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Economic Analysis of Bioethanol Production from Sugar Beet in Türkiye[1]

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Abstract

With developing technology and increasing population, oil consumption in the world has increased rapidly. Countries have turned to alternative energy sources due to the decrease in oil reserves and the monopoly of a few countries, the past oil crises, and the instability of oil prices. In addition, the fact that fossil fuels cause environmental problems has increased the interest in renewable and domestic energy sources in Türkiye as well as in the world. Türkiye is a country that is highly dependent on foreign oil and also is a party to international agreements on climate change. Bioethanol, a renewable energy source, is the most produced and consumed liquid biofuel in the world. Bioethanol is of great importance for Türkiye both economically, strategically, and environmentally. In this article, Türkiye's fuel bioethanol sector will be examined using current data.

Keywords: Bioethanol, sugarbeet, economic analysis
Jel codes: A23, Q1, Q2, Q4, Q5

1. Introduction

The fate of oil, which was once sold as medicine in pharmacies, changed in the mid-1800s when Abraham Gesner refined kerosene from naturally occurring oil, and this event was accepted as the birth of the oil industry. The importance and cruciality of oil began to be better understood after the first oil crisis of 1973. Oil crises especially triggered energy-importing countries to seek for various policies for the sustainable use of energy, and in the 2000s, the search for alternative energy sources began to gain great momentum. (Karagöl and Kavaz, 2017).

Energy is provided from two main sources: fossil fuels and renewable resources. Today, many developed countries meet almost all of their energy needs from fossil fuels such as oil, coal, and natural gas. The increase in greenhouse gas emissions caused by humans due to the intensive use of fossil fuels has brought about global warming and, in turn, climate change. With the environmental awareness that emerged in the 1990s, the UN Framework Convention on Climate Change, which was opened for signature at the UN Environment and Development Conference held in Rio de Janeiro in 1992, was the first and most important step taken

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internationally. The EU and 196 countries became parties to the convention, which entered into force in 1994. Türkiye joined the UNFCCC in 2004 (T.C. Dışişleri Bakanlığı, 2019). The Kyoto Protocol entered into force in 2005 as an international framework agreement within the UNFCCC. Countries that signed this protocol pledged to reduce the emission of carbon dioxide and five other gases that cause greenhouse effects, or if they are unable to do so, to increase their rights through emissions trading. Türkiye officially announced that it would sign the Kyoto Protocol in 2008 (ATB, 2019), and became a party to it in 2009 (T.C. Dışişleri Bakanlığı, 2019).
Bioethanol is one of the important alternative and renewable energy sources. The molecular structure of bioethanol and ethanol is the same. The main reason for the two different names is the difference in their production methods. While bioethanol is produced from biological sources by fermentation, ethanol is obtained from fossil products (Şimşek S. Özdalyan B. Öztürk E. and Şimşek H., 2018). The use of bioethanol as a motor fuel is as old as the history of internal combustion engines. It is known that N.A. Otto used alcohol in his engine work in 1897 (Karaosmanoğlu, 2006). The use of bioethanol as a fuel in automobile engines was first started in engines produced by Henry Ford. The use of bioethanol as fuel in vehicles called the Model T, which was launched in 1908, was considered revolutionary for its time (Hatunoğlu, 2010). Henry Ford said, 118 years ago (1906), "*The fuels of the future will be provided from fruits, grasses, straw, and almost everything*." Ar, 2010). Due to reasons such as global warming and climate change, energy demand, policies regarding rural development, and developing bioethanol production and use technology, bioethanol production and use have increased rapidly and become an important industry.

2. World Energy Outlook

The demand for energy in the world has increased rapidly and keeps increasing due to world population growth and developing technology. World energy consumption and demand data from 1990 to 2040 are shown in Figure 1 on a source basis. The daily energy demand, which was 163 (mpe b/d) in 1990, increased by 63% to 267 (mpe b/d) in 2016. It is estimated that this demand for energy will continue to increase and reach to 361 (mpe b/d) by 2040. A large part of the world energy demand is met by oil. The oil demand, which was 63 (mpe b/d) in 1990, increased by 38% to 87 (mpe b/d) in 2016. It is estimated that this demand for oil will continue to increase over the years and will reach 97 (mpe b/d) by 2040.

