Bioenergy Potential for Energy Generation from Agriculture in Turkey

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Abstract

With both the developing technology and the increasing population in the world, the need for energy approaches the level that cannot be overcome. In line with these needs, state policies are formed and many regions of the world are witnessing energy wars. The damage caused by fossil fuels used to obtain energy is very dangerous. In order to get rid of this negative situation, studies on renewable energy sources are becoming increasingly widespread. Bioenergy, which is one of these sources, will enter our lives more in the near future and will be used as one of our main energy resources. Bioenergy is both used in electricity production and as fuel in vehicles. In this study, it has described the situation in Turkey and in the world of bioenergy. Basic raw materials of bioenergy; oilseed and waste oils. This study was conducted using a quantitative assessment oilseed production in Turkey amounts in different years. Turkey's bioenergy capacity in 2008 had been 102 megawatts while in 2017 increased to the level of 450 megawatts. In order to increase these values to higher levels, the cultivation areas of oilseed plants, which are one of the raw materials of biodiesel, should be increased and evaluated in biodiesel production. The data used in this study consist of statistical figures from the literature. In this study, only the literature was evaluated.

Keywords: Renewable energy sources, bioenergy, oilseed, oilseed production.

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1. Introduction

Energy is the most important asset in the universe in which we live. With the developing technology, there is energy consumption on the basis of every action we routinely perform in our daily life. Therefore, energy is the necessity of both technical and economic development. The main reason for the wars that have been waged throughout history is the desire to have energy resources. Eighty percent of the energy needed worldwide is derived from fossil fuels. The reserve distribution of fossil fuels is 68% coal, 18% oil and 14% natural gas **[1]**.

According to researches, in the near future, all fossil fuels will be exhausted **[2]**. This is one of the main reasons why some developed countries are turning to renewable energy. Another reason is increased environmental pollution. The most important reason why global warming in the world has become so serious is the fossil fuels we have used for hundreds of years.

91.8% of Turkey's oil needs are supplied through imports. 23.2 million tons of crude oil is imported every year. There is a completely external dependence on this issue **[3]**.

Biodiesel has emerged as an alternative to diesel and gasoline fuel used in vehicles. As long as the plant, sun, and water exist, biodiesel production will continue. Therefore, biodiesel is one of the inexhaustible energy sources. Biodiesel is a fuel that can be obtained from animal and vegetable wastes that do not harm the environment. It can also easily deteriorate in nature.

Biodiesel production is a great opportunity to develop its economy for countries with large agricultural areas. Turkey is one of these countries. The basic ingredient of biodiesel includes but not limited to oily seed plants or waste oils.

Waste oils cause serious environmental problems. By pouring vegetable oils from restaurants, hotels, houses and hospitals' kitchens into the sink, it causes the waste in the sewer pipe to stick to and the pipe to narrow. Waste oils poured into the sewage hold other wastes such as magnets. Day to day, the sewer system becomes unusable **[4].** In Turkey; it is forbidden to pour vegetable waste oils in soil and sewer. It is also forbidden to mix used cooking oils directly or indirectly with cooking oils. Vegetable waste oils are collected by collecting licensed companies from schools, hospitals, restaurants, and cafes. According to official data, 1.5 million tons per year in Turkey are used vegetable oil. It is estimated that approximately 350 000 tons of waste oil are produced annually from this vegetable oil **[5]**. 1 liter of vegetable waste oil pollutes one million liters of drinking water **[6]**. Vegetable waste oils constitute 25% of water pollution. Waste oils cover the water surface to prevent oxygen transfer from air to water. Vegetable waste oils reaching the sea, stream, and lake; it can damages birds, fish, and other species **[7]**. Therefore, the use of waste oils in biodiesel production not only reduces the cost but also reduces the negative impact on the environment **[8]**.

When these waste oils are used in biodiesel production, an annual gain of 480 million Turkish lira will be achieved. Also, the amount of greenhouse gas released into the atmosphere will decrease by 900 thousand tons **[4]**.

If biodiesel is used as an alternative fuel, the greenhouse gas effect can be reduced by the effect of exhaust gases in the world. The CO_2 which expelled as exhaust in the use of biodiesel won't remain in nature due to the reuse during the photosynthesis of plants **[8]**.

Biodiesel can be used not only in vehicles but also as fuel in ships and boilers.

2. Materials and Methods

2.1 Energy Consumption Status in the World and Turkey

The use of energy in the world is proportional to population and production. The amount of energy spent to maintain the house thermal balance also leads to a great deal of energy cost. Figure 1 shows the energy expenditure of some selected countries in 2017. The values are given in Figure 1 are in million metric tons of oil equivalent.

