcıoğlu, 2021) In the studies of Salihoglu N. and his colleagues in determining the potential of biogas production from animal waste for the city of Balıkesir, they found that in the data for 2017 there was a potential biogas of 82.815.600 m³ (Salihoğlu, Teksoy, & Altan, 2019). Eryasar A. has carried out experiments according to its prototype biogas system design, solar-powered, thermophilic-continuous-fed, mesophilic-cut fed and mesophilic continuous-fed conditions. In the thermophilic continuous-feeding trial, when the temperature was removed 55°C, the system operation was observed to be irregular, but biogas production started again within 10 days. In the mesophilic-segmented trial, at 37°C, 20 days of waiting time, 70% of the biogas production was observed to occur and there was no change in pH value. In the mesophilic-continuously fed experiment, it was observed that the system, which was stopped for any reason, could produce biogas immediately when the feeding was restarted (Eryaşar, 2007). A study conducted for the city of Sivas determined the potential of biogas production and identified locations where electricity production facilities could be established according to biogas production distribution regions (Yokuş, 2019). In another study, the amount of electricity that can be obtained from biogas energy using animal number data of Tokat city was found to be 124.042 MWh per year (Konuk, 2019). In the research conducted for Kayseri city Kocasinan and Melikgazi districts, the number of animals was determined and the potential of biogas and electricity production was examined and the installation location of the electricity production facility was determined (Poyraz, 2020). In the biogas potential determination study for the city of Çanakkale, it was calculated that biogas can be obtained in a total amount of 96.934.753 m³ per year (Ilgar, 2016). In the study in Eskisehir, depending on the number of animals, biogas potential was determined and daily electricity production capacity was revealed. It is also stated how many tubes of gas are equivalent when biogas energy is desired to be used as tube gas (Öçal, 2013). In the biogas energy production potential for the city of Mugla, the annual electricity production potential was determined to be 1.555.242 MWh (Saz, 2021).

II. Biomass Electric Power Generation İn Türkiye

According to the production license data given by Türkiye's Energy Market Supervisory Authority (EPDK), as of October 2024, 343 biomass plants are in 62 cities. The total installed capacity of the production facilities is 2,538,16 MW and the ratio of Turkey to total electric installed power is 2,10%.

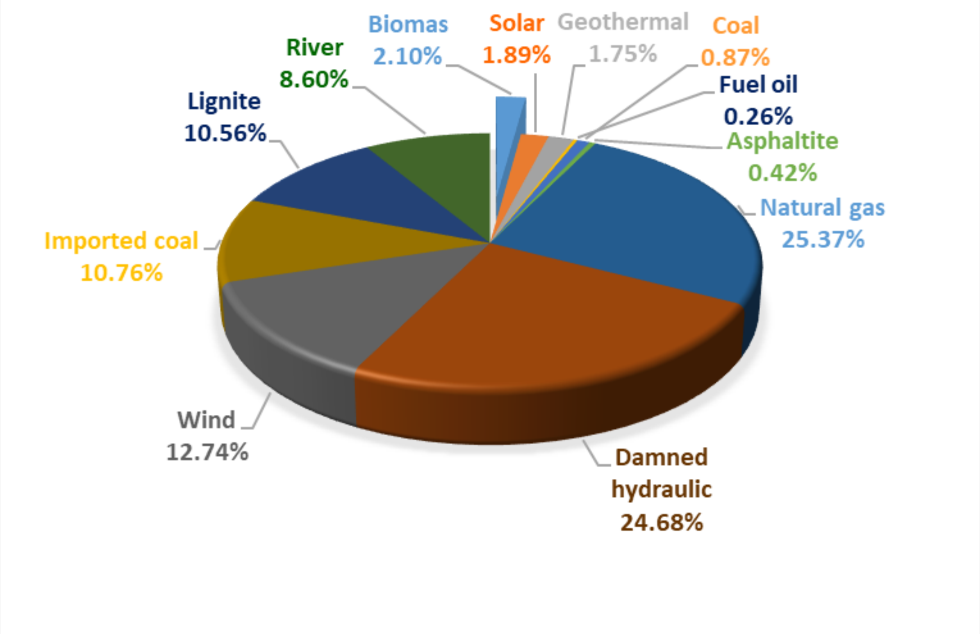

Figure 1. Distribution of Licensed Electric Board Power by Resource (%) (EPDK 2024 October Report)

In the first nine months of 2024, the production of electricity from biomass energy is given in Table 1. According to this table, the share of biomass energy in total electric power generation is 3,03%.