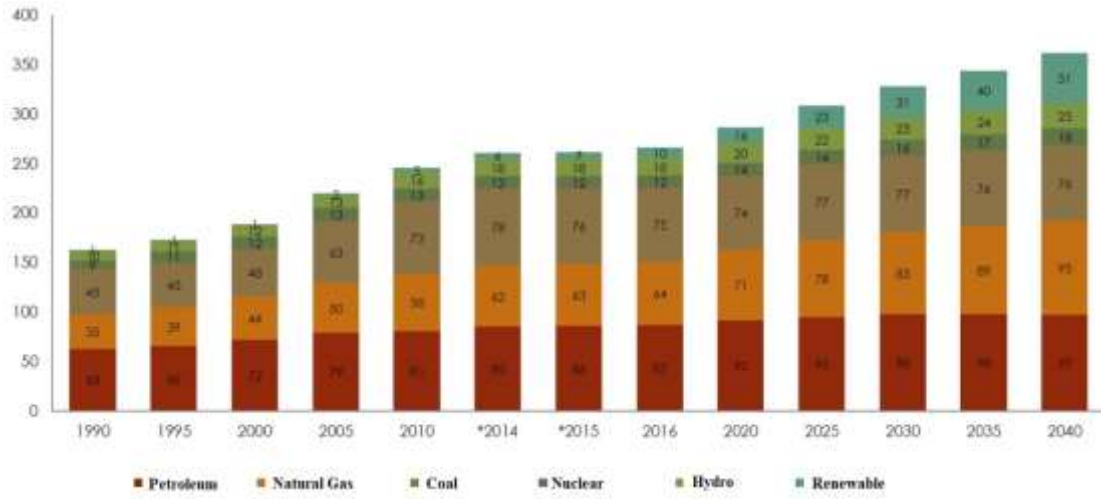


Figure.1 World Energy Demand by Source (Million Oil Equivalent, barrels/day)
Source: TP "2017 and 2018 Crude Oil and Natural Gas Sector Reports". p,4

As for primary energy consumption rates based on 2016 data, oil has become the most consumed primary energy source with a usage of 34.2%, followed by coal with 27.6%, natural gas with 23.4%, hydro with 6.8%, nuclear energy sources with 4.4% and renewable energy sources with 3.6%. Figures show that fossil fuels had the largest share among the primary energy sources used. Renewable and domestic energy sources have become important due to the fact that energy needs are largely met from fossil resources, their reserves are limited and their distribution on the earth is unbalanced, as well as the excessive use of fossil fuels creates air pollution and increasing environmental awareness. Oil has ranked first among underground treasures throughout history. Since currently no energy source can fully replace oil, the demand for oil is still very high. In this regard, in the

transportation sector, which is one of the sectors oil is used the most; biodiesel and bioethanol, which are motor fuels that can be blended with diesel and gasoline or used directly, are important.

3. Outlook in Energy Sector in Türkiye

Türkiye, with its increasing population and developing industry, is among the countries that consume significant amounts of energy in the world. However, since Türkiye has limited natural resources (especially oil), it meets a significant part of its energy demand through imports. Türkiye's primary energy supply in 2021 is only 159.4 million tpe (TP, 2022). The distribution of sources in Türkiye's primary energy supply in 2021 is shown in Figure 2. While natural gas ranked first in energy supply with a share of 31%, oil ranked second with a share of 28%. These were followed by coal with a share of 26%, geothermal with a share of 7%, hydro energy with 3% and other energy sources with a share of 4%. In Türkiye, as in the world, fossil fuels, particularly naturalgas and oil, are the most consumed energy sources.

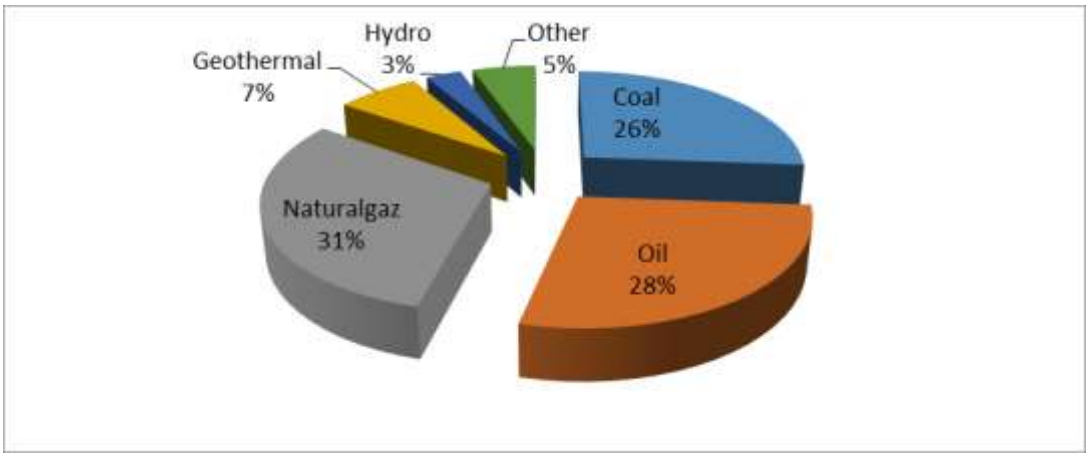


Figure 2. Distribution of Resources in Türkiye's Primary Supply in 2021
Source: TP. (2022). p,40

The supply sources of oil, which is one of the most used energy sources in Türkiye's energy consumption, are given in Figure 3. In 2007, nearly 6% (43 thousand b/d) of the total oil demand of 718 thousand b/d was met by domestic crude oil production. The supply sources of oil have not changed much proportionally over the years, and 6.6% (55 thousand b/d) of the total 832 thousand b/d oil supply in 2018 was met by domestic crude oil production. As a matter of fact, Türkiye is a country that is largely dependent on foreign sources for the oil it needs.