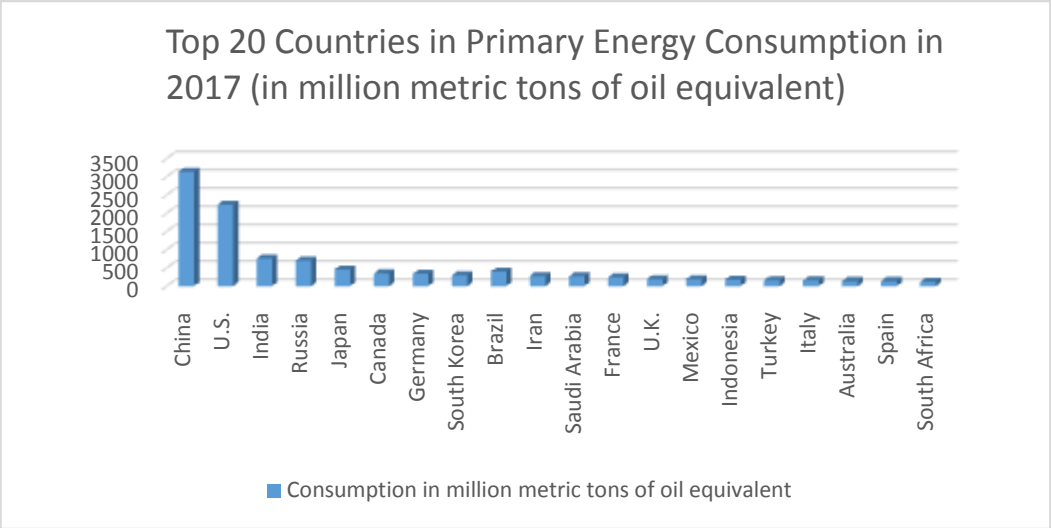

Figure 1. Top 20 Countries in Primary Energy Consumption in 2017 **[9]**

China, the world leader in industrial production due to its high population and cheap labor force, is the leader in energy consumption with 3132,2 million metric tons. Because this energy is fossil-born, it is also China, which causes the highest CO_2 emissions. With 2234,9 million metric tons, the US is the second most energy-consuming country in terms of industrial and transportation expenditures. India ranks third in energy consumption with 753,7 metric tons. Turkey makes the energy expenditure at a lower level compared to developed countries. The amount of energy spent by Turkey in 2017 was 157,7 million metric tons.

The majority of energy consumption in Turkey in 2017, had been in the manufacturing sector with 57%. Transport and construction sectors followed this **[10]**.

Due to increased energy use, the amount of CO_2 released is continuously increasing. Figure 2 shows the period from 1996 to 2016; the quantities resulting from the use of fossil fuels are observed.

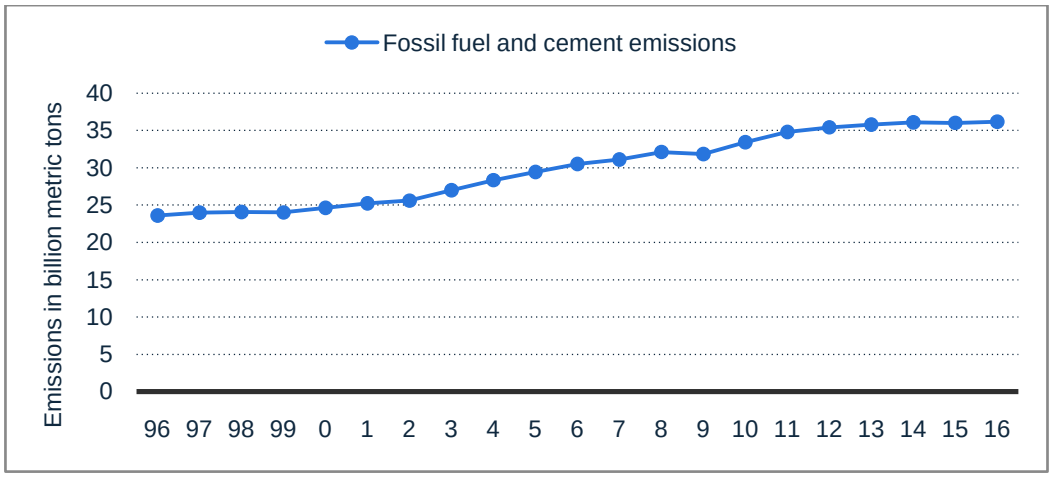

Figure 2. Global CO_2 emissions from 1996 to 2016 (in billion metric tons) **[11]**

The amounts in Figure 2 are in billion metric tons. While the amount of CO_2 released in 1996 was around 24 billion metric tons, it exceeded the 35 billion metric ton limit in 2016. Considering the increasing world population, we can say that the amount of energy used will increase exponentially. If the increased amount of energy continues to use fossil-based fuels, the amount of CO_2 released globally will increase exponentially. These figures clearly show the extent of the hazard. The balance of the air components is increasingly impaired. As a result of this situation, the threat of global warming is increasing.

