ÇUKUROVA UNIVERSITY
INSTITUTE OF NATURAL AND APPLIED SCIENCES

MSc. THESIS

Oğuzhan KAZAZ

BIOMASS ENERGY POTENTIAL OF TURKEY

DEPARTMENT OF MECHANICAL ENGINEERING

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ÇUKUROVA UNIVERSITY
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We certify that the thesis titled above was reviewed and approved for the award of degree of the Master of Science by the board of jury on 13/12/2018.

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ABSTRACT

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: Asst. Prof. Dr. Fırat EKİNCİ

In general, our country meets energy needs from fossil fuels. The main disadvantages of these fuels are that the damage to the environment and our country depends on foreign countries. Biomass can be grown in a wide variety of places, easily stored, help socio-economic developments and its environmental impact is more positive, electricity, chemical raw materials and liquid fuel are used in different industries today. Biomass energy has gained importance for Turkey due to these features and this importance will increase gradually.

In this study, agricultural and animal based biomass energy potential of Turkey is investigated. The agricultural and animal statistical data are obtained from the data of the Turkish Statistical Institute in 2017. According to the study, total sown area is 15.856.351 hectare and 436.049.652,5 tons average dry biomass amount can be obtained from this area. The average dry biomass energy value of this area is 176.600.109,3 TEO. This dry biomass is equivalent to 2.053.859 MW energy. The total number of animals that are used for biomass source is 408.561.087 numbers. The amount of animal waste available in Turkey is 96.655.868,19 tons. 4.309.771.357 m^3/year biogas can be obtained from these wastes. This biogas is equivalent to 2,03 x 10^{10} kWh/year of electrical energy.

Keywords: Agricultural Biomass, Animal-Based Biomass, Biogas, Turkey, Renewable Energy

ÖZ

YÜKSEK LİSANS TEZİ

TÜRKİYE’NİN BİYOKÜTLE ENERJİ POTANSİYELİ

Oğuzhan KAZAZ

ÇUKUROVA ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ
MAKİNE MÜHENDİSLİĞİ ANABİLİM DALI

Danışman : Prof. Dr. Hüseyin AKILLI
Yıl: 2018, Sayfa: 151
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: Prof. Dr. Beşir ŞAHİN
: Dr. Öğr. Üyesi Fırat EKİNCİ

Genel olarak, ülkemiz fosil yakıtlardan enerji ihtiyaçlarını karşılamaktadır. Bu yakıtların ana dezavantajları çevreyi kirletmeleri ve ülkemizin yabancı ülkelere bağımlı olmasıdır. Biyokütle çok çeşitli yerlerde yetiştirilebilir, kolayca depolanabilir, sosyo-ekonomik gelişmelere yardımcı olur ve çevresel etkileri daha olumludur, günümüzde farklı endüstrilerde elektrik, kimyasal hammadde ve sıvı yakıt kullanılmaktadır. Bu özellikler nedeniyle biyokütle enerjisi Türkiye için önem kazanmıştır ve bu önem giderek artmaktadır.

Bu çalışmada Türkiye'nin tarımsal ve hayvansal bazlı biyokütle enerji potansiyeli araştırılmıştır. Tarımsal ve hayvansal istatistiksel verileri Türkiye İstatistik Kurumu 2017 verilerinden elde edilmiştir. Çalışmaya göre, toplam ekilen alan 15.856.351 hektar ve bu alandan elde edilebilecek ortalama kuru biyokütle miktarı 436.049.652, 5 tondur. Bu alanın ortalama kuru biyokütle enerji değeri 176.600.109, 3 TEO. Bu kuru biyokütle 2.053.859 MW enerjisine eşdeğerdir. Biyokütle kaynağı için kullanılan toplam hayvan sayısı 408.561.087 sayıdır. Türkiye'de bulunan hayvan atıkları miktarı 96.655.868, 19 tondur. Bu atıklardan 4.309.771.357 m^3/yıl biyogaz elde edilebilir. Bu biyogaz, 2.03 x 10^{10} kWh/yıl elektrik enerjisine eşdeğerdir.

Anahtar Kelimeler: Tarımsal Biyokütle, Hayvan Bazlı Biyokütle, Biyogaz, Türkiye, Yenilenebilir Enerji

EXPANDED SUMMARY

Energy has a significant priority in human life. As in all countries, developing technology and increasing energy deficit have made it necessary to think more about new energy sources in our country and to produce alternatives quickly. Energy is an important element for our country's economy. Energy is the infrastructure of industrialization and an indispensable element of everyday life. Because of the exhaustion of energy resources, the existence of external dependence and environmental effects, producing safe, adequate amount of cheap and clean energy for the countries is among the main problems of economic and social life. In our country, which is rapidly growing with its industry, economy and population, energy needs are constantly increasing. For this reason, the use of energy generated with high efficiency is of great importance to evaluate the potential of alternative and renewable energy sources as well as the existing energy sources.

The biggest problem caused by fossil fuels on the earth is greenhouse gases. The fact that greenhouse gases caused global warming and climate change has increased the importance of countries to use their own resources more efficiently. Today, the importance of conservation of natural balance, processing and utilization of renewable energy resources is increasing steadily.

In addition to the rapid increase in demand energy, it is a fact that the current energy resources will be depleted in a short time. In addition, depending on the increasing population and energy demand, it is not possible to keep the world emission value within the existing limits. If this pollution continues, the Earth's temperature will increase and the sea level will rise. For these reasons, the use of renewable energy resources in the world's energy production has made it extremely unavoidable.

Renewable energy is eco-friendly. It is a renewable and sustainable energy source with the use of existing resources. Since they produce CO_2 emissions during

the production of renewable energy sources in comparison to fossil fuels such as coal, oil and natural gas, their negative contribution to the environment is very low. Renewable energy resources are becoming more and more important as traditional energy resources are increasingly depleted.

A rapid increase in population and industrialization brought about the need for energy. Biomass energy comes at the top of the resources that will be used to ensure sustainable energy without causing environmental pollution. The fact that biomass energy is an inexhaustible resource is seen as an appropriate and important energy source because it can be obtained everywhere, especially because it helps socio-economic developments for rural areas.

In terms of biomass material production, Turkey is one of the countries that have conditions such as sunbathing and field availability, water resources and climate conditions. Biomass has great potential as a renewable energy in Turkey. Turkey's biomass resources consists of agriculture, forestry, organic urban waste and animal waste.

In this study, agricultural and animal based biomass energy potential of Turkey was investigated. The statistical data were obtained from the data of the Turkish Statistical Institute in 2017. Agricultural biomass sources were determined as oil seeds, edible roots and tubers, cereals, dry pulses, plants used in perfumery, in pharmacy or for similar purposes and fodder crops seed, fodder crops production, raw materials used in textiles to calculate the average agricultural biomass energy potential as MW. Animal waste types were also determined as poultry, sheep and goats, and bovine.

The potential results of biomass obtained from sources of agricultural are as follows. Total sown area is 15.856.351 hectare and 436.049.652,5 tons average dry biomass amount can be obtained from this area. The average dry biomass energy value of this area is 176.600.109,3 TEO. This dry biomass is equivalent to 2.053.859 MW energy.

The potential results of biomass obtained from sources of animal based are as follows. The total number of animals that are used for biomass source is 408.561.087 numbers. The amount of animal waste available in Turkey is 96.655.868,19 tons. 4.309.771.357 m^3/year biogas can be obtained from these wastes. This biogas is equivalent to 2,025592538 x 10^{10} kWh/year of electrical energy, 3.232.328.518 liter/year of oil and 2.844.449.096 liter/year of diesel oil.

Biomass energy sources are an environmentally friendly energy that has a low negative impact on the environment. The main advantages of biomass are the use of national resources that support waste management, which positively affect climate change, provide supply-demand security, promote rural development, provide gains and employment in agricultural and rural areas. In the future, biomass will be replaced as a green alternative to Turkey's energy roadmap.

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LIST OF ABBREVIATONS

A	: Area
ADBA	: Average Dry Biomass Amount
ADBEV	: Average Dry Biomass Energy Value
ADBTV	: Average Dry Biomass Thermal Value
BEPA	: Biomass Energy Potential Atlas
CH_4	: Methane Gas
CO_2	: Carbon Dioxide
EPDK	: Energy Market Regulatory Authority
ETKB	: Ministry of Energy and Natural Resources
GW	: Gigawatt
GWh	: Gigawatt Hour
H_2	: Hydrogen
Ha	: Hectar
K	: Kelvin
kcal	: Kilogram Calorie
kg	: Kilogram
Ktoe	: Kilotonne of Oil Equivalent
kWh	: Kilowatt Hour
Lt	: Liter
Lng	: Liquefied Natural Gas
MJ	: Megajoule
Mtoe	: Million Tons of Oil Equivalent
MW	: Megawatt
MWh	: Megawatt Hour
PH	: Potential Hydrogen
R & D	: Research and Development
RES	: Renewable Energy Source

SBB	: T.C. Cumhurbaşkanlığı Strateji ve Bütçe Başkanlığı
TEIAS	: Turkish Electricity Transmission Corporation
TEO	: Tons Equivalent Oil
TEP	: Tons Equivalent Petrol
TJ	: Terajoule
TL	: Turkish Lira
TSI	: Turkish Statistical Institute
TWh	: Terawatt hour
USD	: United States Dollar
YEGM	: Enerji İşleri Genel Müdürlüğü
^{o}C	: Degree Celsius

1. INTRODUCTION

Significant advances have been made in Turkey's economy in the last 15 years and significant developments have been experienced in economic magnitude. Turkey is the 17th largest economy in world and 6th largest economy in Europe in 2017. Our country is also an active member of the G-20, where the most powerful economies are represented. The energy sector plays an important role in achieving this economic growth. The average growth of our primary energy supply between 2003 and 2016 shows that the economy is growing with energy consumption (ETKB, 2017a). As a result of the economic developments and the increasing level of welfare, there is a rapid increase in demand in all areas of the energy sector.

While countries are determining their policies internationally, energy supply security has become more important than ever. Economic growth, demand for energy and environmental relations are of fundamental importance even for countries with the richest resources. In the world, the balance is changed and the energy sector is extremely dynamic. The energy strategy to be determined by our country is a very critical issue.

1.1. Turkey's General Energy Policy

The importance of energy policies is not limited to community welfare, economic development, industry and contribution to growth. There are two factors that determine the global policies of countries. The first is that secure energy supply security and second is that give advantage to their countries in the energy market.

It is very important to implement a national policy in the energy and natural resources area of our country, which aims to take place in the top ten economies of the world. In this context, the National Energy and Mine Policy has been set up to prioritize national and domestic production. These policies, which are formed in the fields of energy and natural resources, are determined by considering the themes of Energy Supply Security, Predictable Markets and Localization in Energy and Natural Resources (ETKB, 2017a).

Eight main themes and sixteen objectives have been introduced in the strategic plan of 2015-2019 prepared by the Ministry of Energy and Natural Resources (Table 1.1). In this plan, sustainability, which is seen as an indispensable approach in the process of gaining and consuming energy and natural resources into the economy, has been evaluated not as a separate theme but as a framework covering all themes.

In the Medium Term Plan of 2018-2020 prepared by the Ministry of Development, various policies have been developed for the development of our country. One of the areas covered by these policies is energy. Eight policies have been identified in the field of energy that are to increasing share of renewable energy in total energy production, to continue Program for Renewable Energy Resource Areas which will reduce dependency on foreign equipment in renewable energy investments, to increase exploration of oil, natural gas, shale gas and coal in order to ensure the increase in domestic reserves, to continue use of local lignite in an environment friendly manner, to launche a programme for energy efficient use in transport, industry and housing sectors, to take measures in public electricity generation power plants, electrical transmission and distribution networks to enhance energy efficiency, to supporte technological investments in priority sectors such as energy, health, automotive, railway systems, information and defence industries, to increase exploration investments in the mining sector and prioritization of ore processing/enrichment investments with R & D and technology transfer for exploration and production technologies in the context of the use of mineral resources (SBB, 2017).

Table 1.1. Strategic plan for the period 2015-2019 (ETKB,2018)

THEME 1	**Energy Safety Assurance**
Objective 1	Powerful and Reliable Energy Infrastructure
Objective 2	Optimum Diversity Of Resources
Objective 3	Effective Demand Management
THEME 2	**Energy Efficiency and Energy Saving**
Objective 4	Turkey That Uses Energy Efficiently
Objective 5	Capacity for Energy Efficiency and Saving
THEME 3	**Good Governance and Stakeholder Interaction**
Objective 6	A Strong Ministry Of Corporate Capacity
Objective 7	A Ministry That Uses Information Technologies Effectively
Objective 8	A High Level Of Coordination
THEME 4	**Regional and International Events**
Objective 9	Turkey Integrated Into Regional Energy Markets
Objective 10	A Strong Actor In The International Arena
THEME 5	**Technology, R & D and Innovation**
Objective 11	Domestic Technology in Energy and Natural Resources
Objective 12	A Result-Oriented R & D Approach
THEME 6	**Improving of Investment Environment**
Objective 13	Competitive and Transparent Markets
Objective 14	Improved Investment Processes
THEME 7	**Secutity Of Raw Material Supply**
Objective 15	Security Of Non-Energy Raw Material Supply Security
THEME 8	**Efficient and Effective Use of Raw Materials**
Objective 16	Efficient and Effective Use of Non-Energy Natural Raw Materials

In terms of primary energy sources, some targets have been set within the scope of reducing our country's dependence on foreign and ensuring supply security. These objectives are diversification of resources and routes, drilling and seismic exploration activities, strengthening of energy infrastructure, prioritization of energy efficiency and environmental and sustainability. In this context, some of the goals that are planned to be achieved are; at least 10% of our country's electric energy production from nuclear power plants with the commissioning of Akkuyu and Sinop nuclear power plants, diversification of resources, country and route for natural gas imports, to increase oil and natural gas exploration and production activities on land and at sea to reveal new sources of supply and development of existing reserves, to carry out seismic searches in the Mediterranean and Black Sea with Barbaros Hayrettin Pasha and Oruç Reis ships, to accelerate drilling and exploration activities aimed at coal exploration, and in this direction providing necessary incentives and increasing the amount of drilling, to increase Turkey's natural gas storage capacity to 20% of the country's annual consumption, to determinate of natural gas transmission system in accordance with short-and mid-term supply-demand balance and long-term production-development plans, to establish and operation of natural gas according to certain criteria in regions where economic activities are intensive, to supporte efficiency-enhancing projects of industrial enterprises to accelerate energy efficiency, reduce energy intensity and improve energy efficiency market, to increase effectiveness in energy efficiency, energy supply security, reduction of external dependence risks, environmental protection and combating air pollution, to encourage the use of natural gas instead of coal in energy consumption for heating and to improve the air quality of our country by expanding the use of natural gas (ETKB, 2017a).

It is very important to make reforms and incentives that will open the way for private sector in our country, because it is one of the biggest supporters of projects taking place in the fields of energy and natural resources. In this context, arrangements for energy and natural resources are planned in the fields of renewable energy, nuclear energy, electricity generation, transmission and distribution infrastructure and energy efficiency. The main targets set in this scope are to update of Solar Energy and Wind Energy Potential Atlases and preparation of Biomass Energy Potential Atlas, to realize of investments in renewable energy source areas, to implement of demand management mechanisms in natural gas, to restructure of public institutions and organizations related to the mining sector, institutionalization of mining sector and establishment of "Mining Coordination Committee" with representatives from public institutions (ETKB, 2017a).

1.2. Turkey's Energy Outlook

Table 1.2 shows licensed and unlicensed installed capacity, peak demand, licensed and unlicensed electricity generation, consumption, import and export data in 2017. According to the Table 1.2, consumption and licensed production increased by 5,22% and 7,34% in 2017, respectively and peak demand and licensed installed capacity increased by 6,54% and 5,16%, respectively compared to 2016. It is observed that unlicensed power and production values increased by 202,74% and 166,42% respectively.

Compared to 2016, imports were 2.73 TWh by decreased 57,36% and exports were 3,30 TWH by increased 128,84%. The ratio of exports to imports rose to 120,92% in 2017 from 22,53% in 2016.

Table 1.2. Licensed and unlicensed installed capacity, peak demand, licensed and unlicensed electricity generation, consumption, import and export data (EPDK, 2018)

	Unit	2014	2015	2016	2017
Licensed Installed Capacity	MW	69.520	73.146,90	77.563,44	81.563,32
Unlicensed Installed Capacity	MW	29,99	359,04	1.048,21	3.173,32
Peak Demand	MW	41.003	43.289,00	44.733,98	47.659,65
Licensed Generation	GWh	251.962	261.783,30	272.563,63	292.574,58
Unlicensed Generation	GWh	3,92	222,72	1.137,87	3.031,56
Consumption	GWh	257.220	265.724,40	277.522,01	292.003,54
Import	GWh	7.953	7.411,10	6.400,13	2.729,06
Export	GWh	2.696	2.964,60	1.442,08	3.300,10

An electric power plant can meet or carry a maximum capacity of an electric network is called the installed power. Licensed capacity represents the actual capacity licensed by the government authorities concerned. Before actual production begins, government authorities must declare the required capacity to be vested after the inspection of existing facilities in the establishment. Unlicensed capacity can be defined as in the framework of the legal arrangements made to increase the efficiency of energy resources and energy in our country, real or legal persons have the right to produce their own energy. Real or legal persons who have the right to produce their own energy are exempt from the obligation to obtain any license or to establish a different company.

Figure 1.1 shows the demand and increase rate of electricity by years. Electricity demand has been increasing steadily since 2009, however there is a decrease in the rate of increase from 2011 to 2013 compared to other years. An increase of 5,22% was realized in 2017.

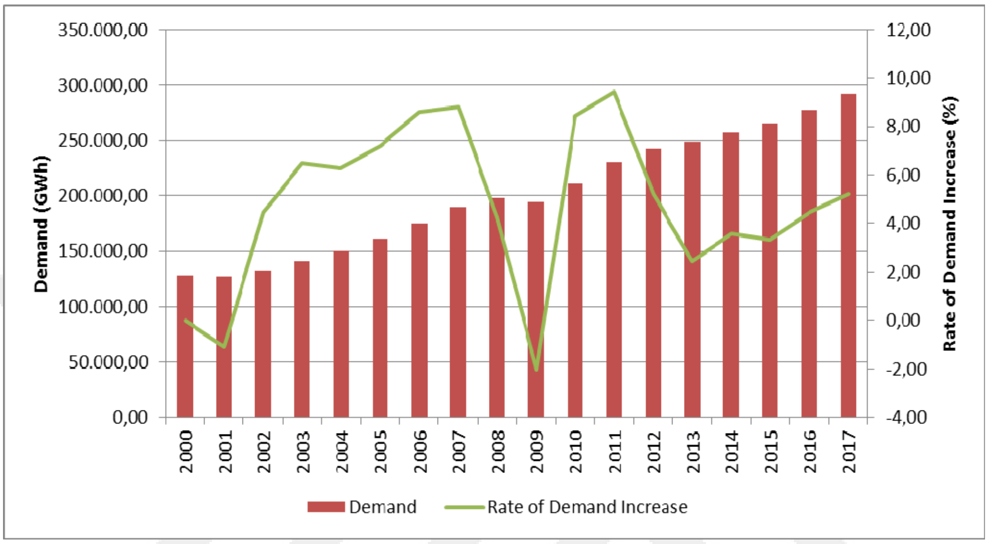

Figure 1.1. Electric energy demand and rate of increase by years (EPDK, 2018)

In Turkey, the daily electricity consumption of subscribers is measured and billed in three-time that is day, night and peak. The peak demand can be defined as the electricity tariff that is spent during the most intensive hours of consumption (between 17.00-22.00). According to the Figure 1.2, the change in the peak demand is similar to the energy demand in general. In 2017, the increase in the peak demand was realized as 6%. Figure 1.3 shows the relationship between peak demand and electricity demand between 2000 and 2017. According to the Figure 1.3, electrical energy demand and peak demand increase rates were close to each other. The highest rate of demand was realized in 2010 with 12%, while the lowest rates were realized in 2009 and 2013 with 2%.

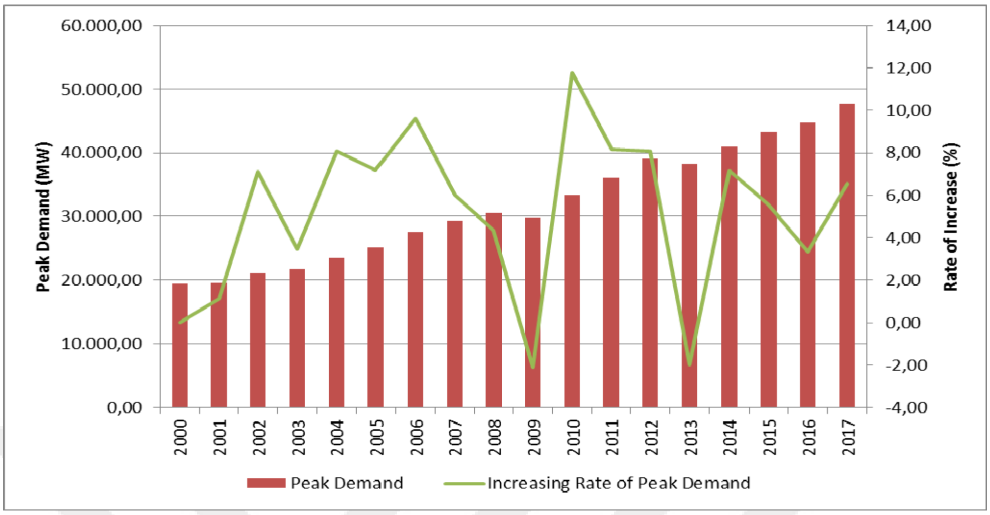

Figure 1.2. Peak demand and rate of increase by years (EPDK, 2018)

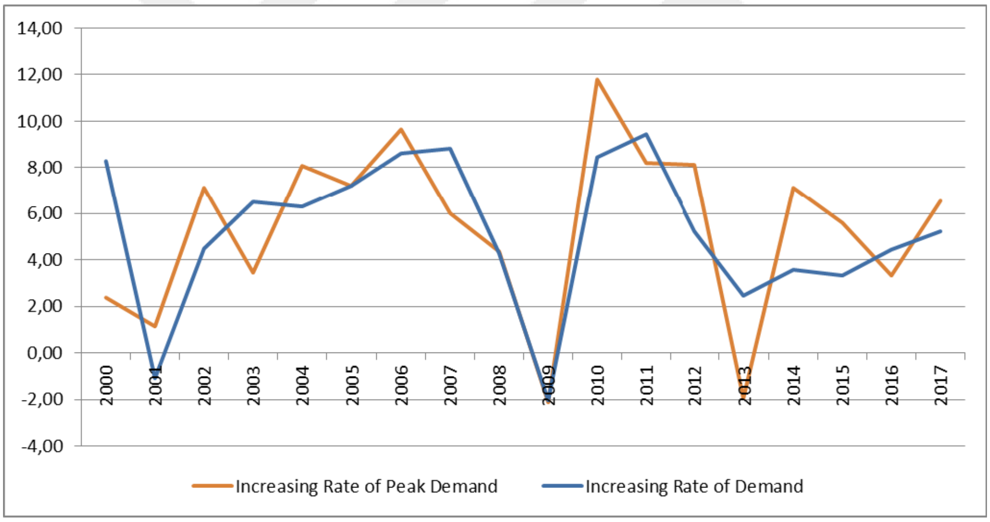

Figure 1.3. Rate of increase of demand and peak demand by years (EPDK, 2018)

The Figure 1.4 shows the monthly change in licensed electricity generation and electricity consumption. As can be seen from the Figure 1.4, the highest values of monthly production and consumption were reached in July and August and approximately the same values were measured for both months. However, the lowest values of monthly production and consumption were reached in February and April and approximately the same values were measured for both months.

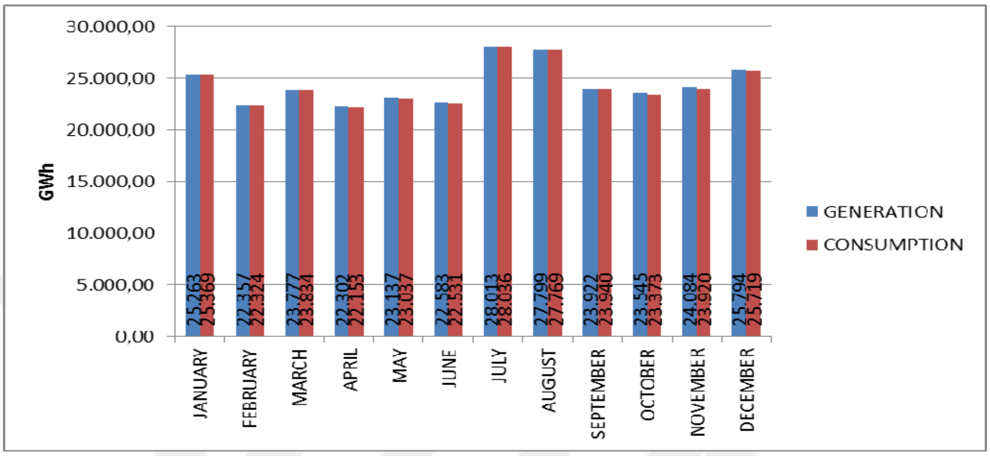

Figure 1.4. Monthly distribution of licensed electricity generation and consumption in 2017 (EPDK, 2018)

Distribution of licensed electricity generation in Turkey by sources is given in Figure 1.5. In the production of licensed electrical energy in 2016, the share of natural gas fired power plants was 32,16%, the share of wind power plants was 5,69%, and the share of geothermal power plants was 1,77%. Compared to the year 2016, the share of natural gas fired power plants, wind power plants and geothermal power plants rose to 37,18%, 6,10% and 2,04%, respectively in 2017 (EPDK, 2018).

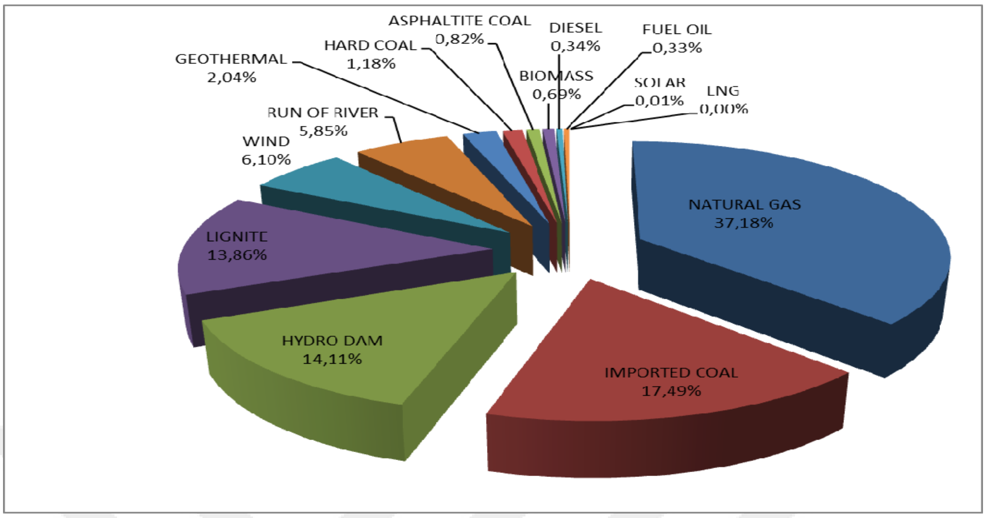

Figure 1.5. Percentage distribution of licensed electricity generation in 2017 (EPDK, 2018)

Figure 1.6 shows the development of licensed electricity generation from 1990 to 2017 on the basis of resources. As can be seen from the Figure 1.6, the share of renewable energy sources (geothermal, wind, solar and biomass) in electricity production has increased every year. Especially before 2009, the ratio of renewable energy sources is almost 0%, and it is observed that it has been increasing steadily since this year.

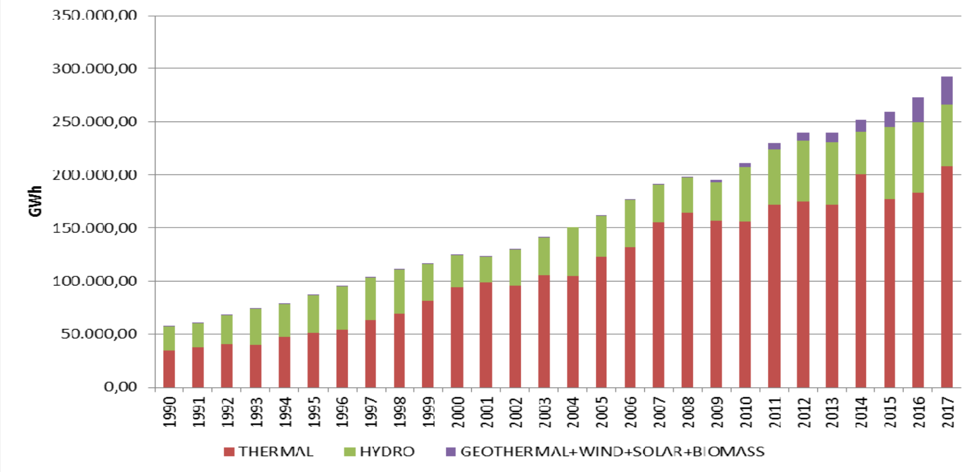

Figure 1.6. Development of licensed electricity generation by source between 1990-2017 (EPDK, 2018)

The provinces where licensed electricity production is the most and the least in 2017 are shown in Table 1.3. According to the Table 1.3, the highest electricity production was realized in Izmir, Zonguldak, Adana, Sakarya, Hatay and Çanakkale that are 6,70%, 6,53%, 5,76%, 5,38%, 5,34%, 5,19% respectively, while the lowest electricity production was realized in Bartın, Bitlis, Yozgat, Nigde and Ağrı provinces that have the same rates with 0%.

Table 1.3. Distribution of licensed electricty generation in 2017 (EPDK, 2018)

Province	Generation (MWh)	Share (%)
İZMİR	19.611.109,13	6,70
ZONGULDAK	19.114.455,26	6,53
ADANA	16.860.131,85	5,76
SAKARYA	15.730.416,43	5,38
HATAY	15.620.106,18	5,34
ÇANAKKALE	15.173.356,93	5,19
AĞRI	5.743,10	0,00
NİĞDE	5.063,17	0,00
YOZGAT	4.028,45	0,00
BİTLİS	820,16	0,00
BARTIN	283,28	0,00

As it can be seen from the Figure 1.7 the established power of Turkey has increased steadily since 1977. The installed power, which was 4.727,20 MW in 1977, increased by approximately 18 times and reached 85.20,00 MW in 2017. The biggest increase in the installed power when examined within five-year periods is observed to be between 2012-2017. This situation shows that Turkey uses its resources in the most efficient way and also activates new energy sources.

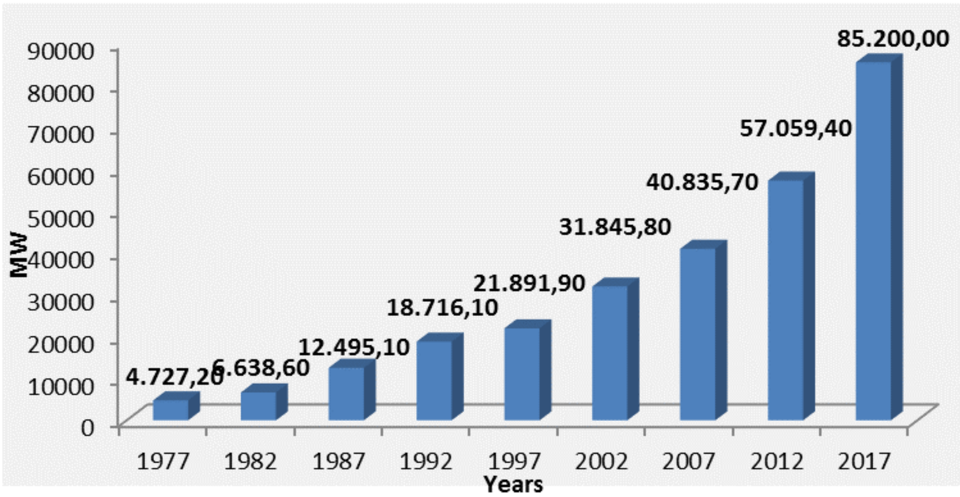

Figure 1.7. Annual development of Turkey's installed capacacity (TEIAS, 2018)

Development of Turkey's installed capacity by primary energy resources between 2007 and 2017 is shown in Figure 1.8. According to the Figure 1.8 the five primary energy resources which are thermal, hydro, geotermal, wind and solar are shown. As can be seen from the figure, while thermal energy has the largest share, solar energy has the least proportion. Thermal energy, which had a 66,78% share in 2007, declined to 55,08% in 2017. Hydraulic energy is the same as the thermal energy in the change, but the rate of change is very low. The ratio of primary energy resources was realized as 32,01% with a decrease of 0,79% in 2017 (Table 1.4).

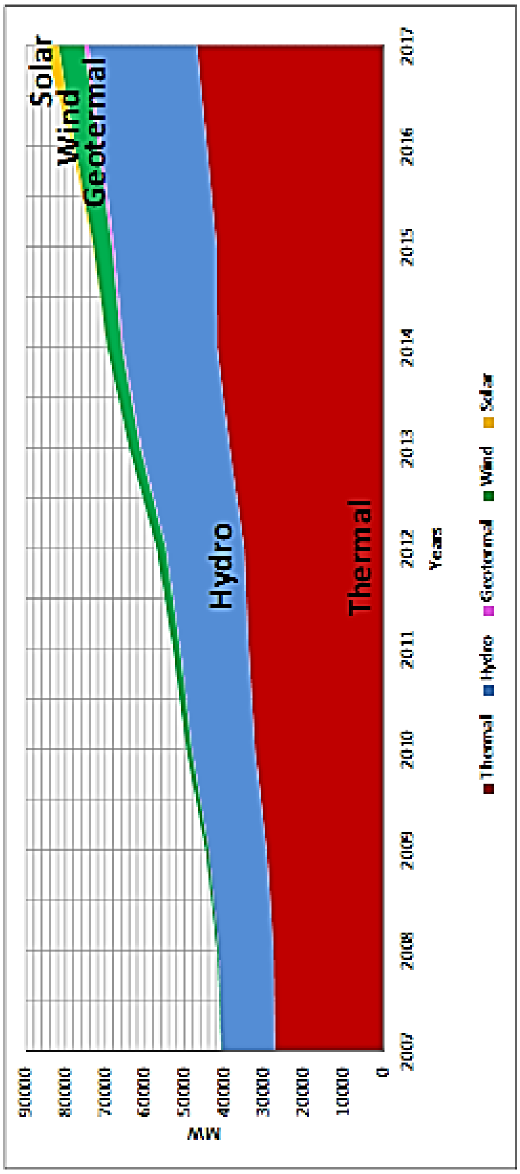

Figure 1.8. Development of Turkey's installed capacity by primary energy resources (2007-2017) (TEIAS, 2018)

Table 1.4. Development of Turkey's installed capacity by primary energy resources (2007-2017) (TEIAS, 2018)

						Unit: MW
	Thermal	**Hydro**	**Geotermal**	**Wind**	**Solar**	**Total**
2007	27.271,6	13.394,9	22,9	146,3	-	40.835,7
%	66,78	32,80	0,06	0,36	-	100,00
2017	46.926,3	27.273,1	1.063,7	6.516,2	3.420,7	85.200,0
%	55,08	32,01	1,25	7,65	4,01	100,00

Figure 1.9 shows the distribution of Turkey's installed capacity by primary energy resources in 2017. Renewable energy sources have the largest share among primary energy sources with 38.751,1 MW (45,58%). When the renewable energy resources are examined in itself, the dams have the largest share of 19.776 MW (23,21%). This rate is followed by the lake and the rivers with 8,80%, the wind 7,65%, and the sun with 4,01%. The second largest primary energy source in the installed power is natural gas with a 22.002,2 MW (25,82%).