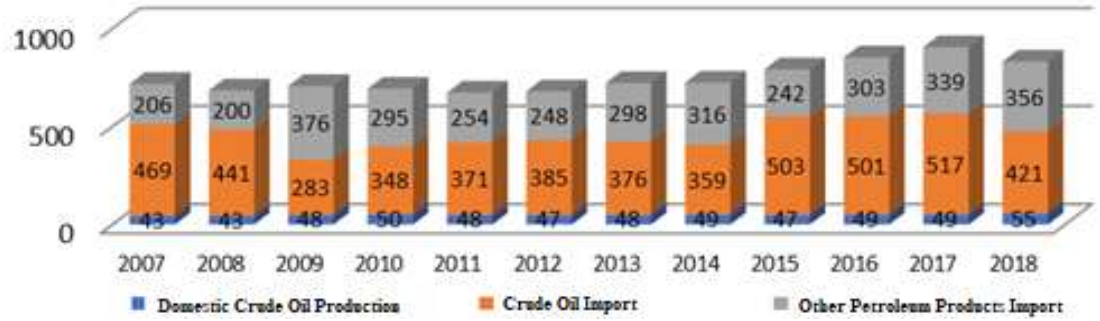


Figure 3. Türkiye's Oil Supply Sources (1.000 b/d)
Source: TP. (2019). p:34

4. Bioethanol

With developing technology and increasing population, energy demand in the world is increasing rapidly. A large part of this energy is met by fossil fuels, especially oil. However, countries have turned to alternative energy sources due to reasons such as the decrease in oil reserves and the monopoly of a small number of countries, the resulting dependence on foreign energy, oil crises, instability of oil prices, and the environmental problems caused by fossil fuels. In this regard, in the transportation sector, which is one of the sectors oil is used

the most; biodiesel and bioethanol, which are motor fuels that can be blended with diesel and gasoline or used directly, are important.

Bioethanol is a type of renewable fuel made from plant materials such as corn, sugar cane, sugar beets or other biomass. It is produced through fermentation of sugars found in plants and uses yeast to convert the sugars into ethanol and carbon dioxide.

Positive Environmental Impacts:

- Renewable source of energy
- Reduction of Greenhouse Gas Emissions
- Improved Air Quality
- Utilization of Agricultural Waste: This helps in waste management and reduces the environmental burden associated with agricultural waste disposal. This practice can also enhance the overall sustainability of agricultural practices.
- Commonly used as a fuel for vehicles, either in its pure form or blended with gasoline. It is also used in heating, disinfectant and cologne production.

Negative Environmental Impacts:

- Land Use Change: The conversion of forests or grasslands into agricultural land for energy crops. This can result in habitat loss, biodiversity decline, and increased carbon emissions from soil disturbance
- Water Consumption: Water shortages may occur in some regions due to agricultural irrigation used to grow energy crops.
- Fertilizer and Pesticide Use: If fertilizers and pesticides are used unconsciously in order to obtain more energy crops, environmental damage may occur.
- Food vs. Fuel Debate: This issue needs to be addressed comprehensively due to food shortage, which is one of the problems brought by the increasing population in today's world. In Türkiye, biofuels are not produced in sufficient quantities to create a food crisis (Ar, 2008).

Challenges in Bioethanol production:

- High Production Costs (compared to petroleum and other bioethanol producers)
- Limited Feedstock Availability: Despite Türkiye being a major agricultural producer, the current output of crops such as wheat and sugar beets is insufficient to meet the demand for bioethanol production.
- Lack of Advanced Technologies
- Inconsistent Policies: This inconsistency can deter long-term investments in the bioethanol sector.

bioethanol ın the world

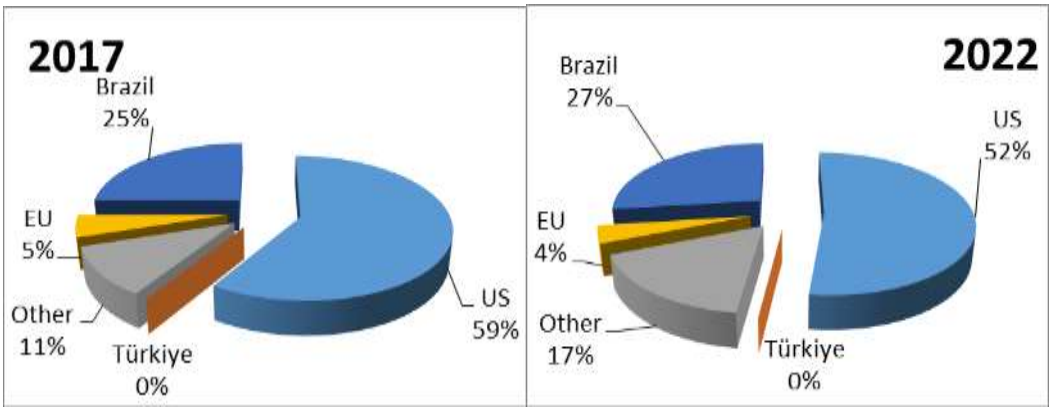
World fuel ethanol production increased by approximately 20% in the last 10 years, from 90.36 billion liters to 108.18 billion liters. More than 80% of this production is carried out by America and Brazil. While America had a 56% share and Brazil had a 30% share in 2013, in 2022 the shares of both countries in total production decreased, America's share decreased to 54% and Brazil's share decreased to 28%. Europe's share in total production has not changed much in the last decade and remained around 5%.