The only way to get rid of this situation is to obtain the energy needed from clean sources. Every state in the world has a clean energy rate in the ratio of investment in clean energy. The more the investment increases, the more power plants are installed and the resulting energy rate increases. In Figure 3, some countries have invested in clean energy in 2017. The values given are in billion dollars.

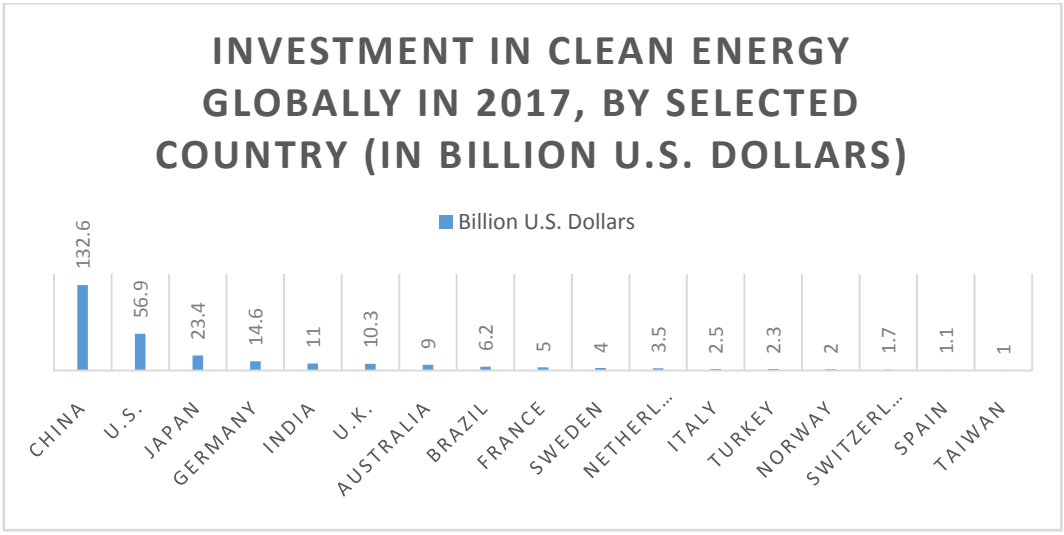

Figure 3. Investment in Clean Energy Globally in 2017, by selected country **[12]**

In according to Figure 3, China is the leading country in this area with $ 132,6 billion. Turkey is below the level expected by $ 2,3 billion. However, the awareness that is required in both managers and society is formed over time. Thus, Turkey's renewable energy capacity is increasing.
The Figure 4 shows Turkey's total renewable energy capacity up to 2017 from 2008. The values given are in megawatts.

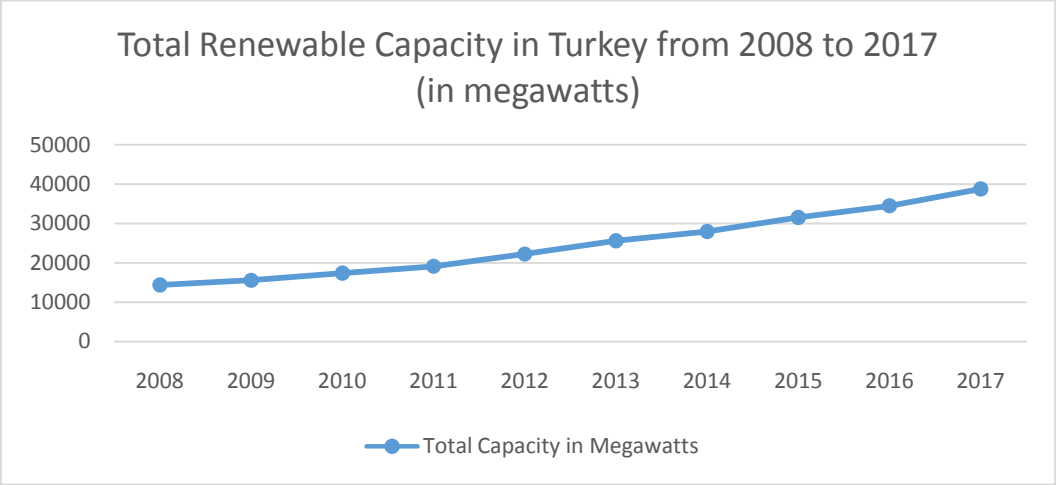

Figure 4. Total Renewable Capacity in Turkey from 2008 to 2017 **[13]**

According to the Figure 4, Turkey's renewable energy potential is increasing with each passing year. This value, which was below 15 000 megawatts in 2008, approached 40 000 megawatts in 2017. The reason for this is the increase in investment and training of people in this field. Both due to environmental and economic issues, Turkey is turning to renewable energy.

