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Determination of Biomass Energy Potential That Can Be Obtained from Agricultural and Animal Wastes of Konya Province

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Abstract: In the recent study, the annual biomass and biogas energy potential of Konya between 2011 and 2020 was determined according to the data obtained from the Turkish Statistical Institute (TSI). In 2020, throughout Turkey, 12.74% of biomass sources were produced in Konya. The total amount of dry biomass that can be obtained and its energy equivalent are 13.3 million tons and 62549.3 MWh in 2011, 19.5 million tons, and 91661.9 MWh in 2020, respectively. It has been determined that 11.6% of the biomass energy potential that can be obtained from grains across the country in 2020 is in Konya. Tuber plant production covers 22% of Turkey. In 2020, with 11649 MWh, the highest biomass energy potential was obtained in Cihanbeyli, and at least in Derebucak, with 47.7 MWh. In addition, it has been determined that 98.5 million m^3 of biogas from 13.4 million animals in 2011; and in 2020, 165.6 million m^3 of biogas can be obtained from 15 million animals. By evaluating the existing biomass and biogas energy potentials in Konya with this data that can be obtained, it is thought that it can have a very important biomass energy source for both the province and the country.

Konya İlinin Tarımsal ve Hayvansal Atıklarından Elde Edilebilecek Biyokütle Enerji Potansiyelinin Belirlenmesi

Anahtar Kelimeler
Enerji, Biyokütle potansiyeli, Kuru biyokütle miktarı, Biyogaz potansiyeli, Konya

Öz: Bu çalışmada, Türkiye İstatistik Kurumu (TÜİK)'ndan alınan verilere göre Konya ili 2011-2020 yılları arasındaki yıllık biyokütle ve biyogaz enerji potansiyeli belirlenmiştir. 2020 yılında Türkiye genelinde biyokütle bitkilerinin %12,74'ünün üretimi Konya'da yapılmıştır. Elde edilebilecek toplam kuru biyokütle miktarı ve enerji eşdeğeri sırasıyla 2011 yılında 13,3 milyon ton ve 62549,3 MWh, 2020 yılında 19,5 milyon ton ve 91661,9 MWh'tir. 2020 yılında ülke genelinde tahıllardan elde edilebilecek biyokütle enerjisi potansiyelinin %11,6'sının Konya'da olduğu hesaplanmıştır. Yumru bitki üretimi ise ülke genelinin %22'sini kapsamaktadır. 2020 yılında 11649 MWh ile en yüksek biyokütle enerji potansiyeli Cihanbeyli ilçesinde, en az ise 47,7 MWh ile Derebucak ilçesinde elde edilmiştir. Ayrıca, ilde 2011 yılında 13,4 milyon hayvandan 98,5 milyon m^3 biyogaz; 2020 yılında ise 15 milyon hayvandan 165,6 milyon m^3 biyogaz elde edilebileceği belirlenmiştir. Elde edilebilecek bu veriler ile Konya ilindeki mevcut biyokütle ve biyogaz enerjisi potansiyelleri değerlendirilerek hem il hem de ülke için çok önemli biyokütle enerji kaynağına sahip olabileceği düşünülmektedir.

1. INTRODUCTION

Bioenergy, not only improves environmental sustainability; it also improves the sustainability of energy, agriculture, forestry, and other sectors [1]. The increasing population causes serious needs on both the energy requirement and the food sector. Because current fossil fuels are insufficient and the demand for energy use in industry is constantly increasing to meet needs, efforts for alternative and sustainable searches have increased [2-5]. Fossil fuels cause a continuous decrease in the resources used in energy production, environmental causes such as global warming and destruction of nature,

and pose a great threat to future generations. Therefore, alternative energy sources such as sustainable wind energy, geothermal energy, solar energy, and biofuel energy are all very important [6-8]. In addition, the evaluation of plant-based wastes and the reduction of emissions that cause global warming are important for biomass fuels.

Biomass is a general term used for all organic matter derived from plants and accepted as organic carbon. It has always been an important source of energy for humanity throughout history [9]. Biomass is important in meeting the needs of fuel and consumer goods, as well as providing a renewable fixed carbon source. Agricultural and forestry wastes, wood and annual crops, and municipal waste are some of the renewable energy sources [10]. It is recognized as the renewable energy source with the highest potential to contribute to the energy needs of both developed and developing economies worldwide [10-12]. In addition, energy from waste-based biomass can significantly contribute to the goals of the Kyoto Protocol in reducing greenhouse gas emissions (GHG) and mitigating the problems associated with climate change [10, 13].

Biomass can also be referred to as renewable organic materials from plants and animals, both living and dead. It can be directly burned to generate heat or converted into liquid or gaseous forms through various processes [14]. Plant sources, also known as energy plants, absorb more carbon dioxide (CO_2) than other plants, use less water, and are more drought resistant [15, 16].