Table 1: WORLD Fuel Ethanol Production (mln litres)

Country	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Argentina	473	671	815	890	1,105	1,114	1,073	809	1,008	1,159
Australia	300	230	210	195	210	220	220	180	175	175
Brazil	27,325	28,210	29,702	27,881	27,593	33,179	35,154	32,603	29,796	30,539
Canada	1,715	1,755	1,720	1,740	1,730	1,750	1,890	1,698	1,750	1,800
China	2,790	3,200	3,000	2,650	3,300	3,000	3,200	2,800	3,250	3,300
Colombia	388	406	456	434	403	467	444	394	397	347
EU	4,398	4,563	4,706	4,310	4,618	4,834	5,181	4,793	5,009	5,006
India	270	304	783	1,000	877	1,627	1,850	1,730	2,961	4,081
Paraguay	205	190	205	243	272	400	450	515	525	540
Peru	170	145	152	122	115	120	130	100	100	140
Philippines	172	236	265	270	275	326	376	330	355	360
Thailand	949	1,058	1,174	1,216	1,461	1,473	1,659	1,473	1,326	1,425
USA	50,398	54,286	56,051	58,202	59,973	60,790	59,720	52,717	56,840	58,147
Others	811	865	977	978	934	1,072	1,140	1,025	1,034	1,164
Total	**90,364**	**96,119**	**100,216**	**100,132**	**102,866**	**110,372**	**112,488**	**101,166**	**104,527**	**108,183**

Source: ISO 2023 Ethanol Yearbook. P,1

This shows that countries other than America and Brazil have produced more fuel ethanol in recent years and have begun to take a larger share in total production. As a matter of fact, while the share of countries other than America and Brazil in total production was 14% in 2013, it increased to 18% in 2022. On the other hand, Türkiye's share in total production is almost non-existent. Türkiye, which produced 89 million liters of bioethanol in 2022, has a very low share in the world bioethanol production of 108.18 billion liters.



Figue 4. Shares of Countries in Bioethanol Production
Source: ISO, 2018, s:1-75[2] ISO, 2023, s:8-16, "TADAB, (2013-2022) "2013-2022 Yılı Yakıt Biyoetanolü İstatistikleri" Avaible at:< https://www.tarimorman.gov.tr/TADAB/Link/38/Resmi-Istatistikl>

Sugar cane used for fuel ethanol in the world in 2018, with 372.7 million tons, took a 64% share of the raw materials used in world bioethanol production. In 2022, it became the most used raw material with 304.7 million tons, taking a 58% share of the raw materials used in world bioethanol production (ISO, 2018).

Table 2: WORLD Feedstock Use for Fuel Ethanol Production (thousand tonnes)

Feedstock		2018	2019	2020	2021	2022
Grains*	EU	9,900	11,100	10,300	10,700	10,800
	Canada	4,700	5,300	4,700	4,900	5,400
	USA	145,900	143,600	126,800	137,600	139,000
	Brazil	1,900	3,500	6,600	9,100	9,500
	China	5,600	7,300	6,400	6,800	7,200
	Others	4,100	3,700	3,400	4,400	4,100
	Total	**172,200**	**174,500**	**158,200**	**173,500**	**176,200**
Cane and beet molasses	EU	400	400	300	500	500
	Brazil	5,000	5,400	10,000	11,500	12,100
	Colombia	500	500	400	500	400
	Australia	100	200	100	100	100
	India**	6,800	6,600	7,600	10,400	14,000
	Philippines	1,200	1,200	1,100	1,200	1,300
	Thailand	4,000	4,600	3,600	3,400	4,000
	Others	2,400	2,800	2,600	2,300	2,600
	Total	**20,400**	**13,600**	**25,700**	**29,900**	**35,300**
Sugar beet	**Total**	**6,400**	**6,500**	**5,700**	**4,700**	**6,100**
Sugar cane	Brazil	357,100	371,500	315,400	260,200	287,100
	Colombia	3,200	3,200	2,800	3,100	3,100
	Others	12,400	12,400	12,200	16,600	14,500
	Total	**372,700**	**387,100**	**330,400**	**279,900**	**304,700**
Cassava (fresh equivalent)	China	4,900	2,300	2,000	3,500	3,500
	Thailand	2,800	2,900	3,600	3,200	3,000
	Others	300	500	400	400	400
	Total	**8,000**	**5,700**	**6,000**	**7,100**	**7,000**

* Wheat, corn, rye, sorghum, oats, triticale, barley, gross value
** Including B-Molasses
Source: F.O. Licht

Source: ISO, 2023 Ethanol Yearbook

In recent years, the share of sugar cane in the total has decreased, while the share of cereal grains and molasses (sugar cane and sugar beet) has increased. As a matter of fact, cereal grains (corn, wheat, sorghum, etc.), which had a share of 30% with a use of 172.2 million tons in 2018, ranked second with a share of 33% with a use of 176.2 million tons in 2022. Molasses (sugar cane and sugar beet), which had a share of 4% with its use of 20.4 million tons in 2018, will have a share of 7% with its use of 35.3 million tons in 2022. On the other hand, the share of sugar beet and cassava did not change much and remained at 1%.

