

Energy criticism of Turkey and comparison with the world: energy harvesting, development, challenges, and opportunities

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Abstract

Scientists have turned to work for the development of renewable energy sources when the effects of polluted and harmful greenhouse gases released into the atmosphere as a result of the consumption of non-renewable energy resources become noticeable. At the same time, due to the increase in the world's population and countries need to meet the growing energy demand to ensure their social well-being. Although the majority of this energy demand is still provided by fossil fuels, it seems to be insufficient in the near future. In this study, Turkey and the state of the world's energy resources are examined in this article. Energy reserves, production and consumption of countries are emphasized. The ranking of the countries producing electricity from biofuel, hydroelectric, geothermal and wind energy is given and their power capacities are examined on a country basis. The state of the world in terms of energy resources has been examined and the most frequently used renewable energy resources are mentioned by showing the continents where renewable energy resources are used more frequently. It is known that Turkey is a dependent country given its existing energy resources. In this context, renewable energy sources are extremely important for Turkey's development and social welfare.

Keywords: Energy sources, Non-renewable energy, Renewable energy, Situation of energy

Türkiye'ye yönelik enerji kritiği ve dünya ile karşılaştırılması: enerji hasadı, kalkınma, zorluklar ve fırsatlar

Özet

Yenilenemeyen enerji kaynaklarının tüketilmesinin sonucu atmosfere salınan kirlili ve zararlı sera gazlarının etkileri fark edilebilir bir duruma geldiğinde bilim insanlarını yenilenebilir enerji kaynaklarının geliştirilmesi için çalışmalar yapmaya yönelmiştir. Aynı zamanda dünyanın nüfusunun artması, ülkelerin toplumsal refahını sağlayabilmesi için artan enerji talebini karşılamaları gerekmektedir. Bu enerji talebinin çoğunluğu hala fosil yakıtlardan sağlansa da yakın gelecekte yetersiz kalacağı görülmektedir. Bu çalışmada, Türkiye ve dünyanın enerji kaynaklarının durumu incelenerek, ülkelerin enerji rezervleri, üretim ve tüketimlerine vurgu yapılmaktadır. Biyoyakıt, hidroelektrik, jeotermal ve rüzgâr enerjisinden elektrik üreten ülkelerin sıralaması verilmiştir ve güç kapasiteleri ülke bazında incelenmiştir. Dünyanın enerji kaynakları bakımından durumu incelenmiş ve yenilenebilir enerji kaynaklarının daha sık kullanıldığı kıtalar gösterilerek en çok kullanılan yenilenebilir enerji kaynaklarına değinilmiştir. Türkiye'nin mevcut enerji kaynakları göz önüne alındığında dışa bağımlı bir ülke konumunda olduğu bilinmektedir. Bu bağlamda Türkiye'nin kalkınması ve toplumsal refahı açısından yenilenebilir enerji kaynakları son derece önemlidir.

Anahtar Kelimeler: Enerji kaynakları, Enerjinin durumu, Yenilenebilir enerji, Yenilenemez enerji

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1.Introduction

Society as a whole world is increasingly expanding. The demand for energy in this rapidly rising population is rapidly increasing. The economy of a nation depends on the production of its own energy. It is clear that a country's economic growth is advanced with the help of energy generation. The energy can be found in geothermal, hydro, solar, wind, electrical chemical, nuclear, mechanical, thermal forms and can be converted by some methods is used in every area of our daily life, has essential importance. Energy sources are classified as renewable and non-renewable according to their generation. Energy sources are divided into two as primary and secondary energy sources according to their transformability (Figure 1).