2.2 Biodiesel Usage Status of the World and in Turkey

Nowadays biomass energy can be divided into two classes as classical and modern. The simple incineration of the animal wastes and the trees is defined as conventional biomass also biodiesel obtained from oilseed plants can be defined as modern biomass energy source **[14]**.
Turkey is a country which has high potential in terms of both classical and modern biomass energy. Turkey's taking place in the sun region and be conducive to agriculture in terms of climatic conditions; it gives itself an advantage in terms of biomass.
World energy agenda is becoming more and more aware of the bioenergy. This issue is becoming increasingly widespread worldwide. The Figure 5 shows the global bioenergy capacities from 2007 to 2017.

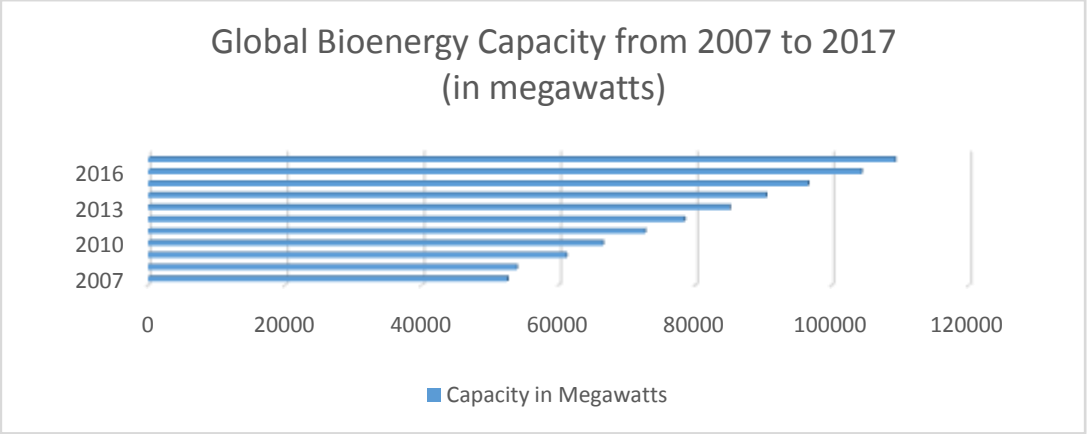

Figure 5. Global Bioenergy Capacity from 2007 to 2017 **[15]**

According to the Figure 5, it is possible to say that bioenergy capacity is increasing worldwide. The capacity, which was around 45 000 megawatts in 2007, approached 110 000 megawatts in 2017.
Some countries have made more progress on biodiesel than others. In the Figure 6, the values of some countries with energy gain in the biodiesel area are given in 2017. The values given are in megawatts.