5. Bioethanol in Türkiye

In Türkiye, the concept of biofuel was first brought to the agenda as fuel alcohol at the Agricultural Congress in 1931. In the plan prepared in 1936 with the directives of Ataturk, the 23rd section was devoted to the synthetic gasoline industry. In line with this plan, the importance of fuel production by utilizing country resources instead of importing fuels is emphasized. This plan could not be implemented due to the death of Ataturk and the Second World War, but in 1942, 20% of the gasoline consumed by the Turkish army was met by using bioethanol (Yılmaz, 2013). In Türkiye, special consumption tax (SCT) exemption was introduced for biodiesel in 2011. Compulsory blending was implemented to be at least 1% as of 2014, at least 2% as of 2015, and 3% as of

2016 (YEGM, 2019). However, compulsory blending of biodiesel was abandoned due to the fact that biodiesel was produced from oil plants and there was a shortage of edible oil in Türkiye and it was an importer of many vegetable oil plants (TÜİK, 2019). Later, as of the beginning of 2018, compulsory biodiesel application was reintroduced, with a blending rate of 0.5%, provided that it was from vegetable waste oil and domestic agricultural products (Energ Institute, 2019).

Although bioethanol was used in Türkiye for the first time, its legal regulation was first published in 2005, with a 2% SCT exemption for bioethanol to be blended into gasoline, but no blending obligation was introduced (TTJ, 2012). The blending obligation started as of 2013 as at least 2% (v/v) for gasoline to be sold domestically, provided that it was produced from domestic agricultural products, and continued to be at least 3% as of 2014, but the SCT exemption remained at 2%. There was no obligation to mix at least 3% bioethanol in each liter of gasoline sold in Türkiye. There was only an obligation to blend bioethanol at 3% of the total gasoline sales at the end of the year. This obligation could be fulfilled by not adding it at all during certain periods of the year, or by mixing it with gasoline at a maximum rate of 10% in other periods. In addition, there was no physical inspection of the obligation, only an inspection at the end of the year, provided that it was documented (T.C. Resmi Gazete, 2012). Due to the impact of the pandemic "Covid-19" experienced in the world in 2020, the demand for bioethanol increased rapidly due to the fact that bioethanol was a good disinfectant and the main raw material of cologne production. Therefore, there was a problem in the trade of bioethanol between countries and many countries did not want to export bioethanol. Accordingly, due to the Covid-19 epidemic in Türkiye in 2020, in order to meet the ethanol needs of disinfectant and cologne-like health hygiene product manufacturers, EMRA suspended the obligation to blend ethanol into gasoline types between 13 March and 13 June, and bioethanol was used as a raw material in the production of disinfectant and cologne. In this context, the suspension of the blending decision was extended until July 1 so that licensees could make the necessary adjustments before the gradual transition. From this date, a gradual transition was made in the blending application and it was decided that ethanol blending into gasoline types applied at 2 percent between July 1 and September 1, 2020, and then continued at 3% (AA, 2020). Finally, with the change made in November 2023, the 3% (v/v) blending obligation within the scope of the procedures and principles regarding the blending of ethanol obtained from domestic agricultural products into gasoline types in Türkiye was reduced to 2% (v/v) as of 2022 (EPDK, 2023). As of 2023, blending mandates in Türkiye is 2% ethanol and 98% gasoline. It is 27% in Brazil and 10-15% in the US.

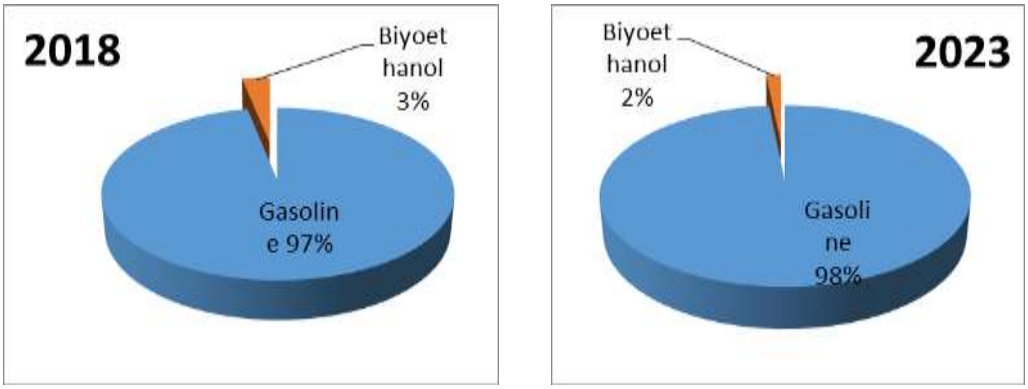


Figure 4. Domestic Gasoline/Bioethanol Usage Rate in Türkiye (2018/2023)
Source: EPDK, 2019, p:III-56, EPDK, 2023, p:29 and p. 68