Biomass still continues to be used for cooking and home heating in many countries around the world. Biomass fuels are used in transportation and electricity generation in some countries to reduce dependency on fossil fuels, pollution and GHG [14, 17]. Sources which are used for production of biomass energy; forest wastes (energy crops, various trees, etc.), oilseed crops (canola, sunflower, soybean, etc.), sugar and starch crops (potato, wheat, corn, sugar beet, etc.), fiber crops, protein crops, vegetables and the other agricultural wastes (branches, stems, straw, roots, bark, etc.), crop wastes, food processing wastes, animal manure, slaughterhouse wastes, urban wastes, industrial wastes, industrial and domestic wastewater [14].

And it is converted into energy in two ways: biochemical and thermochemical (Figure 1). Biogas is the process of producing fuel (CO_2, CH_4) by digesting biomass in a closed oxygen-free environment in the biomethanization process of biochemical transformations by microorganisms [18, 19]. Bioethanol is produced as a result of glucose or containing sugars which can be converted to glucose and the fermentation of biological resources (such as cellulose, starch, and sucrose) [19]. Plants with high bioethanol potential and widely used in its production; include barley, corn, potato, sugar beet, and wheat [20]. Gasification, one of the thermochemical processes, is a combustible gas process obtained by exposing biomass sources containing carbon atoms to high temperatures. Materials are burned by giving air in a controlled manner, such as methane, hydrogen, carbon monoxide, carbon dioxide, and nitrogen gases [19]. Pyrolysis is the most classical and easiest method applied to obtain gas using biomass. It is a series of physical and chemical events that occur when organic matter is heated up to 900 °C in an oxygen-free environment. As a result of this process, water, charcoal, organic compounds, tar, and gases are produced [21]. Direct combustion is the process of obtaining heat by burning the raw material. This process is the most classical method known and used since the discovery of fire. Chemical conversion, known as transesterification (esterification), is used to produce biodiesel by converting vegetable, and animal oils and greases to fatty acid methyl esters [17, 22-25].

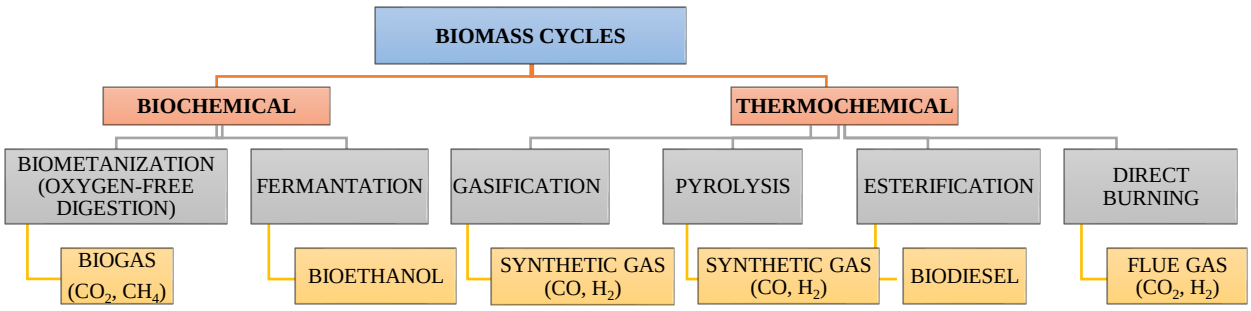

Figure 1. Biomass conversion systems [17].

In 2018, the global local supply of biomass was reported as 55.6 EJ (egza joules). The major part of this local supply (85%) consists of solid biomass sources, including wood chips, wood pellets and other biomass sources. In addition, in 2019, there were 1.9 billion m^3 of wood fuel produced worldwide [26]. Wood pellets are one of the fastest growing bioenergy sectors worldwide. Municipal and industrial waste sectors accounted for 5%, biofuels in liquid form accounted for 7%, biogas 3%. Between 2000 and 2018, the annual average growth rate of the bioenergy sector was 2%. Among all raw material sources, liquid biofuels were the fastest growing sector with a growth rate of 13%, followed by biogas with 9% (Table 1). In 2018, 637 TWh of electricity was produced from biomass worldwide. Of total generated power, 66% was obtained from solid biomass sources and 19% was obtained from municipal and industrial wastes [26].

Table 1. Globally where local biomass are supplied [28].

Years	Municipal Waste	Industrial Waste	Solid Biofuels	Biogases	Liquid Biofuels	Total
2000	0.74	0.49	40.5	0.29	0.43	42.5
2005	0.96	0.45	42.8	0.51	0.87	45.6
2010	1.18	0.77	45.1	0.85	2.53	50.5
2015	1.38	0.90	46.2	1.29	3.45	53.2
2016	1.42	1.04	46.9	1.30	3.58	54.3
2017	1.44	1.07	47.3	1.33	3.72	54.9
2018	1.45	1.13	47.6	1.36	3.98	55.6