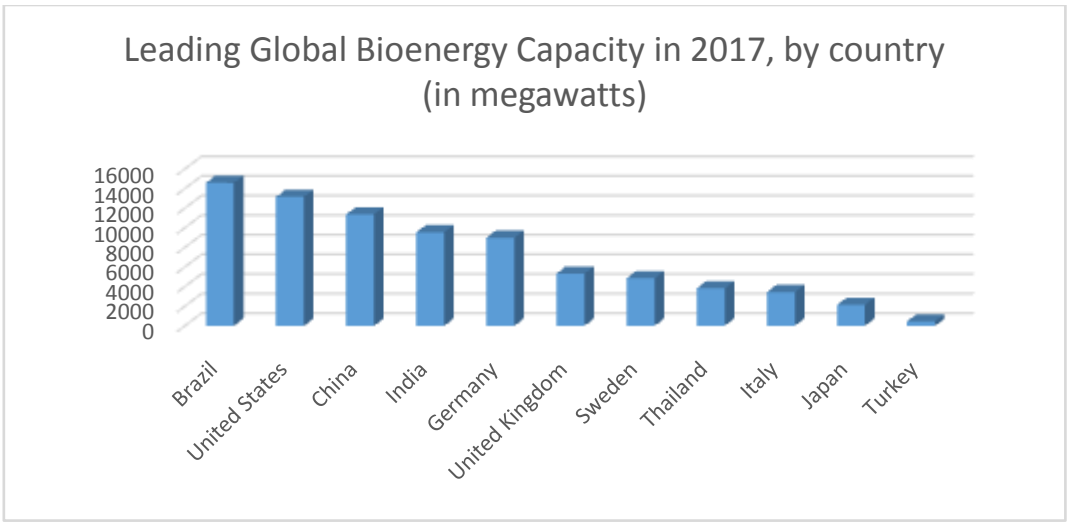

Figure 6. Leading Global Bioenergy Capacity in 2017 **[16]**

Looking at the Figure 6, it can be said that Brazil has the highest biodiesel capacity for 2017. Then, there are USA and China. Given the high levels of investment in clean energy, it is normal for the USA and China to be at the top of the list. However, the reason Brazil is so advanced in this regard is that it has large agricultural lands composed of oilseed plants.
The share of oilseed crops is only 4% of the total arable land in Turkey. This value is 28,2% in Brazil, 20,9% in the US and 19,2% in China **[17]**.
The main source of biodiesel production is oilseed plants. Sunflower, rapeseed, safflower, soy, and sesame can be given as examples.
Although Turkey was still lower than in other countries, though in recent years has focused on bioenergy. It tries to provide the necessary infrastructure and increases its production. The Figure 7 shows the total bioenergy capacity from 2008 to 2017. The values given are in megawatts.

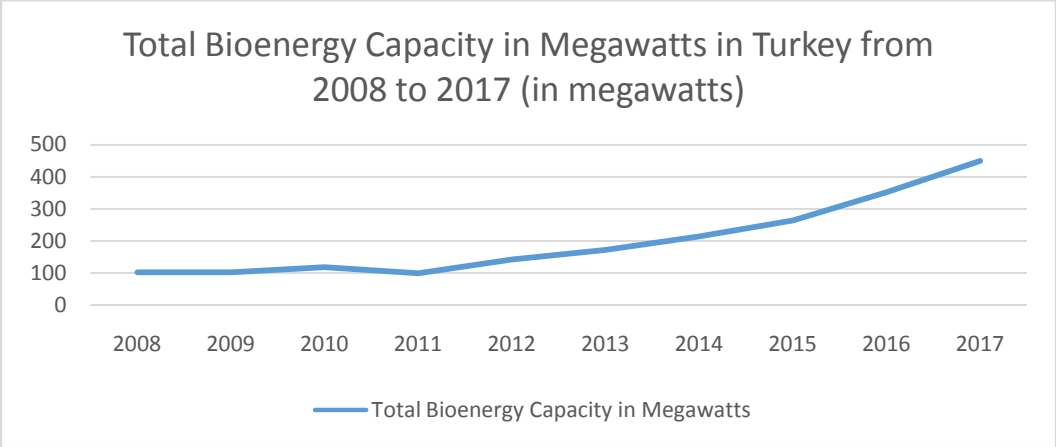

Figure 7. Total Bioenergy Capacity in Megawatts in Turkey from 2008 to 2017 **[18]**

According to the Figure 7, it said that Turkey in the last 10 years its capacity doubled to about 5. These values give hope for the near future.

Most preferred among the oilseed plants, which are the main ingredients of bioenergy; Sunflower, soybean, sesame, rapeseed, and safflower. Cotton, peanuts, poppy, castor oil, flax, and hemp are not preferred for biodiesel production. The reason for this is the rate of energy they provide. As an economic reason, the most efficient ones are preferred. The Figure 8 shows oilseed plant rates worldwide. The figures are from 2010 to 2015.

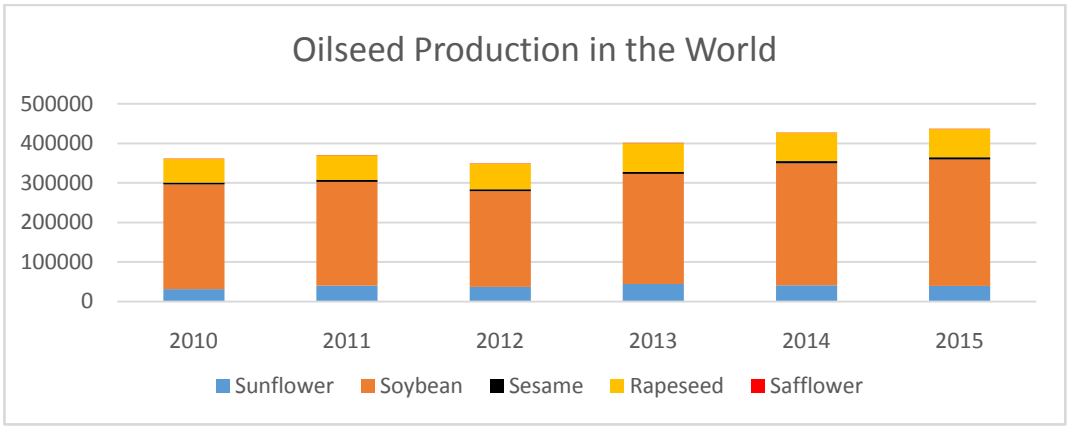

Figure 8. Oilseed Production in the World **[19]**

Looking at the Figure 8; it is seen that the number of oilseed plants obtained in the years has increased. In addition, it can be said that soybean is the most common in terms of production volume in the world and the least produced is safflower.