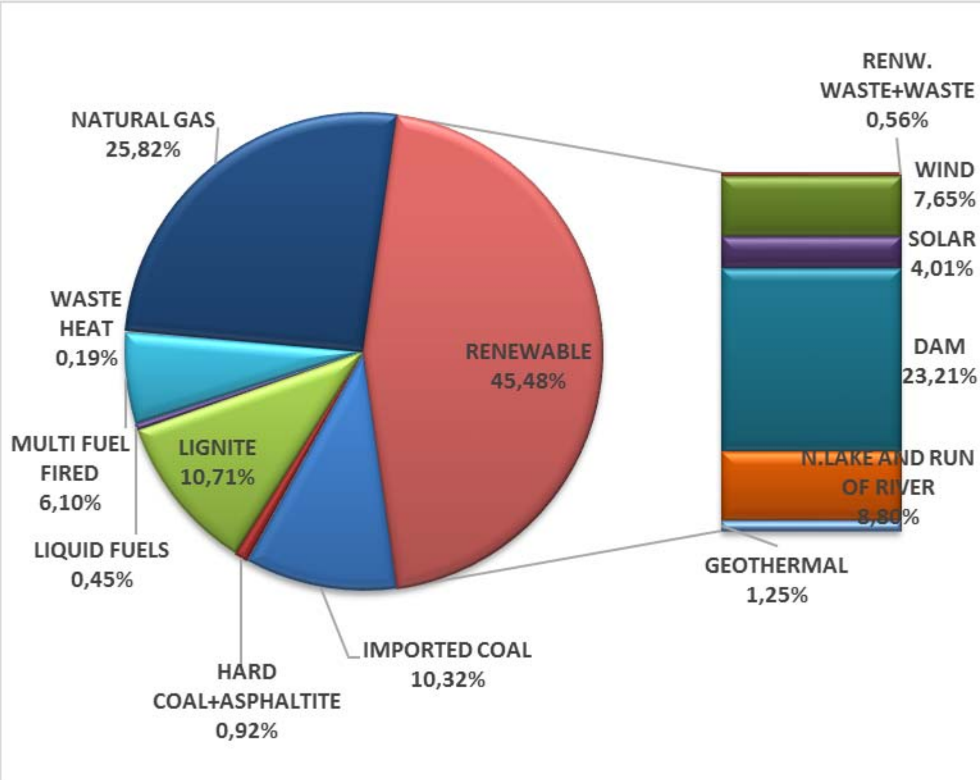

Figure 1.9. The distribution of Turkey's installed capacity by primary energy resources in 2017 (TEIAS, 2018)

Renewable energy is the source of energy that exists in nature and constantly renewing itself. Renewable energy sources are a kind of energy that can be obtained in the world and in nature, mostly without any production process. They are non-fossil sources, CO_2 emissions are realized at a low level, environmental damage and impact is much lower than traditional energy sources. For that reason, in recent years, the share of renewable energy sources in total installed power has been increasing in Turkey.

The ratio of renewable energy in the installed power has been decreasing steadily and the lowest rate was realized in this year with 32,5% until 2007. After this date, there is a continuous increase in the renewable share and it reached the highest rate of 45,7% in 2017. The largest shareholder in this ratio is hydraulic energy with 27.273.1 MW. Hydraulic energy is followed by wind and solar energy that have 6.516,2 MW and 3.420,7 MW respectively as can be seen in Table 1.5.

The development of Turkey's installed power and production between 1993 and 2017 is shown in Table 1.6. According to the Table 1.6, while the total installed power is steadily increasing, electricity production has decreased in some years. Electricity production decreased in 2001 and 2009 compared to the previous year. The total installed power in 2017 is 85.200 MW and its production is 297.277,5 GWh. The largest shareholders in electricity generation are hydraulic and thermal power plants which are similar to the installed power.

Table 1.5. Annual development of domestic resources based installed capacity share in Turkey total installed capacity (2000-2017) (TEIAS, 2018)

YEARS	HYDRO	GEOTERMAL	WIND	SOLAR
2000	11.175,2	17,5	18,9	
2001	11.672,9	17,5	18,9	
2002	12.240,9	17,5	18,9	
2003	12.578,7	15,0	18,9	
2004	12.645,4	15,0	18,9	
2005	12.906,1	15,0	20,1	
2006	13.062,7	23,0	59,0	
2007	13.394,9	23,0	147,5	
2008	13.828,7	29,8	363,7	
2009	14.553,3	77,2	791,6	
2010	15.831,2	94,2	1.320,2	
2011	17.137,1	114,2	1.728,7	
2012	19.609,4	162,2	2.260,6	
2013	22.289,0	310,8	2.759,7	
2014	23.643,2	404,9	3.629,7	40,2
2015	25.867,8	623,9	4.503,2	248,8
2016	26.681,1	820,9	5.751,3	832,5
2017	27.273,1	1.063,7	6.516,2	3.420,7
YEARS	**RENEWABLE WASTES + WASTE HEAT**	**RENEWABLE INSTALLED CAPACITY**	**TOTAL INSTALLED CAPACITY**	**RENEWABLE SHARE**
2000	23,8	11.235,4	27.264,1	41,2
2001	23,6	11.732,9	28.332,4	41,4
2002	27,6	12.304,9	31.845,8	38,6
2003	27,6	12.640,2	35.587,0	35,5
2004	27,6	12.706,9	36.824,0	34,5
2005	35,3	12.976,5	38.843,5	33,4
2006	41,3	13.185,9	40.564,8	32,5
2007	42,7	13.608,1	40.835,7	33,3
2008	59,7	14.281,9	41.817,2	34,2
2009	86,5	15.508,6	44.761,2	34,6
2010	107,2	17.352,8	49.524,1	35,0
2011	125,7	19.105,7	52.911,1	36,1
2012	168,8	22.201,0	57.059,4	38,9
2013	235,0	25.594,5	64.007,5	40,0
2014	299,1	28.017,1	69.519,8	40,3
2015	370,1	31.613,8	73.146,7	43,2
2016	496,4	34.582,2	78.497,4	44,1
2017	641,9	38.915,6	85.200,0	45,7

Table 1.6. Annual development of installed power and generation in Turkey (1993-2017) (TEIAS, 2018)

	INSTALLED CAPACITY (MW)				
YEARS	**THERMAL**	**HYDRO**	**GEOTHERM+WIND+ SOLAR**	**TOTAL**	**INCREASE %**
1993	10638,4	9681,7	17,5	**20337,6**	8,7
1994	10977,7	9864,6	17,5	**20859,8**	2,6
1995	11074,0	9862,8	17,5	**20954,3**	0,5
1996	11297,1	9934,8	17,5	**21249,4**	1,4
1997	11771,8	10102,6	17,5	**21891,9**	3,0
1998	13021,3	10306,5	26,2	**23354,0**	6,7
1999	15555,9	10537,2	26,2	**26119,3**	11,8
2000	16052,5	11175,2	36,4	**27264,1**	4,4
2001	16623,1	11672,9	36,4	**28332,4**	3,9
2002	19568,5	12240,9	36,4	**31845,8**	12,4
2003	22974,4	12578,7	33,9	**35587,0**	11,7
2004	24144,7	12645,4	33,9	**36824,0**	3,5
2005	25902,3	12906,1	35,1	**38843,5**	5,5
2006	27420,2	13062,7	81,9	**40564,8**	4,4
2007	27271,6	13394,9	169,2	**40835,7**	0,7
2008	27595,0	13828,7	393,5	**41817,2**	2,4
2009	29339,1	14553,3	868,8	**44761,2**	7,0
2010	32278,5	15831,2	1414,4	**49524,1**	10,6
2011	33931,1	17137,1	1842,9	**52911,1**	6,8
2012	35027,2	19609,4	2422,8	**57059,4**	7,8
2013	38648,0	22289,0	3070,5	**64007,5**	12,2
2014	41801,8	23643,2	4074,8	**69519,8**	8,6
2015	41903,0	25867,8	5375,9	**73146,7**	5,2
2016	44411,6	26681,1	7404,7	**78497,4**	7,3
2017	46926,3	27273,1	11000,6	**85200,0**	8,5
	GENERATION (GWh)				
YEARS	**THERMAL**	**HYDRO**	**GEOTHERM+WIND+ SOLAR**	**TOTAL**	**INCREASE %**
1993	39779,0	33950,9	77,6	**73807,5**	9,6
1994	47656,7	30585,9	79,1	**78321,7**	6,1
1995	50620,5	35540,9	86,0	**86247,4**	10,1
1996	54302,8	40475,2	83,7	**94861,7**	10,0
1997	63396,9	39816,1	82,8	**103295,8**	8,9
1998	68702,9	42229,0	90,5	**111022,4**	7,5
1999	81661,0	34677,5	101,4	**116439,9**	4,9
2000	93934,2	30878,5	108,9	**124921,6**	7,3
2001	98562,8	24009,9	152,0	**122724,7**	-1,8
2002	95563,1	33683,8	152,6	**129399,5**	5,4
2003	105101,0	35329,5	150,0	**140580,5**	8,6
2004	104463,7	46083,7	150,9	**150698,3**	7,2
2005	122242,3	39560,5	153,4	**161956,2**	7,5
2006	131835,1	44244,2	220,5	**176299,8**	8,9
2007	155196,2	35850,8	511,1	**191558,1**	8,7
2008	164139,3	33269,8	1008,9	**198418,0**	3,6
2009	156923,4	35958,4	1931,1	**194812,9**	-1,8
2010	155827,6	51795,5	3584,6	**211207,7**	8,4
2011	171638,3	52338,6	5418,2	**229395,1**	8,6
2012	174871,7	57865,0	6760,1	**239496,8**	4,4
2013	171812,5	59420,5	8921,0	**240154,0**	0,3
2014	200416,6	40644,7	10901,5	**251962,8**	4,9
2015	179366,4	67145,8	15271,0	**261783,3**	3,9
2016	185798,1	67230,9	21378,7	**274407,7**	4,8
2017	212138,5	58218,5	26920,6	**297277,5**	8,3

The Figure 1.10 shows the monthly change in gross electricity generation. As can be seen from the Figure 1.10, the highest values of monthly production are reached in July and August and approximately the same values are measured for both months that are 28.362,6 GWh and 28.130,4 GWh, respectively. However, the lowest values of monthly production are reached in February, April and June and approximately the same values are measured for three months that are 22.916,2 GWh, 22.583,4 GWh and 22.913,3 GWh, respectively (Table 1.7). The largest shareholders in electricity generation are hydraulic and thermal power plants.

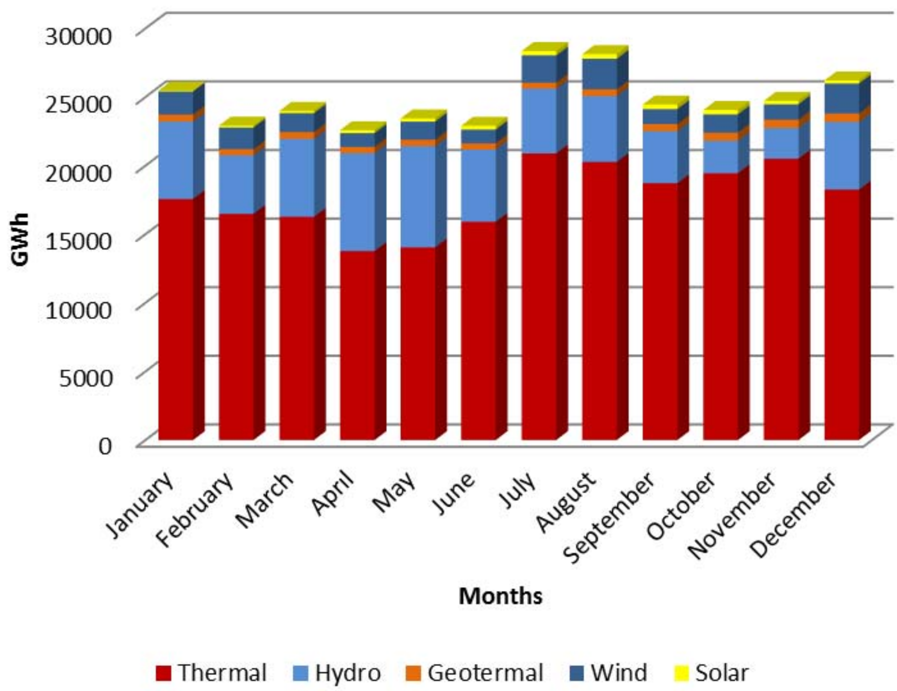

Figure 1.10. Monthly distribution of Turkey's gross electricity generation by primary energy resources in 2017 (TEIAS, 2018)

Table 1.7. Distribution of gross electricty generation by months in 2017 (TEIAS,2018)

Unit: GWh						
Months	**Thermal**	**Hydro**	**Geotermal**	**Wind**	**Solar**	**Total**
January	17.564,4	5.646,7	514,3	1.676,5	77,4	**25.479,3**
February	16.481,4	4.274,2	448,9	1.579,5	132,2	**22.916,2**
March	16.266,4	5.687,5	498,3	1.381,4	165,0	**23.998,7**
April	13.771,2	7.137,6	455,9	1.008,2	210,5	**22.583,4**
May	14.045,5	7.377,2	470,4	1.314,2	234,8	**23.442,2**
June	15.913,7	5.257,4	453,9	1.009,1	279,1	**22.913,3**
July	20.895,6	4.719,8	431,5	1.991,1	324,6	**28.362,6**
August	20.269,0	4.803,6	491,7	2.233,7	332,4	**28.130,4**
September	18.718,6	3.789,2	529,7	1.082,4	335,4	**24.455,3**
October	19.449,3	2.361,6	595,3	1.331,8	320,7	**24.058,6**
November	20.508,3	2.232,4	611,1	1.123,4	254,3	**24.729,6**
December	18.255,0	4.931,3	626,3	2.172,3	223,0	**26.207,9**
Total	**212.138,5**	**58.218,5**	**6.127,5**	**17.903,8**	**2.889,3**	**297.277,5**

Figure 1.11 shows the distribution of licensed power by type of fuel. In the total licensed installed capacity in 2016, the rate of natural gas plants (including liquid and natural gas fired plants) was 32,68%, the rate of dam-hydroelectric plants was 25,17%, the rate of lignite plants was 11,95%, the rate of imported coal-based plants was 9,82%, the rate of river-hydroelectric plants was 9,21%, the rate of wind farms was 7,40% and the rate of geothermal plants was 1,06%. Compared to the year 2016, the share of natural gas plants, dam-hydroelectric plants, lignite plants decreased to 32,29%, 24,21% and 11,36%, respectively while imported coal-based plants, river hydroelectric plants, wind farms and geotermal plants rose to 10,96%, 9,22%, 7,95% and 1,30%, respectively in 2017 (EPDK, 2018).

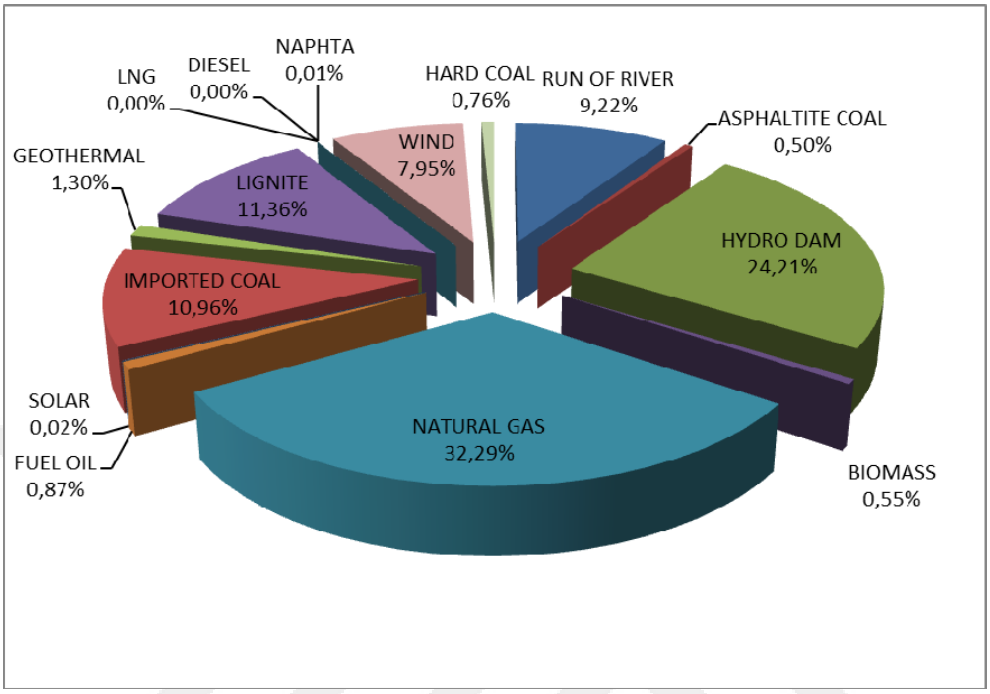

Figure 1.11. Distribution of licensed installed power by resources in 2017 (EPDK,2018)

Figure 1.12 shows the development of licensed installed capacity from 1990 to 2017 on the basis of resources. As can be seen from the Figure 1.12, the share of renewable energy sources (geothermal, wind, solar and biomass) in electricity production has increased every year. Especially before 2009, the ratio of renewable energy sources is almost 0%, and it is observed that it has been increasing steadily since this year.

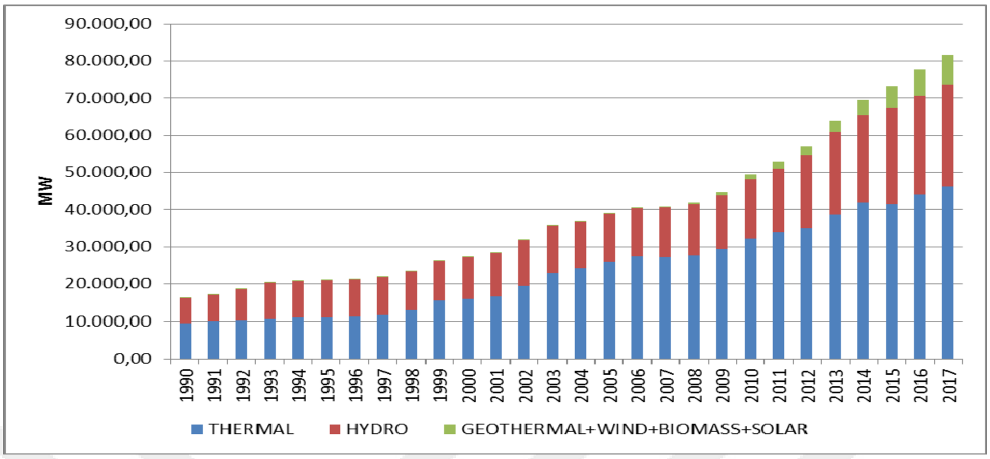

Figure 1.12. Development of licensed installed capacity by source between 1990-2017 (EPDK, 2018)

The provinces where licensed installed capacity is the most and the least in 2017 are shown in Table 1.8. According to the Table 1.8, the highest installed capacity was realized in İzmir, Kahramanmaraş, Samsun, Adana, Çanakkale, Şanlıurfa and Zonguldak that are 5,29%, 5,20%, 4,67%, 4,57%, 4,38%, 4,25%, 4,06% respectively, while the lowest installed capacity was realized in Niğde, Iğdır, Bayburt, Bartın, Aksaray, that have the same rates with 0,03%, Ağrı (0,01%), Çankırı and Bitlis, that have the same rates with 0%.

Table 1.8. Distribution of licensed installed capacity in 2017 (EPDK, 2018)

Province	**Installed Capacity (MW)**	**Share (%)**
İZMİR	4.318,74	5,29
KAHRAMANMARAŞ	4.244,08	5,20
SAMSUN	3.811,17	4,67
ADANA	3.727,07	4,57
ÇANAKKALE	3.573,80	4,38
ŞANLIURFA	3.465,22	4,25
ZONGULDAK	3.312,73	4,06
AKSARAY	27,69	0,03
BARTIN	26,41	0,03
BAYBURT	25,70	0,03
IĞDIR	22,58	0,03
NİĞDE	22,33	0,03
AĞRI	9,50	0,01
ÇANKIRI	2,75	0,00
BİTLİS	0,60	0,00

The total electricity generation of the unlicensed installed capacity in 2016 was 1.048,21 MW. 89,6% of this production is generated from photovoltaic solar energy systems. In 2017, this production was increased by about 3 times and it reached 3,173.32 MW. As in 2016, the largest ratio belongs to photovoltaic solar power plants with 93,87%, followed by natural gas with 2,71% and biomass with 2,10%. Compared to 2016, the ratio of photovoltaic solar power plants increased, while the ratio of other resources decreased. (Table 1.9, Figure 1.13)

Table 1.9. Comparison of unlicensed installed capacity by sources (EPDK, 2018)

Resource Type	2016		2017	
	Installed Capacity (MW)	Share (%)	Installed Capacity (MW)	Share (%)
Solar (Photovoltaic)	939,19	89,60	2.978,84	93,87
Natural Gas	51,85	4,95	85,88	2,71
Biomass	36,42	3,47	66,72	2,10
Wind	13,75	1,31	32,20	1,01
Hydraulic	5,78	0,55	8,69	0,27
Solar (Concentrated)	1,22	0,12	1,00	0,03
Total	**1.048,21**	**100,00**	**3.173,32**	**100,00**

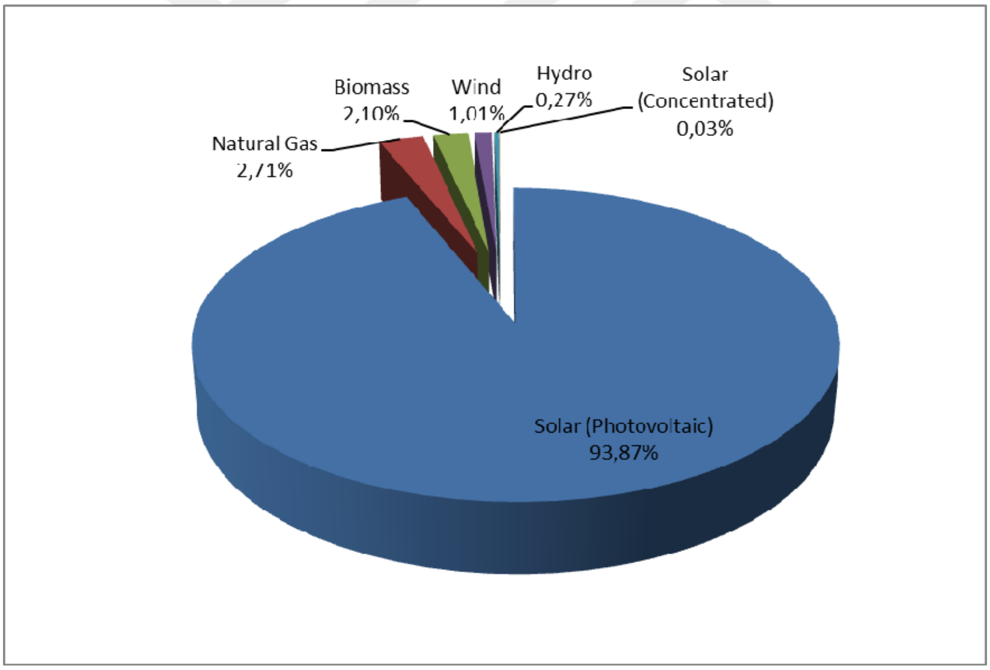

Figure 1.13. Distribution of unlicensed installed capacity by sources in 2017 (EPDK, 2018)

The provinces where unlicensed installed capacity is the most and the least in 2017 are shown in Table 1.10. Compared to 2016, the rate of Afyonkarahisar increased while the rates of other provinces decreased when the provinces within the first five were examined. The ratios of Afyonkarahisar increased to 4,24%. The rates of the lowest unlicensed installed capacity decreased in 2017 when compared to the 2016.

Table 1.10. Comparison of unlicensed installed capacity by province (EPDK, 2018)

Province	2016		2017	
	Installed Capacity (MW)	Share (%)	Installed Capacity (MW)	Share (%)
KONYA	199,236	19,01	437,610	13,79
KAYSERİ	127,408	12,15	279,644	8,81
ANKARA	54,872	5,23	158,775	5,00
AFYONKARAHİSAR	25,601	2,44	134,668	4,24
ANTALYA	48,211	4,60	117,885	3,71
BARTIN	0,250	0,02	0,250	0,01
KASTAMONU	0,250	0,02	0,250	0,01
SİİRT	0,192	0,02	0,192	0,01
BATMAN	0,044	0,00	0,044	0,00
SİNOP	0,004	0,00	0,004	0,00

Data on electricity imports in 2017 by months are shown in Figure 1.14. The highest electricity imports on a monthly basis were carried out in January, while the lowest was in October. In 2017, a total of 2.729.060,87 MWh electricity imports were realized. 76,02% of this imports were made from Bulgaria, 18,08% from Georgia, 5,88% from Iran, and 0,02% from Greece (EPDK, 2018).

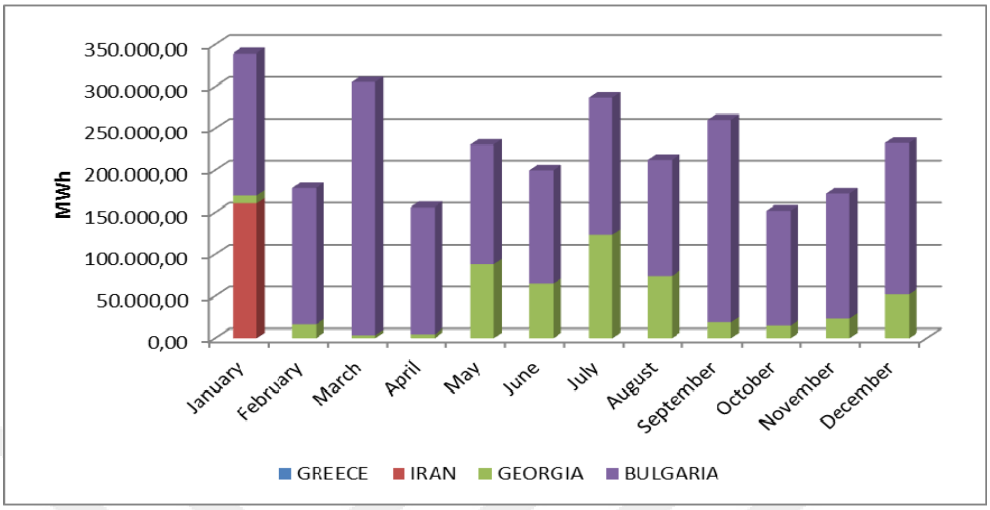

Figure 1.14. Electricity imports in 2017 by months (EPDK, 2018)

Data on electricity exports in 2017 by months are shown in Figure 1.15. The highest electricity imports on a monthly basis were carried out in May and November, while the lowest was in February. In 2017,a total of 3.300.096,20 MWh electricity imports were realized. 96,97% of this imports were made to Greece, 3,03% to Georgia and Bulgaria (EPDK, 2018).

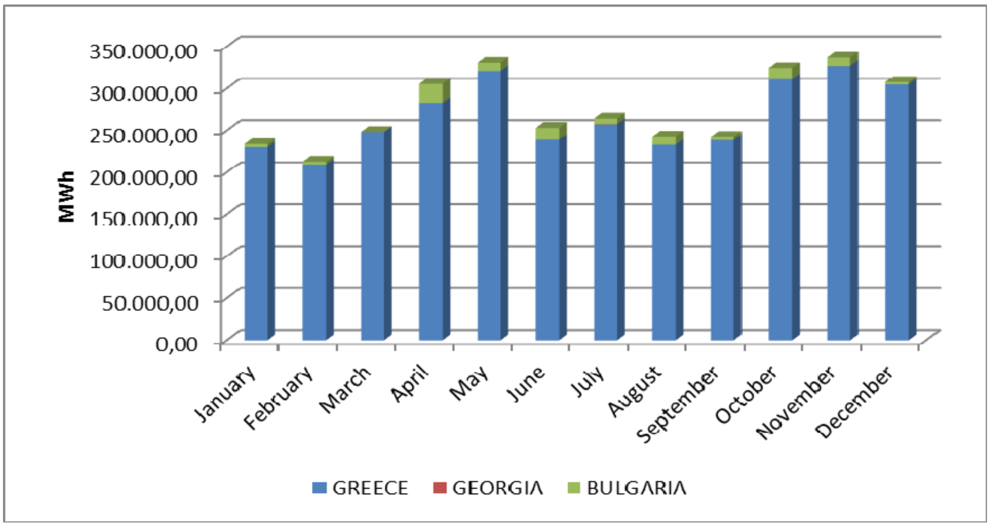

Figure 1.15. Electricity exports in 2017 by months (EPDK, 2018)

Table 1.11 shows the number of RES Support Mechanism participants by years. The number of participants and the increase in installed capacity have been increasing steadily since 2014. The total number of participants in 2017 increased by approximately 30 times compared to 2011 and reached 647. The total installed power operating under the RES Support Mechanism was 17.399,94 MW in 2017. When the distribution of this installed power according to the source type is examined, it is seen that the hydraulic power plants have the largest share with 11.096,26 MW (63,77%) and the wind is the second with 5.238,70 MW (30,11%) (Table 1.12) (EPDK, 2018).

Table 1.11. Number of RES Support Mechanism participants by years (EPDK, 2018)

Type	2011	2012	2013	2014	2015	2016	2017
Solar	-	-	-	-	-	-	2
Hydraulic	4	44	14	40	126	388	418
Wind	9	22	3	21	60	106	141
Biomass	3	8	15	23	34	42	57
Geothermal	4	4	6	9	14	20	29
Total	**20**	**78**	**38**	**93**	**234**	**556**	**647**

Table 1.12. Installed capacity of the RES Support Mechanism participants by years (EPDK, 2018)

Type	2011	2012	2013	2014	2015	2016	2017
Solar	-	-	-	-	-	-	12,90
Hydraulic	21	930	217	598	2.116,33	9.960,00	11.096,26
Wind	469	685	76	825	2.732,14	4.319,83	5.238,70
Geothermal	72	72	140	228	389,92	599,16	752,11
Biomass	45	73	101	147	185,23	203,72	299,97
Total	**608**	**1.760**	**534**	**1.798**	**5.423,63**	**15.082,72**	**17.399,94**

Development of the generation within the scope of RES Support Mechanism is shown at Table 1.13. The production of 207 years, including unlicensed plants, increased by about 10% to 50,5 TWh compared to the previous year. When the electricity production is considered on the basis of resources, hydraulic power plants have the highest share with 48,32% and the wind power plants have the second largest share with 33,18%, however solar power plants have the lowest share with 0,05% (Table 1.13, Figure 1.16).

Table 1.13. Yearly generation of RES Support Mechanism participants by years (EPDK, 2018)

Type	2012	2013	2014	2015	2016	2017
Solar	-	-	-	-	-	24.268
Unlicensed	-	-	-	222.724	1.134.024	3.031.558
Hydraulic	2.296.047	528.646	1.072.832	5.683.331	25.520.255	24.417.133
Wind	2.081.745	234.000	2.378.819	8.275.992	14.163.403	16.765.418
Geothermal	487.364	857.527	1.436.579	2.710.856	3.706.764	4.503.345
Biomass	374.002	750.715	925.516	1.050.796	1.306.057	1.789.053
Total	**5.239.158**	**2.370.888**	**5.813.746**	**17.943.699**	**45.830.503**	**50.530.776**

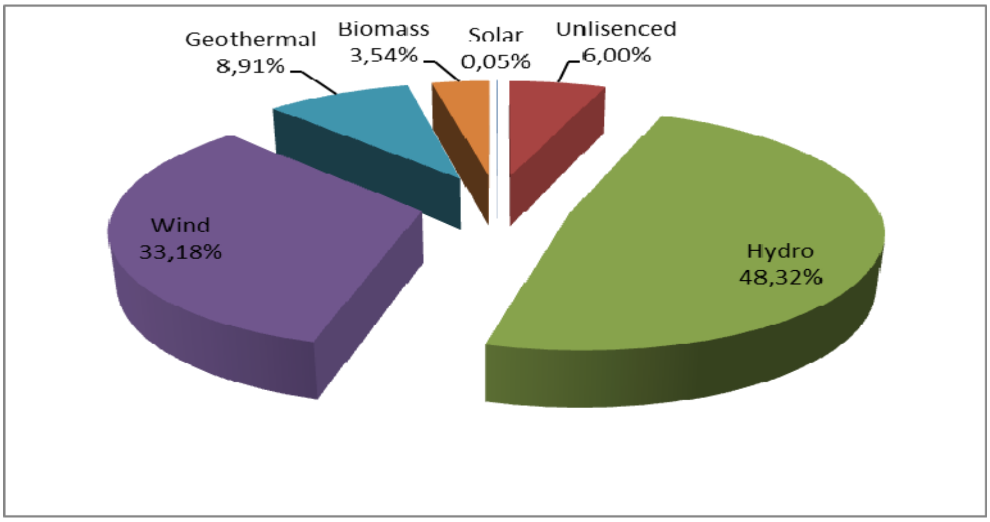

Figure 1.16. Distribution of generation in RES Support Mechanism by sources in 2017 (EPDK, 2018)

Table 1.14 shows the electricity statistics in the first eight months of 2018. The total electricity generation in the first eight months is 335.680,9 GWh. About 40% of this value is the amount of electricity produced by thermal power plants. This amount is followed approximately by natural gas+lng with 17,8%, hydro with 13% and hard coal+imported coal with 12%.