Since the interest in renewable energy systems has increased rapidly in Turkey as well as all over the world in recent years, much research in this field has been conducted to determine biomass energy potentials. According to the data reported by the Ministry of Energy and Natural Resources, it is estimated that Turkey's biomass waste potential is approximately 8.6 million tons of equivalent petroleum (MTEP) [17]. Turkey, which meets its energy needs mostly from petroleum, natural gas and coal imports, paid approximately 50 billion USD in 2008 for these raw materials [27]. In order to encourage energy investments, the draft law on renewable energy sources was adopted and entered into force in 2011. It aims to increase the orientation towards renewable energy sources by giving the highest price guarantee to biomass energy with this law [27, 28]. Süleyman Demirel University, Renewable Energy Resources and Application Center, is carried out joint studies with public institutions on the pyrolysis of biomass [29]. Kurt and Koçer [19] reported that all of the cereals, legumes, industrial plants, oilseeds and tuber plants cultivated in the province of Malatya are produced on an area of approximately 145162 hectares, and the area has a total biomass potential of 3991966 tons. In addition, they calculated the average calorific value of dry biomass as 1596786 tons of equivalent petroleum (TEP). Topal and Topal [30] investigated the potential to produce biomass energy from agricultural products grown in Afyonkarahisar for five years (2006-2010). In the city center and its districts, the highest biomass energy in total is respectively obtained from cereal crops (2251-46960 MW), tuber crops (9-2483 MW), industrial plants (49-2326 MW), legumes (15-2105 MW), and oily plants. Seed crops (44-1688 MW) and forage crops (108-1526 MW). In the study investigating the biomass energy potential of the Eastern Anatolia region (Ağrı, Ardahan, Bayburt, Bingöl, Bitlis, Elazığ, Erzincan, Erzurum, Hakkari, Iğdır, Kars, Malatya, Muş, Tunceli, Van), it has been determined that an average of 47343313 tons of biomass potential can be obtained from a total planted area of 1721578 hectares. The average calorific value of dry biomass was found to be 19174042 TEP. The highest TEP rate was found in Erzurum with 2668021, and the lowest TEP rate was found in Hakkari with 218235 [31]. The potential biomass energy was calculated based on the data obtained from the agricultural products of the province of Elazig between the years 2000-2010. The total biomass energy potential of these products are, respectively; obtained from cereals (132083 MW), forage crops (10934 MW), legumes (8122 MW), industrial crops (6173 MW), tuber crops (1193 MW) and oilseed crops (443 MW) [32]. According to the data of 2016 considering the geographical structure and climatic conditions of Kars province, in the study conducted on the duration of staying indoors, it was calculated that there was 1948 tons/day of wet manure from 442575 cattle and 341 tons/day of wet manure from 567148 sheep and goats. Considering the whole year, it has been reported that the highest amount that can be produced from both bovine and ovine animals (1009723 heads) has the potential to produce 986121 tons of collectable waste manure, and 10171 tons/year of wet manure from 557330 poultry [33]. Demir et al. [34], compared the agricultural biomass energy potential of Mersin province proportionally with the Mediterranean and Turkey between the years 2005-2014. They reported the average dry biomass energy amount as 15.86% in Mersin/Mediterranean region and 1.93% MW in Mersin/Turkey. Kuş et al. [35], determined the annual average (2009-2013) biomass energy potential as 639000 TEP (7432 MW) in their study across the province of Iğdır. Field crops products constituted the majority of this potential. They also stated that the biomass energy potential of the province is equivalent to 3% of Turkey's average. Ekin et al. [36] assessed biomass energy production in the province of Şırnak, bovine and ovine numbers, and the products grown in the region's agricultural areas. They mentioned that 72% of the annual energy need in Turkey are met by importing and that fossil fuel sources that cause global warming constitute 70% of the electricity production in the country, causing environmental pollution. With the appropriate methods, it was concluded that biomass-based wastes and all industrial wastes can be converted into alternative fuels such as transportation fuel, electrical energy or gas, which the city needs.

Agriculture is carried out in approximately 67.7% of the total area of Konya province. The reason why agriculture is growing at such a high rate in Konya, which is known as the agricultural capital of our country, is the high amount of existing water potential and irrigable lands. Many types of vegetables and fruits are produced in Konya, especially field crops (wheat, barley, sugar beet, chickpeas, dry beans, green lentils, red lentils, potatoes, sunflowers, poppy, cumin, safflower, etc.). In addition, the province of Konya contributes to the development of animal husbandry and animal production of the country with its large pastures and plant production areas. It ranks among the top three in the country with the current numbers of bovine, ovine, and poultry. Çumra, Altınekin, Karapınar, Karatay, Ereğli, Kulu, and Cihanbeyli districts are among the districts with the highest agricultural potential in terms of irrigation opportunities of the lands [37]. According to the data of 2021 obtained from Turkish Statistical Institution (TSI), the districts of Kulu, Karatay and Sarayönü in barley production; Karatay, Karapınar and Kadınhanı in sunflower production; Çumra, Karapınar and Altınekin in sugar beet production; Ereğli, Karapınar and Karatay are leading in corn production [38]. In this research, the biomass and biogas energy

potentials of Konya province between the years 2011-2020 were determined and compared with the energy potential in Turkey.