The situation is different for Turkey. As can be seen from the Figure 9, the most produced oilseed plant species is the sunflower. The least produced is sesame. From 2010 to 2015; the number of oily seed plants has increased.

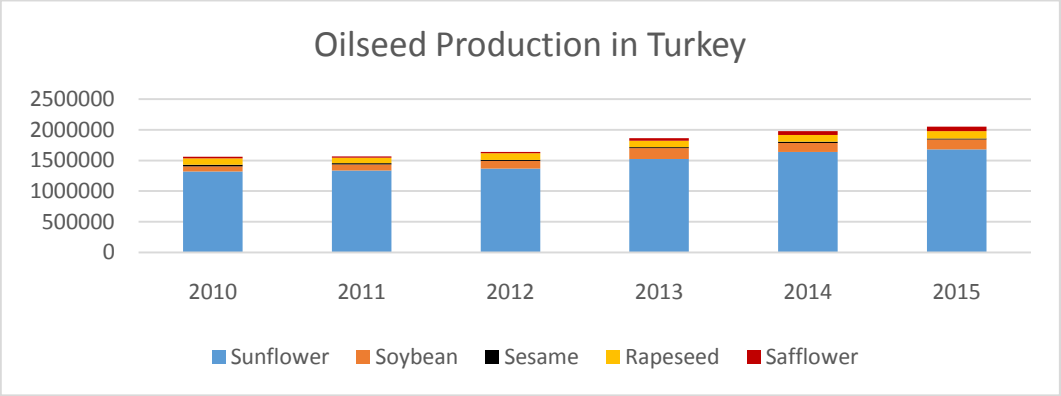

Figure 9. Oilseed Production in Turkey **[20]**

The reason for the increase in the number of seeds produced over the years is the increase in the agricultural area allocated to these areas. The Figure 10 appears in 2015 the percentage of agricultural land devoted to oilseed cultivation in Turkey.

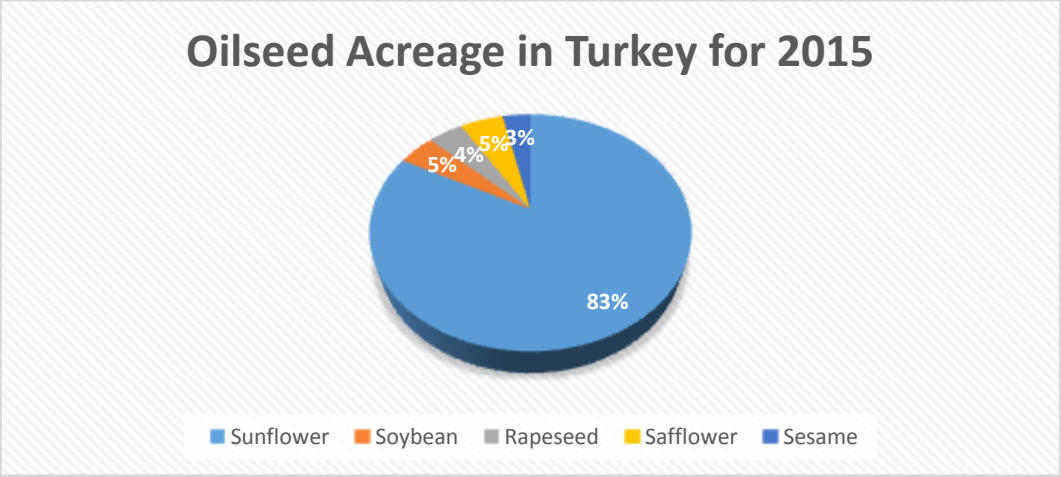

Figure 10. Oilseed Acreage in Turkey for 2015 **[21]**

According to the Figure 10, in 2015, in Turkey, 83 percent of the cultivated oilseed crops is the sunflower. The numerical equivalent of this is 6 853 174 decares. Sunflower cultivation is followed by 367 323 decares of safflower, 360 323 decares of soybeans, 350 817 decares of rape and 280 887 decares of sesame seeds. All values are in terms of decares.

In addition, oilseeds acreage is increasing in Turkey. However, production could not be achieved to meet the need for use in both biodiesel and other subjects. Due to this deficiency, it is necessary to export. Some of the reasons for failure are as follows.

- Inability to compete with foreign market prices due to high production costs in oilseeds
- Turkey is higher than the world price of crude oil
- Failure to compete with alternative products in the regions where they are raised due to low return on the unit area.