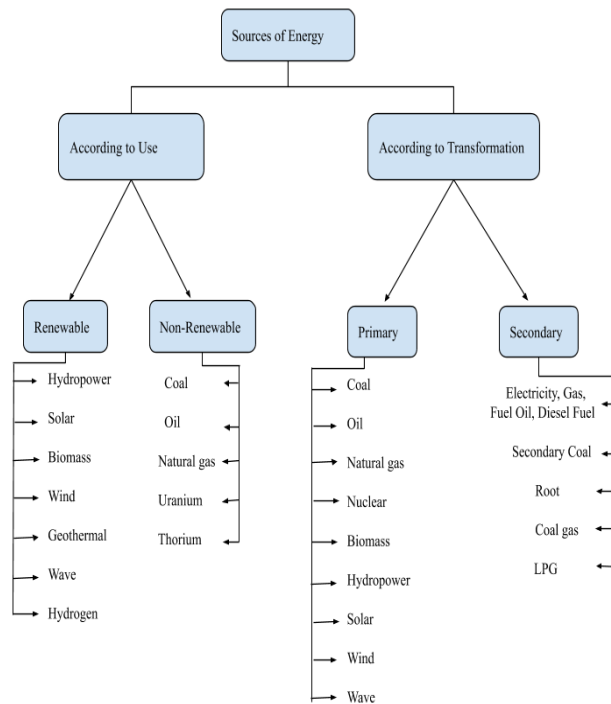


Figure 1. Sources of energy [1]

The state of energy that has never undergone a transformation or change is called primary energy. Primary energy sources; hydropower, biomass, wave, solar and wind are oil, coal, natural gas, nuclear. It is defined as secondary energy to energy that occurs as a result of processing the sources of primary energy. Electricity, air gas, LPG, gasoline, diesel oil, diesel, secondary coal, coke are among these energy sources.

In order to ensure the planned, orderly and systematic use of energy resources that are faced with the danger of exhaustion in our country and our world, it is necessary to determine the situation of the energy resources in our country and our world. In this study, the energy that is used much today is examined.

2.Situation of energy resources in the world and Turkey

2.1. General situation of primary energy in the world and Turkey

Most of the energies used in our world are obtained from primary energy sources. According to the data of 2018 in Table 1, the total primary energy consumed in the world was determined to be 13864.9 Mtep (million tons of equivalent oil). The sources with the largest share in the primary energy distribution in the world are oil (33%), coal (30%), respectively. natural gas (24%), hydroelectric energy (7%), nuclear energy (4%) and other renewable energy sources (2%).

Table 1. The total primary energy consumed in the world [3]

Source of Energy Consumption	
Oil	33%
Natural Gas	24%
Coal	30%
Nuclear	4%
Hydro	7%
Renewable	2%

The distribution of primary energy sources used in electricity generation in the world in 2018 is given in Figure 2. In the same year, the amount of electricity production from primary energy was 26,614.8 TWh. In 2018, 37.3% of our electricity production was made from coal, 29.8% from natural gas, 19.8% from hydropower energy, 6.6% derived from the wind, 2.6% from the sun, 2.5% from geothermal energy, and 1.4% from other sources.

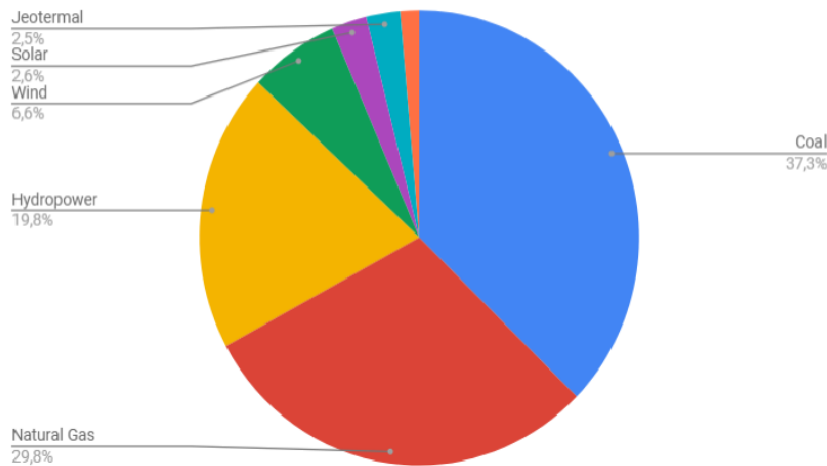


Figure 2. Distribution of primary energy sources used in electricity generation in the world in 2018 [3].