Table 1. 2024 January-October Biomass Electricity Energy Production Amount and Total Electricity Production Rate (EPDK 2024 October Report)

Month	Biomass Installed Capacity(MW)	Biomass Energy Production(MWh)	Total Production(MWh)	Ratio(%)
January	2.078,08	870.639,35	29.220.572,35	2,98
February	2.082,64	1.712.968,22	55.945.484,78	3,06
March	2.085,14	2.594.429,70	83.624.754,97	3,10
April	2.087,02	3.446.703,88	107.827.186,02	3,20
May	2.096,58	4.328.571,81	134.768.591,71	3,21
June	2.104,92	5.170.150,01	163.241.607,28	3,17
July	2.111,58	6.039.326,40	197.706.561,51	3,05
August	2.111,58	6.823.315,49	231.617.200,80	2,95
September	2.111,58	7.609.954,65	260.203.209,90	2,92
October	2.125,47	8.480.493,28	287.955.546,39	2,95
	Total	**47.076.552,79**	**1.552.110.715,71**	**3,03**

III. Biogas Energy Production

Biogas is a mixture of colorless, odorless and air-light, bright blue flame formed by the breakdown of organic-derived wastes in an oxygen-free environment (anaerobic fermentation). In the content of biogas, 50% - 70% methane, 30% - 40% carbon dioxide, 5% - 10% hydrogen, 1% - 2% nitrogen and 0,3% percent water vapor and hydrogen sulfide. Biogas is about 20% lighter than air, with ignition temperature between 650 °C – 750 °C. Its thermal value is about 20 MJ/m³ and its combustion efficiency is 60%. The gas obtained through the anaerobic fermentation process has very similar properties to natural gas. The most important output of this process is methane. Methane is used as a fuel with superior properties in many areas. One of the most common areas where biogas is used in power generation is internal combustion engines. In small-scale plants (<200kW), electricity generation efficiency can reach up to 25%, while in large-scale plants, this efficiency reaches 30%-35% (Öztürk, 2012).

Biogas production has benefits in many different areas. These benefits can be listed as follows:

- It is an environmentally friendly and cheap source of energy.
- Provides efficient fertilizer production for plant development.
- Reduces the amount of methane and ammonia in the atmosphere.
- Destroys pathogens in animal manure.

- Reduces external dependence on energy.
- Contributes to the development of rural areas.

In order for the efficiency and quality of biogas production to be high, the reactor with organic waste must work under certain balance conditions. Factors affecting these balance conditions can be listed as follows:

- C/N ratio
- Ambient temperature
- PH value
- Raw material breed
- Quantity of raw materials
- Facility type
- Fermentation time
- Amount of dry matter
- Particle size

In order for the efficiency to be maximum depending on the balance conditions, the C/N ratio should be in the range of 30/1, the ambient temperature should be in the range of 35°C and the pH value in the range of 7-7.2. Another factor that affects productivity is the type of facility. Facilities designed for biogas production are classified according to their capacity as follows:

- Family type: capacity 10-12 m^3
- Farm type: capacity 50-100 m^3
- Village type: capacity 100-200 m^3
- Industry type: capacity 1000-10000 m^3

Reactors in facilities other than the family-type plant are heated. Since the ideal reactor temperature should be 35°C and there is no system to provide it in family-type plants, their efficiency is low compared to other plant types.

Determination of Biogas Potential of Dumlupınar County and Its Effect on Carbon Emission

Dumlupınar is a district in the Central Anatolia Region of Türkiye, connected to the province of Kütahya. It is located southeast of Kütahya provincial center and is about 75 km from the city center of Kütahya. Dumlupınar is geographically located in the west close to the Afyonkarahisar provincial border and in the east is adjacent to the city of Uşak. The district is also known as the site of the Battle of Dumlupınar Square, one of the important historical points of Turkey. Dumlupınar district is at the crossroads in terms of transportation with other districts of Kütahya province and surrounding provinces with road connections. This district, which is close to the western border of Central Anatolia, usually has a structure that provides a living with agriculture and livestock.