2. MATERIAL AND METHOD

Konya province is located between 36° 22'N and 39° 08'N parallels and 31° 14'E and 34° 05'E meridians. The province, with an area of 40841 km^2 and 31 districts, is the largest province in Turkey. Konya province covers 5.21% of the country's surface area. In addition, Konya is in the 7th place in Turkey in terms of population. Its largest districts are Ereğli, Beyşehir and Akşehir. A continental climate prevails in Konya, with hot and dry summers and cold and warm winters. Besides its developing industry, Konya is also known as Turkey's granary [39].

In this study, data from the TSI between 2011 and 2020 was taken into account in order to determine the current biomass and biogas energy potential in Konya. Barley, rye, oat, canola, sunflower, safflower, potato, sugar beet, corn, poppy, fruits and vegetables were used to calculate the biomass energy potential. In the calculation of biogas energy potential, the presence of bovine, ovine and poultry was used. Equation 1-8 below is used to determine the average dry biomass amount, calorific value, and energy value that can be produced in Konya in a year. In addition, the assumptions used for biomass energy equivalents are given below [40].

1 TEP (tons equivalent petroleum)	=	10^7 kcal 42 GJ 11630 kWh 11.630 MWh

The following equations were used to determine the biomass energy value [19, 31, 32, 35].

$$BM_{min}=25*A \text{ [ton]} \quad \text{(Eq. 1)}$$
$$BM_{max}=30*A \text{ [ton]} \quad \text{(Eq. 2)}$$
$$BM_{mean}=(25+30)/2*A \text{ [ton]} \quad \text{(Eq. 3)}$$
$$ID_{min}=3800*BM_{mean} \text{ [kcal kg}^{-1}\text{]} \quad \text{(Eq. 4)}$$
$$ID_{min}=4300*BM_{mean} \text{ [kcal kg}^{-1}\text{]} \quad \text{(Eq. 5)}$$
$$ID_{mean}=(3800+4300)/2*BM_{mean} \text{ [kcal kg}^{-1}\text{]} \quad \text{(Eq. 6)}$$
$$ED_{mean} = ID_{mean}*10^{-7} \text{ TEP} \quad \text{(Eq. 7)}$$
$$ED_{mean}= ID_{mean}*10^{-7}*(11.63) \text{ MWh} \quad \text{(Eq. 8)}$$

The amount of wet manure that can be produced and biogas production differ according to the animal species. In this context, certain assumptions are made. The annual average amount of wet manure obtained from bovine, ovine, and poultry is, respectively, 3.6 tons, 0.7 tons and 0.022 tons. It is known that two-thirds of the wet manure is usable and the rest is lost by mixing with nature [41, 42].

The amount of biogas energy that can be produced from usable wet manure is as follows;

1 tons of usable bovine manure 33 m^3 year^{-1},
1 tons of usable ovine manure 58 m^3 year^{-1},
1 tons of usable poultry manure 78 m^3 year^{-1}'dır.
1 m^3 the electrical energy provided by biogas is 4.70 kWh, the heat energy is 4700-5700 kcal [42].

The cultivated areas of barley, rye, oat, canola, sunflower, safflower, potato, sugar beet, corn, poppy, fruit, and vegetable crops, which we use in calculating the biomass energy potential according to the data obtained from TSI, are given in Figure 2. In 2020, these plants were cultivated on a total of 707654.4 ha of land in Konya. These areas yielded 13897974 tons of product. In the same year, these crops were cultivated on an area of 6879313 ha throughout Turkey, and 109061582 tons of products were obtained. 12.74% of the nationwide production of the specified agricultural products is produced in Konya. Considering the data, the fact that a single province produces at such a high capacity and meets most of the needs in the country on its own shows that the biomass energy potential is quite high. Despite the fact that Cihanbeyli is the district with the highest amount of planting area, with 89934 ha in the same year, the production amount in the district was just 921033 tons. The district with the maximum production is Ereğli with 1871800 tons. In Ereğli, an area of 51771.1 ha was cultivated in 2020 (Figure 2).

In 2020, the districts with the highest production by product type were as follows: barley; in Cihanbeyli, oats; in Ilgın, canola; in Çeltik, sunflower; in Karatay, safflower; in Yunak, potatoes; in Karatay, sugar beet; in Karapinar, poppy; in Akşehir, corn, rye, fruit and vegetables; in Ereğli. In the province, sugar beet production was at its peak with 7228473 tons, and safflower production was made with at least 1812 tons. 31.4% of the sugar beet produced throughout the country is produced in Konya. In the same year, a maximum of 31177124 tons of vegetables and a minimum of 20542 tons of poppy were produced throughout Turkey.