Table 1.14. Monthly distribution of Turkey's gross electricity generation by primary energy resources (TEIAS, 2018)

MONTHLY DISTRIBUTION OF TURKEY'S GROSS ELECTRICITY GENERATION BY PRIMARY ENERGY RESOURCES IN 2018, GWh									
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	TOTAL
Hard Coal + Imported Coal	6.112,9	5.643,1	4.826,6	4.138,6	4.904,9	5.335,6	5.718,8	6.311,6	42.992,0
Lignite	3.611,2	3.511,8	3.781,6	3.629,9	3.790,5	3.716,6	3.861,4	3.805,9	29.709,0
Liquid Fuels	128,3	103,6	99,8	111,0	134,9	130,0	137,9	130,4	976,0
Natural Gas + Lng	9.004,4	7.608,0	6.410,5	6.463,0	5.732,7	6.200,0	10.541,8	7.747,2	59.707,7
Thermal	19.116,8	17.105,8	15.388,1	14.608,6	14.836,7	15.651,5	20.536,6	18.260,3	135.504,4
Hydro	4.524,1	3.586,2	6.254,0	6.329,2	6.481,5	5.661,9	5.839,5	5.573,1	44.249,6
Geotermal + Wind + Solar	2.660,0	2.556,7	3.173,5	2.487,0	2.492,0	2.604,1	2.807,3	3.761,7	22.542,2
Gross Generation	26.300,9	23.248,7	24.815,6	23.424,8	23.810,1	23.917,6	29.183,4	27.595,1	202.296,2
Imports	165,1	188,8	129,6	232,7	288,6	228,3	272,7	229,9	1.735,8
Exports	254,3	206,6	216,1	71,0	134,1	290,2	303,9	278,4	1.754,6
Gross Demand	26.211,7	23.230,9	24.729,1	23.586,5	23.964,7	23.855,6	29.152,2	27.546,5	202.277,3

The aim of this thesis is that agricultural and animal based biomass energy potential of Turkey and on the basis of provinces is investigated. The agricultural and animal statistical data are obtained from the data of the Turkish Statistical Institute in 2017. Agricultural biomass sources are determined as oil seeds, edible roots and tubers, cereals, dry pulses, plants used in perfumery, in pharmacy or for similar purposes and fodder crops seed, fodder crops production, raw materials used in textiles to calculate the average agricultural biomass energy potential as MW. Animal waste types are also determined as poultry, sheep and goats, and bovine.

2. PRELIMINARY WORKS

Ozdingis and Kocar (2018) reported that the current and future situation of Turkey in bioethanol production. They have been divided into three main groups which are improvement in technological developments, innovations in the agricultural sector and climate change for increasing demands for biofuels and bioethanol. As shown in Figure 2.1, sugar is mostly used as a raw material to produce bioethanol in various factories of Turkey. In this study, it is emphasized that Turkey should diversify its raw materials used for bioethanol production. Lignocellulosic biomass materials are a very good source for this. With the use of this resource, the amount of greenhouse gas emissions in Turkey will decrease significantly.

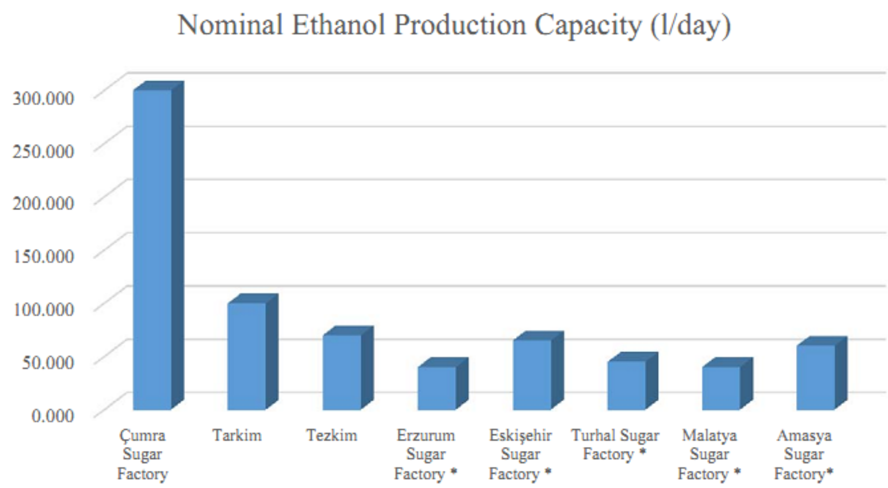

Figure 2.1. Current potential of bioethanol in Turkey, * only potential (Ozdingis and Kocar, 2018)

Boyacı (2017) investigated that to determine the animal waste and biogas potential and equivalence of other types of fuels from the quantities of fertilizers that can be obtained from animal (bovine, ovine, and poultry) wastes in the provinces and districts of Kırşehir. In this study, the animal statistical data were obtained from the data of the Turkish Statistical Institute in 2017. The results are presented in the Table 2.1 When the animal presence of Kırşehir province is examined, it is observed that there are 1347435 animals. Poultry animals constitute 72,15% of the total number of animals in the province. This rate is followed by ovine animals with 16,28% and bovine animals with 11,58%. According to these figures, the total amount of fertilizer is 736504.9 tons/year and the amount of waste available is 406168.3 tons/year. 81,09% of this amount is derived from bovine waste. 11,12% of this ratio is made of poultry waste and 7,79% is composed of ovine waste. The total amount of biogas that can be obtained annually throughout the province is 14855273 m^3. The amount of this biogas is equivalent to 69819781 kWh of electricity, 55477795.7 kg of wood, 11141445.4 liters of oil, and 9804479.9 liters of diesel oil. According to this data, the revenue from electricity is 8529120.97 $, 4393278.05 $ from wood, 17202633.222 $ from oil, 13091220.893 $ from diesel oil.

Table 2.1. Biogas Potential of Kırşehir which can be produced by animal waste (Boyacı, 2017)

District	Total Number of Animals	Total Biogas Amount (m^3/year)
Central	445086	5758495.98
Akçakent	26463	563184.22
Akpınar	39891	855465.97
Boztepe	268376	2818957.93
Çiçekdağı	76250	1425899.05
Kaman	108034	1706130.19
Mucur	383335	1727139.21
Total	**1347435**	**14855272.55**

Melikoglu (2017) investigated that the current and future situation of Turkey and the World in coal and biomass energy. In this study, the installed capacity of Turkey's energy power plants based on energy resources at the end of 2015 has been given in Table 2.2. The prediction of coal consumption for six different region around the world is shown in Figure 2.2 between 2015 and 2035. In addition, he has done research on co-firing and co-gasification of biomass with coal which is a new technology and not widely used in the world. According to Turkey's Vision 2023, installed capacity of coal power plants will have increased from 15 to 30 GW, and installed capacity of biomass power plants will have risen to 2000 MW by 2023. Turkey aims to produce 2000 MW of electrical energy from biomass by 2023. Turkey should spend between 3.8 and 13.6 billion USD in order to produce this value, which is a biomass energy goal in 2023.

Table 2.2. The installed capacity of Turkey's energy power plants based on energy resources at the end of 2015 (Melikoglu, 2017)

Fuel Type	Installed Capacity, MW	Share, %	Number of Power Plants
Fuel oil + asphaltite + naphta + diesel	851.0	1.2	18
Bituminous coal + lignite	9013.4	12.3	28
Imported coal	6064.2	8.3	8
Natural gas + LNG	21222.1	29.0	233
Renew. + waste + semi-waste + pyrolysis oil	344.7	0.5	69
Multiple fuels solid + liquid	667.1	0.9	23
Multiple fuels liquid + natural gas	3684.0	5.0	46
Geothermal	623.9	0.9	21
Hydro (dam type)	19077.2	26.1	109
Hydro (river type)	6790.6	9.3	451
Wind	4498.4	6.1	113
Thermal (unlicensed)	56.5	0.1	24
Wind (unlicensed)	4.8	0	9
Solar (unlicensed)	248.8	0.3	362
Total	**73146.7**	**100.0**	**1514**

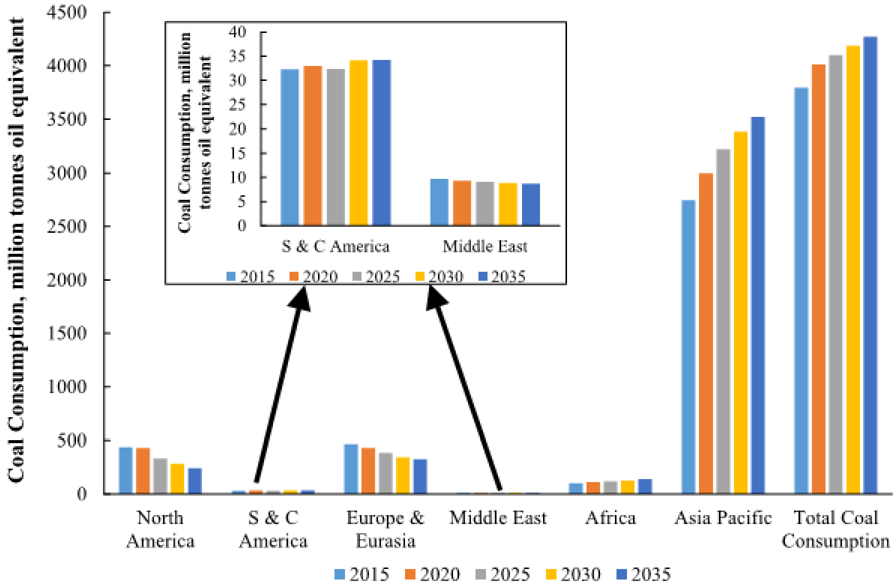

Figure 2.2. The total coal consumption around the World (Melikoglu, 2017)

Ozturk et al. (2017) worked on the biomass and bioenergy opportunities and potential of Turkey and Malaysia. According to study, Turkey produces 1.5 million tons of biodiesel, 3 million tons of bioethanol and 2,5-4 billion m^3 of biogas per year. Figure 2.3 represents the present and estimated biomass energy production in Turkey and total biomass production is expected to reach a level of 52,5 Mtoe by 2030 in Turkey. Malaysia also generate around 15 billion m^3 of biogas per year and it can produce more than 2400 MW of biomass and 410 MW of biogas. Figure 2.4 shows the estimated energy objective which increases every year day from biomass sources by 2030. It is clearly seen that the total production of biomass energy will increase between 2020 and 2030.

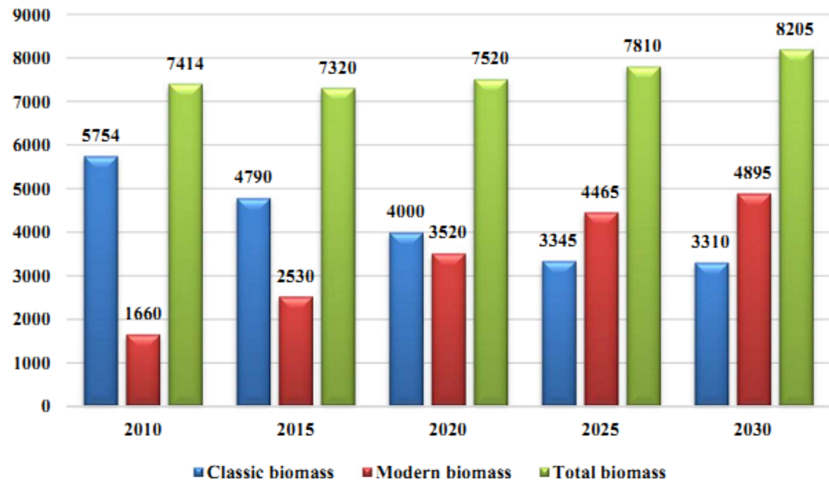

Figure 2.3. Present and estimated biomass energy production in Turkey (Ozturk et al.,2017)

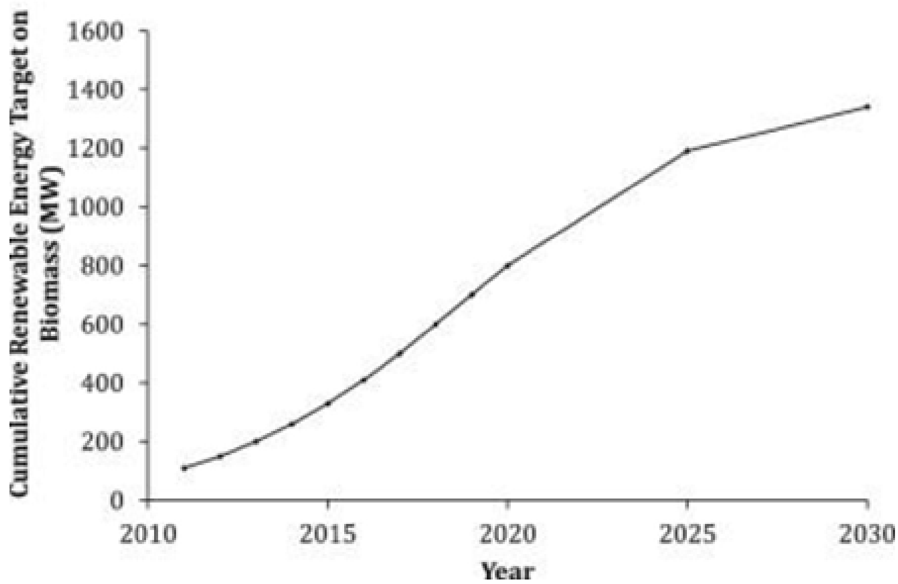

Figure 2.4. Estimated energy objective from biomass sources by 2030 (Ozturk et al.,2017)

Figure 2.5 shows the estimated energy requirement for Turkey by 2030. It is predicted that Turkey's energy demand will be increase four times.

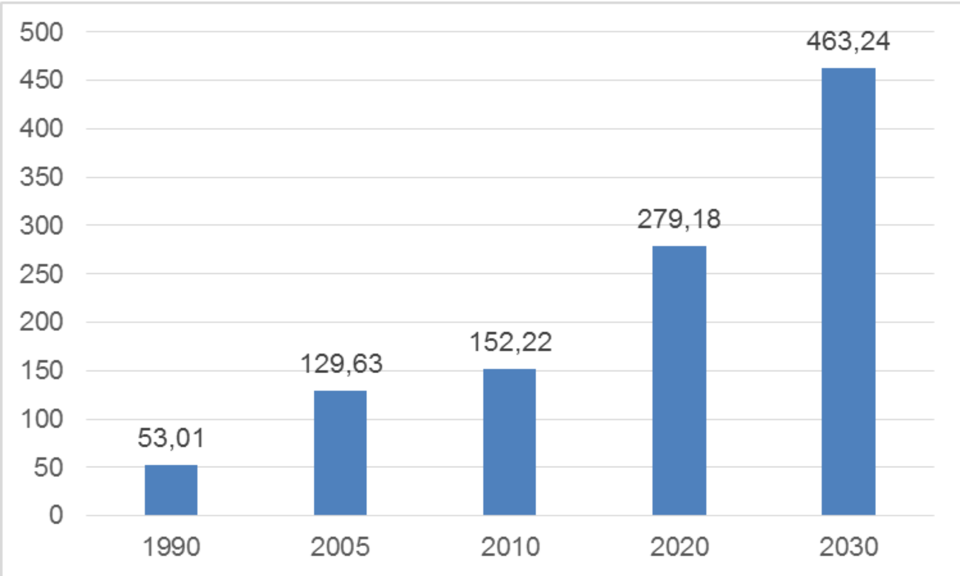

Figure 2.5. Estimated energy requirement for Turkey by 2030 (Ozturk et al.,2017)

Senol et al. (2017) investigated that the potential of biogas and electrical energy that can be produced from poultry in Turkey for the year 2016. In their study, they obtained the total number of poultry in the year 2016 from TSI. According to the study, the amount of biogas and energy obtained from poultry age fertilizer were calculated as 556,85 m^3/year and 13,36 billion MJ, respectively. This value meets a large part of the energy required of our country. In the study, while calculating the TL value of the biogas produced from chicken manure, they excluded the cost expenses in the calculations. Because cost design varies depending on the location of the plant, its status and annual use. The numerical calculations are shown in the Table 2.3.

Table 2.3. Wet fertilizer and biogas amounts, annual, monthly and daily earnings of produced biogas, electrical energy value that can be produced from poultry (Senol et al., 2017)

Total Number of Poultry Animals	**Wet Fertilizer Amount (tons/year)**	**Biogas Amount (m^3/year)**	**Energy Value (MJ/Year)**
320.399.000	7.048.778	556.853.462	13.364.483.088

Annual Earnings (Thousand TL)	**Monthly Earnings (Thousand TL)**	**Daily Earnings (Thousand TL)**
785.163	65.430	2.181

Total Number of Poultry Animals	**Monthly electricity production quantity (kwh)**	**Daily electricity production quantity (kwh)**
320.399.000	218.100.000	7.270.000

Demir et al. (2016) determined agricultural biomass energy potential of Erzincan province between 2006 and 2015 and compared with the data obtained for Turkey and eastern Anatolia region. Based on the values of sugar beet, cereals, fruits, vegetables, dry legumes and forage crops, the average agricultural biomass energy potential was calculated as MW. In this study, the agricultural statistical data was obtained from the data of the Turkish Statistical Institute in 2015. According to the study, it was determined that a total of 14.292 MW of agricultural biomass energy can be obtained in Erzincan province. 9.225 MW energy from cereals, 2.524 MW energy from forage crops, 876 MW energy from dry legumes, 749 MW energy from sugar beets, 463 MW energy from vegetables and 455 MW energy from fruits were obtained. According to the Table 2.4, they found that this value for Erzincan equals 0,59% of the biomass energy potential of Turkey and 5,76% of the Eastern Anatolia region.

Table 2.4. Average dry biomass energy equivalent and proportional distribution (Demir et al., 2016)

	Dry Biomass Energy Equivalent (MW)			Proportional Comparison (%)		
Years	**Turkey**	**Eastern Anatolia Region**	**Erzincan**	**Erzincan / Turkey**	**Erzincan / Eastern Anatolia Region**	**Eastern Anatolia Region / Turkey**
2006	2.475.863	263.233	16.260	0.65	6.17	10.63
2007	2.429.988	254.585	15.667	0.64	6.15	10.47
2008	2.373.592	257.316	15.424	0.64	5.99	10.84
2009	2.343.798	242.501	15.205	0.64	6.27	10.34
2010	2.355.274	238.589	13.292	0.56	5.57	10.12
2011	2.338.280	241.764	13.334	0.57	5.51	10.33
2012	2.329.459	250.901	13.679	0.58	5.45	10.77
2013	2.358.232	241.594	13.425	0.56	5.55	10.24
2014	2.375.447	243.029	13.083	0.55	5.38	10.23
2015	2.367.134	241.729	13.557	0.57	5.60	10.21
Average	**2.374.707**	**247.524**	**14.292**	**0.59**	**5.76**	**10.41**

Singh (2016) worked in India to determine the production of economic energy from agricultural waste. He found that the capacity of the plant is 20 MW and it can be produced at a cost of 5 Rs/kW per hour and the cost for installation is 45,144 Rs/Kwh.

Ozturk and Yuksel (2016) reported that increasing fossil fuels due to factory production, transportation and daily life activities in developing countries, it has negative effects on air pollution and global warming. However, the industrial structure of the countries of sustainable development long-term support by the environment is developing the standard of living economically and environmentally. Therefore, public awareness of environmental issues should be increased and clean energy sources should be used instead of fossil energy.

Saka et al. (2016) examined the distribution of faunal biomass in the Marmara Region. Animal husbandry and animal wastes derived from faunal biomass energy potential were studied for eleven separate cities in this region. Animal waste types were determined as poultry, sheep and goats, and cattle and buffalo. According to the result, Balikesir has the highest faunal growing production, biomass energy potential and faunal waste and it is shown in Figure 2.6. Poultry, cattle and buffalo and sheep and goats were contributed to the energy potential as 34,97%, 61,60%, 3,44%, respectively. According to the study, the animal waste mass in the region is 13,4% of Turkey's potential and 24% of the animals in Turkey are in the Marmara Region.

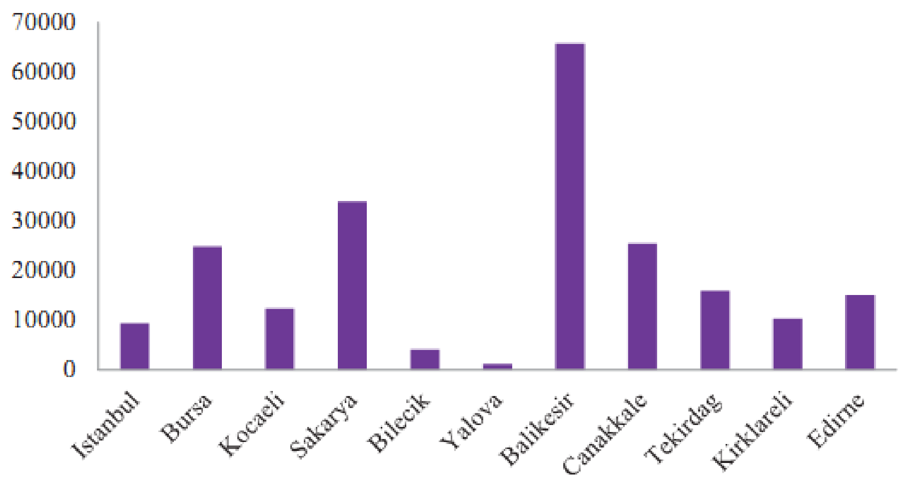

Figure 2.6. Distribution of annual energy due to animal wastes by cities (Saka et al., 2016)

Aybek et al. (2015) calculated that biogas potential from animal wastes and agricultural wastes in Kahramanmaraş province. In this study, the animal and agricultural statistical data were obtained from the data of the Turkish Statistical

Institute in 2014. Cattle, sheep and goat (ovine) were evaluated as animal sources and wheat, barley, rye, corn, cotton, sunflower and soy were also evaluated as agricultural wastes. Based on the these sorces, the biogas energy was calculated as TJ/year. The biogas energy values from animal wastes are shown in Table 2.5. Annual total biogas energy potential which can be obtained from agricultural wastes throughout the province is 2.177 TJ/year and approximately 95% of this energy constitutes animal waste.

Table 2.5. Biogas energy values of animal wastes according to the districts of Kahramanmaraş province (Aybek et al., 2015)

Settlements	**Biogas Energy Values of Animal Wastes (TJ/year)**			
	Bovine	**Sheep and Goat**	**Poultry**	**Total**
Afşin	218.99	53.47	7.82	280.28
Andırın	175.58	55.62	3.80	235.00
Çağlayancerit	14.57	27.91	0.64	43.12
Dulkadiroğlu	178.69	58.02	7.50	244.22
Ekinözü	32.71	7.19	1.12	41.02
Elbistan	273.51	47.95	2.31	323.77
Göksun	140.84	50.73	5.81	197.38
Nurhak	13.18	21.10	0.04	34.32
Onikişubat	208.78	61.67	6.35	276.80
Pazarcık	78.68	134.27	6.38	219.33
Türkoğlu	94.99	66.10	20.26	181.35
Total	**1.430.52**	**584.03**	**62.02**	**2.076.57**

The biogas energy values from agricultural wastes are shown in Table 2.6. The distribution of biogas energy according to the districts is determined from large to small, respectively; Elbistan, Afşin, Pazarcık, Türkoğlu, Dulkadiroğlu, Onikişubat, Göksun, Andırın, Ekinözü, Çağlayancerit and Nurhak.

Table 2.6. Biogas energy values of agricultural wastes according to the districts of Kahramanmaraş province (Aybek et al., 2015)

Settlements	**Biogas Energy Values of Agricultural Wastes (TJ/year)**							
	Wheat	**Barley**	**Rye**	**Corn**	**Cotton**	**Sunflower**	**Soy**	**Total**
Afşin	4.68	1.52	0.01	3.50		3.88		13.59
Andırın	1.30	0.02		2.71		0.25	0.01	4.28
Çağlayancerit	0.25	0.08		0.16				0.50
Dulkadiroğlu	1.06	0.09		8.92	0.34	0.16	0.11	10.69
Ekinözü	0.39	0.26		0.01		0.07		0.72
Elbistan	4.46	1.35		16.04		1.93		23.78
Göksun	3.20	0.85	0.01	0.40		0.65		5.12
Nurhak	0.18	0.06						0.24
Onikişubat	1.84	0.12		3.61	0.09	0.02	0.03	5.73
Pazarcık	1.58	0.54		18.12	0.50		0.01	20.75
Türkoğlu	1.32	0.03	0.01	13.12	0.49		0.03	14.99
Total	**20.25**	**4.94**	**0.03**	**66.58**	**1.43**	**6.95**	**0.19**	**100.36**

Demir et al. (2015) determined agricultural biomass energy potential of Mersin province between 2005 and 2014 and compared with the data obtained for Turkey and Mediterranean Region. Based on the values of cereals, fruits, vegetables, dry legumes and oil seeds, the average agricultural biomass energy potential was calculated as MW. In this study, the agricultural statistical data was obtained from the data of the Turkish Statistical Institute in 2014. According to the study, it was determined that a total of 45.228 MW of agricultural biomass energy can be obtained in Mersin province. 21.717 MW energy from cereals, 3.246 MW energy from dry legumes, 4.212 MW energy from vegetables, 14.445 MW energy from fruits and 1.608 MW energy from oil seeds were obtained. According to the Table 2.7, they found that this value for Mersin equals 1.93% of the biomass energy potential of Turkey and 15.86% of the Mediterranean Region.

Table 2.7. Average dry biomass energy equivalent and proportional distribution (Demir et al., 2015)

	Dry Biomass Energy Equivalent (MW)			**Proportional Comparison (%)**		
Years	**Turkey**	**Mediterranean Region**	**Mersin**	**Mersin / Turkey**	**Mersin / Mediterranean Region**	**Mediterranean Region / Turkey**
2005	2.577.456	304.929	45.090	1,75	14,79	11,83
2006	2.474.697	293.629	45.539	1,84	15,51	11,87
2007	2.368.420	282.114	44.233	1,87	15,68	11,91
2008	2.311.859	280.835	43.795	1,89	15,59	12,15
2009	2.292.692	282.866	44.875	1,96	15,86	12,34
2010	2.324.016	286.980	43.549	1,87	15,18	12,35
2011	2.313.550	291.824	48.006	2,07	16,45	12,61
2012	2.233.890	272.957	45.580	2,04	16,70	12,22
2013	2.273.570	278.738	46.458	2,04	16,67	12,26
2014	2.298.670	278.599	45.161	1,96	16,21	12,12
Average	**2.346.882**	**285.347**	**45.228**	**1,93**	**15,86**	**12,17**

Eryilmaz et al. (2015) determined the production potential of the biogas from animal waste in Yozgat province and its districts. In addition, biogas production potential from animal waste in the Central Anatolia Region and Turkey was determined and comparisons were made. In this study, the animal statistical data were obtained from the data of the Turkish Statistical Institute in 2012. The results are presented in the Table 2.8. According to the results, Yozgat has the potential of biogas with the value of 45.070 million m^3 of animal waste. The Central district ranks first with 6.546 million m^3 biogas, the Akdağmadeni district ranks second with 6.521 million m^3 and Sorgun district ranks third with 5,166 million m^3. The potential of the animal-based biogas of the Yozgat constitutes 7,024% of the Central Anatolia region. Whereas about 18,022% potential of the animal-based biogas in Turkey is included by the Central Anatolia Region, the participation rate of the Yozgat is 1,266%.

Table 2.8. Biogas Potential of Yozgat which can be produced by animal waste (Eryilmaz et al., 2015)

Settlements	Number of Animals	Animal Waste Potential (ton/year)	Biogas Production Amount (m^3)
Central	275068	166462	6546399
Akdağmadeni	188042	182770	6521803
Aydıncık	22570	33534	1228536
Boğazlıyan	135141	100615	4881449
Çandır	9215	8204	373575
Çayıralan	29689	42963	1678271
Çekerek	57253	139179	4910280
Kadışehri	50041	79501	2833703
Saraykent	34230	53447	1865067
Sarıkaya	61074	86714	3252634
Sorgun	322100	137725	5166888
Şefaatli	41394	43997	1836481
Yenikafalı	27807	21173	965687
Yerköy	107911	67387	3009321
Total	**1361535**	**1163677**	**45070100**

Yuruk and Erdogmus (2015) calculated that biogas potential from animal wastes in Düzce province and counties using TSI data for 2013. They evaluated cattle, sheep and goat (bovine) and poultry data and calculated biogas production potential depending on the animal potential available in Düzce centers and districts. The results are presented in the Table 2.9. According to the results, if biogas from the existing animal potential will be produced, the districts with the highest weight potential are Merkez and Akçakoca.

Table 2.9. Biogas potential of Düzce which can be produced by animal waste (Yuruk and Erdogmuş, 2015)

Settlements	**Type of Animals**	**Number of Animals**	**Fertilizer Amount (tons/year)**	**Biogas Amount (m^3/year)**	**Total Biogas Amount (m^3/year)**
MERKEZ	Cattle	31.000	111.600	3.682.800	9.358.749
	Ovine	3.500	2.450	142.100	
	Poultry	3.224.854	70.947	5.533.849	
AKÇAKOCA	Cattle	4.000	14.400	475.200	6.078.739
	Ovine	400	280	16.240	
	Poultry	3.256.002	71.632	5.587.299	
CUMAYERİ	Cattle	3.001	10.804	356.519	728.709
	Ovine	200	140	8.120	
	Poultry	212.162	4.668	364.070	
ÇİLİMLİ	Cattle	6.050	21.780	718.740	1.930.953
	Ovine	400	280	16.240	
	Poultry	696.954	15.333	1.195.973	
GÖLYAKA	Cattle	7.801	28.084	926.759	1.360.031
	Ovine	3.500	2.450	142.100	
	Poultry	169.681	3.733	291.173	
GÜMÜŞOVA	Cattle	4.247	15.289	504.544	1.097.377
	Ovine	750	525	30.450	
	Poultry	327.729	7.210	562.383	
KAYNAŞLI	Cattle	3.501	12.604	415.919	1.269.456
	Ovine	889	622	36.093	
	Poultry	476.366	10.480	817.444	
YIĞILCA	Cattle	6.511	23.440	773.507	2.624.737
	Ovine	2.000	1.400	81.200	
	Poultry	1.031.486	22.693	1.770.030	

Sancak et al. (2014) investigated the number of animals and the production of biogas in Turkey and on the basis of provinces. They also tried to calculate the energy generated by the production of biogas. In this study, the number of animals was obtained from the data of the Turkish Statistical Institute in 2012. The results of the study are shown in the Table 2.10. According to the study, the amount of cattle waste available in Turkey is about 76,7 million tons and 2,5 billion m^3 of biogas can be obtained from these wastes. They found this biogas equivalent to 11,9 billion kWh of electrical energy, 2,9 billion m^3 of natural gas and 1,9 billion liters of gasoline. They found the contribution of electrical energy to the Turkish economy to be 3,215 million TL. If natural gas production is made from the biogas obtained, approximately 2,9 billion m^3 of natural gas production can be made and the contribution of this production to the country's economy is estimated to be 2,3 billion TL. In tis study, the annual contribution of natural gas production from biogas to the regional economy is estimated to be as follows: 501,2 million to the Eastern Anatolia region, 390,7 million to the Central Anatolia region, 365,5 million to the Black Sea region, 354,4 million to the Marmara region, 335 million to the Aegean region, 2014 million to the Mediterranean region and 155,6 million. According to the study, the sample regions to be established biogas plant can be shown in the Northeast Anatolia, Aegean, Western Black Sea and Central Anatolia Regions.

Table 2.10. The number of animals, wet fertilizer, amount of biogas and electricity generation (Sancak et al., 2014)

Region	Number of Animals	Wet Fertilizer	Amount of Biogas	Electricity Generation (kWh)
Northeastern Anatolia	2.051.166	11.230.134	370.594.417	1.741.793.760
Middle East Anatolia	1.002.147	5.486.755	181.062.909	850.995.673
Southeast Anatolia	948.132	5.191.023	171.303.749	805.127.621
Istanbul	78.471	429.629	14.177.748	66.635.415
Western Marmara	1.224.233	6.702.676	221.188.297	1.039.584.997
Aegean	2.040.962	11.174.267	368.750.809	1.733.128.804
Eastern Marmara	844.040	4.621.119	152.496.927	716.735.557
Western Anatolia	974.748	5.336.745	176.112.595	827.729.196
Mediterranean	1.226.648	6.715.898	221.624.627	1.041.635.749
Central Anatolia	1.405.247	7.693.727	253.893.002	1.193.297.108
Western Black Sea	1.699.370	9.304.051	307.033.675	1.443.058.271
Eastern Black Sea	527.183	2.886.327	95.248.789	447.669.306
Turkey	**14.022.347**	**76.772.350**	**2.533.487.544**	**11.907.391.458**

Ulusoy et al. (2013) calculated that biogas potential from animal wastes and agricultural wastes for Turkey and Bursa. In this study, the animal and agricultural statistical data were obtained from the data of the Turkish Statistical Institute in 2010. Cattle, sheep, goat, buffalo, chicken and turkey-goose were evaluated as animal sources and wheat, barley, rice, corn, sunflower, sugar beet, potatoes, bean-pea, tomatoes and silage corn were also evaluated as agricultural wastes. Based on the these sorces, the biogas energy was calculated as TJ/year and the biogas amount was calculated as m^3/year. The results are presented in the Table 2.11. According to the study, it can be said that the potential of agricultural waste is an important raw material for the biogas plants, which are established and installed, especially when the products are processed as canned tomatoes and peas. Compared to animal waste capacity in Turkey and Bursa, cattle, chicken and sheep are mainly ranked, but in Bursa province, the percentage of chicken waste is seen to outweigh the distribution.

Table 2.11. Compost facilities in Turkey and biogas amount (Ulusoy et al., 2013)

	Taken to Landfills ton/year	**Biogas Amount m^3/year**	**Energy Equivalent Tj/year**	**Taken to Compost Ton/yıl**	**Biogas Amount m^3/year**	**Energy Equivalent Tj/year**
Turkey	1374686	17527260	36807	194452	24792630	521
Antalya	572294	72967485	1532	52110	6644025	140
Aydın	181219	23105423	485	1806	230265	5
Denizli	169476	21608190	454	376	47940	1
İstanbul	5590843	712832483	14969	140160	17870400	375
Bursa	605836	77244090	1622	15146	1931102	41
Bursa	605836	77244090	1622	54525	6951980	146

Acaroglu and Aydogan (2012) studied the biofuels potential from the agricultural wastes and governance policies which are about alternative fuels in Turkey. According to the study, using the animal and agricultural wastes, production of bioethanol and biodiesel were determined.