According to the data obtained from Dumlupinar District Agriculture Directorate in December 2024, there are a total of 2820 cattle and 12281 small ruminants in the center and villages as seen in Table 2 and Table 3.

Table 2 Dumlupınar County Number of Cattle

	CATTLE		
VILLAGES	**FEMALE**	**MALE**	**TOPLAM**
AĞAÇKÖY	129	50	**179**
ALLIÖREN	175	88	**263**
ARPALI	46	14	**60**
BÜYÜKASLIHANLAR	239	58	**297**
EYDEMİR	84	12	**96**
HAMURKÖY	503	137	**640**
HAMURKÖY-KAĞNICI	15	2	**17**
KIZILCAKÖY	150	64	**214**
KÜÇÜKASLIHANLAR	262	118	**380**
CAFERGAZİ	103	43	**146**
CUMHURİYET	114	43	**157**
TURGUTÖZAL	21	8	**29**
ZAFER	97	42	**139**
SELKİSARAY	34	3	**37**
YÜYLÜK	120	46	**166**
TOPLAM	**2.092**	**728**	**2.820**

Table 3 Dumlupınar County Number of Small Ruminants

	SHEEP			GOAT			SHEEP-GOAT		
VILLAGES	FEMALE	MALE	TOTAL	FEMALE	MALE	TOTAL	FEMALE	MALE	TOTAL
AĞAÇKÖY	4	3	7	0	0	0	4	3	7
ALLIÖREN	776	150	926	34	11	45	810	161	971
ARPALI	193	0	193	0	0	0	193	0	193
BÜYÜKASLIHA NLAR	332	0	332	7	0	7	339	0	339
EYDEMİR	976	324	1.300	189	112	301	1.165	436	1.601
HAMURKÖY	873	193	1.066	80	7	87	953	200	1.153
HAMURKÖY-KAĞNICI	79	18	97	0	0	0	79	18	97
KIZILCAKÖY	161	9	170	0	0	0	161	9	170
KÜÇÜKASLIHA NLAR	1.083	64	1.147	0	13	13	1.083	77	1.160
MERKEZ	68	29	97	0	0	0	68	29	97
CAFERGAZİ	1.093	213	1.306	3	0	3	1.096	213	1.309
CUMHURİYET	1.737	215	1.952	0	0	0	1.737	215	1.952
TURGUTÖZAL	141	435	576	0	0	0	141	435	576
ZAFER	594	309	903	0	0	0	594	309	903
SELKİSARAY	192	21	213	0	0	0	192	21	213
YÜYLÜK	1.028	314	1.342	144	54	198	1.172	368	1.540
TOTAL	**9.330**	**2.297**	**11.627**	**457**	**197**	**654**	**9.787**	**2.494**	**12.281**

Depending on the animal type, the amount of age fertilizers an animal can produce per year is given as an average value, as in Table 4, while Table 5 gives the amount of biogas that can be produced depending on the age fertilizer type.

Table 4 Annual Age Fertilizer Production Amount Depending on Animal Type

Animal Species	Age Fertilizer Quantity (tons/ year)
Cattle	3,6
Small Ruminants	0,7

Table 5 Biogas Production Linked to Fertilizer Quantity

Fertilizer Type	Amount of (tons)	Biogas Amount (m³/year)
Cattle	1	33
Small Ruminants	1	58

According to the number of animals taken from Dumlupinar District Agriculture Directorate, the total annual age fertilizer and the amount of biogas that can be obtained are calculated and Table 6 is given.

Table 6 Annual Biogas Amount That Can Be Produced

Animal Species	Number of Animals	Amount of Fertilizer (tons/ year)	Biogas Amount (m³/year)
Cattle	2.820	10.152	335.016
Small Ruminants	12.281	8.596,7	498.608,6
Total	**15.101**	**18.748,7**	**833.624,6**

According to the table, the annual biogas production potential (YBUP) is 833.624,6 m³ and the hourly biogas production potential (SBUP) is 95,16 m³. The facility that can be established according to the potential of my hourly biogas production should be a village type. 1 m³ biogas can produce equivalent to 4,7 kW/h electric energy. The annual biogas electricity generation potential (YBEUP) is eq.1 to 3.918,035 MWh/year. The hourly biogas electricity generation potential (SBEUP) is eq.2 to 447,252 kWh. The power of the electricity generation plant should be about 450 kWe. However, considering that the number of animals may increase in the coming years, the installed power can be designed at a higher capacity.