With the production of 115 million liters of ethanol in Türkiye in 2018, approximately 68% of the existing 169 million lt/year production capacity was used and 32% of the idle capacity occurred. In addition, with the fuel bioethanol production of 92.7 mln lt, it allocated 54% of its current production capacity and 80% of the ethanol it produced to fuel bioethanol and produced 96% of the fuel bioethanol it consumed during the year. In 2022, with the production of 108.9 million liters of ethanol, approximately 65% of the existing 169 million lt/year production capacity was used and 35% of the idle capacity occurred. In addition, with its fuel bioethanol production of 88.9 mln lt, it allocated approximately 53% of its current production capacity and 82% of the ethanol it produced to fuel bioethanol, and produced 99% of the fuel bioethanol it consumed during the year.

Table 3: Türkiye Fuel Ethanol Balance (mln litres)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Opening Stocks	39.3	40.3	43.7	45.3	49.0	59.7	73.5	82.8	165.8	131.6
Production	85.0	101.0	105.0	106.1	111.1	115.0	110.4	94.5	133.3	108.9
Fuel Ethanol	58.8	81.4	85.3	91.8	93.7	92.7	97.4	64.5	108.3	88.9
Non-fuel Ethanol	26.2	19.6	19.7	14.3	17.3	22.3	13.0	30.0	25.0	20.0
Imports	83.4	91.6	90.7	91.1	101.4	97.7	100.8	246.8	139.9	124.3
Exports	6.7	4.1	0.9	0.7	1.1	0.5	0.5	5.0	9.6	13.2
Consumption	160.7	185.0	193.2	192.8	200.6	198.5	201.5	253.2	297.8	264.7
Fuel Ethanol	52.7	78.0	85.2	91.8	98.6	96.5	96.4	68.2	108.8	89.7
Non-fuel Ethanol	108.0	107.0	108.0	101.0	102.0	102.0	105.0	185.0	189.0	175.0
Ending Stocks	40.3	43.7	45.3	49.0	59.7	73.5	82.8	165.8	131.6	86.9

Source: F.O. Licht

Source: ISO 2023 Ethanol Yearbook, p,75.

Sugarcane is the plant most used in the production of bioethanol, which is the most produced and consumed liquid biofuel in the world but it cannot be grown in Türkiye due to climatic conditions. However, corn, wheat and sugar beet can be grown easily in many regions of Türkiye with their fertile soil and suitable climate structure. Bioethanol production in Türkiye is carried out using only corn, wheat and sugar beet molasses. As of 2019, there are 4 facilities producing bioethanol in Türkiye (TADB, 2019).
Those are;

1. Agricultural Chemical Technologies Industry and Trade Inc. (TARKIM)
2. Agricultural Chemical Technologies Industry and Trade Inc. (TEZKIM)
3. Konya Sugar Industry and Trade Inc. Çumra Bioethanol Plant Branch
4. TŞFAŞ Eskişehir Sugar Factory

Of these facilities; Konya Sugar and Eskişehir Sugar Factories use sugar beet molasses as raw material, while TEZKIM and TARKIM use wheat and corn by mixing them in different proportions.
Figure 6 shows the installed bioethanol production capacity rates of companies producing bioethanol in Türkiye. Türkiye's installed bioethanol production capacity, which was 154 million liters/year in 2017, increased to 169 million liters/year in 2018 with the start of bioethanol production by Eskişehir Sugar Factory affiliated with TŞFAŞ. Konya Sugar, which had 55% of the country's capacity in 2017, decreased to 50% with the Eskişehir Sugar factory starting production in 2018. Likewise, the capacity of TARKIM, which had 26% of the country's capacity in 2017, decreased to 23% in 2018, while TEZKIM's capacity rate, which was 19%, decreased to 18%. With the restart of bioethanol production in 2018, Eskişehir Sugar Factory has 9% of the country's bioethanol capacity. (Güven and Güneşer "2007", Aydın K. "2016", TŞFAŞ "2018"., Konya Sugar "2018").

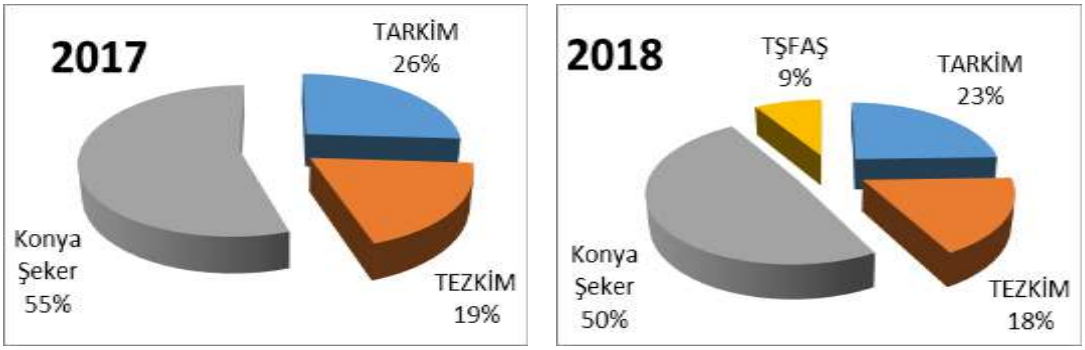


Figure 5. Türkiye's Installed Bioethanol Production Capacity by Company
Source: (Güven and Güneşer, Aydın K., TŞFAŞ 2018., Konya Sugar 2018).