Topal and Arslan Topal (2012a) calculated biomass amount and thermal value obtained from agricultural products produced in Sivas province between 2005-2010. Pulses, industrial plants, cereals, oil seeds, fodder crops and tubers are used for biomass sources. They calculated the average biomass energy potential as MW. The results of the study are shown in the Table 2.12 as tons. According to the study, biomass energy quantities were determined that 25.092 MW from pulses, 6.615 MW from industrial plants, 287.761 MW from cereals, 20.777 MW from oil seeds, 58.469 MW from fodder crops and 3.270,39 MW from tubers.

Table 2.12. Average dry biomass amounts in Sivas (Topal and Arslan Topal, 2012a)

Type of Field Crops						
Years	**Pulses**	**Industrial Plants**	**Cereals**	**Fodder Crops**	**Oil Seeds**	**Tubers**
2005	548625	226930	12206287,5	1077917,5	935	83270
2006	406491,25	239409,5	11441446,5	1199951,5	7768,75	100485
2007	245159,75	204781,5	9870250,5	2306581,75	16280	115744,75
2008	295391,25	218743,25	8072660,75	2102996,5	8846,75	109573,75
2009	305844	260419,5	9725479,5	2821412	6465,25	154211,75
2010	355608	306471	9438852,5	2837249,25	3572,25	127715,5

Topal and Arslan Topal (2012b) investigated the biomass energy potentials of Afyonkarahisar between the 2006-2010. Using the data from the Turkish Statistical Institute for 2011, the amount of agricultural products that constitute biomass potential in Afyonkarahisar province was calculated using the fields in hectare. Pulses, industrial plants, cereals, fodder crops, oil seeds and tubers were used as biomass sources. They calculated the average biomass energy potential as MW. They evaluated the biomass energy potential of all products in Afyonkarahisar province. The results of the study are shown in the Table 2.13. It was determined that 57.185 MW for 2006, 58.100 MW for 2007, 51.230 MW for 2008, 49.161 MW for 2009 and 53.329 MW for 2010.

Table 2.13. Average dry biomass amounts for Afyonkarahisar region (Topal and Arslan Topal, 2012b)

	Type of Field Crops					
Years	**Pulses**	**Industrial Plants**	**Cereals**	**Fodder Crops**	**Oil Seeds**	**Tubers**
2006	356.043	650.576	9.519.859	587.166	625.724	334.276
2007	349.250	463.383	10.108.279	666.311	415.885	349.674
2008	342.386	487.935	8.700.115	580.503	385.412	320.169
2009	319.545	664.274	7.944.079	598.474	565.364	288.126
2010	304.466	719.048	8.763.230	566.445	568.155	338.198
Total	**1.671.690**	**2.985.216**	**45.035.562**	**2.998.899**	**2.560.541**	**1.630.443**

Fall and Werner (2011) worked on the biogas production opportunities and potential of Burkino Faso. In this study, wastes and biogas potential of agricultural and animal production enterprises, food industry enterprises and institutions within the framework of solid waste management were determined. As a result, the estimated number of biogas plants and plant costs were calculated by 2015.

Haefke (2010) studied the biogas potential of the state of Illinois in the United States. Using the statistical data of the country, meat, poultry and dairy producing enterprises and landfill sites were determined. The estimated total energy potential from these enterprises was determined.

Severoglu (2010) investigated that biomass is the world's fourth largest source of energy and meets about 14% of energy needs. Most of the biomass energy consists of 64% wood and wood waste, 24% municipal solid waste, 5% agricultural waste and 5% landfill gases.

Kurt and Nacar Kocer (2010) calculated the average amount of dry biomass obtained in a year and the average thermal value of dry biomass in Malatya city. In addition, they made a variety of recommendations to benefit from biomass potential for Malatya province. Using the data from the Turkish Statistical Institute for 2007, the amount of agricultural products that constitute biomass potential in Malatya province was calculated using the fields in hectare. Cereals, pulses, industrial plants, oil seeds and tubers plants were used as biomass sources. It was accepted that an average of 25-30 tons of dry biomass per year was obtained from a hectare field (average of 27.5 tons/ dry biomass). The results of the study are shown in the Table 2.14. In 2007, the average amount of dry biomass produced in one year in Malatya city center and districts was found as tons. The calorific value for dry biomass was theoretically accepted as 4000 kcal/kg. By assuming that 1 kcal = 10^{-7} TEP, the energy potential for dry biomass was calculated theoretically in TEP. According to the study, the total energy potential for dry biomass was calculated as 1.596.786,4 TEO (tons equivalent oil).

Table 2.14. Amount and thermal value of dry biomass belonging to districts in Malatya province (Kurt and Nacar Kocer, 2010)

Settlements	Total Sown Area, ha	Average Dry Biomass Amount, tons	Average Dry Biomass Energy Value, TEO
CITY CENTER	18.877,9	519.142,25	207.656,9
AKÇADAĞ	28.804,3	792.118,25	316.847,3
ARAPKİR	6.374,2	175.290,5	70.116,2
ARGUVAN	19.152	526.680	210.672
BATTALGAZİ	4.437,9	122.042,25	48.816,9
DARENDE	12.961,5	356.441,25	142.576,5
DOĞANŞEHİR	7.659,8	210.644,5	84.257,8
DOĞANYOL	295,6	8.129	3.251,6
HEKİMHAN	11.553	317.707,5	127.083
KALE	380,3	10.458,25	4.183,3
KULUNCAK	6.734,8	185.207	74.082,8
PÖTÜRGE	1.493	41.057,5	16.423
YAZIHAN	23.011,2	632.808	253.123,2
YEŞİLYURT	3.426,9	94.239,75	37.695,9
TOTAL	**145.162,4**	**3.991.966**	**1.596.786,4**

3. MATERIALS AND METHODS

3.1. Biomass Energy

Biomass is defined as organic matter containing renewable, plant and animal wastes and food, forest by-products and urban wastes. It is one of the largest energy sources among the renewable energy sources that do not pollute the environment. Biomass is becoming increasingly important because of the limited resources of fossil fuels and their negative effects on the environment. Biomass energy is widely used in the world as a source of energy obtained by direct processing of animal and plant wastes and provides significant contributions to the world economy. Biomass energy is defined as any kind of fuel obtained from biofuels and living organisms. Biomass energy is one of the sources of energy to be utilized as long as it is sustainable development that does not cause environmental pollution. Biomass is an environment where solar energy is collected and stored by photosynthesis. The solar rays that come on green plants and photosynthetic organisms perform two basic tasks which are temperature control for chemical reactions and light stimulation of electrons for carbon and oxygen production (Anonymus, 2007).

Biomass can be used in different areas. For example; Biomass can be used on a wide scale from heating to power generation, ptoduction of solid, liquid, gas fuel and obtaining chemicals. Heat and/or electricity can be generated from biomass during combustion processes. The gas product obtained during the gasification processes can be converted to heat or electricity and can be used as raw material in the production of liquid fuel or chemicals. Liquid fuels such as ethanol can be produced from sugary, starchy or cellulosic plants and biodiesel can be produced from oil plants.

Biomass energy have both advantages and disadvantages. The advantages of biomass energy are; it is possible to create settlements with self-sufficient energies with biomass, bioenergy creates business areas in rural areas, the harmful effects on the environment are less than other energy sources such as fossils, it can be grown everywhere and suitable for storage and bioenergy is a great advantage for local electricity generation because transmission losses are minimal. However, the disadvantages of biomass energy are; bioenergy production costs are higher than conventional fuels. The main reasons for this are the high cost of raw material supply, collection, transportation and storage. Bioenergy is a type of soil-based energy. The increase in demand for bioenergy will increase the pressure on the natural habitat and the soil where agricultural products are cultivated. The amount of excess water required to grow bioenergy products and the chemical fertilizers used to increase the yield of the soil have negative effects on the environment. High technology is needed. Because they need large residential areas, they create competition in terms of agricultural areas and energy efficiency is low when compared to fossil fuels (YEGM, 2018).

3.2. Biomass Sources

Biomass energy sources have different properties from fossil fuels, such as coal, oil, and natural gas. Biomass sources are generally non-homogenous in nature, with high water and oxygen content, low density and low thermal value; these properties have a negative impact on fuel quality. Biomass resources can be divided into three groups which are herbal resources, animal waste and city and industrial waste (Anonymus, 2007).

3.2.1. Herbal Resources

We can count forest products, energy forests, C4 and C3 plants, sugar and starch containing plants, oil seed plants and some algae and water plants as vegetable sources.

3.2.2. Animal Waste

It is used to obtain energy from fertilizers which are considered as animal waste. The biogas produced by fermentation of animal manure in an oxygen-free environment is an example of this.

3.2.3. City And Industrial Waste

It is used by converting solid, domestic and industrial wastes into methane gas with aerobic organisms in waste storage places. Table 3.1 shows the physical and chemical contents of biomass resources.

Table 3.1. The physical and chemical contents of biomass resources (Anonymus, 2007)

	Wood	**Cereal**	**Urban Waste**	**Animal Waste (Fertilizer)**
Carbon (%)	50-53	45	47,6	35,1
Hydrogen (%)	5,8-7	5,8	6	5,3
Nitrogen (%)	0-0,3	2,4	1,2	2,5
Sulphur (%)	0-0,1	0	0,3	0,4
Oxygen (%)	38-44	42,5	32,9	38,7
Volatile Matter (%)	77,1-87	80	77	76,5
Fixed Carbon (%)	13-21	0	11	0
Ash (%)	0,1-2	4	12	23,5
Moisture (%)	25,6-60	16	20	7-35
H/C Ratio	1,4-1,6	1,5	1,5	1,8
Calorific Value (MJ/Kg) (Dry)	19,8-21	16,7	19	13,4

3.3. Biomass Conversion Technologies

Biomass sources have low density and low thermal value in a non-homogenous structure with high water and oxygen content. These negative properties of biomass can be eliminated by physical processes and conversion processes. The biomass conversion systems, products and application areas are presented in Table 3.2 and Figure 3.1.

Table 3.2. The methods used in biomass sources and the fuels obtained using these techniques and application areas (YEGM, 2018)

Biomass	Conversion Method	Fuels	Application Areas
Forest Waste	Anaerobic Digestion	Biogas	Power generation, heating
Agricultural Waste	Pyrolysis	Ethanol	Heating, transportation
Energy Crops	Direct Combustion	Hydrogen	Heating
Animal Waste	Fermentation, Anaerobic Digestion	Methane	Heating, transportation
Organic Garbage	Gasification	Methanol	Aircraft
Algae	Hydrolysis		Synthetic oil, rockets
Energy Forests	Biophotolysis	Diesel	Product drying
Herbal And Animal Fats	Esterification Reaction	Diesel	Heating, transportation, greenhouse cultivation

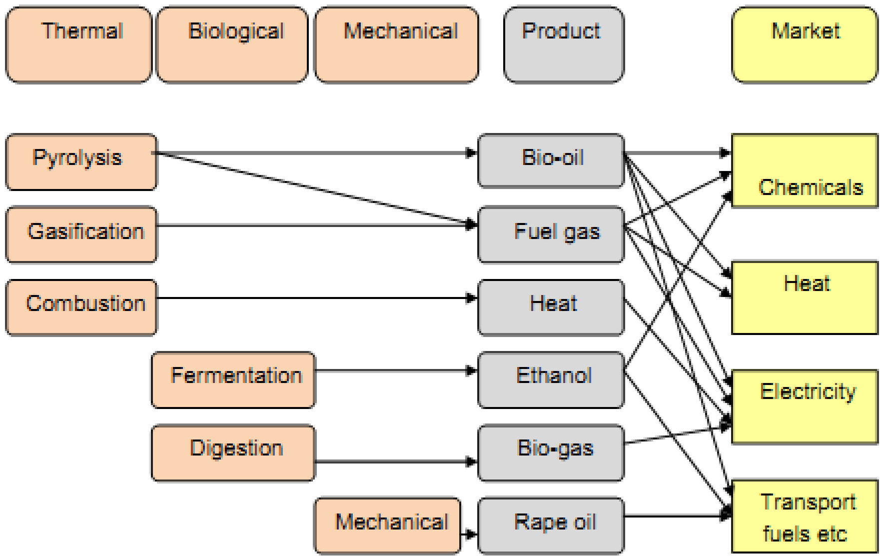

Figure 3.1. Representive of biomass conversion systems, products and application areas (Bilgen et al., 2015)

3.3.1. Direct Combustion

Although it is the oldest known method, new combustion systems have been developed to increase efficiency in recent years. This is an exothermic reaction and the resulting waste materials are carbon dioxide, water vapor and some metal oxides. The energy produced can be used in heat or steam supply, surface heating, industrial processes or electricity production. The amount of energy released as a result of combustion reaction is a function of biomass combustion enthalpy and the resulting combustion enthalpy can be calculated with the help of thermodynamic data (Klass, 1998).

Heat efficiency in combustion processes depends on the amount of moisture of the biomass. The moisture content of the biomass to be used for energy production should not exceed 50%. A biomass source with 50% humidity has about 20-22% thermal efficiency as a result of burning process provided with 25% air surplus (Jiınenez and Gonzâlez, 1991).

The selection of equipment in the systems where biomass is burned directly depends on the type, quantity and characteristics of the fuel used, the desired final energy form, the relationship of the system with other systems in the plant, the methods and environmental factors required for waste disposal. The main components of direct combustion are steam boilers that produce steam at high temperature and pressure and turbines that use this steam in the process of generating electricity. It has the option of working with cogeneration system since direct combustion technologies can produce electricity and heat at the same time (Yılmaz, 2015).

3.3.2. Anaerobic Digestion

Anaerobic digestion is a biological process and is carried out by microorganisms that can live in a completely oxygen-free environment. As a result of this process, methane gas (CH_4) is released (YEGM, 2018).

Anaerobic degradation applied in the world either alone or in other processes together, it is used to balance and eliminate domestic, urban, agricultural, industrial biomass waste and waste water. During decomposition, the total of organic wastes required by biological oxygen in the waste and pathogenic organisms reduced. As a result of anaerobic digestion, the biogas are basically composed of methane and carbon dioxide, and a small amount of other gases such as hydrogen sulfide and oxygen (Cagal, 2009).

3.3.3. Fermantation

There are different rates of hemicellulose and lignin in biomass. Cellulose is applied after enzymatic hydrolysis, chemical hydrolysis, enzymes or chemical processes can be broken down by glucose. Chemical hydrolysis conditions sometimes disrupt glucose so that this process must be done carefully. With the fermentation of glucose, many chemical products can be obtained that equivalent to the products obtained from ethanol, acetone, butanol and crude petroleum products.

In other words, it is a cheap biomass source for cellulose, glucose and many other products (YEGM, 2018).

It is the process of converting starch and cellulose into bioethanol in biomass (Celik, 2012). Alcohol fermentation is an old method which is used sugar. Cellulose and starch can also be provided. Methane fermentation is the event of digestion of biomass in the airless environment by methane bacteria (Yılmaz, 2015).

Fermentation converts biomass liquid to combustible fuel. The transformation of raw material energy with fermentation is in use on a wide scale with a global production of about 20 GW etanol (Cagal, 2009).

3.3.4. Pyrolysis

It is the oldest and simplest method which is used to obtain biomass gas, and it is a chemical and physical phenomenon that occurs when wood is heated up to 900°C in an oxygen-free environment. As a result of pyrolysis, substances are obtained like gases, tar, organic compounds, water and wood charcoal (YEGM, 2018).

Biomass can be converted into fuel products from biological (fermentation and anaerobic) or thermochemical (gasification, liquefaction) routes. Among these conversion processes, pyrolysis is considered to be an effective technology that can be converted into bio oils and gas products. In particular, pyrolysis is important in terms of high energy density and ease of use, storage and transport due to bio oils (Yang, 2010).

Pyrolysis can be divided into two main groups which are traditional pyrolsis and fast pyrolsis. Traditional pyrolysis is a technology used to produce coal and chemical substances, such as methanol and acetic acid. The purpose of rapid pyrolysis is the conversion of biomass in a liquid media. Fast pyrolysis can be easily stored and transported (Yanık, 2007).

Slow pyrolysis is a long-term pyrolysis method that is applied to ensure the conversion of biomass into more valuable products. Traditional pyrolysis is the slow decomposition of organic compounds consisting of most lignocellulose polymers in biomass by heat effect in an oxygen-free environment (Sharma and Bakhshi, 1993).

In fast pyrolysis, biomass is applied at a temperature of 673-923 K for a few seconds. As in traditional pyrolysis, the selectivity of certain special chemicals is also low in rapid pyrolysis. Rapid heating of biomass causes the degradation of polymeric components in biomass. As a result, primary gas products consisting of oxygenated monomers and polymers are formed. Fast and efficient cooling of the product obtained as a result of rapid pyrolysis and short in the reactor ensures the formation of specific products (Ganesh and Banerjee, 2001).

3.3.5. Gasification

Gasification is a process of thermochemical conversion, typically performed by partial oxidation of biomass at 800-900°C and obtained from a combustible mixture of gases (Goyal et al., 2008). It is the process of obtaining combustible gas by decomposition of solids such as carbon-containing biomass at high temperature. During this process, biomass is burned with air supplied to the fuel cell and the resulting products include hydrogen, methane, carbon monoxide, carbon dioxide and nitrogen (YEGM, 2018). The gasification process is designed to produce low or medium energy fuel gases, hydrogen or chemicals which are used for chemicals (Klass, 1998).

Biomass raw materials contain high amounts of volatile substances. Biomass raw materials are volatile at medium temperatures and these organic volatile substances can be converted into gas products immediately. Most solid products have high reactivity as a result of the gasification of biomass raw materials (Cagal, 2009). Gas produced as a result of gasification can be used in heat, steam production and combined heat and power plants (Kaltschmitt et al., 2007).

3.3.6. Biophotolysis

Biomass is the process of obtaining hydrogen and oxygen from some microscopic algae with the help of solar energy. These algae in seawater work as a kind of solar battery, which decomposes seawater photosynthetically (YEGM, 2018).

3.4. Biodiesel

Biodiesel is extracted as a result of a short chain alcohol (methanol or ethanol) reaction of vegetable or animal oils which are obtained from oily seed plants accompanied by a catalyst and used as a fuel. Although biodiesel does not contain petroleum, it can be used as a fuel by mixing it with an oil-based diesel at any rate. Pure biodiesel and diesel-biodiesel blends can be used to any diesel engine without any modification or minor modifications on the engine (YEGM, 2018).

3.4.1. Biodiesel Production Method

Although there are various methods of biodiesel production, the most widely used method today is the transesterification (alcoholysis) method. The oil that will be used as raw material in the reaction of transesterification is esterified by monohydric alcohol and by giving the fatty acid esters and glycerin as the main product in the presence of catalysts. Furthermore, in the esterification reaction, mono and di-glycerides, excess of reactants and free fatty acids are formed as by-products. In biodiesel production, canola (rapeseed), sunflower, soybean etc. vegetable oils obtained from oily seed plants, waste frying oils and animal oils and alcohol as methanol, alkaline catalysts as catalysts (sodium hydroxide, potassium hydroxide and sodium methyl) are preferred (YEGM, 2018). The biodiesel production is presented in Figure 3.2.

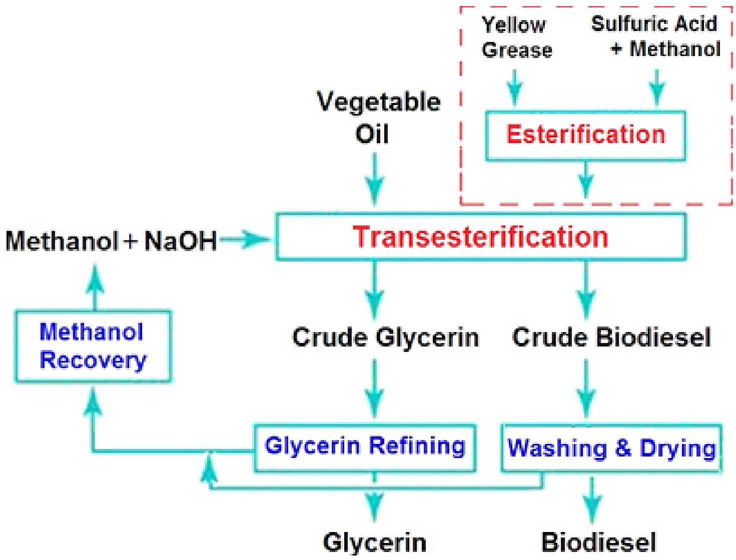

Figure 3.2. Technical representive of biodiesel production (Guo et al., 2015)

The following process steps are followed in biodiesel production (Anonymus, 2007);

a) Mixing of alcohol and catalyst: Sodium hydroxide (caustic soda) or potassium hydroxide is used as catalyst. The catalyst is a standard mixer and dissolves in alcohol using the mixer.

b) Reaction: The mixture of alcohol/catalysts is taken into the container where the reaction will take place and vegetable/waste vegetable or animal fat is added. The system is completely closed to the atmosphere in order to prevent the loss of alcohol. The mixture is mixed at specific temperature, time and speed and the reaction is completed.

c) Separation: After the reaction is complete, glycerin and biodiesel are obtained as two main products. The density of the glycerin phase in the same chamber is much higher than the biodiesel phase, and these two phases can be separated by gravity and the glycerin phase are easily removed from the bottom of settling vessel.

d) Alcohol removal: After the glycerin and biodiesel phases are separated, excess alcohol in each phase is removed by a flash evaporation or distillation process and the reaction mixture is neutralized. The glycerin and ester phases are separated.

e) Glycerine neutralization: The glycerine byproduct contains unused catalysts and soaps that are neutralized with an acid and are sent to storage tank for storage as raw glycerine. In some cases, the salt produced by the chemicals used during the recovery of this phase is recycled to be used as fertilizer. In many cases, salt is left in the glycerin. Water and alcohol are removed for the purpose of obtaining glycerin at 80-88% purity.

f) Neutralization and washing process: After separation from glycerin, the acid is washed together with the acid solution to remove and neutralize the residues in the biodiesel. Biodiesel which is removed from water is sent to storage.

3.4.2. Environmental Characteristics of Biodiesel

Some environmental characteristics of biodiesel are; As biodiesel is obtained from agricultural plants, it does not effect greenhouse effect as it converts carbon dioxide through photosynthesis and accelerates carbon cycle. The amount of sulfur contained in biodiesel, which is considered to be environmentally friendly, is much lower than the diesel, because it can easily decompose by bacteria. Therefore, it prevents negative environmental effects. Biodiesel converts carbon dioxide with photosynthesis in the biological carbon cycle and accelerates the carbon cycle, and also has no effect on increasing greenhouse gas emissions. Biodiesel provides lower exhaust gas emissions compared to diesel fuel. Compared to diesel fuel, the carbon monoxide emissions from biodiesel are less than 48%. The negative effects of biodiesel on the ozone layer are 50% less than diesel fuel. Biodiesel eliminates many environmental factors resulting from the use of diesel fuel. In biodiesel emissions, 80-90% reductions in the potential cancer-causing polyclical emissions from aromatic hydrocarbons and derivatives (pah) were determined (YEGM, 2018).

3.5. Bioethanol

Bioethanol is an alternative fuel that is obtained by fermentation of sugar, starch or cellulose essences such as sugar beet, corn, wheat and is blended with gasoline at certain rates. Bioethanol is a clear, colorless and characteristic liquid. It is a high octane fuel (113) and the boiling point is 78.5^{o}C and the freezing point is -114.1^{o}C. Raw materials of bioethanol are sugar beet, sugar cane, corn, sweet sorghum, potatoes, wheat, agricultural waste and woody plants (YEGM, 2018).

3.5.1. Production of Bioethanol

Starch is first converted to sugar, then the sugar is directly fermented with the conversion of bioethanol is provided. The following process steps are followed in bioethanol production (Anonymus, 2007);

a) Hydrolysis: The conversion of carbohydrates (cellulose and hemicellulose) into sugar at a certain temperature with concentrated and diluted sulfuric acid.

b) Fermentation: It is the conversion of the sugar released during hydrolysis into ethanol with yeast. In fermentation, the sugar solution is cooled, PH is adjusted and is given to continuous fermenters. Yeast is added and converts the added yeast sugar into 8% ethanol. The solution is transferred to the centrifugal and sent to the distillation process after deposition of the unwanted substances.

c) Purification: The solution is preheated and given to two series distillation columns. The first column separates the water and the second separate the remaining water with impurities and the fusel oil is obtained. Motor vehicles can be damaged by water and ethanol mixing, so it is useful to dry the bioethanol produced.

d) Drying: The solution is cooled and passed through an absorption column containing zeolite and the remaining water is separated. It takes 24 hours for the zeolite inside the colon to be ready for re-use. Dried bioethanol is ready for storage.

There are various application areas of bioethanol such as transportation, cogeneration and chemical products. Table 3.3 shows the application areas of bioethanol.

Table 3.3. Application areas of bioethanol (YEGM, 2018)

Transportation	**Cogeneration**	**Small House Appliances**	**Chemical Products**
Mixing with gasoline	Reducing NO_x emissions in fossil fuel plants	In ovens	Ethylene production
As additives in diesel engines	For CO2 trading	Lighting	Hydrogen production
In the latest technology vehicles (hybrid, fuel cell)	Steam injection gas turbines	Heating and cooling devices	Glycol ether
Agricultural machines	Combined cycle power plants	Storing food (cooling)	Ethyl acrylate
	Diesel power generators		Acetic acid
	Small cogeneration (or cooling) Stirling systems		Ethyl acetate
	Eliminating salinity of water		Aset aldehyde
			Ethyl ether
			Ethyl + chlorine

Some environmental and social benefits of bioethanol are; Bioethanol reduces exhaust emissions. Bioethanol blends greatly reduce hydrocarbon emissions resulting in a reduction of the ozone layer. High-level bioethanol blends reduce nitrogen oxides emissions by up to 20%. Bioethanol reduces benzene and butadine emissions with carcinogenic effect by 50%. Biodiesel provides a significant reduction in sulfur dioxide and particulate emissions. By creating a new market with high added value for agricultural products, it contributes to the development of the cultivation of plants used as ethanol raw materials. Provides new and domestic investment - employment opportunities with the development of energy-oriented agricultural activities. Increase in income and welfare levels of farmers engaged in energy-intensive agriculture. Creates an alternative domestic, renewable and strategic energy source for the needs of imported petroleum (YEGM, 2018).

3.6. Biogas

It is a colorless, odorless, air-light, bright blue flame that emerges as a result of organic based waste or residual fermentation in an oxygen-free environment. It is a mixture of 40-70% methane, 30-60% carbon dioxide, 0-3% hydrogen sulfide and very small amounts of nitrogen and hydrogen (YEGM, 2018).

3.6.1. Production Of Biogas

The following process steps are followed in biogas production (Anonymus, 2007);

a) Fermentation and hydrolysis: At this stage, bacterial groups called fermantative and hydrolytic bacteria convert carbonhydrates, proteins and fats into carbon dioxide, acetic acid and volatile organic compounds that can be dissolved in a large proportion of them.

b) Formation of acetic acid: At this stage, groups of acetogenic bacteria (acid-forming) that convert the essential fatty acids into acetic acid and some acetogenic bacteria convert essential fatty acids into acetic acid and hydrogen.

c) Formation of methane gas: In this final phase of anaerobic fermentation, the groups of bacteria forming methane are activated. While some methane-producing bacteria release methane and water using CO_2 and H_2, other methane-forming bacteria form release CH_4 and CO_2 by using the acetic acid as a result of the second stage.

Biogas efficiency from various sources and methane quantities in biogas is shown in Table 3.4. According to the table, the highest methane ratio is found in waste water sludge and pig fertilizer.

Table 3.4. Biogas efficiency from various sources and methane quantities in biogas (YEGM, 2017)

Source	Biogas Efficiency (liter/kg)	Methane Ratio (&)
Cattle fertilizer	90-310	65
Poultry fertilizer	310-620	60
Pig fertilizer	340-550	65-70
Wheat straw	200-300	50-60
Rye straw	200-300	59
Barley straw	290-310	59
Corn stalks and scraps	380-460	59
Linen and hemp	360	59
Grass	280-550	70
Vegetable scraps	330-360	Variable
Agricultural scraps	310-430	60-70
Peanut shell	365	-
Fallen tree leaves	210-290	58
Algae	420-500	63
Waste water sludge	310-800	65-80

Some benefits of biogas are; Animal and plant organic waste/residual substances are mostly burned directly or given as fertilizer to agricultural lands. This type of waste is used especially in heat generation by burning is seen more widely. In this way, the desired property can not be produced heat, heat production after the use of waste as fertilizer is not possible. Biogas technology allows both the energy to be obtained and the waste to be taken into the soil from organic origin wastes. Cheap and environmentally friendly source of both energy and fertilizer. Provides recycling of waste. Weed can be found in animal manure seed germination feature loses. The smell of animal manure is disappearing to a degree that can not be felt (YEGM, 2018).

4. RESULT AND DISCUSSION

4.1. Biomass Potential of Turkey

Biomass resources are studied in two main groups which are wet biomass and dry biomass. Biomass sources that can be used in energy production; plant-based wastes, animal-origin wastes and city and industry origin wastes can be examined under three main headings. According to Turkey Biomass Energy Potential Atlas which is develop by the General Directorate of Renewable Energy, Turkey’s biomass potential in resource based is shown in Table 4.1.

Table 4.1. Turkey’s biomass potential in resource based (BEPA, 2018)

Source	Potential(TOE/year)
Energy Value of Animal Wastes	1 176 198
Energy Value of Agricultural Wastes	39 877 285
Energy Value of Urban Organic Waste	2 315 414
Energy Value of Forest Wastes	859 899
Total	44 228 795

It is clearly seen in Figure 4.1 that the major biomass resource is agricultural waste which is constituted 90% of all resources according to the Turkey Biomass Energy Potential Atlas. However, the other resources which is used for generating energy from biomass have low ratios that are between 2% and 5%.

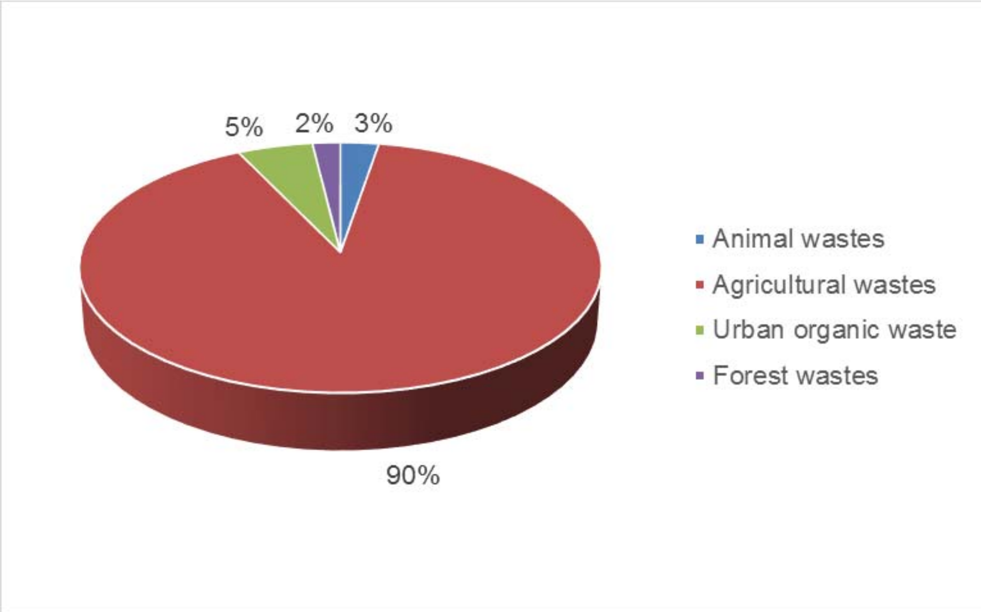

Figure 4.1. Percent ratio of Turkey's biomass potential in resource based (BEPA, 2018)

Many agricultural waste in Turkey can not be evaluated because of the scattered waste, transportation and labor costs. Although 50-65 Mtoe (million tons of oil equivalent) agricultural waste and 11.05 Mtoe animal waste are produced in Turkey per year, only 60% of these waste produced can be used for energy production. It is known that the energy obtained from agricultural and animal wastes is equal to 22-27% of Turkey's annual energy consumption.

4.1.1. Average Biomass Amount and Heat Value From Agricultural Production

Turkey is a country where agriculture has been developed. Vegetable production is often characterized by imbalances and inefficiencies due to factors such as unplanned vegetable production, fluctuations in product prices, high production costs of farmers, migrations to cities, and so on. If land ownership is used more efficiently and product prices and crop production potential are increased, the cost of raising crops will be balanced. Table 4.2. shows that Turkey's presence and information on the use of land are given, without meadow and pasture fields, according to Turkish Statistical Institute datas.

Table 4.2. The existence of Turkey's land (TSI, 2018a)

		Land (decare)
Total land		233 757 880
Area of cereals and other crop products	**Sown area**	155 317 343
	Fallow land	36 974 137
Area of vegetable gardens		7 982 650
Area of fruits, everage and spices		33 433 816
Ornamental plants area		49 934

It is clearly seen in Figure 4.2 that the sown area is accounted for 67% of all Turkey’ land without meadow and pasture fields while the area of vegatable gardens have the lowest ratio which is 3%. However, the secon main areas are fallow land and area of fruits, everage and spices which are 16% and 14%,respectively.

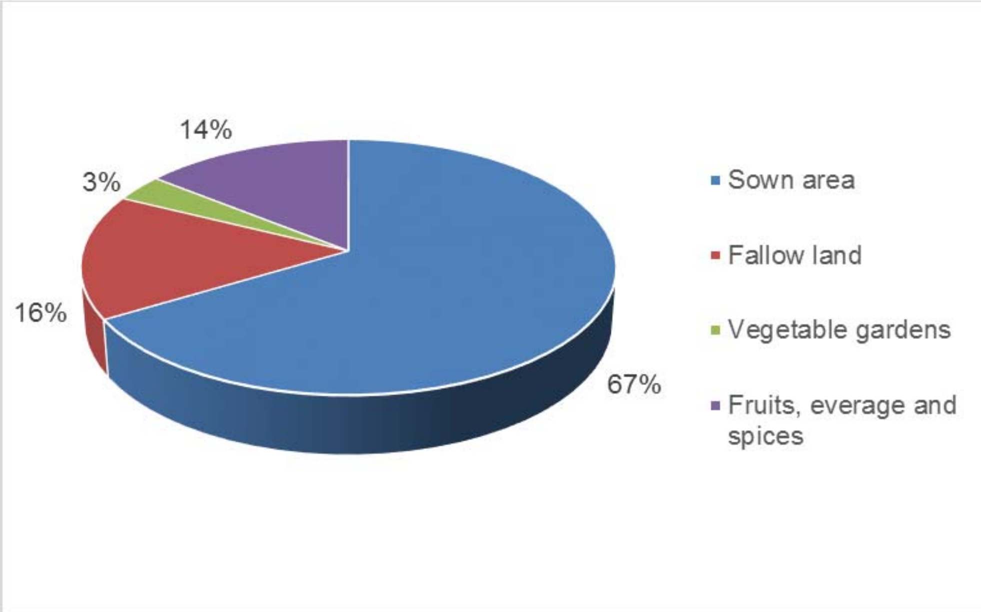

Figure 4.2. The rate of existence of Turkey's land

The energy potential that can be obtained from agricultural wastes in our country is 5,4 million tons of oil equivalent. In addition, our country has a potential equivalent of 5,9 million tons of oil equivalent as wood, forest and industrial waste.