Figure 3 shows Turkey's primary energy production from 1990 to 2018. While Turkey's primary energy production was 25.1 Mtoe in 1990, it was 39.7 Mtoe in 2018. The increase from 1990 to 2018 has been 57.8%.

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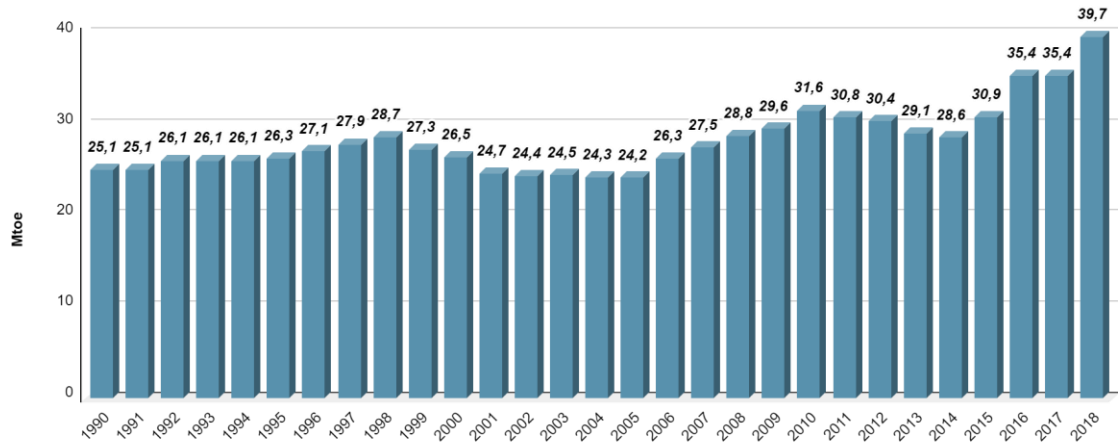


Figure 3. Turkey's primary energy production by years (Mtoe) [3]

Energy consumption per capita in Turkey and some countries is given in Figure 4. In 1990, Turkey consumed 10,345 kWh of energy per capita, while in 2019, 21,609 kWh of energy per capita was consumed and this amount was almost doubled.