Derived from the oilseed in Turkey yield are shown in the Figure 11. The values used were obtained from 2015 data.

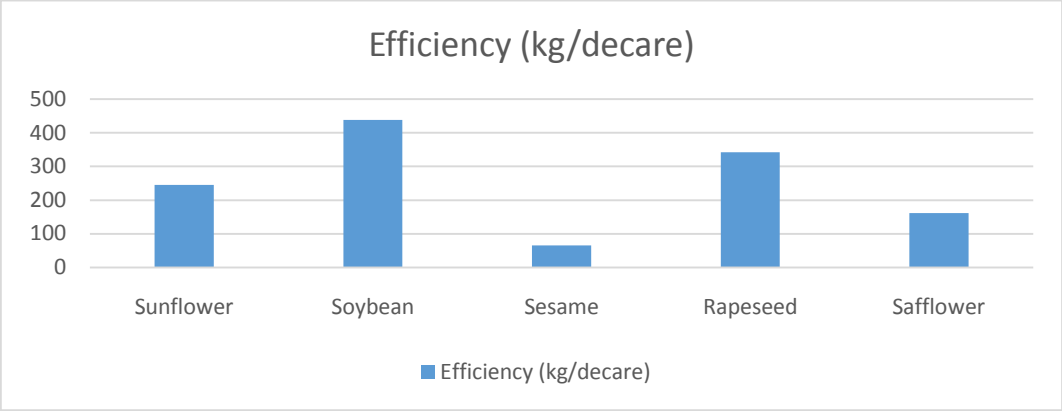

Figure 11. The yields of oilseed crops in Turkey at 2015 **[22]**

As can be seen from the Figure 11; the highest yield was obtained from soybean with 438 kg/decare. It was followed by rapeseed with 342 kg/decare, sunflower with 245 kg/decare, safflower with 162 kg/decare and sesame with 66 kg/decare. Based on these values; it can be said that Turkey should give to priority soybean production in general. If the priority had been given to soybean production instead of sunflower production in Turkey, it could be a higher level on bioenergy.

2.3. Biodiesel Potential of Turkey

Turkey's bioenergy potential is shown in the Figure 12.

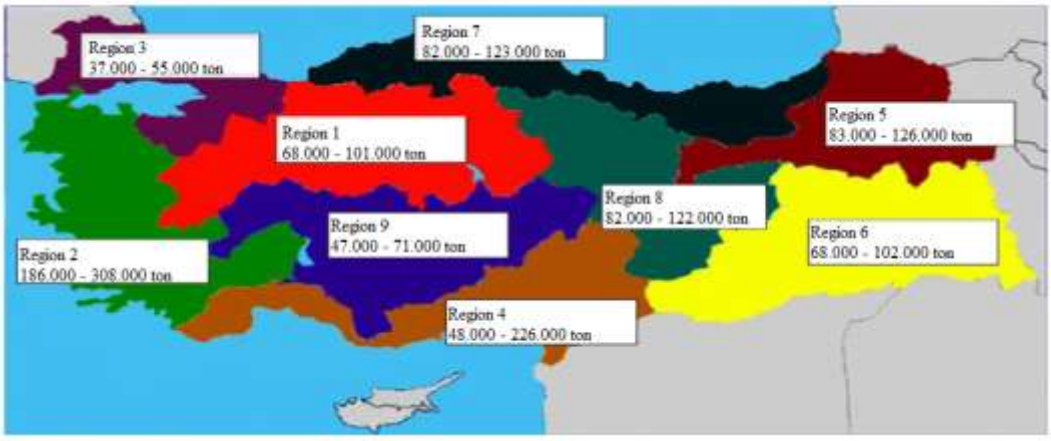

Figure 12. Bioenergy potential of Turkey **[23]**

As can be seen from the Figure 12; some regions are more advanced in this regard than others. The main reason for this is; that the relevant regions are more suitable for oilseed crop cultivation. Region 3 has the least capacity due to Turkey's industry zone. Region 4, which includes favorable for Turkey's mainly agricultural land, has the highest capacity.

Together with the production from industrial zones, countries are increasing their production volumes and expanding their economies. A certain part of the energy spent to make these productions can be provided from biodiesel. Agricultural lands are helping us in this regard. The more these are evaluated, the more so will the country's economy.

The status of biodiesel in Turkey is shown in the Figure 13.

Figure 13. The current status of biodiesel production in Turkey **[23]**

The Figure 13 shows the number of companies actively working in the biodiesel field in Turkey and regional distribution are shown. This number is insufficient. The number of companies working in this field should be increased as soon as possible and this situation should be improved. The most fundamental task of a country which to want to be powered should be to produce its own energy and not to be dependent on the other countries.