$$YBEUP=YBUP \times 4,7 \quad (1)$$

$$SBEUP=SBUP \times 4,7 \quad (2)$$

According to the amount of biogas produced, a village-type biogas production plant can be established in terms of capacity. Costs for the installation of this production facility; include costs such as basic equipment cost, construction cost, engineering cost, management, commission and interest expenses. All of these costs are called total plant cost (TPC). Biogas plant investment and operating expenses are determined by eq.3 and eq.4 (Öztürk, 2012).

$$C_{BP} = -46{,}482 \ln(x) + 620.22 \quad (3)$$

$$O_{BP} = 0.1[-46{,}482 \ln(x) + 620.22] \quad (4)$$

C_{BP}, anaerobic fermentation plant investment expenses (€/ton/year),
O_{BP}, anaerobic fermentation plant operating expenses (€/ton)
x, the amount of biomass processed annually (ton/year).

The investment expense of a biogas production plant that can be established in Dumlupınar is 162,88 €/ton/year and the fermentation plant operating expense is 16,28 €/ton. The cost of electricity production varies between 3-10 c€/kWh. When the annual production capacity is 3.918.035 kWh and the unit cost is 6 c€, the total annual electricity production cost is calculated as 235.082,1 €/year. The price of supporting biogas renewable energy sources for the year 2024 determined by the EPDK is 266,75 kr/kWh. According to this, annual electric energy revenue will be 10.451.358,36 ₺ and 2024 average exchange rate will be 326.604,95 € earnings. The annual net profit is 91,522,85 €, and the investment cost return period is 4.7 years.

The use of biogas in place of fossil fuels saves carbon by reducing net greenhouse gas emissions. From fossil fuels, coal produces 0,95 kg CO_2 /kWh, natural gas 0,55 kg CO_2 /kWh, diesel 0,74 kg CO_2 /kWh carbon emission. The average emission amount of biogas is 0,1-0,2 kg of CO_2/kWh. When the emission difference between biogas and coal is taken into account, 3,330,33 tons/year of carbon savings are achieved with the annual electricity generation capacity of the biogas power plant that can be installed. In the study conducted for a public institution in Dumlupınar district, it was revealed that the carbon savings of the roof type solar power plant of 51 kWp is 32,082 kg (İrişik, Tunca, & Olcay, 2023).

IV. Conclusions And Suggestions

With the increase of the human population and the acceleration of industrialization, the demand for energy is increasing day by day. However, the reserves of fossil fuels, which are heavily used in energy production, are gradually decreasing and these resources are expected to be depleted in the near future. In addition, greenhouse gases released into the atmosphere as a result of burning fossil fuels lead to serious environmental problems such as global warming, climate change and air pollution. This has led to the need for more sustainable and environmentally friendly energy sources around the world. Within renewable energy systems, biogas stands out as an environmentally conscious and sustainable source of energy.

Dumlupınar district produces high amounts of organic waste due to intensive farming and livestock activities. Appropriate evaluation of these wastes is of great importance both economically and environmentally. This study reveals the earnings of a biogas electricity generation plant that can be established in the region in Table 7. Thanks to biogas production, waste management in the region will be made more efficient and a new source of income will be created for local people.

Table 7 Gains

Annual Energy Production	3.918. 035 kWh
Prevented CO_2 Emission	3.330,33 ton/year
Total Investment Cost of	430.153,4 €
Annual Net Income Amount	91.522,85 €
Depreciation Period	4,7 year

The use of fossil fuels not only increases external dependence in the field of energy but also causes environmental destruction. Carbon dioxide (CO_2), methane (CH_4) and nitrogen oxides (NOx) released during the combustion of fossil fuels trigger global warming, leading to greenhouse effect in the atmosphere. Biogas plants, on the other hand, convert organic waste into energy, both evaluate these wastes and significantly reduce greenhouse gas emissions. According to the researches, thanks to a biogas plant to be established in Dumlupınar, 3.330,33 tons of CO_2 emissions will be prevented annually. This will make significant contributions to environmental sustainability on both a regional and global scale. The fact that the return period of facility cost is 4,7 years reveals that it can be invested. In addition, with the establishment of this facility, it will contribute to the employment of Dumlupınar district. farmers in the region can come together and carry out the installation and operation of this facility under the cooperative roof.