Energy use per person

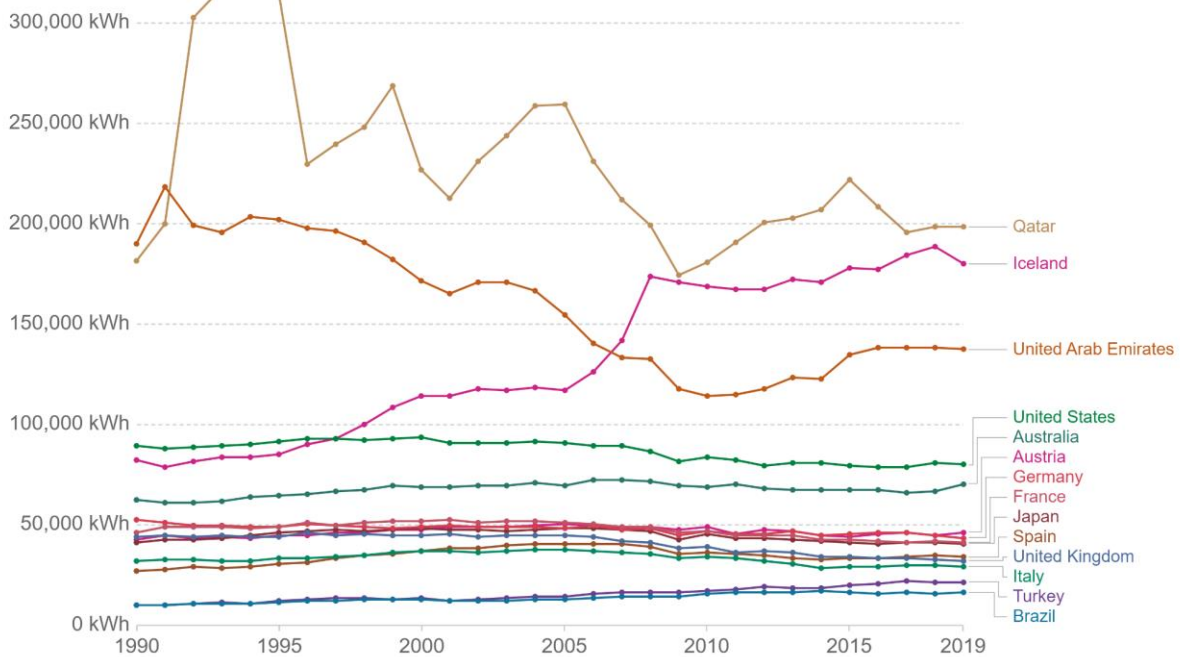


Figure 4. Amount of energy per capita of some countries [4]

And also, Turkey amounted to 81,647 MW of installed capacity as of October 31, 2017. As of the end of October 2017, the share of natural gas in installed power was 28 percent, the share of hydropower was 33 percent and the share of coal was 21 percent [5].

2.2. Status of non-renewable energy in the world and Turkey

The most important non-renewable energy sources are; coal, petroleum and natural gas, these sources constitute a large part of world energy production. The world oil reserve in 2019 was 244.1 billion tons, the natural gas reserve was 197 trillion m³, and the coal reserve was 1,054.79 billion tons [6].

According to the Republic of Turkey Ministry of Energy and Natural Resources; in terms of reserves and production amounts, our country can be evaluated in lignite at the world level and at the lower levels in hard coal. An average of 3.2% of the total world lignite / sub-bituminous coal reserve is in Turkey. However, since most of our lignites have low thermal value, their use in thermal power plants has come to the fore. Approximately 46% of our country's lignite reserve is located in the Afşin-Elbistan basin. The most important hard coal reserves of our country are in Zonguldak and its vicinity. The total coal reserve in the Zonguldak Basin is 1.30 billion tons, whereas the visible reserve is 506 million tons [7].

The proven oil reserve in the world in 2018 was determined to be 1,729.7 billion barrels. 836.1 billion barrels of oil reserves (48.3%) are found in the Middle East states, 325.1 billion barrels (18.8%) in the South and Central US countries, 236.7 billion barrels (13.7%) in the North American states. In 2018, world oil production reached 94.7 million barrels/day. Crude oil, which has a strategically important place among primary energy sources, met 31.4% of the world's primary energy demand as of 2018. On average, 70% of the world's producible oil and organic gas reserves are located close to our country. Turkey is a neighbor with its geopolitical position as the world's proven oil and natural gas reserves, with three-quarters of the country. According to MENR data, in addition to our crude oil imports in 2018, 17.7 million tons were imported. On the other hand, 8.9 million tons of petroleum products were exported [8, 11].

It observes that the consumption of natural gas in Turkey is increasing every year. In 2017, the total primary energy demand in Turkey was 145.3 Mtoe. Only 30.49% of this demand is met by natural gas [8, 10]. While our country realized 20.697 million dollars of imports in 2017, this figure increased by 10.7% in 2018 to 22.911 million dollars [10]. Most of Turkey's imports (36.7%) are carried out through the Russian state. When the import and domestic total energy supply (MTEP) ratios are analyzed, it is seen that Russia's share is higher than the energy provided from domestic sources [11].

In Table 2, electrical energy production and shares by energy resources are given. As can be seen here, between 1970 and 2019, an average of 30.5% coal, 13.6% liquid fuels, 30.3% natural gas and 32.9% hydro energy were consumed, and a total of 5500 TWh electricity was produced within 50 years.