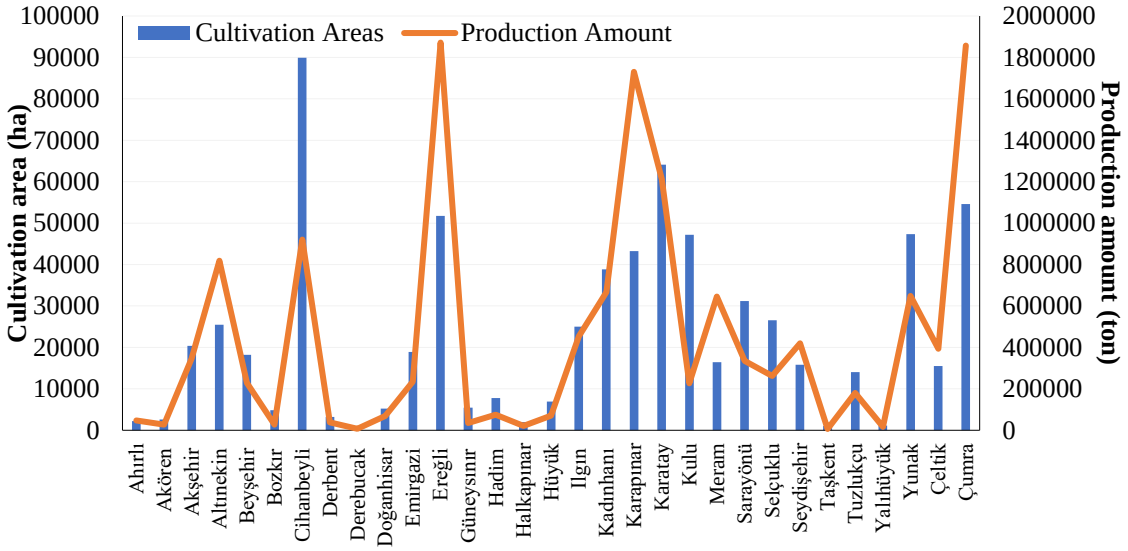

Figure 2. Total cultivation areas and production amounts by districts in 2020

In 2020, Konya's production rate to the country's production rate was for barley, rye, oat, canola, sunflower, safflower, potato, sugar beet, corn, poppy, fruit and vegetable crops as; 15.3%; 8.4%; 6.9%; 13.7%; 14.7%; 8.5%; 12.3%; 31.4%; 9.5%; 22.8%; 4.4% and 4.3%, respectively. Konya has grown the most barley, sugar beet and sunflower since 2011 (Figure 3). Every year, the highest production amounts were obtained from sugar beet, barley, and corn.

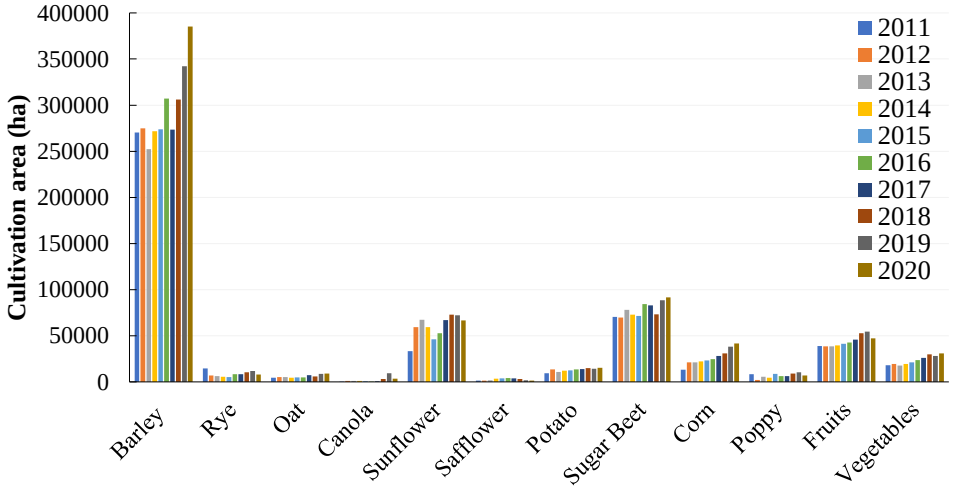

Figure 3. Cultivation area (ha) by year and crop type

Total plant production in Konya has generally shown an increasing trend every year since 2011 (Figure 4). While the product with the highest cultivation area was barley in all years, the product with the highest production was sugar beet. 31.4% of sugar beet production in Turkey is produced in Konya. According to the data received from TSI, as seen in Figure 4, approximately 9-13% of the total production in Turkey between the years 2011-2020 is met from the province of Konya.

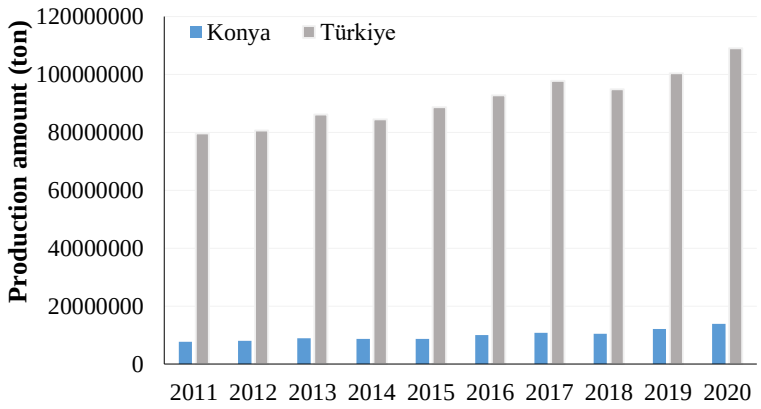

Figure 4. Total production amount in Konya by years (tons)