The total cultivation areas of the biomass potential products (oil seeds, edible roots and tubers, cereals, dry pulses, plants used in perfumery, in pharmacy or for similar purposes and fodder crops seed, fodder crops production, raw materials used in textiles) using the 2017 TSI data are given in the following tables.

The total sown area of plantation of oil seeds which are used as a biomass source is illustrated in Table 4.3. Overall, there are six different type of seeds that are made of cultivation and there are huge differences between the them. It can be seen that the sunflower has the highest value (84%) and is considered as a major source whereas the another sources have the nearly same ratios that are between 2% and 5%, but the soybean, sesame and safflower have the same rate (3%) (Figure 4.3).

Table 4.3. Total cultivation areas of the oil seeds (TSI, 2018a)

Oil Seeds	
Types	**Sown Area (decare)**
Soybean	316 695
Groundnut	419 495
Sunflower	7 796 217
Sesame	280 316
Safflower	273 762
Rapeseed	165 195
Cotton seed	-
Flax (seed)	0
Hemp (seed)	24
Poppy (seed)	-
Total	9 251 704

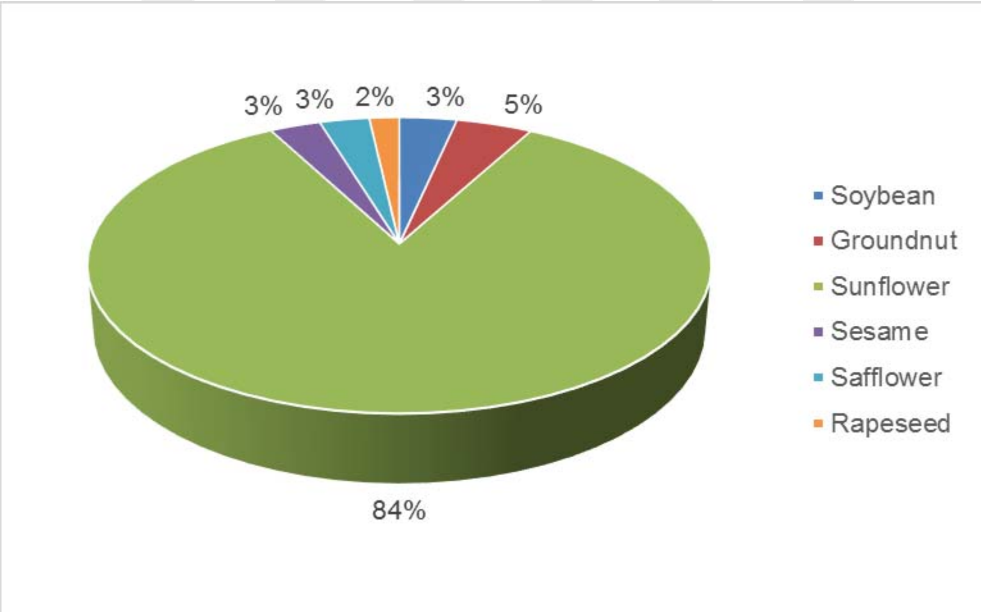

Figure 4.3. The ratio of plantation of oil seeds

The total sown area of plantation of edible roots and tubers which are used as a biomass source is illustrated in Table 4.4. In general, there are three main sources which are tobacco, sugar beets and potatoes (other) as a source of biomass. It is clearly seen that while the area of sugar beets has the highest percentage (59%), the tobacco has the least proportion (16%) (Figure 4.4).

Table 4.4. Total cultivation araes of the edible roots and tubers (TSI, 2018a)

Edible Roots and Tubers	
Types	**Sown Area (decare)**
Tobacco	950 000 (*)
Sugar beets	3 392 171 (*)
Potatoes (other)	1 428 835
Potatoes (sweet)	792
Jerusalem artichokes	524
Sugar cane	32
Total	4 343 519 (*)

(*) estimated

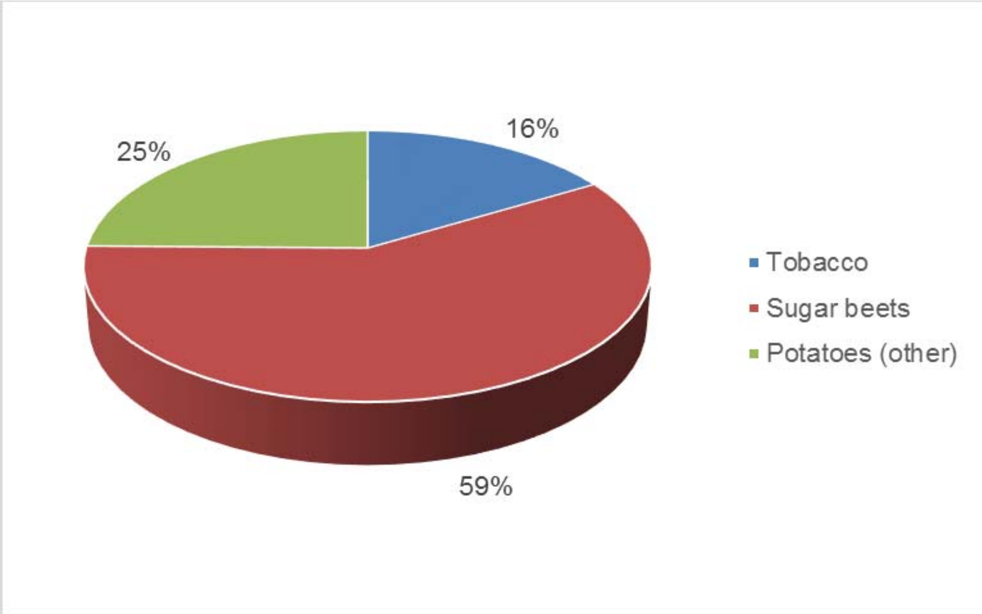

Figure 4.4. The ratio of plantation of edible roots and tubers

The sown area of plantation of cereals which are used as a biomass source is showed in Table 4.5. In general, there are twelve different type of cereal seeds even though there are three basic cereals according to the cultivated areas. According to the figure, the wheat area has the largest rate (71%) so that it is considered as a major biomass source between cerals. The barley and maize have the highest second and third ratio that are 23% and 6%, in order of (Figure 4.5).

Table 4.5. Total cultivation araes of the cereals (TSI, 2018a)

Cereals	
Types	**Sown Area (decare)**
Wheat	76 688 785
Barley	24 247 372
Maize	6 390 844
Rice in the husk	1 095 599
Rye	1 010 923
Oats	1 128 796
Spelt	30 764
Millet	21 779
Canary gras	5 743
Mixed grain	3 300
Triticale	456 414
Sorghum	6
Total	111 080 325

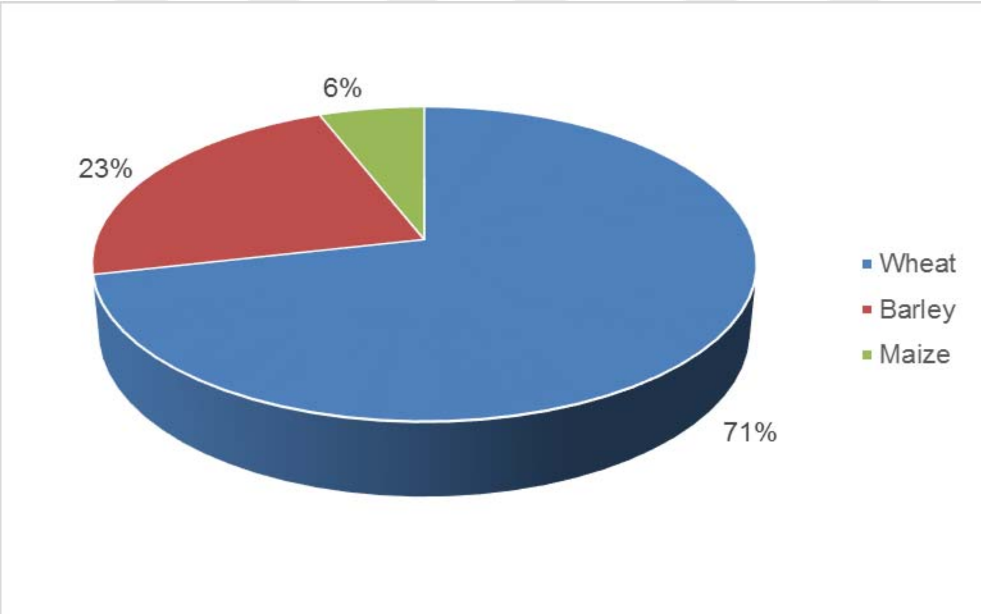

Figure 4.5. The ratio of plantation of cereals

The sown area of dry pulses which are used as a biomass source is showed in Table 4.6. Overall, there are ten different type of dry pulses seeds even though there are five main dry pulses according to the cultivated areas. According to the figure, the chick pea area has the largest rate (51%) so that it is considered as a major biomass source between dry pulses. There are two different type of lentil which are red and green. Red lentil area has the 34% rates which is very high when compared to the green lentil area (3%) (Figure 4.6).

Table 4.6. Total cultivation araes of the dry pulses (TSI, 2018a)

Dry Pulses		
Types		**Sown Area (decare)**
Broad bean		53 123
Pea		9 415
Chick pea		3 953 099
Bean (dry)		897 221
Lentil	**Red**	2 693 181
	Green	232 201
Kidney beans		14 129
Wild vetches		28 410
Fenugreek		14 499
Grass pea		9 555
Total		7 904 833

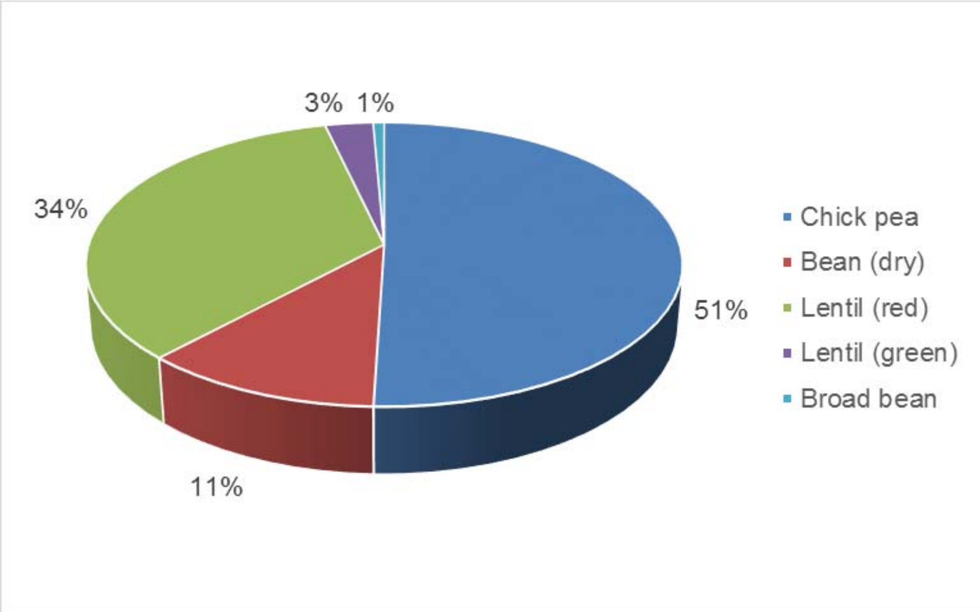

Figure 4.6. The ratio of plantation of dry pulses

The cultivation area of plants which is used in perfumery, in pharmacy or for similar purposes and fodder crops seed is showed in Table 4.7. The cow vetches and poppy have the highest first and second ratio that are 61% and 30%, respectively while other types of plants have the lowest proportion which is between 1% and 4%, but the sugar beet seed, lavander and salvia have the same percentge (1%) (Figure 4.7).

Table 4.7. Total cultivation araes of the plants used in perfumery, in pharmacy or for similar purposes and fodder crops seed (TSI, 2018a)

Plants Used in Perfumery, in Pharmacy or for Similar Purposes and Fodder Crops Seed	
Types	**Sown Area (decare)**
Poppy (capsule)	237 314
Lupin	3 714
Hop	3 300
Cow vetches (grain)	476 722
Alfalfa (seed)	15 848
Clover (seed)	0
Sainfoin (seed)	1 155
Melissa	207
Nettle	5
Salvia	4 123
Rose (for oil)	33 277
Lavander	6 606
Sugar Beet Seed	8 072
Total	790 343

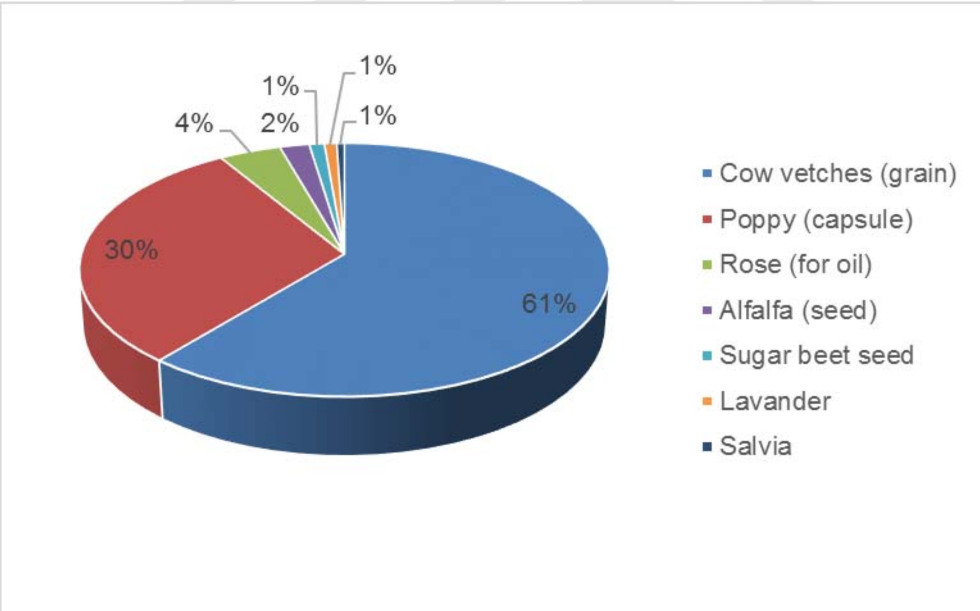

Figure 4.7. The ratio of plantation of plants used in perfumery, in pharmacy or for similar purposes and fodder crops seed

Table 4.8 shows the total sown area of fodder crops. In general, although there are eight different types of fodder crops, three of them have same ratio (1%) which are wheat, barley and grass pea. The maize and cow vetches have the nearly same percentage that are 25% and 23%, respectively. The planting area of sainfoin (10%) also has twice the rate of oats and the alfalfa has the largest proportion (34%) (Figure 4.8).

Table 4.8. Total cultivation araes of the fodder crops (TSI, 2018a)

Fodder Crops	
Types	**Sown Area (decare)**
Sainfoin	1 961 808
Wild vetches	29 273
Maize	4 862 296
Beets for fodder	20 620
Turnip (for fodder)	69 823
Wheat (Green)	302 033
Barley (Green)	149 419
Rye (Green)	14 810
Pea (Fodder) (Green)	69 595
Cow vetches	4 456 256
Clover	4 000
Alfalfa	6 594 319
Oats (Green)	1 063 555
Sorghum (Green)	17 929
Triticale (Green)	95 258
Grass pea (Green)	142 649
Italian ryegrass	77 268
Total	19 930 911

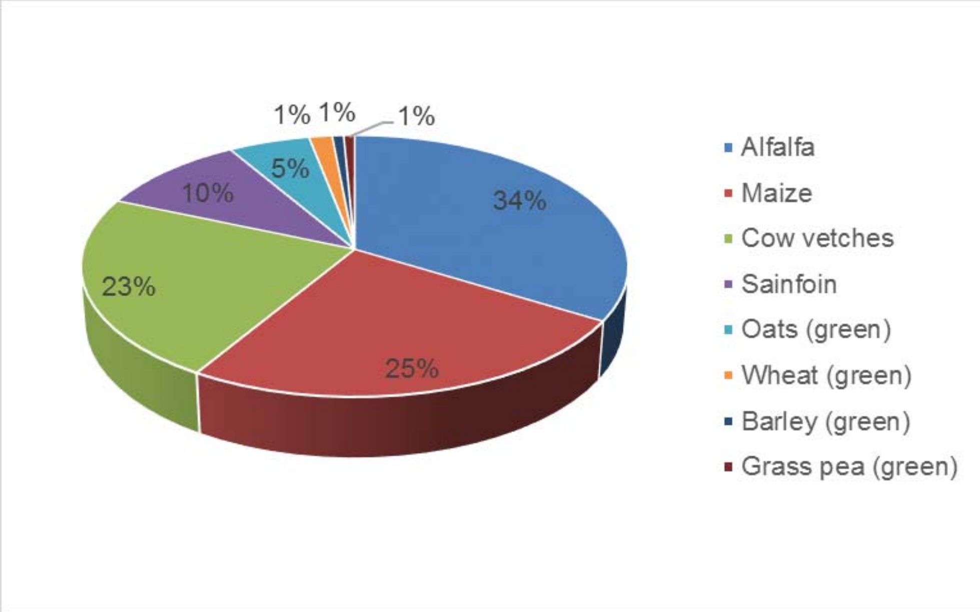

Figure 4.8. The ratio of plantation of fodder crops

The sown area of raw materials used in textiles is illustrated in Table 4.9. It is clearly seen in Table 4.9 that the amount of raw cotton are very high compared to the other types, therefore the rate of raw cotton can be assessed 100%.

Table 4.9. Total cultivation araes of the raw materials used in textiles (TSI, 2018a)

Raw Materials Used in Textiles	
Types	**Sown Area (decare)**
Cotton (raw)	5 018 534
Cotton (lint)	-
Flax (fibre)	50
Hemp (fibre)	46
Total	5 018 630

When Table 4.10 is examined by products for sown area, the cereals have the highest rate (70%) whereas the raw materials used in textiles and edible roots and tubers have the lowest same ratios (3%) (Figure 4.9). In table, the estimated data have not been taken into account for Total 1, however the total value is obtained by adding the estimated value for Total 2.

Table 4.10. Total cultivation araes of the biomass potential products (TSI, 2018a)

Products	**Sown Area, decare**	**Sown Area, hectare**
Oil Seeds	9251704	925170,4
Edible Roots and Tubers	4343519(**)	434351,9(**)
Cereals	111080325	11108032,5
Dry Pulses	7904833	790483,3
Plants Used in Perfumery, in Pharmacy or for Similar Purposes and Fodder Crops Seed	790343	79034,3
Fodder Crops Production	19930911	1993091,1
Raw Materials Used in textiles	5018630	501863
Total 1	153976746	15397674,6
Total 2	158320265	15832026,5

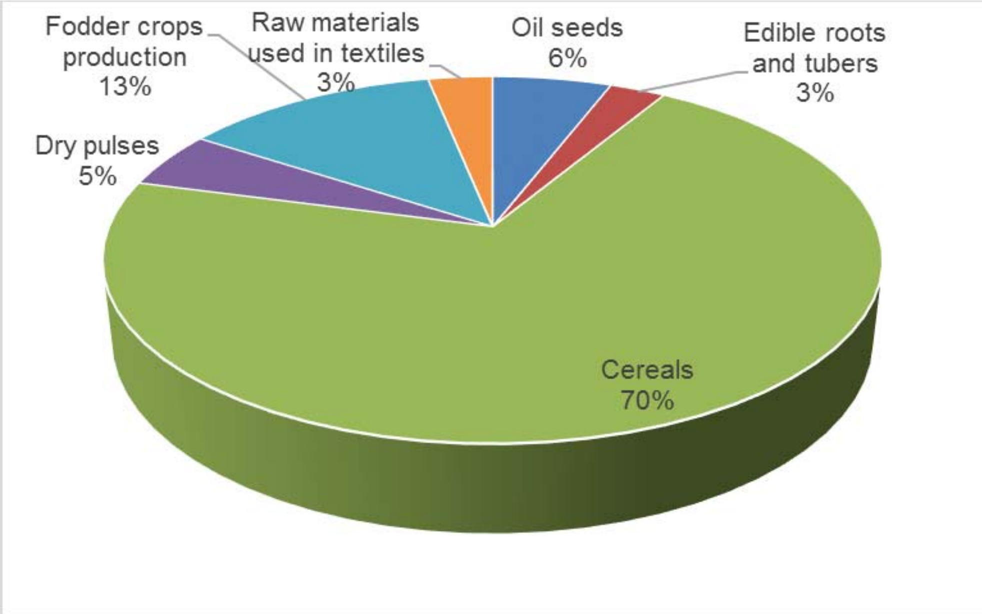

Figure 4.9. The ratio of cultivation araes of the biomass potential products

It is obtained from a medium fertile hectare area with 80-100 tons of wet and 25-30 tons of dry biomass per year (Balat, 2005). In general, the thermal value of dry biomass varies between 3800-4300 kcal/kg (Kocer and Unlu, 2007). In the calculation of energy equivalent of agricultural biomass, 1 kcal = 1.10^{-7} TEO (tons equivalent oil) and 1 TEO = 0.01163 MW equivalents were used (Topal and Arslan Topal, 2012).

According to this, the average amount of dry biomass that can be produced in a year, average dry biomass thermal value and average dry biomass energy value were calculated using the following equations (Demir et al., 2015; Kuş et al., 2016).

$$\text{ADBA} = \left(\frac{25+30}{2}\right) X\,A \quad (4.1)$$

$$\text{ADBTV} = ADBA\,X\left(\frac{3800+4300}{2}\right) \quad (4.2)$$

$$\text{ADBEV} = ADBTV\,X\,1.10^{-7} \quad (4.3)$$

ADBA: Average Dry Biomass Amount, tons
ADBTV: Average Dry Biomass Thermal Value, kcal/kg
ADBEV: Average Dry Biomass Energy Value, TEO
A: Area, ha

It is clearly seen in Table 4.11 that although there are seven main agricultural crops, plants used in perfumery, in pharmacy or for similar purposes and fodder crops seed have very low quantity when compared to the other types so that it can be neglected in Figure 4.10 and ** represents the estimated value.

Table 4.11. Average dry biomass amount and value and equivalent potential of dry biomass energy

Products	**Average Dry Biomass Amount, tons**	**Average Dry Biomass Energy Value, TEO**	**Equivalent Potential of Dry Biomass Energy, MW**
Oil Seeds	25442186	10304085,33	119836,5124
Edible Roots and Tubers	11944 677,25 (**)	4837597,286 (**)	56261,22155 (**)
Cereals	305470893,8	123715712	1438813,73
Dry Pulses	21738290,75	8804007,754	102390,6102
Plants Used in Perfumery, in Pharmacy or for Similar Purposes and Fodder Crops Seed	2173443,25	880244,5163	10237,24372
Fodder Crops Production	54810005	22198052,13	258163,3462
Raw Materials Used in textiles	13801232,5	5589499,163	65005,87526
Total 1	423436051,3	171491600,9	1994447,318
Total 2	435380728,6	176329198,2	2050708,539

The highest rate of energy in dry biomass is obtained from cereals (70%) while raw materials used in textiles and edible toots and tubers have both same and the least rates (3%). The total ratio of these two crops is equal to the oil seed's proportion. Fodder crops production also has the second largest rate (13%). The rates of dry biomass amount and energy value are same because of the constant coefficients. In table, the estimated data have not been taken into account for Total 1, however the total value is obtained by adding the estimated value for Total 2.

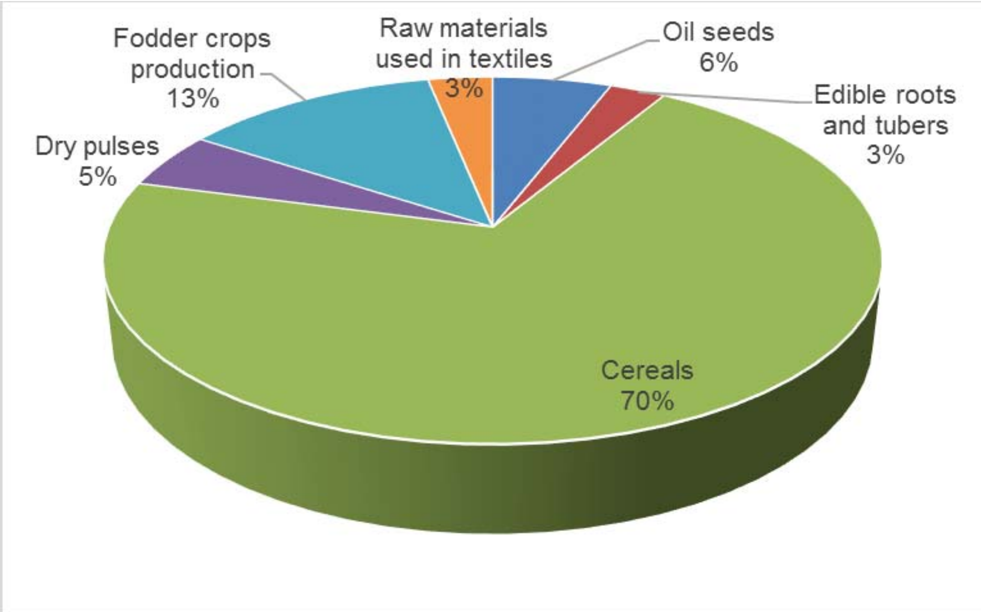

Figure 4.10. The ratio of equivalent potential of dry biomass energy

4.1.2. Average Biomass Amount and Heat Value From Agricultural Production By Region

There are seven different types of agricultural products (perfumery, pharmacy plants, sugar beet, fodder crops seed/potatoes, dry pulses, edible roots and tubers/raw materials in textiles/fodder crops/sugar beet/cereals/oil seeds) that are used for sources of biomass.

It is obtained from a medium fertile hectare area with 80-100 tons of wet and 25-30 tons of dry biomass per year (Balat, 2005). In general, the thermal value of dry biomass varies between 3800-4300 kcal/kg (Kocer and Unlu, 2007). In the calculation of energy equivalent of agricultural biomass, 1 kcal = 1.10^{-7} TEO (tons equivalent oil) and 1 TEO = 0.01163 MW equivalents were used (Topal and Arslan Topal, 2012).

According to this, the average amount of dry biomass that can be produced in a year, average dry biomass thermal value and average dry biomass energy value were calculated using the following equations (Demir et al., 2015; Kuş et al., 2016).

$$\text{ADBA} = \left(\frac{25+30}{2}\right) X\, A \tag{4.4.}$$

$$\text{ADBTV} = ADBA\, X \left(\frac{3800+4360}{2}\right) \tag{4.5}$$

$$\text{ADBEV} = ADBTV\, X\, 1.10^{-7} \tag{4.6}$$

ADBA: Average Dry Biomass Amount, tons
ADBTV: Average Dry Biomass Thermal Value, kcal/kg
ADBEV: Average Dry Biomass Energy Value, TEO
A: Area, ha

According to the Turkish Statistical Institute data in 2017 (TSI, 2018b), the total sown area, average dry biomass amount and value and equivalent potential of dry biomass energy are shown in Table 4.12.

Table 4.12. Total sown area, average dry biomass amount and value and equivalent potential of dry biomass energy by region

	Total Sown Area, ha	**Average Dry Biomass Amount, tons**	**Average Dry Biomass Energy Value, TEO**	**Equivalent Potential of Dry Biomass Energy, MW**
Turkey	15856351	436049652,5	176600109,3	2053859
Istanbul	66163	1819482,5	736890,4125	8570,035
Western Marmara	1412744	38850460	15734436,3	182991,5
Aegean	1619592	44538780	18038205,9	209784,3
Eastern Marmara	829855	22821012,5	9242510,063	107490,4
Western Anatolia	2451271	67409952,5	27301030,76	317511
Mediterranean	1544298	42468195	17199618,98	200031,6
Central Anatolia	2325219	63943522,5	25897126,61	301183,6
Western Black Sea	1370582	37691005	15264857,03	177530,3
Eastern Black Sea	97936	2693240	1090762,2	12685,56
Northeastern Anatolia	972875	26754062,5	10835395,31	126015,6
Middle East Anatolia	827748	22763070	9219043,35	107217,5
Southeast Anatolia	2338071	64296952,5	26040265,76	302848,3

For sown area, the Southeast Anatolia, Central Anatolia and Western Anatolia have the same highest rates (15%) whereas the Eastern Black Sea has the lowest rate (1%). It is clearly seen that the Istanbul has very low quantity, that the percentage of its corresponds to 0%, when compared to the other region. The Aegean and Mediterrenean have also same percentages and the total of them are equal to 20%. The Western Marmara and Western Black Sea have also same ratios, that are approximately same rate for the total of Aegean and Mediterrenean (20%), and the total of them are equal to 18%. The Eastern Marmara and Middle East Anatolia have the second least rate (5%) (Figure 4.11).

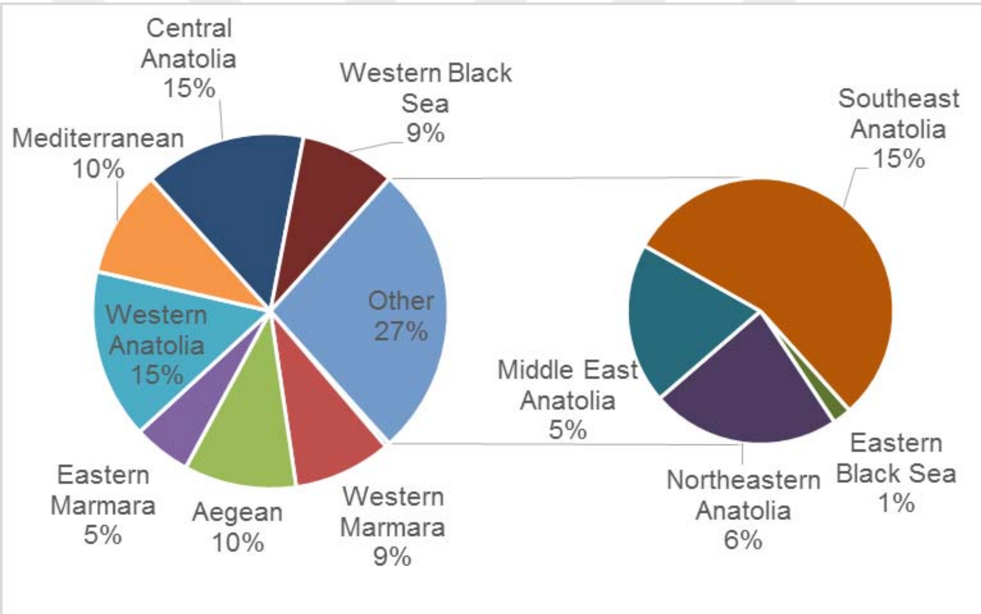

Figure 4.11. Sown area rate by region

For dry biomass amount that the Southeast Anatolia, Central Anatolia and Western Anatolia have the same highest rates (15%) whereas the Eastern Black Sea has the lowest rate (1%). It is clearly seen that the Istanbul has very low quantity, that the percentage of its corresponds to 0%, when compared to the other region. The Aegean and Mediterrenean have also same percentages and the total of them are equal to 20%. The Western Marmara and Western Black Sea have also same ratios, that are approximately same rate for the total of Aegean and Mediterrenean (20%), and the total of them are equal to 18%. The Eastern Marmara and Middle East Anatolia have the second least rate (5%) (Figure 4.12).

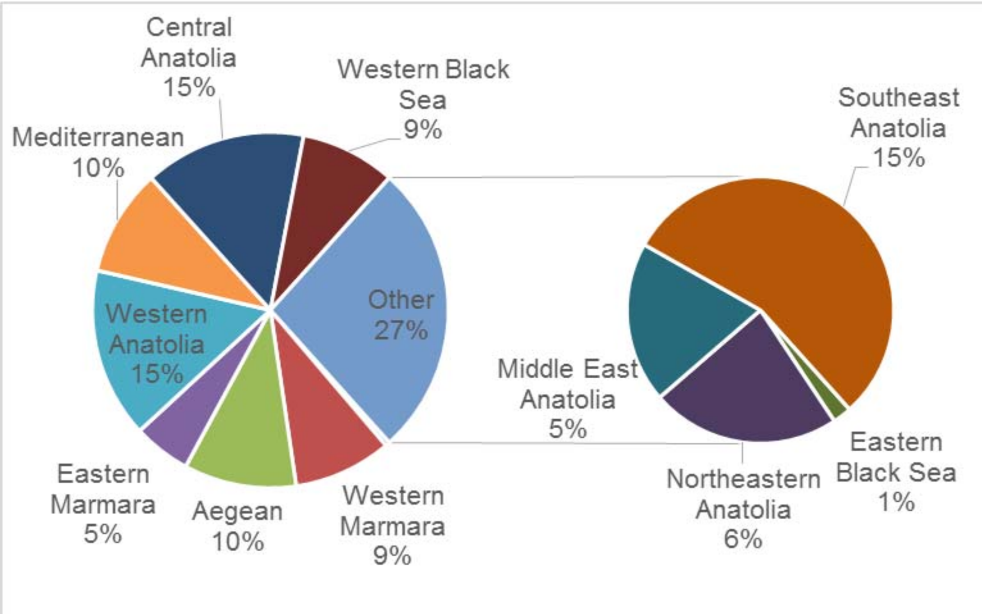

Figure 4.12. Potential of average dry biomass rate by region

For dry biomass energy value that the Southeast Anatolia, Central Anatolia and Western Anatolia have the same highest rates (15%) whereas the Eastern Black Sea has the lowest rate (1%). It is clearly seen that the Istanbul has very low quantity, that the percentage of its corresponds to 0%, when compared to the other region. The Aegean and Mediterrenean have also same percentages and the total of them are equal to 20%. The Western Marmara and Western Black Sea have also same ratios, that are approximately same rate for the total of Aegean and Mediterrenean (20%), and the total of them are equal to 18%. The Eastern Marmara and Middle East Anatolia have the second least rate (5%) (Figure 4.13).