When evaluated economically, the return period of the cost of the biogas plant was calculated as 4,7 years. This period indicates that the investment is profitable and sustainable. Having an investment that can amortize itself in a short time can encourage the spread of biogas facilities. In addition, with the operation of the facility, the unemployment rate in the region will be reduced and rural development will be contributed. Local people, especially farmers and livestock workers, can take over the operation of the biogas plant through cooperation. Thus, both energy production becomes sustainable and vitality is provided to the economy of the region.

As a result, the biogas energy production system offers great advantages both from an environmental and economic point of view. A biogas plant to be established in Dumlupinar district will boost energy independence, reduce greenhouse gas emissions and support regional development. Such projects are an important step in the transition to renewable energy and aim to create a more livable environment by minimizing the negative effects of fossil fuels.

References

[1] Baum, R., Wajszczuk, K., Pepliński, B., & Wawrzynowicz, J. (2013). Potential For Agricultural Biomass Production For Energy Purposes İn Poland: A Review. Contemporary Economics, 7(1), 63–74. Retrieved From Https://Doi.Org/10.5709/Ce.1897-9254.74

[2] Bijarchiyan, M., Sahebi, H., & Mirzamohammadi, S. (2020). A Sustainable Biomass Network Design Model For Bioenergy Production By Anaerobic Digestion Technology: Using Agricultural Residues And Livestock Manure. Energy, Sustainability And Society, 10(1). Retrieved From Https://Doi.Org/10.1186/S13705-020-00252-7

[3] Bilgili, M. E. (2022). Exploitable Potential Of Biomass Energy İn Electrical Energy Production İn The Mediterranean Region Of Turkey. Journal Of Agricultural Sciences / Tarim Bilimleri Dergisi, 28(4), 666–676. Retrieved 13 January 2025 From Https://Doi.Org/10.15832/ANKUTBD.944680

[4] Eryaşar, A. (2007). Kırsal Kesime Yönelik Bir Biyogaz Sisteminin Tasarımı, Kurulumu, Testi Ve Performansına Etki Eden Parametrelerin Araştırılması (Doktora Tezi). Ege Üniversitesi, İzmir . Retrieved 16 January 2024 From Https://Tez.Yok.Gov.Tr/Ulusaltezmerkezi/Tezdetay.Jsp?İd=Zlıhx5qry26sfyffztqu3g&No=Mui-Mewntu792a4thhkicw

[5] Fitri, H., Gürdil, G. A. K., Demirel, B., Cevher, E. Y., & Roubík, H. (2023). Biomass Potential From Agricultural Residues For Energy Utilization İn West Nusa Tenggara (WNT), Indonesia. GCB Bioenergy, 15(11), 1405–1414. Retrieved 13 January 2025 From Https://Doi.Org/10.1111/GCBB.13100

[6] Ilgar, R. (2016). Hayvan Varlığına Göre Çanakkale Biyogaz Potansiyelinin Tespitine Yönelik Bir Çalışma. Doğu Coğrafya Dergisi, 21(35), 89. Retrieved 16 January 2024 From Https://Doi.Org/10.17295/DCD.08733

[7] Konuk, M. (2019). Tokat İlindeki Hayvansal Atıkların Biyogaz Potansiyelinin Belirlenmesi (Yüksek Lisans Tezi). Tokat Gaziosmanpaşa Üniversitesi, Tokat.

[8] Navickas, K., Venslauskas, K., & Zuperka, V. (2009). Potential And Possibilities Of Biogas Production From Agricultural Raw Materials İn Lithuania. Retrieved 16 January 2025 From

[9] Öçal, F. (2013). Biyogaz Enerjisi Üretimi Ve Eskişehir İli İçin Uygulama (Yüksek Lisans Tezi). Eskişehir Ozmangazi Üniversitesi, Eskişehir.