3. FINDINGS AND DISCUSSION

Cultivation areas of cereals, industrial plants, tuber plants, fruits and vegetables which are cultivated in Konya province and Turkey between 2011-2020 years that dry biomass amounts, calorific values, and energy values are given in Table 2. Konya's vegetative production areas account for 7.8% of the country's total cultivation area in 2011 and 10.3% in 2020. Since 2011, it has been observed that the amount of dry biomass that can be obtained and the energy value generally tend to increase. Between 2011 and 2020, there was an approximately 47% increase in total dry biomass in Konya and a 10.5% increase in Turkey.

Table 2. Change of total biomass energy potential by years

Years	Cultivated Area		Amount of Dry Biomass		Calorific Value		Energy Value		Energy Value	
	ha		10^8 ton		10^8 kcal kg^{-1}		TEP		MWh	
	Konya	Turkey	Konya	Turkey	Konya	Turkey	Konya	Turkey	Konya	Turkey
2011	482898	6202076	0.132	1.71	537.8	6907.6	5378.3	69075.6	62549.4	803349.5
2012	513527.2	6108299	0.141	1.68	571.9	6803.1	5719.4	68031.2	66516.7	791202.7
2013	505806.4	6136232	0.139	1.69	563.3	6834.2	5633.4	68342.3	65516.7	794820.7
2014	516392.3	6234879	0.142	1.71	575.1	6944.1	5751.3	69441	66887.9	807598.4
2015	512676.8	6329910	0.141	1.74	571	7049.9	5710	70499.4	66406.6	819907.7
2016	572611.8	6343125	0.157	1.74	637.7	7064.7	6377.5	70646.6	74170	821619.5
2017	564183.2	6077700	0.155	1.67	628.3	6769	6283.6	67690.4	73078.2	787239.2
2018	612102.1	6266415	0.168	1.72	681.7	6979.2	6817.3	69792.2	79285.1	811683.2
2019	680296.2	6677508	0.187	1.84	757.7	7437.1	7576.8	74370.7	88118.2	864931.7
2020	707654.4	6879313	0.195	1.89	788.1	7661.8	7881.5	76618.3	91661.9	891071.4

To compare years according to the data obtained from TSI, it is understood that the year in which the most cultivation and energy is obtained in Konya is 2020 (Figure 5). In the province, cereals are the products that have the highest amount of dry biomass and energy value, while vegetables have the lowest amount of product groups. While the total amount of dry biomass was approximately 13.3 million tons in 2011, it increased to 19.5 million tons in 2020. The total biomass energy value that can be obtained was calculated as 62549.3 MWh in 2011 and 91661.9 MWh in 2020.

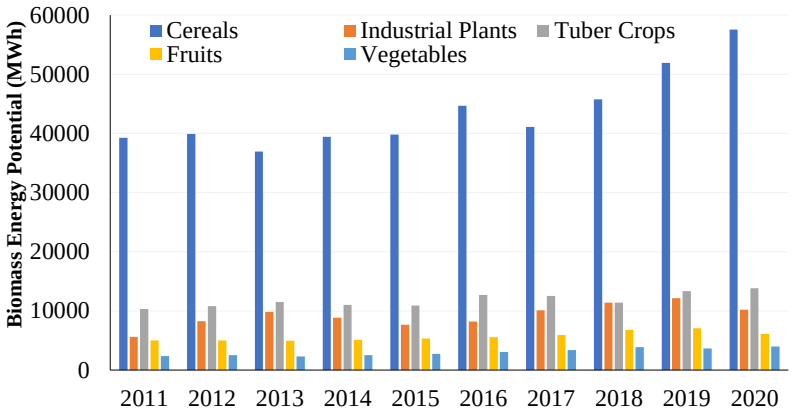

Figure 5. Biomass energy potential by product type and year

The biomass energy potential (MWh) to be obtained from cereals (barley, rye, oats, and corn), industrial plants (canola, sunflower, safflower, and poppy), tuber crops (potato, sugar beet), fruits, and vegetables in Konya and in Turkey is given in Figure 6. It has been calculated that the most biomass energy can be obtained from cereals in Konya and Turkey in 2020. While the energy that can be obtained from cereals is 496793.4 MWh in Turkey, it is 57525.7 MWh in Konya. Konya has the highest share with approximately 22% of the energy potential that can be obtained from tuber plants produced throughout the country. The share of biomass energy that can be obtained from vegetables produced throughout the country is occupied by the province of Konya, with approximately 4%. While the least biomass energy is obtained from tuber plants with 62966.02 MWh throughout the country, it is obtained from vegetables with 4000.6 MWh in Konya (Figure 6).