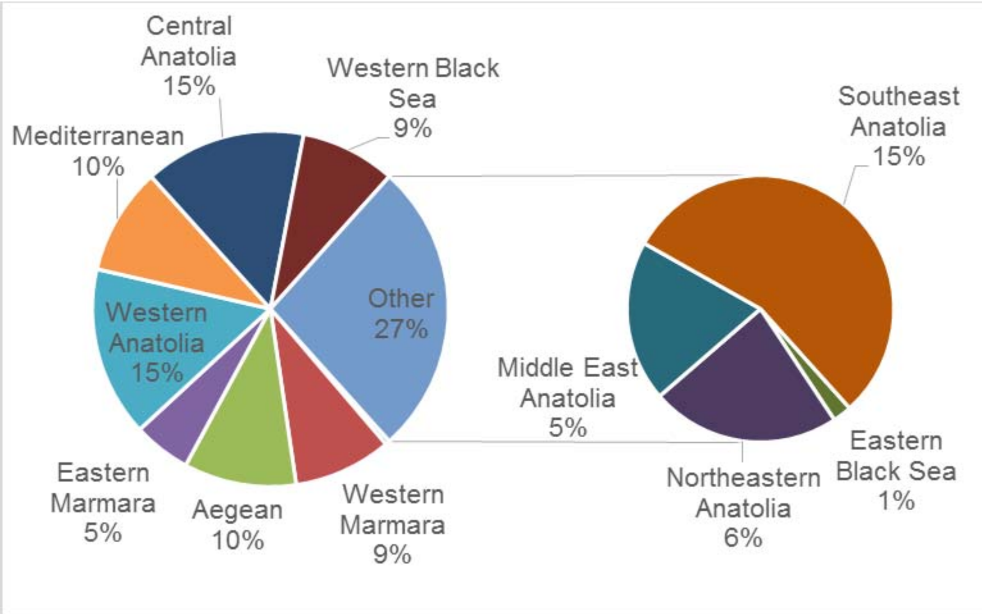

Figure 4.13. Potential of average dry biomass energy rate by region

For equivalent potential of dry biomass energy; the Southeast Anatolia, Central Anatolia and Western Anatolia have the same highest rates (15%) whereas the Eastern Black Sea has the lowest rate (1%). It is clearly seen that the Istanbul has very low quantity, that the percentage of its corresponds to 0%, when compared to the other region. The Aegean and Mediterrenean have also same percentages and the total of them are equal to 20%. The Western Marmara and Western Black Sea have also same ratios, that are approximately same rate for the total of Aegean and Mediterrenean (20%), and the total of them are equal to 18%. The Eastern Marmara and Middle East Anatolia have the second least rate (5%) (Figure 4.14).

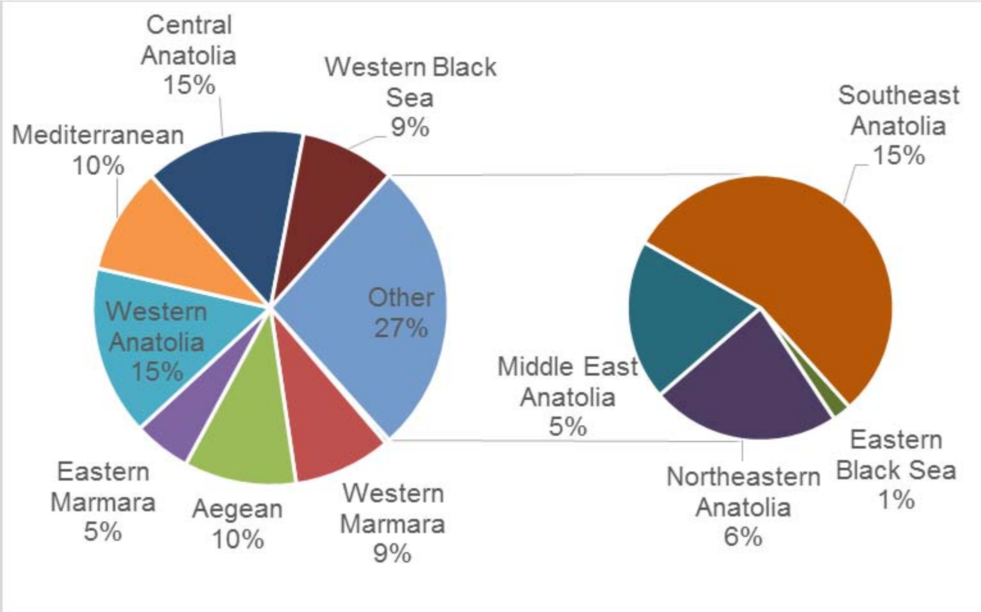

Figure 4.14. Equivalent potential of dry biomass energy rate by region

The amount of sown areas of some agricultural products that are perfumery, pharmacy plants, sugar beet, fodder crops seed, potatoes, dry pulses, edible roots and tubers and raw materials in textiles used as biomass sources are given in Table 4.13 by region in 2017 as hectare.

Table 4.13. Total cultivation areas of the biomass potential products by region (TSI, 2018b)

	Sown Area of Agricultural Biomass Sources, hectare		
	Perfumery, Pharmacy Plants, Sugar Beet, Fodder Crops Seed	**Potatoes, Dry Pulses, Edible Roots and Tubers**	**Raw Materials in Textiles**
Turkey	78789	930701	501488
Istanbul	3	50	-
Western Marmara	454	11539	260
Aegean	15846	101187	107391
Eastern Marmara	1944	18875	-
Western Anatolia	15415	131200	-
Mediterranean	6947	101259	100131
Central Anatolia	6896	195447	-
Western Black Sea	28076	29134	5
Eastern Black Sea	-	13086	-
Northeastern Anatolia	1147	10287	534
Middle East Anatolia	78	23730	-
Southeast Anatolia	1983	294908	293167

For Turkey in 2017, the total sown area for perfumery, pharmacy, etc. plants, sugar beet and feed crops seeds is 78.520 hectares. Considering the amount of sown area, it is observed that the Western Black Sea (30%), Aegean (20%) and Western Anatolia (20%) regions have a large proportion of dry biomass potential (Figure 4.15).

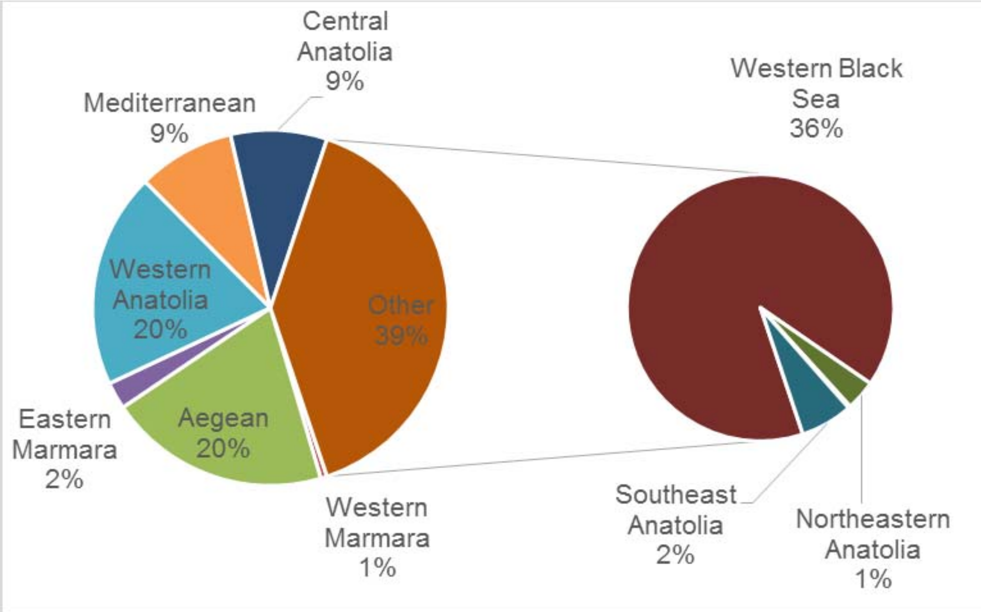

Figure 4.15. Perfumery, pharmacy etc. plants, sugar beet, fodder crops seed rate by region

The total sown area for potatoes, dry pulses, edible roots and tubers is 930.701 hectares. Considering the amount of sown area, it is observed that the Southeast Anatolia (32%), Central Anatolia (21%), Western Anatolia (14%) and Mediterranean (11%) regions have a large proportion of dry biomass potential in 2017 (Figure 4.16).

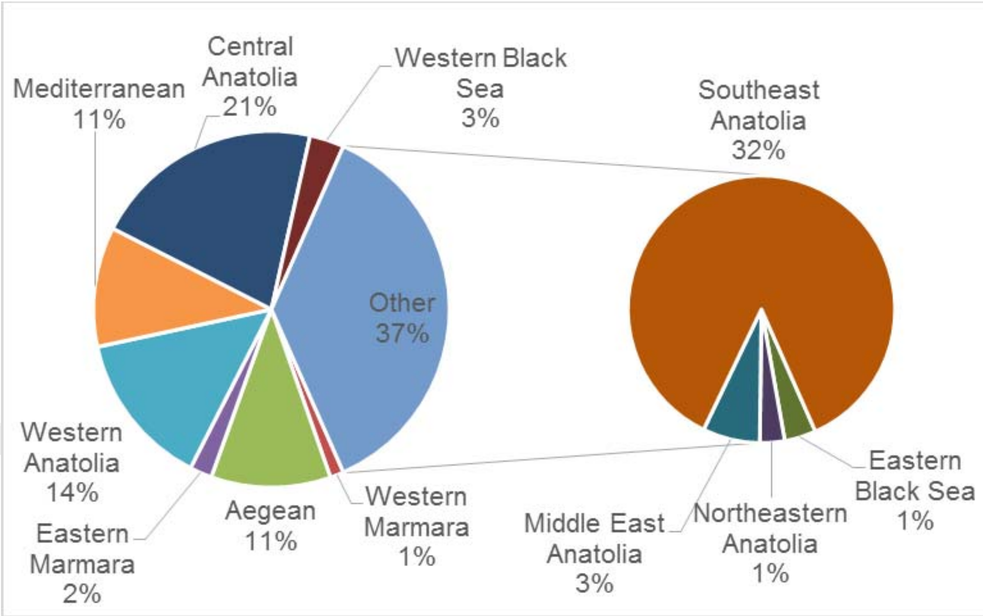

Figure 4.16. Potatoes, dry pulses, edible roots and tubers rate by region

The total sown area for raw materials in textiles is 501.488 hectares. Considering the amount of sown area, it is observed that the Southeast Anatolia (59%), Aegean (21%) and Mediterranean (20%) regions have a large proportion of dry biomass potential in 2017 (Figure 4.17).

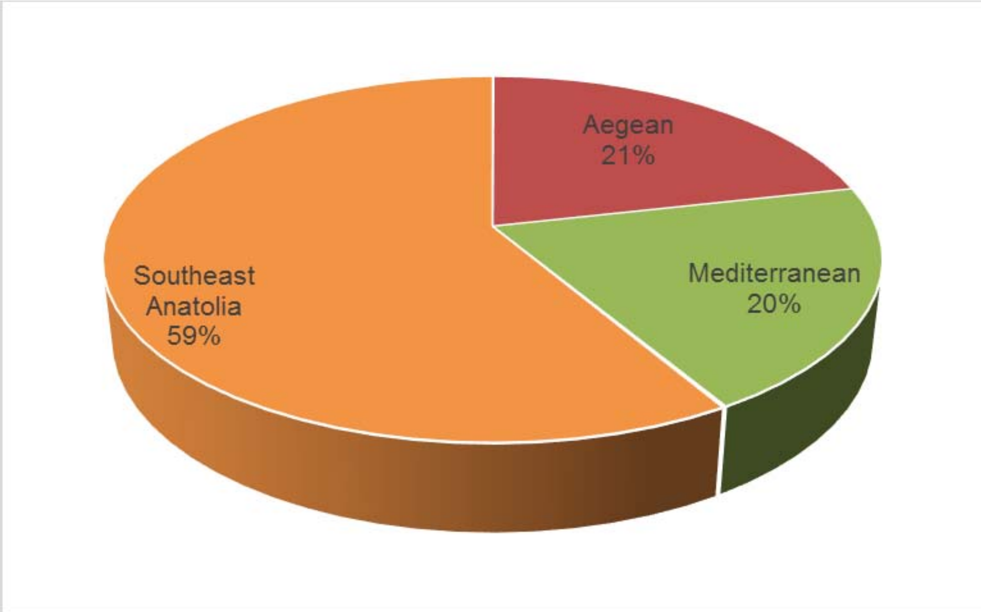

Figure 4.17. Raw materials in textiles rate by region

The amount of sown areas of some agricultural products that are fodder crops, sugar beet, cereals and oil seeds used as biomass sources are given in Table 4.14 by region in 2017.

Table 4.14. Total cultivation areas of the biomass potential products by region (TSI, 2018b)

	Sown Area of Agricultural Biomass Sources, hectare			
	Fodder Crops	**Sugar Beet**	**Cereals**	**Oil Seeds**
Turkey	1 988 087	338 886	11 093 438	924 962
Istanbul	3 810	102	40 621	21 577
Western Marmara	179 718	2 067	831 773	386 933
Aegean	297 470	25 548	1 022 510	49 640
Eastern Marmara	147 581	25 156	598 904	37 395
Western Anatolia	103 535	102 494	1 978 311	120 316
Mediterranean	119 687	14 407	1 051 420	150 447
Central Anatolia	175 157	103 013	1 789 496	55 210
Western Black Sea	182 074	29 787	1 019 659	81 847
Eastern Black Sea	18 032	468	66 350	-
Northeastern Anatolia	409 864	16 635	529 164	5 244
Middle East Anatolia	306 933	15 976	475 865	5 166
Southeast Anatolia	44 227	3 234	1 689 365	11 187

For Turkey in 2017, The total sown area for fodder crops is 78.789 hectares. Considering the amount of sown area, it is observed that the Northeastern Anatolia (21%), Middle East Anatolia (16%) and Aegean (15%) regions have a large proportion of dry biomass potential (Figure 4.18).

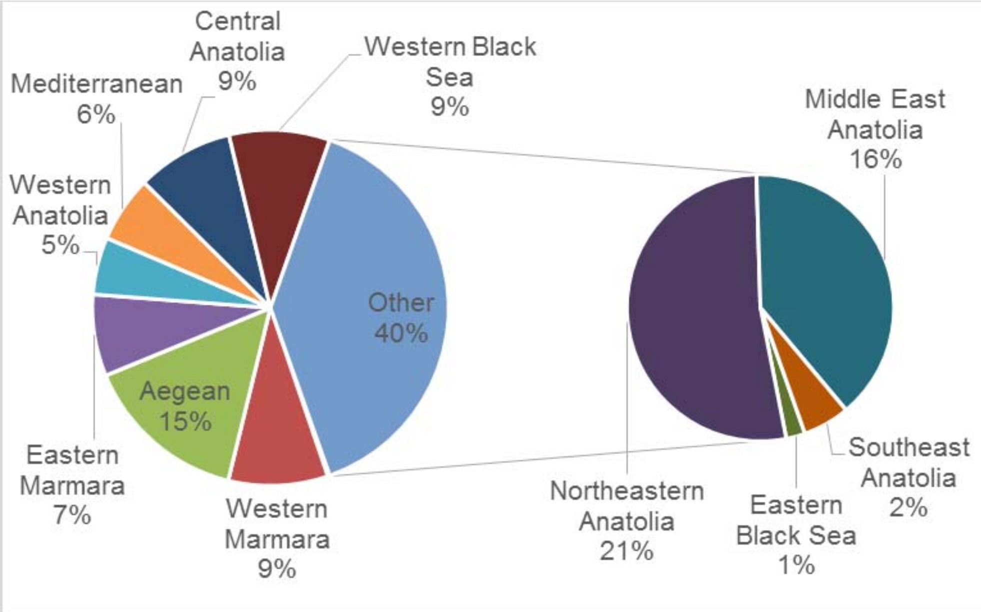

Figure 4.18. Fodder crops rate by region

The total sown area for sugar beet is 338.886 hectares. Considering the amount of sown area, it is observed that the Western Anatolia (30%) and Central Anatolia (30%) regions that have same proportions have a large proportion of dry biomass potential in 2017 (Figure 4.19).

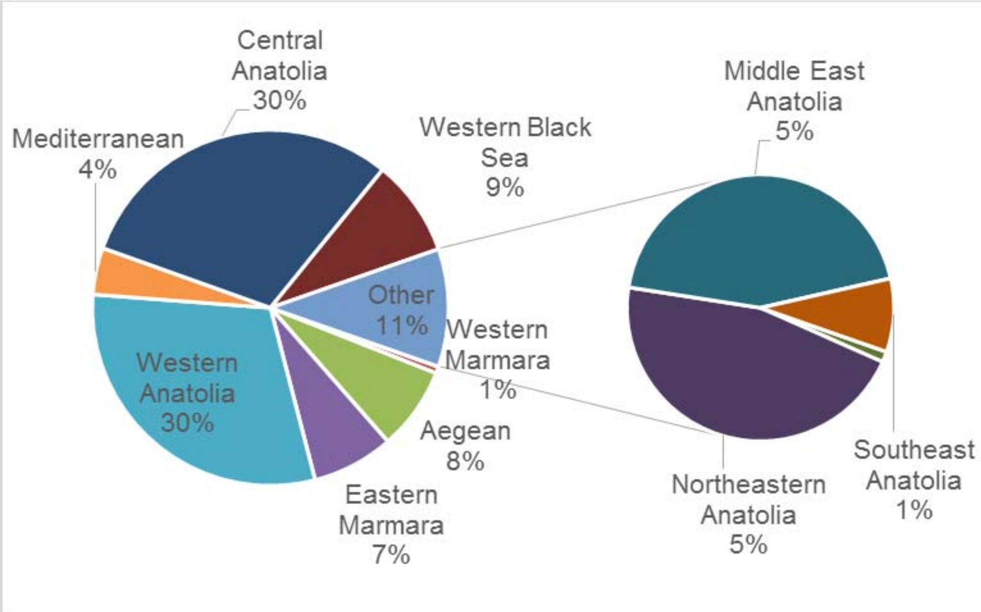

Figure 4.19. Sugar beet rate by region

The total sown area for cereals 11.093.438 hectares. Considering the amount of sown area, it is observed that the Western Anatolia (18%), Central Anatolia (16%) and Southeast Anatolia (15%) regions have a large proportion of dry biomass potential in 2017 (Figure 4.20).

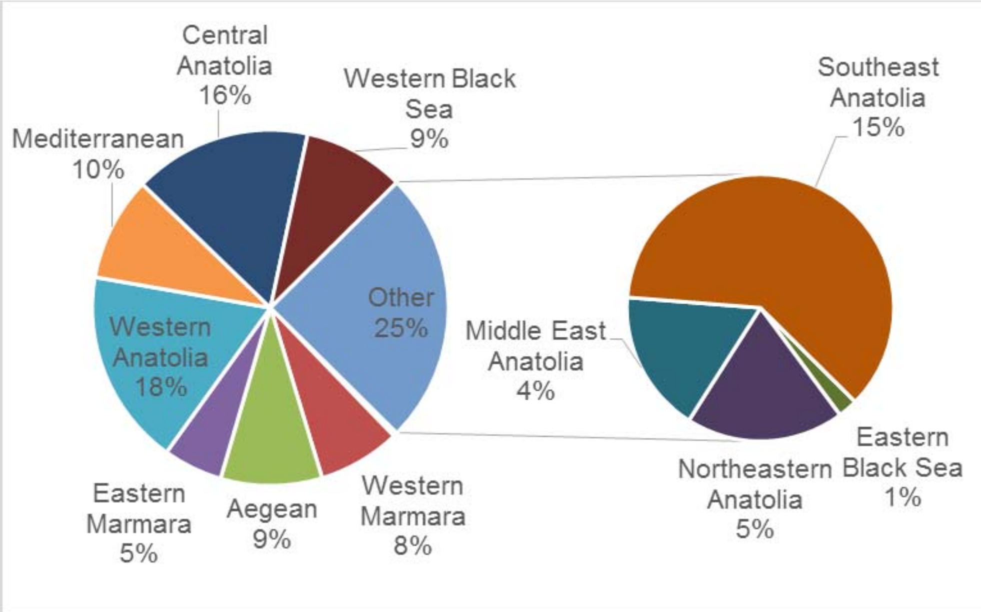

Figure 4.20. Cereals rate by region

The total sown area for oil seeds is 924.962 hectares. Considering the amount of sown area, it is observed that the Western Marmara (42%), Mediterranean (16%) and Western Anatolia (13%) regions have a large proportion of dry biomass potential in 2017 (Figure 4.21).

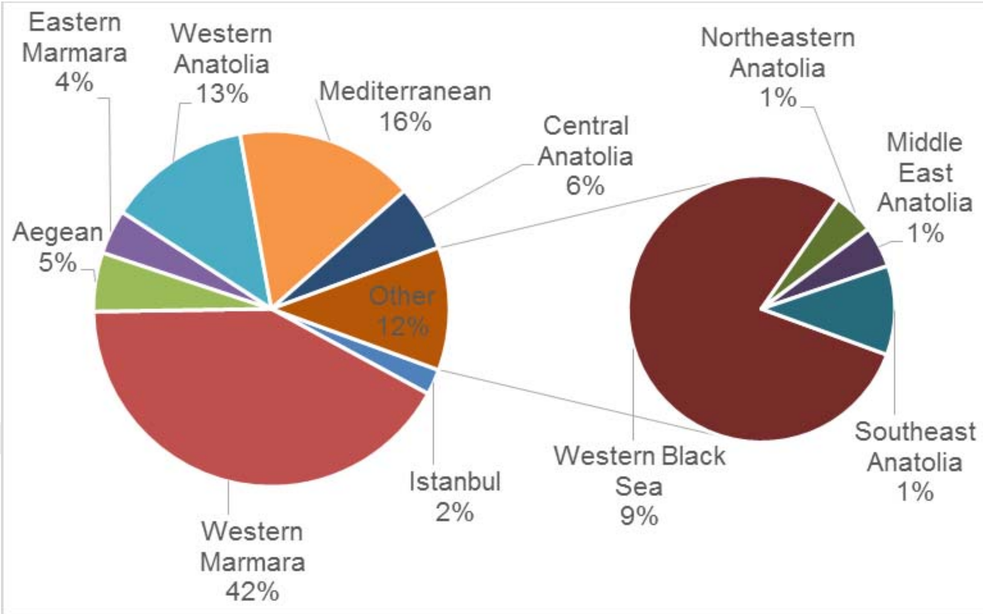

Figure 4.21. Oil seeds rate by region

The average dry biomass amount of some agricultural products (perfumery, pharmacy plants, sugar beet, fodder crops seed, potatoes, dry pulses, edible roots and tubers and raw materials in textiles) obtained from Turkey and regions are given in Table 4.15.

Table 4.15. Average dry biomass amount by region

	Average Dry Biomass Amount, tons		
	Perfumery, Pharmacy plants, Sugar Beet, Fodder Crops Seed	**Potatoes, Dry Pulses, Edible Roots and Tubers**	**Raw Materials in Textiles**
Turkey	2 166 698	25 594 278	13 790 920
Istanbul	82,5	1 375	-
Western Marmara	12 485	317 322,5	7 150
Aegean	435 765	2 782 643	2 953 253
Eastern Marmara	53 460	519 062,5	-
Western Anatolia	423 912,5	3 608 000	-
Mediterranean	191 042,5	2 784 623	2 753 603
Central Anatolia	189 640	5 374 793	-
Western Black Sea	772 090	801 185	137,5
Eastern Black Sea	-	359 865	-
Northeastern Anatolia	31 542,5	282 892,5	14 685
Middle East Anatolia	2 145	652 575	-
Southeast Anatolia	54 532,5	8 109 970	8 062 093

The average dry biomass amount of some agricultural products (fodder crops, sugar beet, cereals and oil seeds) obtained from Turkey and regions are given in Table 4.16.

Table 4.16. Average dry biomass amount by region (fodder crops, sugar beet, cereals and oil seeds)

	Average Dry Biomass Amount, tons			
	Fodder Crops	Sugar Beet	Cereals	Oil Seeds
Turkey	54672392,5	9319365	305069545	25436455
Istanbul	104775	2805	1117077,5	593367,5
Western Marmara	4942245	56842,5	22873757,5	10640658
Aegean	8180425	702570	28119025	1365100
Eastern Marmara	4058477,5	691790	16469860	1028363
Western Anatolia	2847212,5	2818585	54403552,5	3308690
Mediterranean	3291392,5	396192,5	28914050	4137293
Central Anatolia	4816817,5	2832858	49211140	1518275
Western Black Sea	5007035	819142,5	28040622,5	2250793
Eastern Black Sea	495880	12870	1824625	-
Northeastern Anatolia	11271260	457462,5	14552010	144210
Middle East Anatolia	8440657,5	439340	13086287,5	142065
Southeast Anatolia	1216242,5	88935	46457537,5	307642,5

When the Table 4.15 and 4.16 are examined, it is observed that the same rankings and ratios are involved in the creation of average dry biomass amount (Figure 4.15, 4.16, 4.17, 4.18, 4.19, 4.20, 4.21). The results show that 2.166.698 tons dry biomass could be obtained from perfumery, pharmacy plants, sugar beet, fodder crops seed, 25.594.278 tons dry biomass from potatoes, dry pulses, edible roots and tubers, 13.790.920 tons dry biomass from raw materials in textiles, 54.672.392,5 tons dry biomass from fodder crops, 9.319.365 tons dry biomass from sugar beet, 305.069.545 tons dry biomass from cereals and 25.436.455 tons dry biomass from oil seeds.

The average dry biomass energy value of some agricultural products (perfumery, pharmacy plants, sugar beet, fodder crops seed, potatoes, dry pulses, edible roots and tubers and raw materials in textiles) obtained from Turkey and regions are given in Table 4.17.

Table 4.17. Average dry biomass energy value by region

	Average Dry Biomass Energy Value, TEO		
	Perfumery, Pharmacy Plants, Sugar Beet, Fodder Crops Seed	**Potatoes, Dry Pulses, Edible Roots and Tubers**	**Raw Materials in Textiles**
Turkey	877512,5	10365682	5585323
Istanbul	33,4125	556,875	-
Western Marmara	5056,425	128515,6	2895,75
Aegean	176484,8	1126970	1196067
Eastern Marmara	21651,3	210220,3	-
Western Anatolia	171684,6	1461240	-
Mediterranean	77372,21	1127772	1115209
Central Anatolia	76804,2	2176791	-
Western Black Sea	312696,5	324479,9	55,6875
Eastern Black Sea	-	145745,3	-
Northeastern Anatolia	12774,71	114571,5	5947,425
Middle East Anatolia	868,725	264292,9	-
Southeast Anatolia	22085,66	3284538	3265147

The average dry biomass amount of some agricultural products (fodder crops, sugar beet, cereals and oil seeds) obtained from Turkey and regions are given in Table 4.18.

Table 4.18. Average dry biomass energy value by region (fodder crops, sugar beet, cereals and oil seeds)

	Average Dry Biomass Energy Value, TEO			
	Fodder Crops	Sugar Beet	Cereals	Oil Seeds
Turkey	22142318,96	3774343	123553165,7	10301764
Istanbul	42433,875	1136,025	452416,3875	240313,8
Western Marmara	2001609,225	23021,21	9263871,788	4309466
Aegean	3313072,125	284540,9	11388205,13	552865,5
Eastern Marmara	1643683,388	280175	6670293,3	416486,8
Western Anatolia	1153121,063	1141527	22033438,76	1340019
Mediterranean	1333013,963	160458	11710190,25	1675603
Central Anatolia	1950811,088	1147307	19930511,7	614901,4
Western Black Sea	2027849,175	331752,7	11356452,11	911571
Eastern Black Sea	200831,4	5212,35	738973,125	-
Northeastern Anatolia	4564860,3	185272,3	5893564,05	58405,05
Middle East Anatolia	3418466,288	177932,7	5299946,438	57536,33
Southeast Anatolia	492578,2125	36018,68	18815302,69	124595,2

When the Table 4.17 and 4.18 are examined, it is observed that the same rankings and ratios are involved in the creation of average dry biomass energy (Figure 4.15, 4.16, 4.17, 4.18, 4.19, 4.20, 4.21). The results show that 877.512,5 TEO dry biomass energy could be obtained from perfumery, pharmacy plants, sugar beet, fodder crops seed, 10.365.682 TEO dry biomass energy from potatoes, dry pulses, edible roots and tubers, 5.585.323 TEO dry biomass energy from raw materials in textiles, 22.142.318,96 TEO dry biomass energy from fodder crops, 3.774.343 TEO dry biomass energy from sugar beet, 123.553.165,7 TEO dry biomass energy from cereals and 10.301.764 TEO dry biomass energy from oil seeds.

The equivalent dry biomass energy of some agricultural products (perfumery, pharmacy plants, sugar beet, fodder crops seed, potatoes, dry pulses, edible roots and tubers and raw materials in textiles) obtained from Turkey and regions are given in Table 4.19.

Table 4.19. Equivalent potential of dry biomass energy by region

	Equivalent Potential of Dry Biomass Energy, MW		
	Perfumery, Pharmacy Plants, Sugar Beet, Fodder Crops Seed	**Potatoes, Dry Pulses, Edible Roots and Tubers**	**Raw Materials in Textiles**
Turkey	10205,47	120552,9	64957,3
Istanbul	0,388587	6,476456	-
Western Marmara	58,80622	1494,637	33,67757
Aegean	2052,519	13106,66	13910,26
Eastern Marmara	251,8046	2444,862	-
Western Anatolia	1996,691	16994,22	-
Mediterranean	899,8388	13115,99	12969,88
Central Anatolia	893,2328	25316,08	-
Western Black Sea	3636,66	3773,702	0,647646
Eastern Black Sea	-	1695,018	-
Northeastern Anatolia	148,5699	1332,466	69,16855
Middle East Anatolia	10,10327	3073,726	-
Southeast Anatolia	256,8563	38199,18	37973,66

The equivalent dry biomass energy of some agricultural products (fodder crops, sugar beet, cereals and oil seeds) obtained from Turkey and regions are given in Table 4.20.

Table 4.20. Equivalent potential of dry biomass energy by region (fodder crops, sugar beet, cereals and oil seeds)

	Equivalent Potential of Dry Biomass Energy, MW			
	Fodder Crops	**Sugar Beet**	**Cereals**	**Oil Seeds**
Turkey	257 515,2	43 895,61	1 436 923	119 809,5
Istanbul	493,506	13,21197	5 261,603	2 794,85
Western Marmara	23 278,72	267,7367	107 738,8	50 119,09
Aegean	38 531,03	3 309,21	132 444,8	6 429,826
Eastern Marmara	19 116,04	3 258,435	77 575,51	4843,742
Western Anatolia	13 410,8	13 275,96	256 248,9	15 584,43
Mediterranean	15 502,95	1 866,126	136 189,5	19 487,27
Central Anatolia	22 687,93	13 343,18	231 791,9	7 151,303
Western Black Sea	23 583,89	3 858,284	132 075,5	10 601,57
Eastern Black Sea	2 335,669	60,61963	8 594,257	-
Northeastern Anatolia	53 089,33	2 154,717	68 542,15	679,2507
Middle East Anatolia	39 756,76	2 069,357	61 638,38	669,1475
Southeast Anatolia	5 728,685	418,8972	218 822	1 449,042

When the Table 4.19 and 4.20 are examined, it is observed that the same rankings and ratios are involved in the creation of equivalent dry biomass energy (Figure 4.15, 4.16, 4.17, 4.18, 4.19, 4.20, 4.21). The equivalent dry biomass energy obtained from Turkey and regions are given in Table 4.19 and 4.20. The results show that 10.205,47 MW equivalent dry biomass energy could be obtained from perfumery, pharmacy plants, sugar beet, fodder crops seed, 120.552,9 MW equivalent dry biomass energy from potatoes, dry pulses, edible roots and tubers, 64.957,3 MW equivalent dry biomass energy from raw materials in textiles, 257.515,2 MW equivalent dry biomass energy from fodder crops, 43.895,61 MW equivalent dry biomass energy from sugar beet, 1.436.923 MW equivalent dry biomass energy from cereals and 119.809,5 MW equivalent dry biomass energy from oil seeds.

4.1.3. Animal-Based Fertilizer and Biogas Amounts

Our country has an important place in animal husbandry as well as agricultural production. The vast majority of animal breeding is done by cows, sheep and poultry. The use of modern biomass technologies to convert wastes generated from animal husbandry into energy is a matter of concern. Animal husbandry has an important place in our country's economy. The livestock sector fulfills important functions in terms of providing industrial input, creating employment opportunities, increasing foreign sales, adequate and balanced nutrition possibilities.

When the biogas plants are being designed, firstly the capacitance needs to be determined. For this purpose, only animal feces should be used; the daily amount of fertilizer, the nutrients of the animals, and the solids content of fertilizers must be known (Kocer et al., 2006).

Other acceptances to be made when biogas accounts are made are: In 2017, the price of electricity is 0,30 TL for 1 kWh electricity (Senol et al., 2017).

The amount of fertilizer fertilizer obtained from different type of animals which are used as a biomass source is illustrated in Table 4.21. In general, there are three main sources which are bovine, sheep and goat and poultry as a source of biomass. It is clearly seen that while the fertilizer of bovine has the highest percentage (83%), the poultry has the least proportion (1%) which is very low rate when compared other two types (Figure 4.22).