[10] Olcay, K., Giray Tunca, S., & Arif Ozgur, M. (2024). Forecasting And Performance Analysis Of Energy Production İn Solar Power Plants Using Long Short-Term Memory (LSTM) And Random Forest Models. IEEE Access, 12, 103299–103312. Retrieved From Https://Doi.Org/10.1109/ACCESS.2024.3432574

[11] Poyraz, H. N. (2020). Kayseri İli İçin Hayvansal Atık Kaynaklı Biyogazdan Elektrik Enerjisi Üretim Potansiyelinin Ve Maliyetinin Araştırılması (Yüksek Lisans Tezi). Erciyes Üniversitesi, Kayseri. Retrieved 16 January 2024 From Https://Tez.Yok.Gov.Tr/Ulusaltezmerkezi/Tezdetay.Jsp?İd=Pv0npu0yng8rpgf922peiw&No=Cwl8mdxixpsc-Tmwfwhcıa

[12] Šafařík, D., Hlaváčková, P., & Michal, J. (2022). Potential Of Forest Biomass Resources For Renewable Energy Production İn The Czech Republic. Energies, 15(1). Retrieved 13 January 2025 From Https://Doi.Org/10.3390/EN15010047

[13] Salihoğlu, N. K., Teksoy, A., & Altan, K. (2019). Büyükbaş Ve Küçükbaş Hayvan Atıklarından Biyogaz Üretim Potansiyelinin Belirlenmesi: Balıkesir İli Örneği. Ömer Halisdemir Üniversitesi Mühendislik Bilimleri Dergisi. Retrieved 16 January 2024 From Https://Doi.Org/10.28948/NGUMUH.516798

[14] Saz, S. (2021). Muğla İli Biyogaz Potansiyelinin Belirlenmesi (Yüksek Lisans Tezi). Muğla Sıtkı Koçman Üniversitesi, Muğla. Retrieved 16 January 2024 From Https://Tez.Yok.Gov.Tr/Ulusaltezmerkezi/Tezdetay.Jsp?İd=Eg7y9rwuq705nv-3w8hvhq&No=Oyt58IygnHcJPNEmMwhmHQ

[15] Seyitoğlu, S. S., & Avcıoğlu, E. (2021). An Investigation For The Potential Of Biogas To Be Produced From Animal Waste İn Corum. Gazi Üniversitesi Fen Bilimleri Dergisi Part C: Tasarım Ve Teknoloji, 9(2), 246–261. Retrieved 16 January 2024 From Https://Doi.Org/10.29109/GUJSC.889846

[16] Tunca, S. G. (2025). Experimental And Economic Comparison Of Fuels Used In Rotary Kilns On Energy Efficiency. IOSR Journal Of Mechanical And Civil Engineering, 22(1), 01–07. Retrieved From Https://Doi.Org/10.9790/1684-2201010107

[17] Weremczuk, A. (2023). The Energy Potential Of Agricultural Biomass İn The European Union. Scientific Journal Of The Warsaw University Of Life Sciences (SGGW) - Problems Of World Agriculture / Problemy Rolnictwa Światowego, 23(4), 44–60. Retrieved 13 January 2025 From Https://Doi.Org/10.22630/PRS.2023.23.4.16

[18] Yokuş, İ. (2019). Sivas İli Hayvansal Atık Kaynaklı Sürdürülebilir Biyogaz Üretimi İçin Optimum Tesis Lokasyonlarının Belirlenmesi (Doktora Tezi). Ankara Üniversitesi, Ankara."

[19] Zhao, G. (2018). Assessment Of Potential Biomass Energy Production İn China Towards 2030 And 2050. International Journal Of Sustainable Energy, 37(1), 47–66. Retrieved From Https://Doi.Org/10.1080/14786451.2016.1231677

[20] İrişik, M., Tunca, S. G., & Olcay, K. (2023). Güneş Enerjisi Santrallerinin Kamu Kurumu Enerji Verimliliği Ve CO2 Emisyonları Üzerindeki Etkilerinin İncelenmesi. Mühendislik Alanında Akademik Araştırma Ve Derlemeler 1 (S. 470-486). İçinde Platanus Publishing.

[21] Öztürk, H. H. (2012). Enerji Bitkileri Ve Biyoyakıt Üretimi. Adana: Hasat Yayıncılık Ltd. Şti.