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Table 2. Electricity generation and shares by energy resources [11]

Year	Total	Coal	Liquid fuels	Natural gas	Hydro
	(GWh)				
1970	8,623	32.7	30.2	-	35.2
1971	9,781	30.4	41.2	-	26.7
1972	11,242	26	43.9	-	28.5
1973	12,425	26.1	51.3	-	21.0
1974	13,477	28.8	44.8	-	24.9
1975	15,623	26.3	34.5	-	37.8
1976	18,283	23.7	29.6	-	45.8
1977	20,565	23.8	33.4	-	41.7
1978	21,726	25.7	30.7	-	43.0
1979	22,522	28.6	25.1	-	45.7
1980	23,275	25.6	25.0	-	48.8
1981	24,673	24.9	23.6	-	51.1
1982	26,552	24.2	22.4	-	53.4
1983	27,347	31.4	27.1	-	41.5
1984	30,614	33	23.0	-	43.9
1985	34,219	43.9	20.7	0.2	35.2
1986	39,695	49	17.6	3.4	29.9
1987	44,353	39.8	12.4	5.7	42.0
1988	48,049	26	6.9	6.7	60.3
1989	52,043	38.9	8.2	18.3	34.5
1990	57,543	35.1	6.8	17.7	40.2
1991	60,246	35.8	5.6	20.8	37.6
1992	67,342	36.5	7.8	16.0	39.5
1993	73,808	32.1	7.0	14.6	46.1
1994	78,322	36	7.1	17.6	39.1
1995	86,247	32.5	6.7	19.2	41.2
1996	94,862	32	6.9	18.1	42.7
1997	103,296	32.8	6.9	21.4	38.5
1998	111,022	32.2	7.2	22.4	38.0
1999	116,44	31.8	6.9	31.2	29.8
2000	124,922	30.6	7.5	37.0	24.7
2001	122,725	31.3	8.4	40.4	19.6
2002	129,4	24.8	8.3	40.6	26.0

2003	140,581	22.9	6.6	45.2	25.1
2004	150,698	22.8	5.0	41.3	30.6
2005	161,956	26.6	3.4	45.3	24.4
2006	176,3	26.4	2.4	45.8	25.1
2007	191,558	27.9	3.4	49.6	18.7
2008	198,418	29.1	3.8	49.7	16.8
2009	194,813	28.6	2.5	49.3	18.5
2010	211,208	26.1	1.0	46.5	24.5
2011	229,395	28.8	0.4	45.4	22.8
2012	239,497	28.4	0.7	43.6	24.2
2013	240,154	26.6	0.7	43.8	24.7
2014	251,963	30.2	0.9	47.9	16.1
2015	261,783	29.1	0.9	37.9	25.6
2016	274,408	33.7	0.7	32.5	24.5
2017	297,278	32.8	0.4	37.2	19.6
2018	304,802	37.2	0.1	30.3	19.7
2019	303,898	37.1	0.1	18.9	29.2

2.3. Status of renewable energy in the world and Turkey

Renewable energy sources which are hydropower energy, geothermal energy, biomass energy, solar energy and wind energy, are widely used in the world. According to the Renewable Energy 2018 Global Situation Report, Table 3 shows the power capacities of renewable energies in 2017.

Table 3. Renewable energy power capacities of 2017 [12]

Rank	Wind	Biomass	Solar	Solar (PV)	Hydropower	Geothermal
1st	China	USA	Spain	China	China	USA
2nd	USA	Brazil	USA	USA	Brazil	Philippines
3rd	Germany	China	South Africa	Japan	Canada	Indonesia
4th	India	India	India	Germany	USA	Turkey
5th	Spain	Germany	Morocco	Italy	Russia	New Zealand

As can be seen from Table 3, we can see that Turkey's interest in renewable energy is less than other countries. Due to the geopolitical position of our country, we should not forget that we have highly efficient regions and focus more on renewable energy.

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Hydropower is among the most popular methods of renewable energy sources. By building dams on rivers, storing water in large reservoirs and generating electrical energy by making use of the potential energy of water. The Status of Hydropower in the World in 2017 is given in Table 3.