Table 4.21. The amount of fertilizer obtained from different type of animals (YEGM,2018)

Number of Animals	Type of Animals	Wet Fertilizer Amount (tons/year)
1	Bovine	3,6
1	Sheep and goat	0,7
1	Poultry	0,022

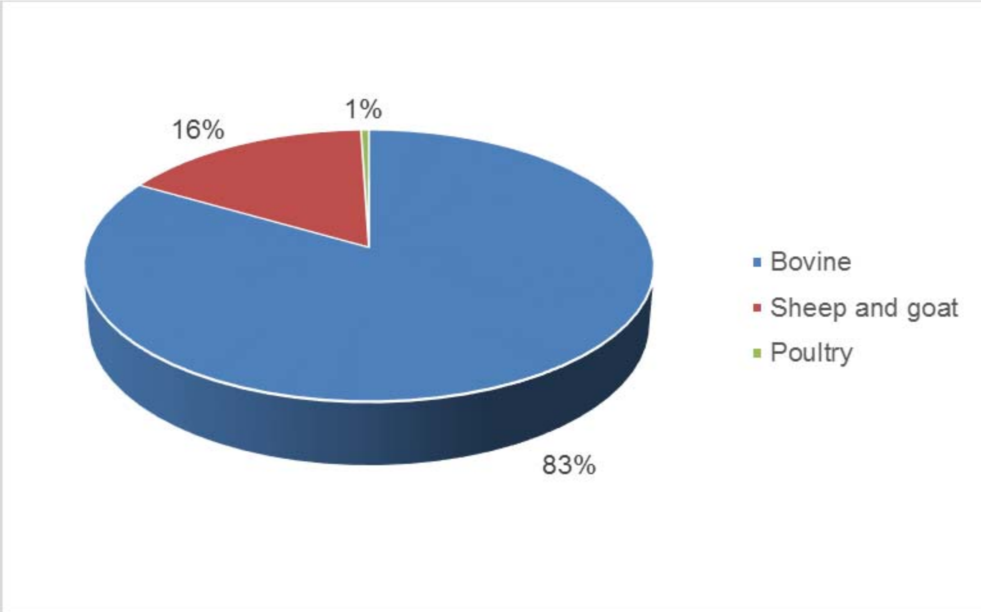

Figure 4.22. The ratio of fertilizer obtained from different type of animals

The amount of biogas obtained from different type of animals is showed in Table 4.22. In general, there are three main sources which are cattle, sheep and poultry as a source of biogas. It is clearly seen that the the rate of biogas from obtained poultry has the highest percentage (46%) whereas the cattle has the least proportion (20%). The sheep also has the second largest rate (34%) (Figure 4.23).

Table 4.22. The amount of biogas obtained from different type of animals (YEGM,2018)

Type of Fertilizer	**Fertilizer Amount**	**Obtained Biogas Amount (m^3/year)**
Cattle	1 ton	33
Sheep	1 ton	58
Poultry	1 ton	78

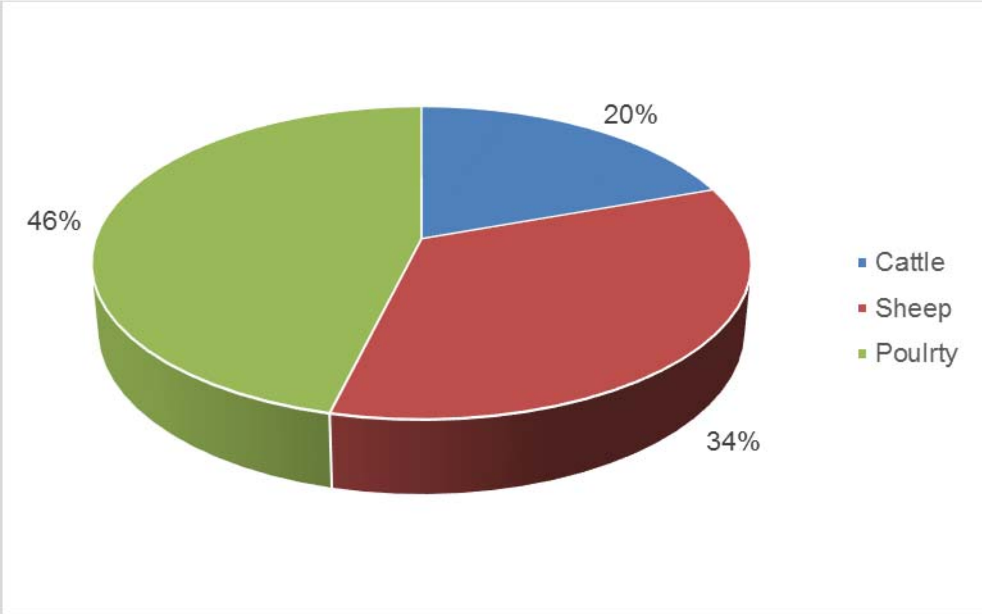

Figure 4.23. The ratio biogas obtained from different type of animals

The total number of bovine animals which are used as a biogas source is illustrated in Table 4.23. In general, there are four different types of bovine animals which are buffaloes, domestic cattle, cross bred cattle and culture cattle as a source of biogas. It is clearly seen that even though cultura cattle and cross bred cattle have nearly same ratios, the culture cattle has the highest percentage (48%). However, the buffaloes have the lowest rate which is 1%. The cross bred cattle and domestic cattle have the second and third largest rate that are 41% and 10%, respectively (Figure 4.24).

Table 4.23. Total number of bovine animals (TSI, 2018a)

Type and Races of Bovine Animals	Head
Cattle - Culture	7 804 588
Cattle - Cross-bred	6 536 073
Cattle - Domestic	1 602 925
Buffaloes	161 439
Total	16 105 025

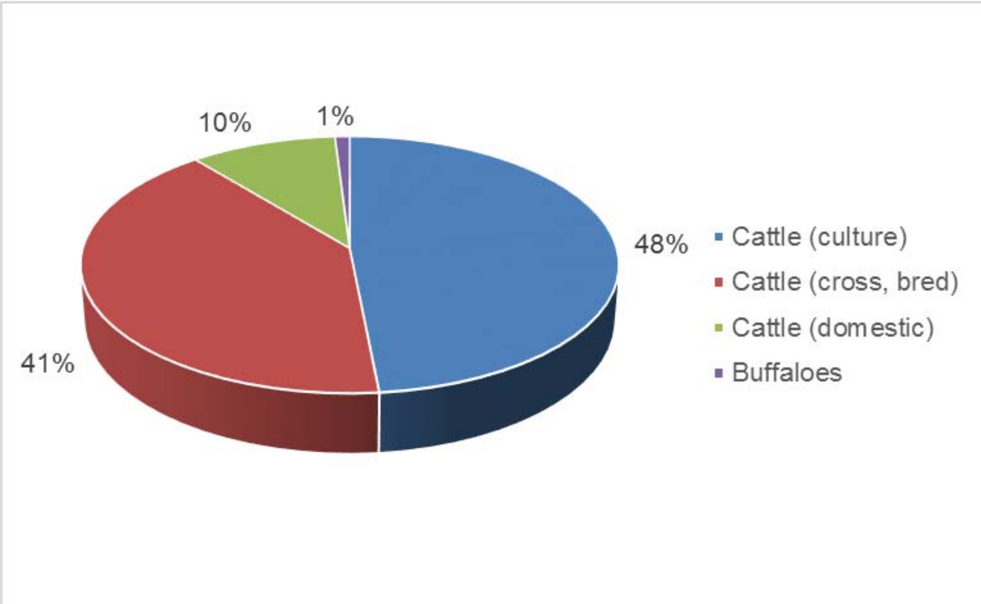

Figure 4.24. The ratio of bovine animals

Table 4.24 shows the total number of sheep and goat which are used as a biogas source. It is clearly seen that although there are two main types and four different races of sheep and goat, angora goats have very low quantity when compared to the other races so that we can neglect them. The domestic sheep has the highest rate (71%) whereas merino sheep has the least ratio (5%). Ordinary goats also have the second largest proportion (24%) (Figure 4.25).

Table 4.24. Total number of sheep and goat (TSI, 2018a)

Type and Races of Sheep and Goat	Head
Sheep - Domestic	31 257 408
Sheep - Merino	2 420 228
Goats - Ordinary	10 419 027
Goats - Angora	215 645
Total	44 312 308

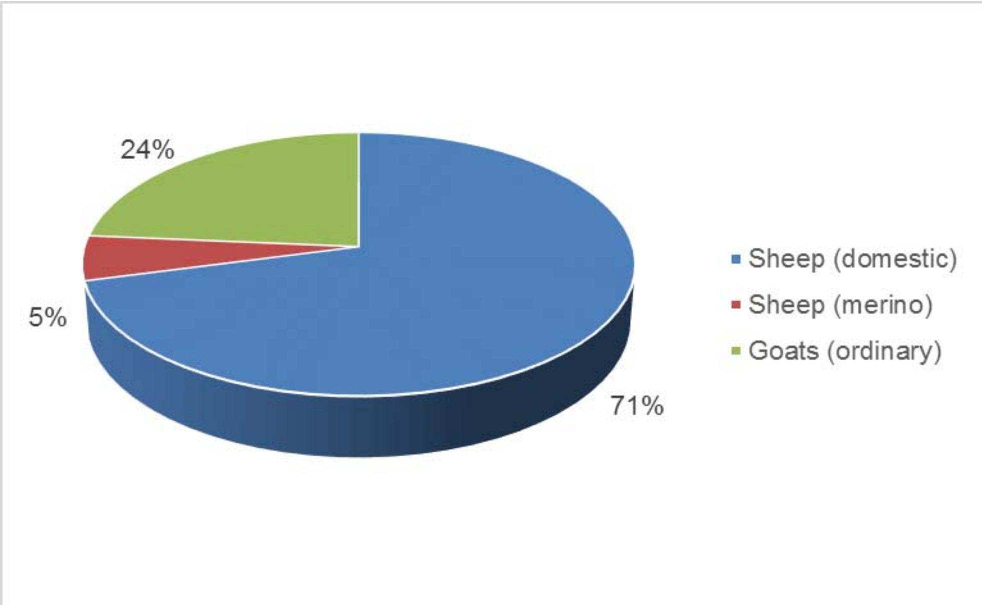

Figure 4.25. The ratio of sheep and goat

It is clearly seen in Table 4.25 that although there are five different types of poultry animals, the geese and ducks have very low quantity when compared to the other types so that we can neglect them. The broilers have the highest rate (64%) while turkeys have the least ratio (1%). Laying hens also have the second largest proportion (35%) (Figure 4.26).

Table 4.25. Total number of poultry animals (TSI, 2018a)

Types of Poultry Animals	Number
Laying hens	121 556 027
Broilers	221 245 322
Turkeys	3 872 460
Geese	978 384
Ducks	491 561
Total	348 143 754

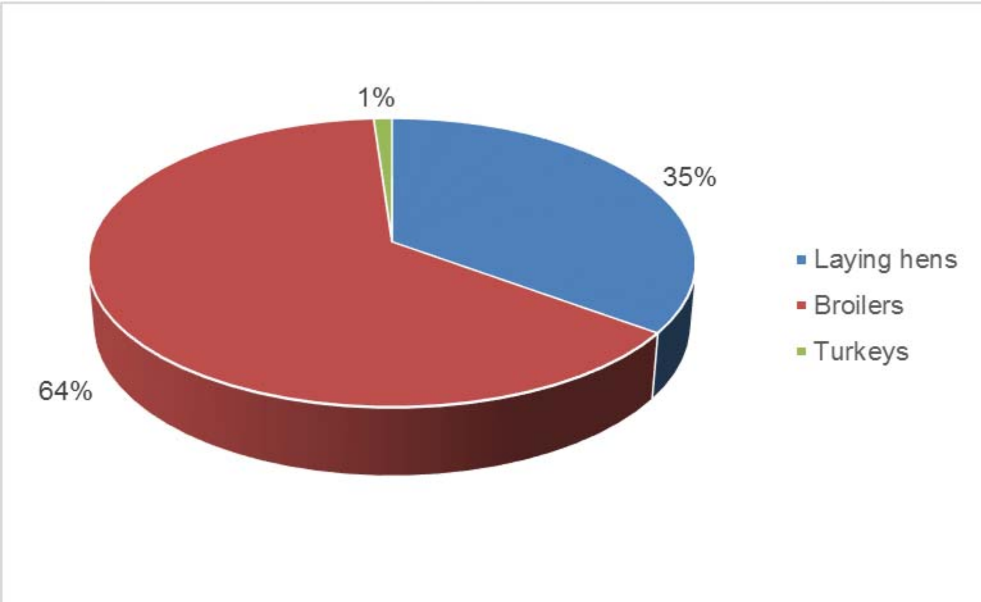

Figure 4.26. The ratio of poultry animals

Wet fertilizer and biogas amounts are calculated and showed in Table 4.26 depending on the number of animals in Turkey.

Table 4.26. Wet fertilizer and biogas amounts

Type of Animals	Number of Animals (number)	Wet Fertilizer Amount (tons/year)	Biogas Amount (m^3/year)
Bovine	16105025	57978090	1913276970
Sheep and goat	44312308	31018615,6	1799079705
Poultry	348143754	7659162,588	597414681,9
Total	408561087	96655868,19	4309771357

The ratio of wet fertilizer from different type of animals is showed in Figure 4.27. In general, there are three main sources which are bovine, sheep and goat and poultry as a source of fertilizer. It is clearly seen that the the rate of wet fertilizer from obtained bovine has the highest percentage (60%) whereas the poultry has the least proportion (8%). The sheep and goat also have the second largest rate (32%) which equal to nearly the half of the bovine rate.

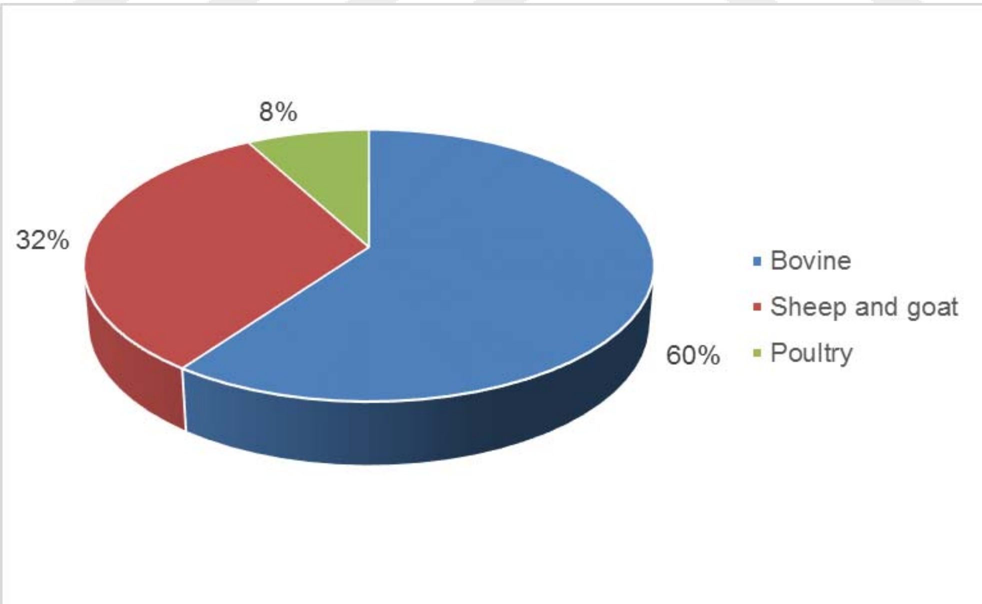

Figure 4.27. The ratio of wet fertilizer from different types of animals

The ratio of biogas from different type of animals is showed in Figure 4.28. In general, there are three main sources which are bovine, sheep and goat and poultry as a source of fertilizer. It is clearly seen that the the ratio of biogas from obtained bovine and sheep and goat have nearly same percentages that are 44% and 42%, recpectively. However, the poultry has the least proportion (14%).

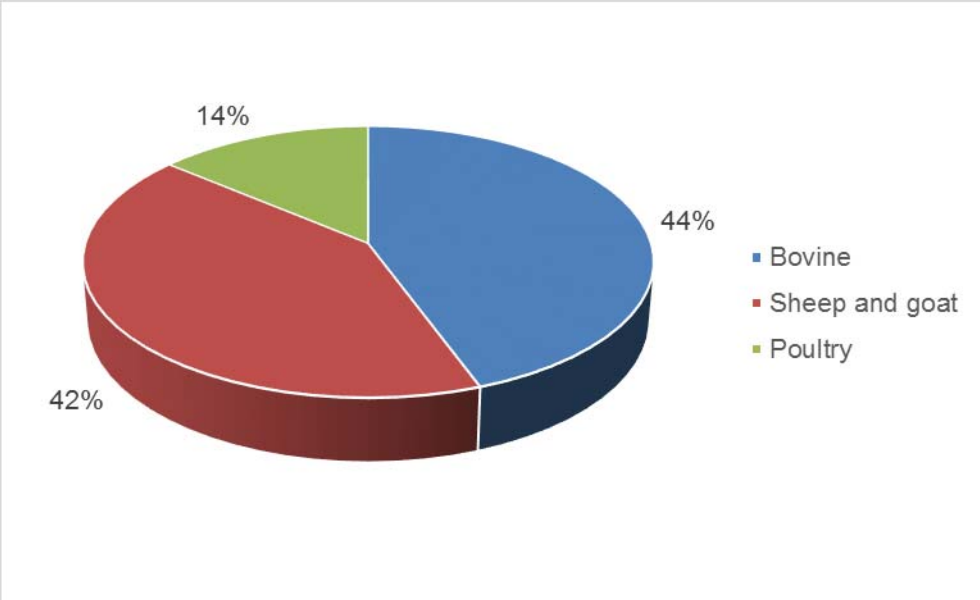

Figure 4.28. The ratio of biogas from different types of animals

1 m^3 of biogas is equivalent to 4.70 kWh of electricity (YEGM, 2018). The kWh equivalent of the amount of biogas that can be obtained is calculated and showed in Table 4.27.

Table 4.27. Electric energy equivalence of biogas quantity

Electric Energy Equivalent (kWh/year)			
Bovine	**Sheep and Goat**	**Poultry**	**Total**
8992401759	8455674614	2807849005	2,025592538 x 10^{10}

1 m^3 of biogas is equivalent to 0.66 liters of diesel oil and 0.75 liters of equivalent oil (YEGM, 2018). The amount of biogas that can be obtained is calculated in terms of diesel oil and oil equivalents and showed in Table 4.28.

Table 4.28. Oil and diesel oil equivalence of biogas amount

	Bovine	**Sheep and Goat**	**Poultry**	**Total**
Oil Equivalent (liter/year)	1434957728	1349309779	448061011,4	3232328518
Diesel Oil Equivalent (liter/year)	1262762800	1187392605	394293690,1	2844449096

The ratio of oil and diesel oil equivalence of biogas are illustrated in Figure 4.29. It is clearly seen in Table 4.28 that although the amount of oil and diesel oil equivalence of biogas is different from each other, the rate of them is same. It is seen that the the ratio of oil and diesel oil equivalence of biogas from obtained bovine and sheep and goat have nearly same percentages that are 44% and 42%, in order of while the poultry has the least proportion (14%).

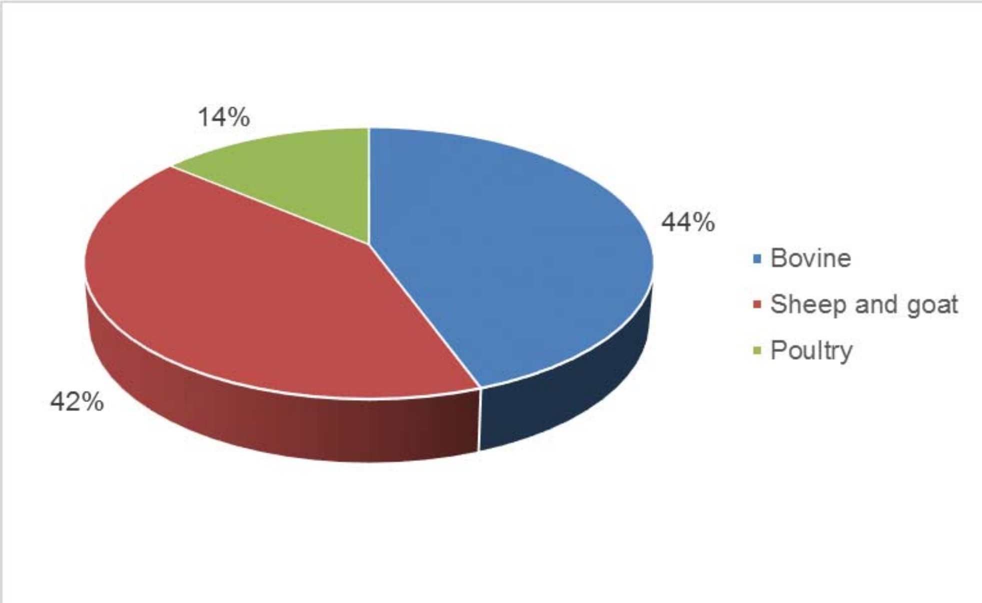

Figure 4.29. The ratio of oil and diesel oil equivalence of biogas

4.1.4. Animal-Based Fertilizer and Biogas Amounts By Region

There are three different types of animals which are bovine, sheep and goat and poultry as main sources of biogas. According to the Turkish Statistical Institute data in 2017, the total number of animals are shown in Table 4.29. It is clearly seen in Table 4.29 that the poultry has the highest percentage (85%) while the bovine has the least proportion (4%). The sheep and goat also has the second largest rate (11%) (Figure 4.30).

Table 4.29. Number of animals by region (TSI, 2018b)

	Type of Animals		
	Bovine	**Sheep and Goat**	**Poultry**
Turkey	16 105 025	44 312 308	348 143 754
Istanbul	99 031	132 772	1 867 036
Western Marmara	1 183 088	2 832 255	42 217 102
Aegean	2 513 054	4 920 126	103 004 949
Eastern Marmara	860 722	1 670 030	89 506 899
Western Anatolia	1 395 197	4 206 751	29 311 254
Mediterranean	1 307 146	5 411 393	29 670 190
Central Anatolia	1 646 920	3 197 127	9 998 467
Western Black Sea	1 804 401	1 411 004	22 776 487
Eastern Black Sea	535 671	576 953	753 702
Northeastern Anatolia	2 180 909	4 236 773	2 470 855
Middle East Anatolia	1 114 445	6 873 138	9 156 435
Southeast Anatolia	1 464 441	8 843 986	7 410 378

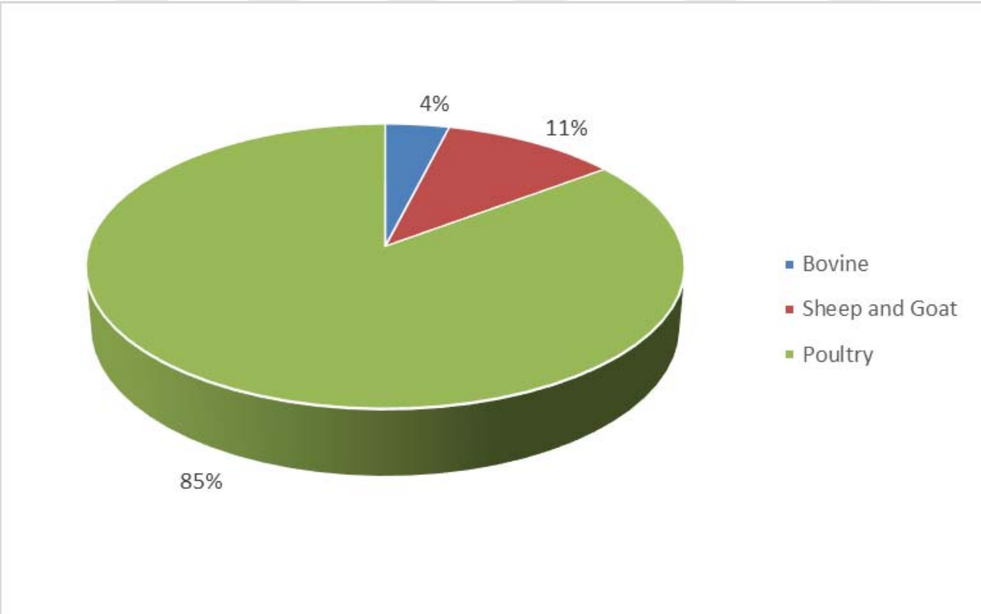

Figure 4.30. The proportion of animals in Turkey

According to the table, the Aegean has the highest rate (16%) whereas the Istanbul has the lowest rate (1%). The Northeastern Anatolia and the Western Black Sea have the second and third largest rate that are 14% and 11%, respectively. The Western Anatolia and the Southeast Anatolia have also same percentages and the total of them are equal to 18%. The Western Marmara and the Middle East Anatolia have also same ratios, that are approximately same rate for the Mediterranean (8%), and the total of them are equal to 14% which is equal to the ratio of the Northeastern Anatolia. The Eastern Black Sea has the second least rate (3%) (Figure 4.31).

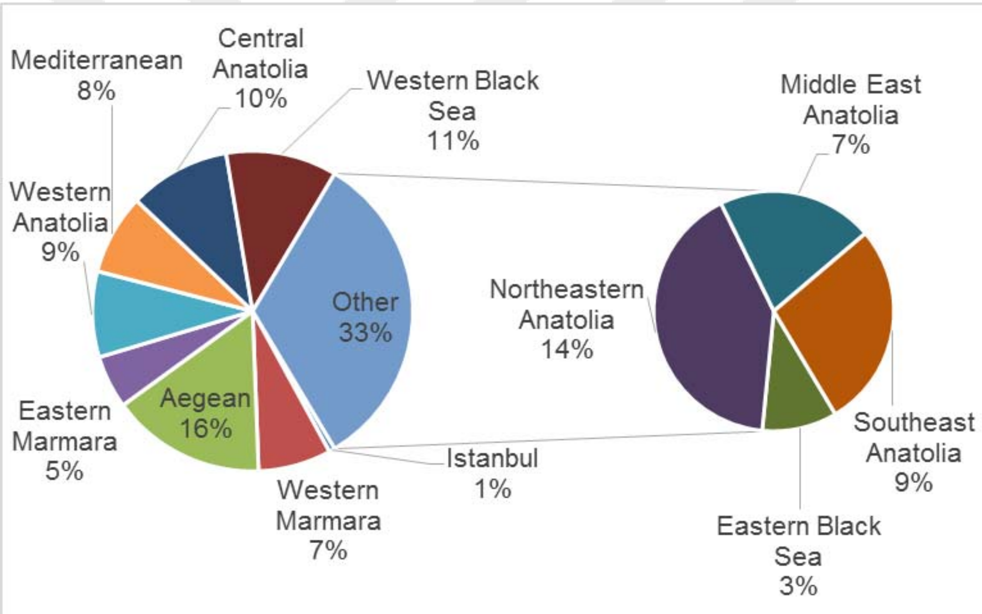

Figure 4.31. Bovine rate by region

For sheep and goat; the Southeast Anatolia has the highest rate (20%) while Eastern Black Sea and Western Black Sea have the lowest rates that are 1% and 3%. The total of them are equal to 4% which is equal to the ratio of the Eastern Marmara. It is clearly seen that the Istanbul has very low quantity, that the percentage of its corresponds to 0%, when compared to the other region. The

Middle East Anatolia and Mediterranean have the second and third largest rate that are 16% and 12%, respectively. The Northeastern Anatolia and Western Anatolia have also same ratios, that are approximately same rate for the Aegean (11%), and the total of them are equal to 20% which is equal to the ratio of the Southeast Anatolia (Figure 4.32).

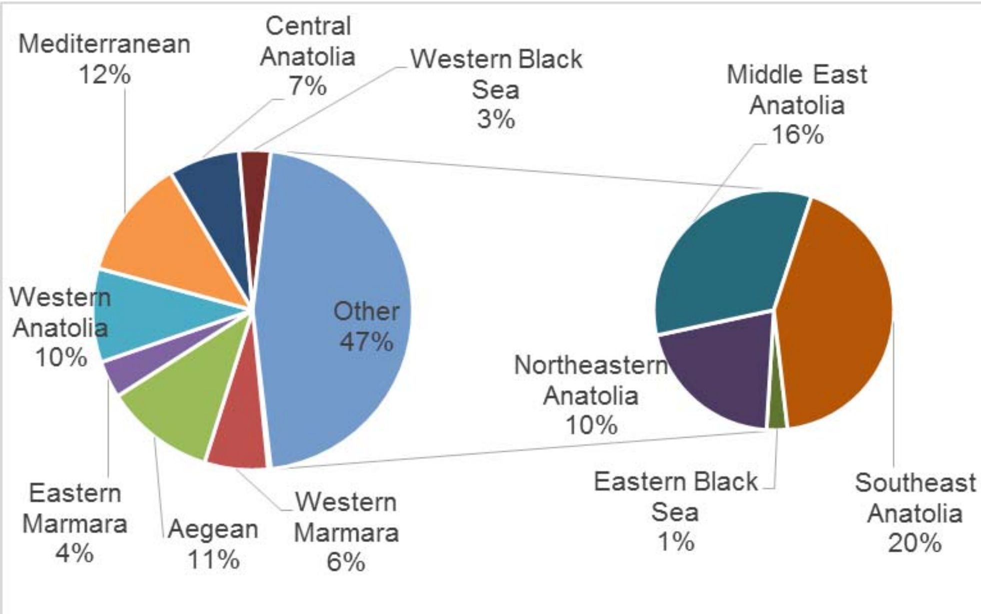

Figure 4.32. Sheep and goat rate by region

For poultry; the Aegean has the highest ratio (30%) whereas the Northeastern Anatolia and Southeast Anatolia have the lowest rates that are 1% and 2%. The total of them are equal to 3% which is equal to the ratio of the Middle East Anatolia and Central Anatolia. It can be seen that the Istanbul has very low quantity, that the percentage of its corresponds to 0%, when compared to the other region. The Eastern Marmara and Western Marmara have the second and third largest rate that are 26% and 12%, in order of. The Western Anatolia and Mediterranean have also same ratios (8%), that are approximately same rate for the Western Black Sea (7%) (Figure 4.33).

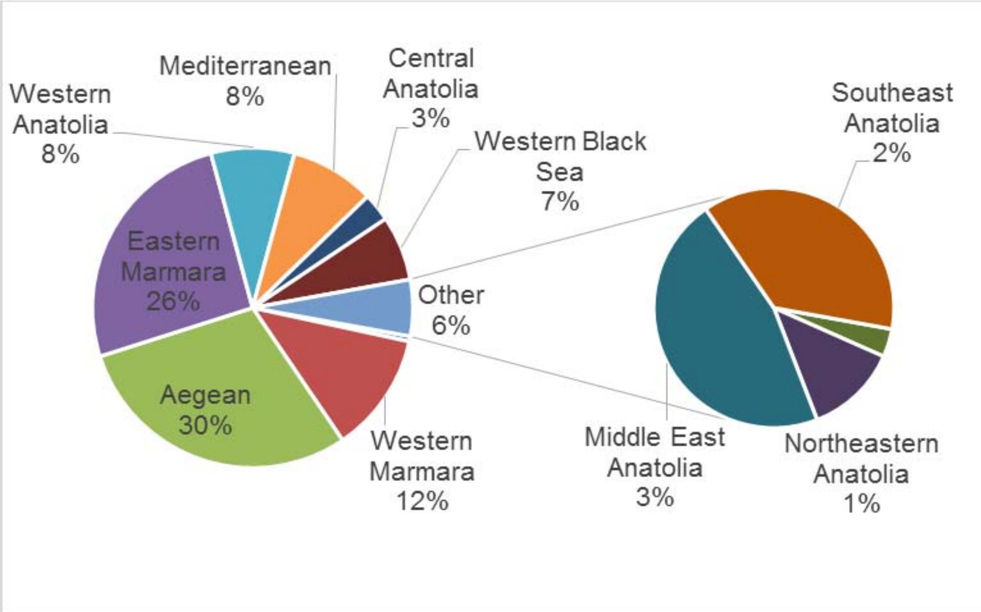

Figure 4.33. Poultry rate by region

The amount of heat supplied by 1 m^3 biogas is 4700-5700 kcal/m^3 and effective equivalents to other fuels are given below.

1 m^3 biogas = 4,70 kwh electric power = 0,62 liter kerosene = 3,47 kg wood = 1,46 kg coal = 0,43 kg butane = 1,18 m^3 natural gas = 0,66 liter diesel oil = 0,75 liter oil

The amount of fertilizer (tons/year) and biogas (m^3/year) that can be produced depending on the animal potential in Turkey and its regions have been determined according to the values stated above.

The production amounts of wet fertilizer, biogas and electric power which can be obtained from bovine in Turkey and regions are given in Table 4.30 for 2017.

Table 4.30. Wet fertilizer and biogas amounts, electric power generation from bovine by region

	Wet Fertilizer Amount (tons/year)	Biogas Amount (m^3/year)	Electric Power Generation (kwh)
Turkey	57 978 090	1 913 276 970	8 992 401 759
Istanbul	356 511,6	11 764 882,8	55 294 949,2
Western Marmara	4 259 117	140 550 854	660 589 016
Aegean	9 046 994	298 550 815	1 403 188 831
Eastern Marmara	3 098 599	102 253 774	480 592 736
Western Anatolia	5 022 709	165 749 404	779 022 197
Mediterranean	4 705 726	155 288 945	729 858 041
Central Anatolia	5 928 912	195 654 096	919 574 251
Western Black Sea	6 495 844	214 362 839	1 007 505 342
Eastern Black Sea	1 928 416	63 637 714,8	299 097 260
Northeastern Anatolia	7 851 272	259 091 989	1 217 732 349
Middle East Anatolia	4 012 002	132 396 066	622 261 510
Southeast Anatolia	5 271 988	173 975 591	817 685 277

Table 4.30 shows that approximately 57,9 million tons of wet fertilizer per year is obtained from bovine in Turkey. Considering the amount of fertilizer and bovine wastes, it is observed that the Aegean (16%), Northeast Anatolia (14%), Western Black Sea (11%) and Central Anatolia (10%) regions have a large proportion of biogas potential (Figure 4.34). It is observed that 1,9 billion m^3 of biogas can be obtained from these fertilizer and that the amount of biogas has an energy potential equivalent to 8.992.401 – 10.905.678 million kcal. The current generated biogas is equivalent to electricity energy of 8.992.401.759 kwh.

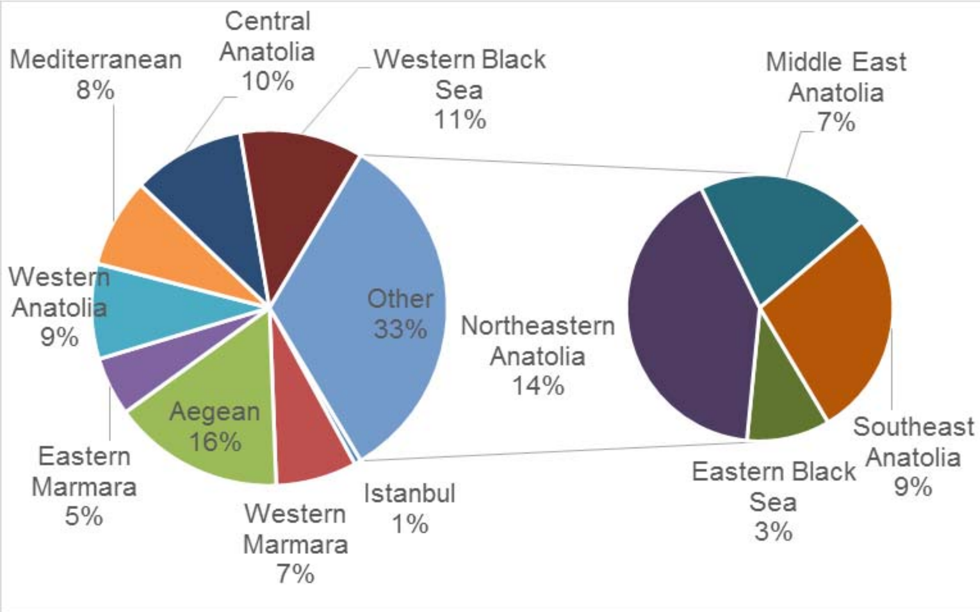

Figure 4.34. Wet fertilizer rate from bovine by region

The calorific values of biogas obtained from Turkey and regions are given in Table 4.31.