*As of 2018, Türkiye's Installed Bioethanol Production Capacity was 169 million liters/year.
Çumra (Konya) Sugar Factory, which has an installed capacity of 84 million liters/year and produces bioethanol from sugar beet molasses, used 34% of its installed bioethanol production capacity with the delivery of 29 million liters of bioethanol in 2017. In 2018, it used 36% of its installed capacity with the delivery of 30 million liters, and in 2023, it used 43% of its installed capacity with the production of 35 million liters of bioethanol. Eskişehir Sugar Factory, which has an installed capacity of 15 million liters/year, delivered 377,496 liters of bioethanol in 2018, which is 2.5% of its installed capacity.

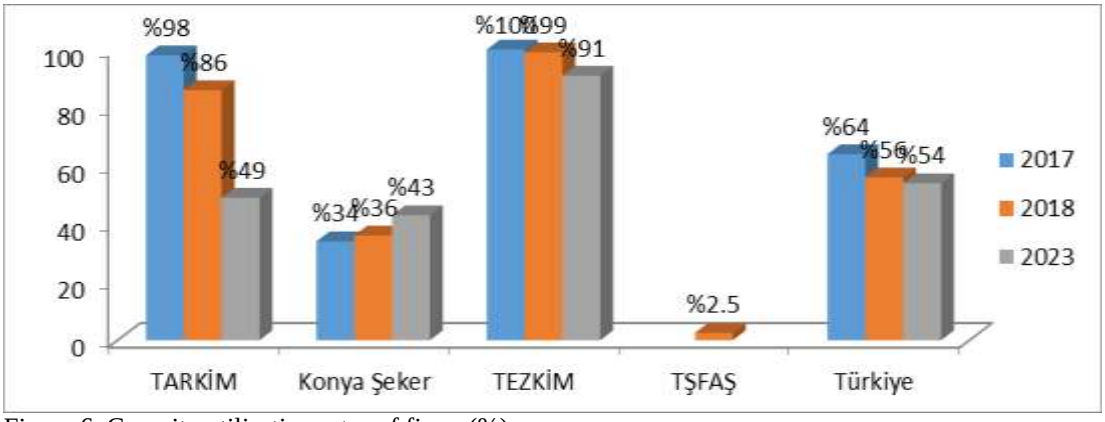


Figure 6. Capasity utilisation rates of firms (%)
* It was created by the author using EPDK 2018, p:VII-59, EPDK 2019, p:III-56, and EPDK 2023, p.68.

6. Economic Analysis of Bioethanol

Bioethanol production scenarios was designed on installed capacity and feedstock production cost. Comparative analysis was done for three plants used in bioethanol production in Türkiye (sugar beet, wheat and corn). Finally it was determined which product was more advantageous.

Bioethanol production scenarios according to Türkiye's installed bioethanol and idle sugar production capacity are designed in Table 4. As of 2018, bioethanol production facilities in Türkiye are in a position to produce 169 million liters/year of bioethanol if they produce at full capacity. Although this amount is at a level that can meet approximately 5.7% of domestic gasoline consumption in 2018, only approximately 3% of domestic gasoline consumption was met with the delivery of 75,186 tons of bioethanol in 2018.

Türkiye's installed beet sugar production capacity from sugar beet is approximately 3.5 million tons/year (Mülga Sugar Institution, 2018). In the 2017/2018 marketing year, a total of 2 million 770 thousand tons of beet sugar were produced (Head of Sugar Department, 2019). As a result, there is an idle sugar production capacity of approximately 730,000 tons/year in the country. If Türkiye's sugar production capacity from beet was fully used and 730,000 tons of sugar that might be in excess of the sugar produced was converted into bioethanol, 607 million liters of bioethanol could be obtained, and this production amount seems to be sufficient to meet approximately 20% of Türkiye's gasoline consumption in 2018.

If all of the 730,000 tons of sugar in the idle sugar production capacity and the molasses that would come out of the beets required to produce this amount of sugar were converted into bioethanol, 592,984 tons of bioethanol could be obtained. This amount is at a level that can meet 25.4% of the domestic gasoline consumption in 2018, and if we add the amount delivered by Konya and Eskişehir Sugar Factories in 2018 to this amount, it can meet 26.4% of the domestic gasoline consumption in 2018.