Table 4.The Status of hydropower energy in the world in 2017 [13]

Country	Total Capacity (2017)(MW)	Electric Energy Production (2017)(MW)
China	341,190	1,1974.50
USA	102,867	322.39
Brazil	100,273	430.4
Canada	80,895	403.35
India	51,975	135.54
Russia	48,450	178.95
Turkey	27,273	17.03
Total	1,266.96	4,185.00

World hydroelectric consumption increased by 3.1%, slightly above the 10-year average (2.8%). The biggest contributions were posted by China (8 Mtoe) and Brazil (4 Mtoe). The global share of Asia Pacific has increased significantly in recent years: in 2018, Asia Pacific made up 41% of global consumption and only 20% 20 years ago [14]. Renewable energy (excluding hydro) increased 14% in 2018 in energy production and is slightly below the 10-year average growth (16%). However, the energy increase (71 mtoe) was slightly below the record increase of 2017. China accounted for 45% of global growth, and its consumption has increased 20 times over the past 10 years. Wind (142 TWh) contributed more to renewable energy production than the sun (131 TWh). Wind has generated about 50% of renewable energy production in recent years. Solar has continuously increased its share and is now 24%, 13 times higher than in 2013 [1].

Geothermal energy is the heat inside the earth. This heat spreads from the hot zone in the center to the earth and is used for many purposes such as electrical energy production, heating the houses, agriculture, greenhouse. The installed power of geothermal energy around the world can be classified into two categories: electricity and heat production power. World geothermal energy installed power and capacity are given in Table 5. Countries with the highest installed capacity and capacity of geothermal electricity; US, Indonesia, Philippines, Turkey, New Zealand, Mexico, Italy, Iceland, Kenya and Japan [15].

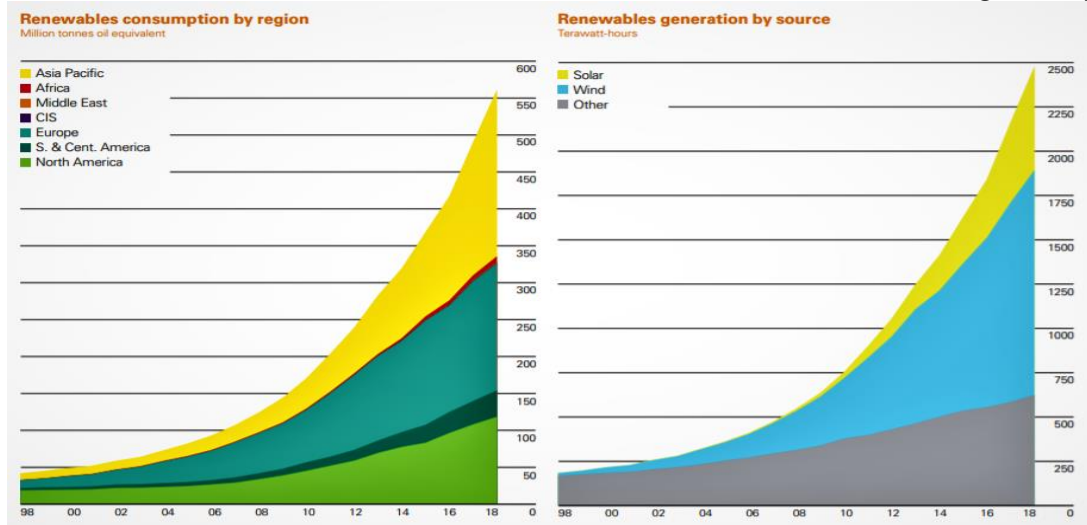


Figure 5. Renewable consumption by region and generation by source.