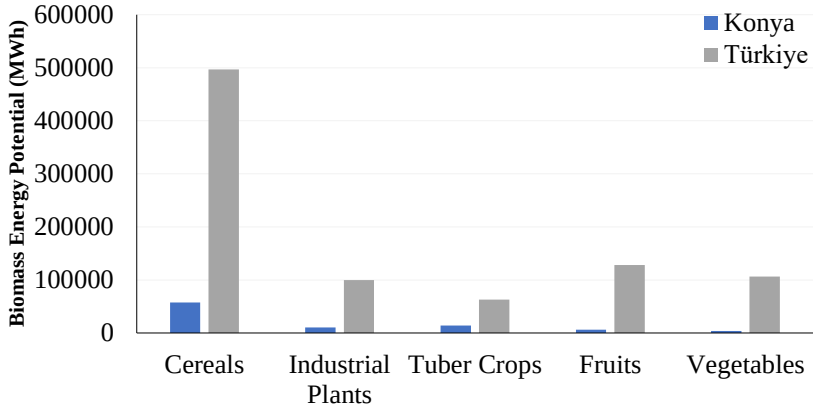

Figure 6. Biomass energy potential to be obtained according to the product type; comparison of Konya and Turkey for 2020

The biomass energy potentials obtained in 2020 by districts are given in Figure 7. The highest energy potential, with 11649 MWh, was obtained in Cihanbeyli district, where the cultivation area is also the highest, and the lowest energy potential was obtained in Derebucak district with 47.7 MWh.

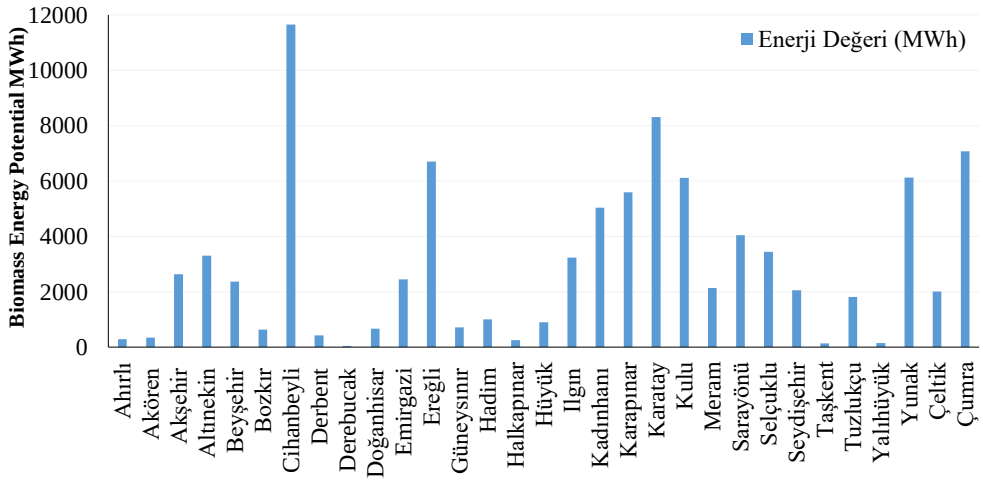

Figure 7. Total biomass energy potential in 2020 by districts

The biogas energy potential that can be obtained according to the total number of bovine, ovine and poultry in Konya between 2011-2020 years is given in Figure 8. Due to the rapid increase in the number of poultry in 2017 compared to other years, the highest number of animals was determined in 2017. Since 2011, there has been an increase of approximately 12% in the total number of animals and 68.1% in the biogas energy potential. The biogas potential that can be obtained has generally increased since 2011 and the maximum energy was obtained in 2020 with 165.6 million m^3.

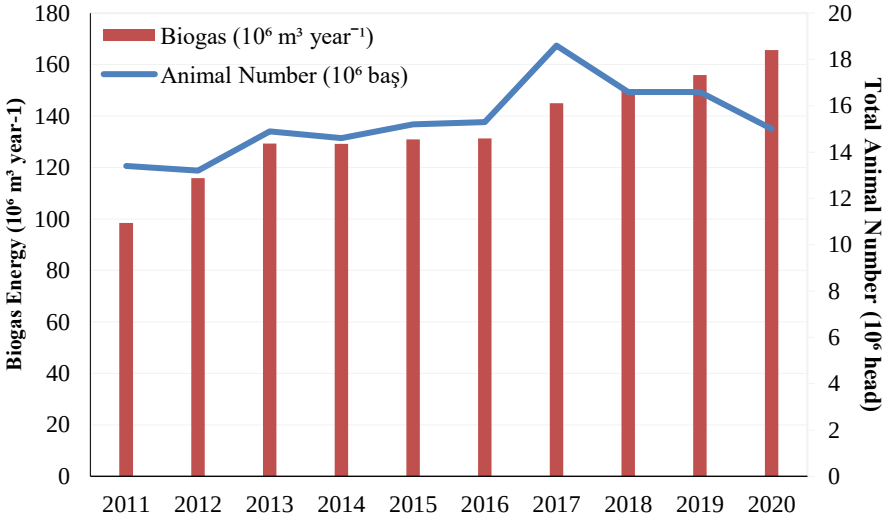

Figure 8. Total number of animals and biogas energy production potential in Konya province by years

The biogas, electricity and heat energy potentials obtained with the existing animal potential in Konya in 2020 are given in Table 3. It is seen that approximately 165.6 million m^3 of biogas energy can be obtained from the total livestock, including bovine, ovine and poultry, in 2020. According to the data received from TSI in 2020, Ereğli district with 176758 bovine, Karapınar district with 368150 ovine and Meram district with 3912225 poultry numbers are leading in Konya.