But if it can activate renewable energy sources and increase its capacity every day; it will reduce its dependence on foreign countries about both energy and economical.

2.4 The Impact on the Economy of the Oilseed Production in Turkey

The last 10 years the total value of agricultural imports and exports in Turkey are shown in Table 1.

Table 1. The total agricultural imports and exports by years in Turkey **[24]**

Year	Export (million US dollars)	Import (million US dollars)
2008	3.923,4	6.151,3
2009	4.347,4	4.593,8
2010	4.934,7	8.895,1
2011	5.166,6	8.869,3
2012	5.188,6	7.446,6
2013	5.653,3	7.718,0
2014	6.029,7	8.588,5
2015	5.756,6	7.176,3
2016	5.397,2	7.041,3
2017	5.287,6	8.990,7

Based on these data, it is seen that imports increased faster than exports. This situation has negative consequences on the Turkey's economy.

The amount of oilseeds produced in Turkey in the last 10 years is shown in Table 2.

Table 2. Oil seed production by years in Turkey **[25]**

Year	**Production (Tonnes)**
2008	2 311 432
2009	2 396 044
2010	2 969 477
2011	3 227 588
2012	3 138 361
2013	3 299 967
2014	3 508 640
2015	3 442 098
2016	3 480 629
2017	3 883 370

It is seen that the amount produced has increased regularly in the last 10 years. The monetary value of production in 2016 was 3 992 877 636 TL, Monetary value of production in 2017 was 4 278 368 636 TL **[25]**.

Due to a lack of oilseeds production in Turkey, significant amounts of oilseeds and their derivatives were imported from abroad every year and for this, large amounts of foreign currency were paid abroad (the highest after oil). In the period between 2008 and 2017, 2.327 thousand tons of oilseeds and 1.197 thousand tons of crude oil were imported. In this process, a total of 2.651 million $/year foreign exchange was paid for the average imports of 1.295 million $/year oilseeds and 1.356 million $/year for crude oil imports **[17]**.

2.5 Advantages and Disadvantages of Biodiesel

Biodiesel is produced from either waste oil or vegetable oil through the process of transesterification when it reacts with monohydric alcohols **[26]**. For this reason, biodiesel is considered a renewable fuel that can replace diesel fuel in the future. It does not create any toxic effects because it can decompose biologically quickly and easily in nature. Studies have shown that biodiesel decomposes faster in water than diesel fuel **[27]**. In addition, biodiesel has many advantages over diesel fuel in terms of fuel properties. Biodiesel is superior to diesel fuel in terms of emissions, cetane number, flash point, and lubricant properties. Therefore, the storage and transport of biodiesel are more reliable. One of the advantages of biodiesel is its lubricating properties. Especially in low sulfur diesel fuels, it is possible to increase the decreasing lubrication by using biodiesel **[28]**. The main compounds affecting the lubrication of biodiesel are fatty acid methyl esters and monoglycerides **[29]**. There is no sulfur in the structure of biodiesel. The sulfur contained in the fuels is combined with the moisture in the air, resulting in acid rain. The absence of sulfur in the biodiesel indicates that it is a green fuel. The negative effects on the ozone layer are 50% less than that of diesel fuel in the use of biodiesel. Glycerin, which is also used in many fields such as cosmetics and pharmaceutical industry, is obtained as a by-product when producing biodiesel. Cold flow characteristics of biodiesel are worse than diesel fuels and can cause problems during cold weather. Furthermore, biodiesels containing high amounts of saturated fatty acids may cause blockages of fuel filters and fuel line pipes in winter **[30]**. Another disadvantage of biodiesel is its tendency to oxidation. Biodiesel in contact with air starts to oxidize rapidly at high temperatures. However,

biodiesel has a higher flash point. This makes it safer in terms of storage and portability of biodiesel, although it does not directly affect combustion **[31]**.

3. Results

Such as the world's developed countries, Turkey's bioenergy production capacity is increasing day to day. Turkey's bioenergy capacity in 2008 had been 102 megawatts while in 2017 increased to the level of 450 megawatts. However, these values are still not at the desired level. As Turkey is an agricultural country, it should produce a lot of these values on bioenergy.

The contribution of biodiesel produced from oilseed plants and waste oils to the national economy is of great importance. In addition to the economy, the most important advantage of biodiesel use is that is harmless to the environment. As a result, the acreage of oilseed crops in Turkey should be increased and should be evaluated in the production of biodiesel.

Recently technology costs have fallen significantly and will continue to decline through technology innovation, competition and growing markets, and regulatory streamlining **[32]**.Therefore, the developed countries of the world give more importance to renewable energy sources. To reduce its dependence on outside Turkey should be increased emphasis on renewable energy sources, necessary legal arrangements should be made and the citizens should be given to environmental awareness.

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