Table 5. World geothermal energy installed power and capacity

Country	Capacity (MW) 2018 ^[16]	Capacity (MW) 2019 ^[17]
Kenya	676	861
Iceland	755	755
Philippines	1868	1918
New Zealand	1005	1005
Indonesia	1948	2133
Mexico	951	962
Italy	944	944
USA	3591	3676
Turkey	1200	1526
Japan	542	601

Biomass can be defined as the total mass of living organisms at a given time. Biomass is also considered an organic carbon. There are several sources of biomass; There are biomass resources that can be obtained from plant, animal, forest products, city and industrial wastes. By these energy sources, biomass energy fuel types are bioethanol, biodiesel and biogas. In Table 6, while total bioethanol production in the world was 105.5 billion liters in 2017; biodiesel production was 30.7 billion liters. While the countries producing the most bioethanol are USA, Brazil, China and Canada; It is concluded

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that the countries producing the most biodiesel are USA, Brazil, Germany, Argentina, China, France. Turkey about 8.6 million tons of biomass waste potential oil equivalent (toe) is estimated to be 1.5-2 and the amount of biogas can be produced MTEP [12].

Table 6. Biofuels global production [12]

Country	Ethanol	Biodiesel (FAME)	Biodiesel (HVO)	Change relative to 2016
USA	60.0	6.0	1.7	1.7
Brazil	28.5	4.3		0.3
Germany	0.9	3.5		0.0
Argentina	1.1	3.3		0.5
China	3.3	1.0		0.2
France	1.0	2.3		-0.3
Thailand	1.5	1.4		0.5
Indonesia	0.1	2.5		-0.3
Canada	1.7	0.5		0.1
Netherlands	0.3	0.4	1.3	0.1
Spain	0.5	1.3		-0.2
Poland	0.2	1.0		0.0
India	0.8	0.2		-0.2
Colombia	0.3	0.6		0.0
EU-28	4.1	11.8	3.5	-0.3
World Total	105.5	30.7	6.5	3.5

Wind energy is one of the most important renewable energy sources. Wind is formed as a result of displacing the heated air and cold air. The existence of wind depends on many factors such as climate change, atmospheric pressure, etc. Wind energy is converted into electrical energy with wind turbines[18]. According to the 2018 data of the World Wind Energy Agency (WWEA), the wind turbine power capacities of the top 3 countries are given in Table 7. Turkey also increased in 2016 took place 11th out of the 6,081 MW while 2017 MW to 6.981.

Table 7. Wind turbine power capacities of the top 3 countries [19]

Country	Total Installed Capacity (2016)(MW)	Total Installed Capacity (2017)(MW)
China	168,730	195,730
USA	82,033	88,775
Germany	56,190	50,019

Three countries with the highest share of wind turbine installed power in electrical energy production is seen in Table 7. China is seen in the first rank, produces 195,730 MW of electricity per year by using wind energy, provides 35% of the total electricity production in this way. The USA produces 88,775 MW of electricity per year, which is 18% of the total annual electricity production, by using wind energy. Wind turbines in Germany produce 56,190 MW of energy per year. The ratio of wind energy in the total electricity generation in Germany is almost 12% [19].

3. Conclusion

Energy and energy sectors are one of the biggest factors in a country's economic enrichment and advancement of its welfare level. It is known that non-renewable energy resources that countries consume unconsciously cause serious damage to the environment. Countries have entered a race by making extremely serious investments in renewable energy sources in order to meet their increasing energy demands. With the increasing interest in renewable energy, environmental pollution has decreased and foreign dependency has decreased.

Since the amount of energy, it produces is insufficient, Turkey imports a large part of its energy needs. As it can be understood from this situation, it is proof that Turkey is an external dependent country. By concentrating more on Turkey's renewable energy resources, it can raise both the economy and the welfare level to very high levels. Compared to many other countries in terms of hydro, wind, solar and geothermal energy potential due to Turkey's geopolitical location, it is seen that Turkey has extremely rich resources. In order to benefit more from the renewable energy potential of our country, more investments should be made in renewable energy sectors. On the other hand, it should be said that it is necessary to turn to renewable energy sources in order to leave a healthy world for future generations.

Contribution of Author

These authors contributed equally to this work.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Research and Publication Ethic Statement

This paper is the authors' own original work, which has not been previously published elsewhere. The paper is not currently being considered for publication elsewhere.

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