Table 1. Türkiye'de Bitoetanol Üretim Senaryoları

	Bioethanol Production (million litre)	Bioethanol Production (ton)	Coverage Rate Based on 2018 Domestic Gasoline Consumption
Bioethanol Production 2018	94	75,186	3.2%
If full capacity used	169	133,341	5.7%
If idle sugar production capacity (730,000 tons of sugar) were used	607	481,800	20.6%
If produced from idle capacity sugar plus its molasses	747	592,984	25.4%

Source: Kıbrıscık, 2019 p,124.

Bioethanol production cost according to the production cost of the relevant products in previous years was calculated in Table 5. In 2018, according to the raw material production cost in Türkiye, corn was the cheapest

raw material with ₺1.71 per liter (based on 1,200 kg/decare corn yield), sugar beet came in second with ₺1.74, and production from wheat was the most costly product with ₺3.12.

Table 5. Bioethanol Production Cost Based on Feedstock Production Cost (₺/lt)

Year	Sugar Beet	Wheat	Corn
2017	1.50	2.95	1.65
2016	1.41	2.40	1.80
2015	1.36	2.30	1.51
2014	1.30	2.44	1.44
2013	1.20	2.06	1.30
2012	1.14	2.06	1.27
2011	1.01	1.51	1.17
2010	0.89	1.59	1.06

Source: * Compiled from TŞFAŞ Activity Reports of the Relevant Years. 2010:29, 2011:38, 2012:39, 2013:32, 2014:42, 2015:37, 2016:46, 2017:42-43, 2019:41

**Bioethanol Productivity; Yılmaz, 2013 p:46.

However, as a result of the calculations made using the data of previous years (2010-2017), it was concluded that the cheapest bioethanol raw material according to the raw material production cost every year was bioethanol produced using sugar beet. Production from wheat was the most costly production between 2010-2017 as it was in 2018. The reason why sugar beet, which was the most advantageous product according to the raw material production cost until 2018, lost this advantage to corn is that in 2018, the yield increased less compared to corn and the production cost increased more compared to corn.

7. Conclusion

Oil ranks first in meeting the world's energy demand. Türkiye is a developing country and parallel to this, its energy demand is also increasing rapidly and this demand is mostly met by using fossil fuels and oil has a large place among these resources. The transportation sector has the largest share in Türkiye's oil use. This energy demand for oil is mostly met by importing since domestic production is very low. In addition, the fact that Türkiye's domestically producible crude oil reserve life is even shorter than the world's crude oil reserve life necessitates the search for energy sources that will provide a substitute for oil within the country or the increase in the production amounts of fuels that provide a substitute.

Problems such as climate change experienced worldwide, the inadequacy of oil supply, fluctuations in crude oil prices and the negative impact of fossil fuels on the environment have been effective in the progress of biofuel policies in recent years. As a result of increasing the domestic use of bioethanol, an advantageous situation may arise in favor of the country using bioethanol in emission trade based on the Kyoto Protocol to which Türkiye is a party.

The production and use of bioethanol, which is the most consumed liquid biofuel in the world, is rapidly increasing. When the bioethanol production policies of countries are examined, the most important issue is to try to obtain the raw materials used in the production process from domestic agricultural products grown in the country instead of importing them. In addition, these countries make the use of bioethanol mandatory with legal regulations in order to reach a certain target in their consumption. In Türkiye, the bioethanol sector, which is newer compared to the world, is an infant industry. Therefore, both the production and consumption of the sector should be supported by the state.

Although the legal maximum blending ratio of bioethanol with gasoline in Türkiye is 10%, the current mandatory blending ratio is 2%. The SCT discount is only applied to a 2% blending ratio. In the first stage, since companies producing from corn and wheat are producing close to full capacity, the idle capacity of companies using sugar beet molasses should be evaluated and full capacity production should be supported. Since Türkiye's currently installed bioethanol capacity is sufficient to meet nearly 4% of gasoline consumption in 2022, the requirement to blend with gasoline should be increased to 4% in the first stage. Since the SCT discount in Türkiye (2019) is only applied to a 2% blending ratio, the cost of bioethanol increases significantly with the

addition of SCT and VAT in blends above 2%. Therefore, the SCT discount in Türkiye should be as much as the applied bioethanol blending ratio. Later, since 10% biofuel can be easily used in today's vehicles without any changes, the construction of bioethanol production facilities using sugar beet as raw material and the increase of bioethanol usage obligation and SCT exemption to 10% may have positive results in terms of the development of the sector.

Since there is no physical inspection of the blending obligation of bioethanol in Türkiye, it is only an inspection carried out at the end of the year with the condition of documenting, there must be a physical inspection in order to eliminate the problems that may arise here. In addition, it is important that the blending obligation, which is at least 2% of the gasoline amount made by the end of the year, not just for each gasoline amount, must be blended at the same rate in each amount and physically inspected.

Since bioethanol is used as the main raw material in the production of disinfectants and cologne, it has become clear once again that bioethanol has a strategic importance in the pandemic (Covid 19) that emerged in 2019, and various restrictions have been imposed on the international trade of bioethanol in this process. Therefore, reconsidering the production policies of bioethanol, a strategic and environmentally friendly product, in Türkiye and achieving maximum production within the possibilities may have positive contributions to the country's economy.

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