Table 3. Number of animals available in Konya province in 2020 and biogas energy potential to be obtained

Animal type	Animal Numbers	Amount of Usable Manure	Biogas Potential	Electricity Energy Potential	Heat Energy Potential
	Head	10^3 ton $year^{-1}$	10^3 m^3 $year^{-1}$	10^6 kWh $year^{-1}$	10^{10} kcal m^{-3}
Bovine (cattle, buffalo)	963047	2311.3	76273.3	358.5	35.8
Ovine (sheep, goat)	2826236	1318.9	76496.8	359.5	35.9
Poultry (hens)	11234107	164.8	12851.8	60.4	6
Total	**15023390**	**3795**	**165621.9**	**778.4**	**77.8**

Konya has 7 biogas plants, 3 of which are in the Karatay district, 2 in the Çumra district, 1 in the Sarayönü district, and 1 in the Meram district. The biogas power plant located in the Çumra district, with 12 MW electrical energy production, is the largest one. In addition to energy production in existing biogas facilities, organic fertilizer production is also carried out [43]. The operation of large biogas power plants in Konya, developing in agriculture and livestock, will provide significant benefits for the province and our country.

4. CONCLUSION

In Konya province, the biomass energy potential that can be obtained from cereals, industrial plants, tuber crops, fruits and vegetables and the biogas potential that can be obtained from the presence of bovine, ovine, and poultry were determined. In 2011, 62549.3 MWh of energy was obtained from 13.3 million tons of dry biomass, and 91661.9 MWh from 19.5 million tons of dry biomass in 2020. It's concluded that every year, the most energy is obtained from cereals and the least energy is obtained from vegetables. When the 2011-2020 annual changes are compared, there has been an increase of 47% in the cultivation area and biomass energy potential, and an increase of 68.1% in the biogas potential. While Cihanbeyli is the district with the most cultivation areas in 2020, Ereğli is the district with the highest production yield. In the same year, it was calculated that 57525.7 MWh of energy could be obtained from cereals, 10217.7 MWh from industrial plants, 13815 MWh from tuber plants, 6102.9 MWh from fruits, and 4000.6 MWh from vegetables throughout the province. In addition, it has been determined that approximately 165.6 million m^3 of biogas energy can be obtained from the total livestock in 2020. In the province of Konya, approximately 613227.7 ha of land in 2011 and 307158.6 ha of land in 2020 remain uncultivated. Every year, there has been a decrease in the uncultivated area throughout the province and an increase in the cultivated area. It has been observed that there has been a decrease of approximately 50% in uncultivated areas since 2011. When compared with similar studies in terms of biomass energy potential; while the annual average biomass energy potential that can be obtained

from plant wastes in Konya is 73419 MWh, this value is 45228 MWh in Mersin [34], 7432 MWh in Iğdır [35], and 53801 MWh in Afyonkarahisar [30].

Konya has a unique opportunity to combine good agricultural land use practices with increasing environmental benefits through biomass production systems. The bioenergy industry can provide an opportunity to strengthen our economy and diversify markets in the agriculture and forestry sectors. There are no fossil fuel deposits such as petroleum, natural gas and uranium in Konya. So, Konya needs fossil fuel imports more than many provinces due to its huge geography and potential to become an industrial center. During the transition to new energy systems, new opportunities for heat (thermal energy), combined heat, power, and potentially the use of biomass for advanced biofuels or cellulosic ethanol are anticipated. Therefore, Konya province should be considered as a very good opportunity to obtain energy from biomass with its fertile agricultural products and infrastructure related to the livestock sector. The biomass energy that can be obtained in Konya has very important potential for Turkey. It is thought that the country's economy will be benefitted by transforming the waste potential in the province into energy with modern methods. Barriers to the production and use of biomass energy in Turkey should be removed. Incentives should be given by developing an appropriate biomass energy policy.

ABBREVIATIONS

A	=	Cultivated area (ha)
BM_{max}	=	Maximum amount of dry biomass (ton)
BM_{min}	=	Minimum amount of dry biomass (ton)
BM_{mean}	=	Mean amount of dry biomass (ton)
ED_{mean}	=	Mean of dry biomass energy value (kcal kg $^{-1}$)
GHG	=	Greenhouse gases
ID_{max}	=	Maximum calorific value of dry biomass (kcal kg $^{-1}$)
ID_{min}	=	Minimum calorific value of dry biomass (kcal kg $^{-1}$)
ID_{mean}	=	Mean of dry biomass calorific value (kcal kg $^{-1}$)
TEP	=	Ton equivalent petroleum

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