Table 4.31. Calorific values of biogas from bovine by region

	Production of Kerosene (lt)	**Production of Diesel Oil (lt)**	**Production of Oil (lt)**
Turkey	1186231721	1 262 762 800	1 434 957 728
Istanbul	7 294 227,34	7 764 822,65	8 823 662,1
Western Marmara	8 7141 529,7	92 763 563,9	105 413 141
Aegean	185 101 505	197 043 538	223 913 111
Eastern Marmara	63 397 339,6	67 487 490,6	76 690 330,2
Western Anatolia	102 764 630	109 394 606	124 312 053
Mediterranean	96 279 145,8	1 024 90 704	116 466 709
Central Anatolia	121 305 540	129 131 703	146 740 572
Western Black Sea	132 904 960	141 479 474	160 772 129
Eastern Black Sea	39 455 383,2	42 000 891,8	47 728 286,1
Northeastern Anatolia	160 637 033	171 000 713	194 318 992
Middle East Anatolia	82 085 560,9	87 381 403,6	99 297 049,5
Southeast Anatolia	107 864 866	114 823 890	130 481 693

When looking at the equivalents of the biogas obtained in Table 4.31 and 4.32, it is equivalent to 1.434.957.728 liters of oil, 1.186.231.721 tons of kerosene, 1.262.762.800 liters of diesel oil, 2.257.666.825 m^3 of natural gas, 6.639.071.086 kg of wood, 2.793.384.37 kg of coal and 822.709.097,1 kg of butane.

Table 4.32. Equivalents of biogas from bovine by region

	Production of Natural Gas (m^3)	**Production of Wood (kg)**	**Production of Coal (kg)**	**Production of Butane (kg)**
Turkey	2257666825	6639071086	2793384376	822709097,1
Istanbul	13882561,7	40824143,3	17176728,9	5058899,604
Western Marmara	165850008	487711465	205204247	60436867,39
Aegean	352289962	1035971329	435884190	128376850,5
Eastern Marmara	120659453	354820594	149290510	43969122,65
Western Anatolia	195584296	575150431	241994129	71272243,55
Mediterranean	183240955	538852639	226721859	66774246,26
Central Anatolia	230871833	678919713	285654980	84131261,28
Western Black Sea	252948150	743839051	312969745	92176020,68
Eastern Black Sea	75092503,5	220822870	92911063,6	27364217,36
Northeastern Anatolia	305728547	899049203	378274304	111409555,4
Middle East Anatolia	156227358	459414349	193298256	56930308,38
Southeast Anatolia	205291197	603695300	254004363	74809504,04

When the Table 4.31 and 4.32 are examined, it is seen that the biodizeline is in the same rankings and ratios as the Figure 4.34 in the formation of calorific and equivalent values (Figure 4.35).

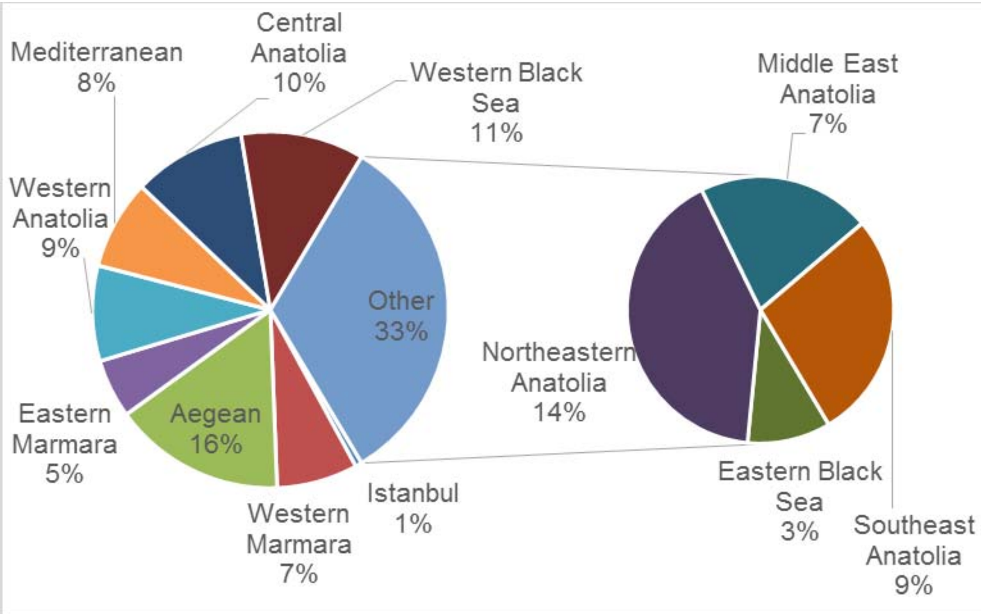

Figure 4.35. Calorific and equivalent values of biogas rate from bovine by region

The production amounts of wet fertilizer, biogas and electric power which can be obtained from sheep and goat in Turkey and regions are given in Table 4.33 for 2017.

Table 4.33. Wet fertilizer and biogas amounts, electric power generation from sheep and goat by region

	Wet Fertilizer Amount (tons/year)	**Biogas Amount (m^3/year)**	**Electric Power Generation (kwh)**
Turkey	31 018 616	1 799 079 705	8 455 674 613
Istanbul	92 940,4	5 390 543,2	25 335 553
Western Marmara	1 982 579	114 989 553	540 450 899
Aegean	3 444 088	199 757 116	938 858 443
Eastern Marmara	1 169 021	67 803 218	318 675 125
Western Anatolia	2 944 726	170 794 091	802 732 226
Mediterranean	3 787 975	219 702 556	1 032 602 012
Central Anatolia	2 237 989	129 803 356	610 075 774
Western Black Sea	987 702,8	57 286 762,4	269 247 783
Eastern Black Sea	403 867,1	23 424 291,8	110 094 172
Northeastern Anatolia	2 965 741	172 012 984	808 461 024
Middle East Anatolia	4 811 197	279 049 403	1 311 532 193
Southeast Anatolia	6 190 790	359 065 832	1 687 609 409

Table 4.33 shows that approximately 31 million tons of wet fertilizer per year is obtained from sheep and goat in Turkey. Considering the amount of fertilizer and large animal wastes, it is observed that the Southeast Anatolia (20%), Middle East Anatolia (16%), Mediterranean (12%) and Aegean (11%) regions have a large proportion of biogas potential (Figure 4.36). It is observed that 1,7 billion m^3 of biogas can be obtained from these fertilizer and that the amount of biogas has an energy potential equivalent to 8.455.674 – 10.254.754 million kcal. The current generated biogas is equivalent to electricity energy of 8.455.674.613 kwh.

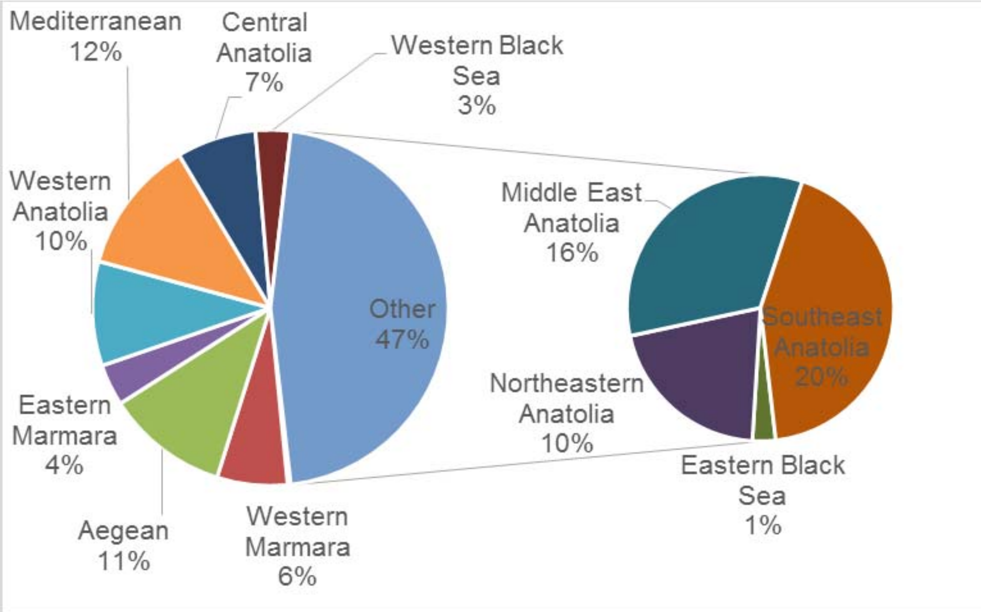

Figure 4.36. Wet fertilizer rate from sheep and goat by region

The calorific values of biogas obtained from Turkey and regions are given in Table 4.34.

Table 4.34. Calorific values of biogas from sheep and goat by region

	Production of Kerosene (lt)	**Production of Diesel Oil (lt)**	**Production of Oil (lt)**
Turkey	1 115 429 417	1 187 392 605	1 349 309 779
Istanbul	3 342 136,78	3 557 758,51	4 042 907,4
Western Marmara	71 293 522,9	75 893 105	86 242 164,8
Aegean	123 849 412	131 839 696	149 817 837
Eastern Marmara	42 037 995,2	44 750 123,9	50 852 413,5
Western Anatolia	105 892 336	112 724 100	128 095 568
Mediterranean	136 215 585	145 003 687	164 776 917
Central Anatolia	80 478 080,8	85 670 215,1	97 352 517,2
Western Black Sea	35 517 792,7	37 809 263,2	42 965 071,8
Eastern Black Sea	14 523 060,9	15 460 032,6	17 568 218,9
Northeastern Anatolia	106 648 050	113 528 569	129 009 738
Middle East Anatolia	173 010 630	184 172 606	209 287 052
Southeast Anatolia	222 620 816	236 983 449	269 299 374

When looking at the equivalents of the biogas obtained in Table 4.34 and 4.35, it is equivalent to 1.349.309.779 liters of oil, 1.115.429.417 tons of kerosene, 1.187.392.605 liters of diesel oil, 2.122.914.052 m^3 of natural gas, 6.242.806.576 kg of wood, 2.626.656.369 kg of coal and 773.604.273,1 kg of butane.

Table 4.35. Equivalents of biogas from sheep and goat by region

	Production of Natural Gas (m^3)	**Production of Wood (kg)**	**Production of Coal (kg)**	**Production of Butane (kg)**
Turkey	2122914052	6242806576	2626656369	773604273,1
Istanbul	6360840,98	18705184,9	7870193,07	2317933,576
Western Marmara	135687673	399013749	167884747	49445507,79
Aegean	235713396	693157191	291645389	85895559,71
Eastern Marmara	80007797,2	235277167	98992698,3	29155383,74
Western Anatolia	201537027	592655494	249359372	73441458,96
Mediterranean	259249016	762367869	320765732	94472098,99
Central Anatolia	153167960	450417646	189512900	55815443,17
Western Black Sea	67598379,6	198785066	83638673,1	24633307,83
Eastern Black Sea	27640664,3	81282292,6	34199466	10072445,47
Northeastern Anatolia	202975321	596885054	251138956	73965583,03
Middle East Anatolia	329278295	968301428	407412128	119991243,2
Southeast Anatolia	423697681	1245958436	524236114	154398307,6

When the Table 4.34 and 4.35 are examined, it is seen that the biogas is in the same rankings and ratios as the Figure 4.36 in the formation of calorific and equivalent values (Figure 4.37).

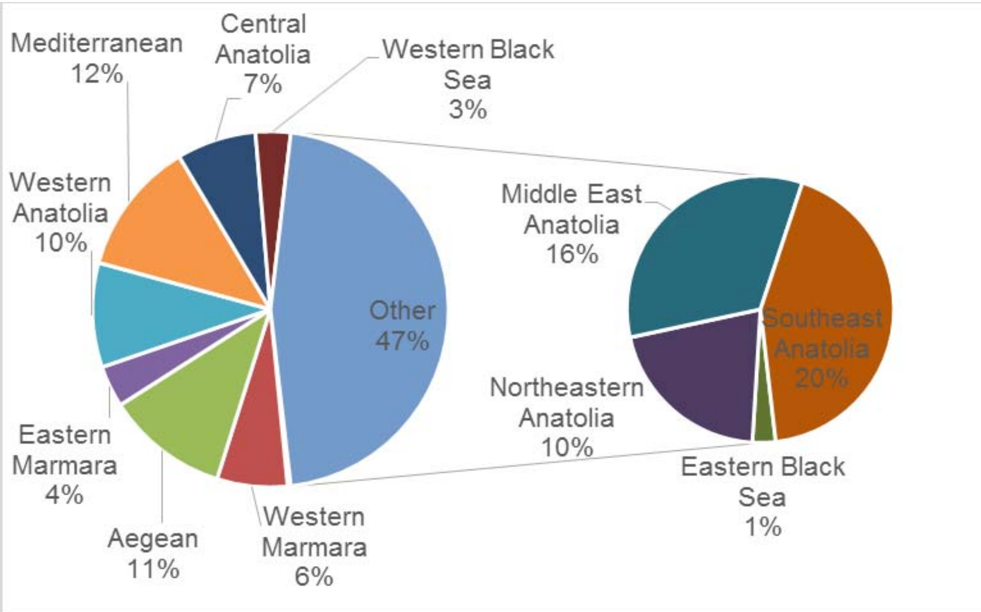

Figure 4.37. Calorific and equivalent values of biogas rate from sheep and goat by region

The production amounts of wet fertilizer, biogas and electric power which can be obtained from poultry in Turkey and regions are given in Table 4.36 for 2017.

Table 4.36. Wet fertilizer and biogas amounts, electric power generation from poultry by region

	Wet Fertilizer Amount (tons/year)	Biogas Amount (m^3/year)	Electric Power Generation (kwh)
Turkey	7 659 163	597 414 681,9	2 807 849 005
Istanbul	41 074,79	3 203 833,776	15 058 018,8
Western Marmara	928 776,2	72 444 547,03	340 489 371
Aegean	2 266 109	176 756 492,5	830 755 515
Eastern Marmara	1 969 152	153 593 838,7	721 891 042
Western Anatolia	644 847,6	50 298 111,86	236 401 126
Mediterranean	652 744,2	50 914 046,04	239 296 016
Central Anatolia	21 9966,3	17 157 369,37	80 639 636,1
Western Black Sea	501 082,7	39 084 451,69	183 696 923
Eastern Black Sea	16 581,44	1 293 352,632	6 078 757,37
Northeastern Anatolia	54 358,81	4 239 987,18	19 927 939,8
Middle East Anatolia	201 441,6	1 5712 442,46	73 848 479,6
Southeast Anatolia	163 028,3	12 716 208,65	59 766 180,7

Table 4.36 shows that approximately 7.6 million tons of wet fertilizer per year is obtained from poultry in Turkey. Considering the amount of fertilizer and large animal wastes, it is observed that the Aegean (30%), Eastern Marmara (26%), Western Marmara (12%) and Western Anatolia and Mediterranean (8%) regions have a large proportion of biogas potential (Figure 4.38). It is observed that 597.4 billion m^3 of biogas can be obtained from these fertilizer and that the amount of biogas has an energy potential equivalent to 8.807.849 – 3.405.263 million kcal. The current generated biogas is equivalent to electricity energy of 2.807.849.005 kwh.

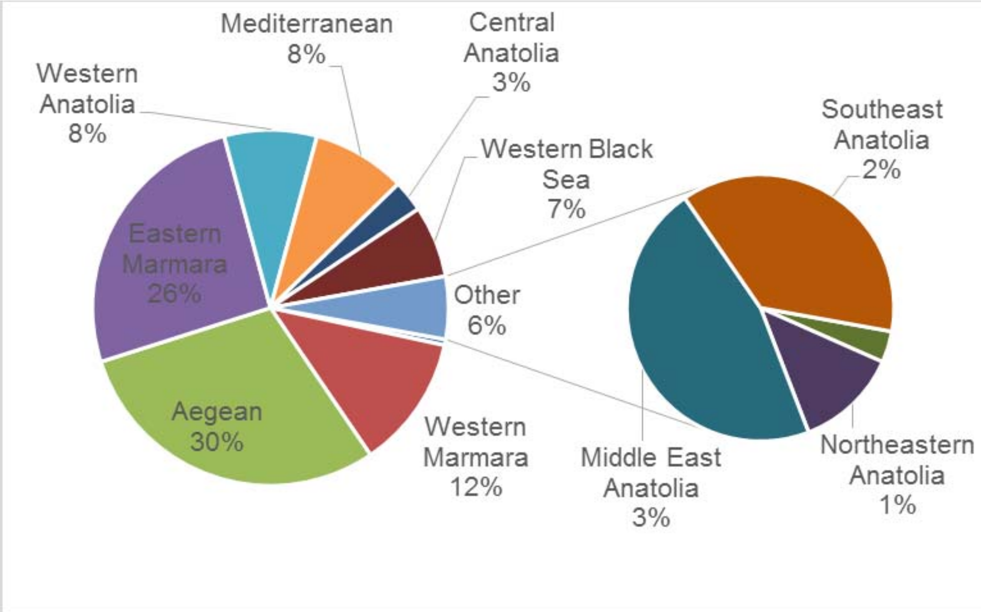

Figure 4.38. Wet fertilizer rate from poultry by region

The calorific values of biogas obtained from Turkey and regions are given in Table 4.37.

Table 4.37. Calorific values of biogas from poultry by region

	Production of Kerosene (lt)	Production of Diesel Oil (lt)	Production of Oil (lt)
Turkey	370397 102,8	394293690	448061011,4
Istanbul	1986376,941	2114530,3	2402875,332
Western Marmara	44915619,16	47813401	54333410,27
Aegean	109589025,3	116659285	132567369,4
Eastern Marmara	95228179,98	101371934	115195379
Western Anatolia	31184829,36	33196754	37723583,9
Mediterranean	31566708,54	33603270	38185534,53
Central Anatolia	10637569,01	11323864	12868027,03
Western Black Sea	24232360,05	25795738	29313338,77
Eastern Black Sea	801878,6318	853612,74	970014,474
Northeastern Anatolia	2628792,052	2798391,5	3179990,385
Middle East Anatolia	9741714,325	10370212	11784331,85
Southeast Anatolia	7884049,362	8392697,7	9537156,486

When looking at the equivalents of the biogas obtained in Table 4.37 and 4.38, it is equivalent to 448.061.011,4 liters of oil, 370.397.102,8 tons of kerosene, 394.293.690 liters of diesel oil, 704.949.324,6 m^3 of natural gas, 2.073.028.946 kg of wood, 872.225.435,5 kg of coal and 256.888.313,2 kg of butane.

Table 4.38. Equivalents of biogas from poultry by region

	Production of Natural Gas (m^3)	**Production of Wood (kg)**	**Production of Coal (kg)**	**Production of Butane (kg)**
Turkey	704949324,6	2073028946	872225435,5	256888313,2
Istanbul	3780523,856	11117303,2	4677597,313	1377648,524
Western Marmara	85484565,5	251382578	105769038,7	31151155,22
Aegean	208572661,1	613345029	258064479	76005291,77
Eastern Marmara	181240729,6	532970620	224247004,5	66045350,63
Western Anatolia	59351772	174534448	73435243,32	21628188,1
Mediterranean	60078574,33	176671740	74334507,22	21893039,8
Central Anatolia	20245695,86	59536071,7	25049759,28	7377668,83
Western Black Sea	46119653	135623047	57063299,47	16806314,23
Eastern Black Sea	1526156,106	4487933,63	1888294,843	556141,6318
Northeastern Anatolia	5003184,872	14712755,5	6190381,283	1823194,487
Middle East Anatolia	18540682,1	54522175,3	22940165,99	6756350,258
Southeast Anatolia	15005126,2	44125244	18565664,63	5467969,719

When the Table 4.37 and 4.38 are examined, it is seen that the biogas is in the same rankings and ratios as the Figure 4.38 in the formation of calorific and equivalent values (Figure 4.39).

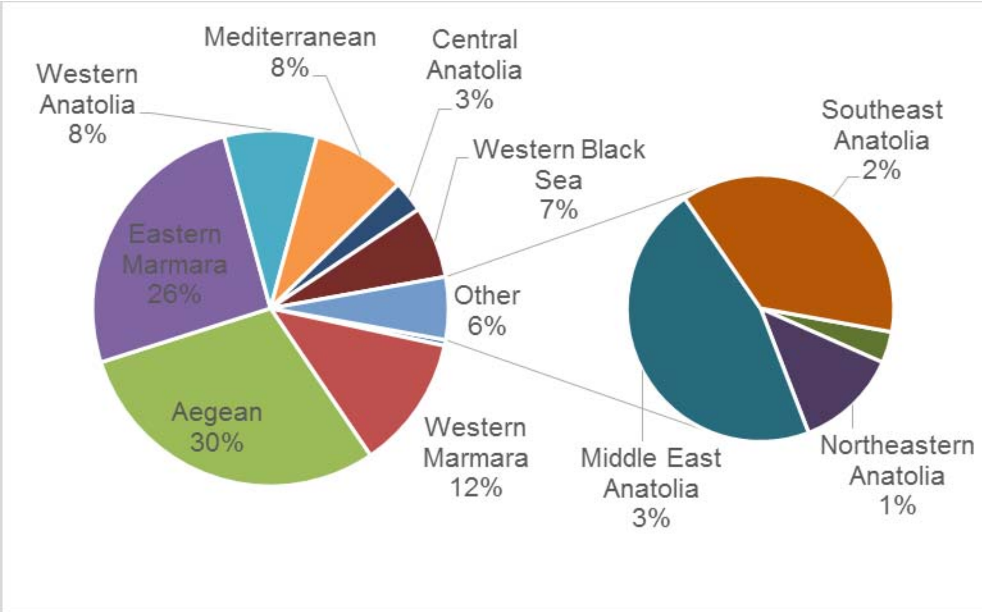

Figure 4.39. Calorific and equivalent values of biogas rate from poultry by region

Figure 4.40 is the general map of Turkey. It shows 7 main regions and 12 sub-regions. The Marmara Region ranks first in electricity consumption per capita, housing electrical energy consumption and industrial enterprises. The Aegean Region is second in housing electrical energy consumption and industrial enterprises in electricity consumption after Marmara Region. The Mediterranean Region ranks third in total energy consumption and after the Black Sea Region, it ranks second with its presence in the forest. Southeast Anatolia and Eastern Anatolia Regions per capita electricity energy consumption and total electricity consumption in the last one regions (Cagal, 2009).

Figure 4.40. Map of Turkey according to regions and sun-regions (Kulcu et al., 2010)

According to the Figure 4.41, the green, brown and pink colors in the circles show the energy that can be obtained from bovine, sheep and goat and poultry, respectively. According to this, the ratios obtained from bovine and poultry are 67% and 25% respectively, while the ratio obtained from sheep and goat is 8%. The Eastern Anatolia region has a high thermal value in terms of production of biogas which can be obtained from cattle. The Black Sea Region also shows similar characteristics to the Eastern Anatolia Region. When we look at the Central Anatolia Region, the energy obtained from poultry is much higher than the Eastern Anatolia and the Black Sea Regions. In the Mediterranean and Aegean Regions, there are poultry, goat and sheep breeding in accordance with the production of biogas. The Marmara Region, which is the first place in poultry husbandry, can benefit from animal wastes within the scope of energy production (Cagal, 2009).

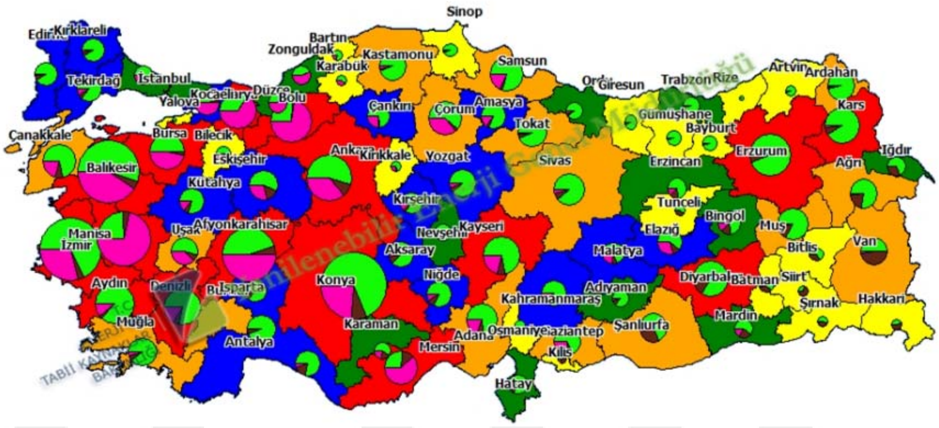

Figure 4.41. Energy value of animal wastes (TEO/year) (YEGM, 2018)

According to the Figure 4.42, the green, brown and pink colors in the circles show the energy that can be obtained from field, fruit and vegetables, respectively. According to this, the ratios obtained from field and vegetables are 84% and 10% respectively, while the ratio obtained from fruit is 6%. In agricultural biomass, most energy can be obtained from field crops throughout Turkey. For the Marmara Region, in the context of biomass energy production, it may be possible to evaluate grain residues and other vegetative residues. Wheat, sugar beet and barley are among the most important agricultural products in the Aegean Region. The cultivated area of cereals and other plant products for the Mediterranean Region is very high. Wheat, sugar beet, oil seeds and barley are the main products of plant products. The majority of the agricultural biomass potential of the Central Anatolia Region is composed of field crops. Black Sea Region is the first in Turkey hazelnut production. The important amount of hazelnuts produced in the region is exported abroad without crustaceans. Biomass energy production can be used in alternative energy production of hazelnuts which are important with high thermal value. In addition to plant products, the energy obtained from wood and non-wood forest products can be of great importance for the Black Sea Region, which has the largest share in the presence of the Turkish forest. Eastern and Southeastern Anatolia Regions due to unfavorable climate conditions, the energy value of vegetables can be obtained is almost negligible (Cagal, 2009).

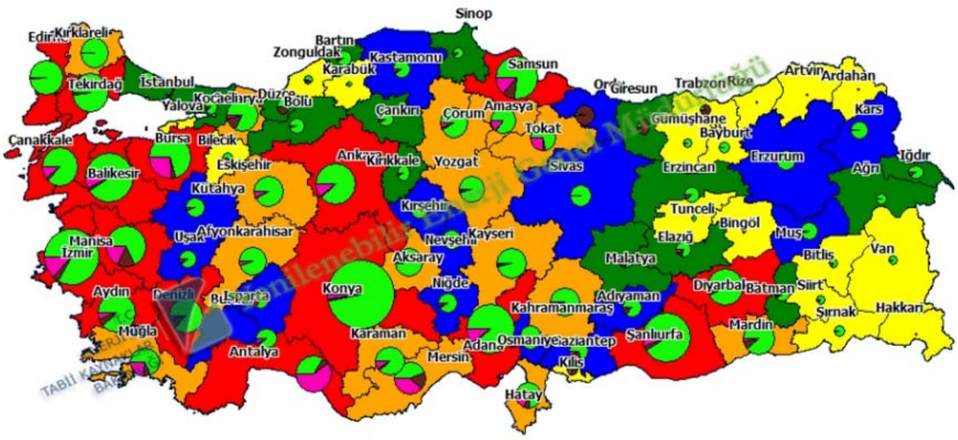

Figure 4.42. Energy value of agricultural wastes (TEO/year) (YEGM, 2018)

5. CONCLUSION AND FUTURE STUDIES

Agricultural and animal based biomass energy potential of Turkey and on the basis of provinces was investigated in this study. The agricultural and animal statistical data were obtained from the data of the Turkish Statistical Institute in 2017. Agricultural biomass sources were determined as oil seeds, edible roots and tubers, cereals, dry pulses, plants used in perfumery, in pharmacy or for similar purposes and fodder crops seed, fodder crops production, raw materials used in textiles to calculate the average agricultural biomass energy potential as MW. Animal waste types were also determined as poultry, sheep and goats, and bovine.

The results of biomass obtained from sources of agricultural origin are as follows in Turkey. Total sown area is 15.856.351 hectare and 436.049.652,5 tons average dry biomass amount can be obtained from this area. The average dry biomass energy value of this area is 176.600.109,3 TEO. This dry biomass is equivalent to 2.053.859 MW energy. When assessed regionally, it is seen that the largest potential in the Wetern Anatolia Region. For this region; the total sown area is 2.451.271 hectare, the average dry biomass amount is 67.409.952,5 tons, the average dry biomass energy value is 27.301.030,76 TEO and this dry biomass is equivalent to 317.511 MW energy.

The results of biomass obtained from sources of animal based are as follows in Turkey. The total number of animals that are used for biomass source is 408.561.087 numbers. The amount of animal waste available in Turkey is 96.655.868,19 tons. 4.309.771.357 m^3/year biogas can be obtained from these wastes. This biogas is equivalent to 2,025592538 x 10^{10} kWh/year of electrical energy, 3.232.328.518 liter/year of oil and 2.844.449.096 liter/year of diesel oil. When the regions are examined according to animal species, the highest values that can be obtained from bovine and poultry animals are obtained from the Aegean Region, while ovine animals (sheep and goat) can be obtained from the Southeast Anatolia Region. The values obtained from bovine animals in the Aegean Region are as follows. The amount of animal waste available is 3.098.599 tons/year and 102.253.774 m^3/year biogas can be obtained. This biogas is equivalent to 1.403.188.831 kWh of electrical energy, 197.043.538 liters diesel oil and 223.913.111 liters of oil. The values obtained from ovine animals (sheep and goat) in the Southeast Anatolia Region are as follows. The amount of animal waste available is 6.190.790 tons/year. 359.065.832 m^3/year biogas can be obtained. This biogas is equivalent to 1.687.609.409 kWh of electrical energy, 236.983.449 liters of diesel oil and 269.299.374 liters of oil. The values obtained from poultry animals in the Aegean Region are as follows. The amount of animal waste available is 2.266.109 tons/year. 176.756.492,5 m^3/year biogas can be obtained. This biogas is equivalent to 830.755.515 kWh of electrical energy, 116.659.285 liters of diesel oil and 132.567.369,4 liters of oil.

2017 TSI data have been observed in our country that a total of 408.561.087 bovine, ovine and poultry can be considered as biomass sources. The biggest problem of these animals is the disposal of their wastes. These problems can be eliminated by biogas production. Because biogas production provides both waste disposal and energy needs. As a result of oxygen-free fermentation, the resulting side product can be stored and there is no deterioration in its structure over time, and when the time is desired, it may be laid in the field.

The energy rivalries of countries have caused oil consumption, global warming and ecosystem degradation. In these energy competitions, our country must create its own energy policy. It is necessary to turn to renewable energy sources because of the reduction of fossil fuels, warming the Earth and eliminating the ecosystem. In order to meet the general energy demand in Turkey, renewable energy resources are needed, which can be used as long as possible. Fossil fuels are very important in meeting Turkey's general energy demand. Since renewable energy sources are useful, feasible, and have an inexhaustible resource, most of the countries use these resources.

The main objective of renewable energy generation is to provide the environment with less harmful and higher quality benefits at low cost. In this context, the best one of the examples is biomass. In addition to generating energy from biomass, a beneficial end product can be obtained and the plant and animal production will increase. Depending on this production, the economic and environmental income of rural areas will increase and in this case social welfare in rural areas will be observed.

Biomass energy is one of the best ways to achieve energy in our country, which is rich in agricultural terms. As can be seen in this study, the implementation of renewable energy sources is a good alternative to obtaining biogas from biomass, which has a useful and significant potential. In Turkey, a wide range of studies have been carried out on biomass and biomass energy potential. It is observed that these studies give significant meaning and value to Turkey's potential for biomass.

Today, biogas technology is an important factor for the production of renewable energy, which can be used to produce energy by processing wastes that cause environmental problems. Agricultural, animal and domestic wastes should be evaluated in meeting Turkey's energy needs and solving the energy problem. Turkey has an important biogas potential in terms of animal waste. However, in addition to determining this great potential, it is also necessary to dispose of animal waste in such a way that it does not pose any danger to the natural environment and human health. The biogas can be used for cooking, warming and lighting in the houses, as well as the use of cogeneration units, which can be added to the facilities, to obtain electrical energy, hot water and hot air.

In the studies, determination of biomass potential should be dealt with first and the varieties of biomass materials should be determined as annual amount. This issue should be considered as a strategic situation. The annual quantities must be determined for each geographic region depending on the kind of biomass materials that will be used for the purpose of energy production. For this purpose, the quantities of biomass that can be obtained from energy forestry, energy farming, byproducts and waste or debris should be investigated. Biomass energy production strategies, application opportunities and economic competitiveness should be investigated and long-term 'Biomass Energy Plan' should be made for our country. Biogas energy is an important source of energy that can meet increasing demands and can be used to replace oil. The use of fossil fuels should be reduced by activating the biogas as an alternative energy source. In addition to raw materials and environmental conditions in the production of biogas, the design of biogas generators is also effective in gas production. For this reason, it is necessary to determine the type of generator which can produce the most gas and which can produce continuously and cheaply. Cost analysis of biogas production should be done. Research and development activities on the production of energy from organic wastes should be increased and technological developments should be created.

In the field of biomass that can be obtained from energy forestry, wood yields can be cultivated outside the forest areas and the growing period of short tree species should be determined. These tree species are determined separately for each geographical region and yield, energy costs and growing techniques should be determined. Biomass energy production strategies, application opportunities and economic competition should be investigated and a long-term plan should be made for our country. Within the scope of this plan, a nationwide study should be carried out for energy forestry and energy plants.

Research and development studies should be carried out, supported and applied for modern biomass production methods and transformation technologies. Special fluidized bed boilers must be developed to be used as solid fuel to be burned with high efficiency in industrial plants and thermal power plants. For this purpose, the countries which have advanced in this technology should be followed, research and development programs should be followed and students should be sent to these countries to be trained.

Energy needs are increasing day by day at a time when climate changes are important and clean and efficient energy usage is highlighted. Environmental problems with industrialization are not only related to the consumption of resources, but also to how these resources are consumed or how much they can be recovered. In this context, although it is an important problem that agricultural, animal, domestic and industrial organic wastes cannot be evaluated sufficiently, the developments in this field are promising.

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