TURKEY'S ENERGY SECTOR OUTLOOK FOR THE PERIOD 2000-2020

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INTRODUCTION

We can state that the types of energy used at present are similar to the types of energy used by the first humans. In this context, the first energy sources, wood fire, solar, wind, and water, are used with different production methods today. The process that started with the increase in wood/charcoal prices in London affected the mode of transportation and triggered the development of rail systems. Afterward, the industrial revolution that started in Europe with the spread of steam engines and oil spread to the whole world. Over time, oil has become an industry where many products are produced that affect the world economy and make life more comfortable in different fields.

Energy sources in the literature; Primary and secondary energy sources are classified in different ways: non-renewable (traditional) and renewable (alternative) energy sources. Primary energy sources; are energy sources that occur in nature without any cycle and transformation, except cleaning and decomposition. Examples of primary energy sources are coal, crude oil, sunlight, wind, flowing rivers, vegetation, and uranium. Secondary energy sources are energy resources that become suitable for use by converting primary energy resources. Electrical energy is an excellent example of secondary energy sources (Saray, 2019). When considered for non-renewable (traditional) energy sources, actually no energy source is non-renewable. However, because fossil fuels take a long time to regenerate, they are called non-renewable energy sources. Examples of non-renewable energy sources are oil, coal, and natural gas (Çepik, 2015) and nuclear energy (Deringöl, 2021). Renewable (alternative) energy sources, on the other hand, can be defined as energy sources that are constantly present in nature and remain unchanged in their cycle. These renewable energy sources that do not cause environmental pollution are solar energy, wind energy, geothermal energy, hydraulic energy, wave energy, hydrogen energy, and biomass energy (Deringöl, 2021).

Among the primary duties of the states is to manage the processes for increasing production and transportation capacities. In general, we can express these processes as the preparation of development and industrialization plans, the determination of urbanization policies, and the welfare of societies. Energy, which has components for the effective management of processes, economic, political and country defense, is a strategic sector at present (İskenderoğlu, Karadeniz, & Ayyıldız, 2017).

The increasing population and industrialization rate in the world from past to present time cause the supply and demand balance in economies to constantly deteriorate and, accordingly, the energy need of global trade and production processes to increase. It can be stated that meeting this energy need, which arises due to the increase in demand, healthily is one of the most fundamental duties of the country's administrations (Orçun, 2019).

For sustainable development, energy consumption, which is an indicator of development, the way of production, method, and environmental effects of energy should be considered. When the use of energy resources is evaluated from an economic point of view, it should bring benefits in ensuring development and raising the welfare level of society. From an environmental perspective, the use of fossil fuels, which cause problems such as increasing environmental pollution, greenhouse gas emissions, and global warming, should be limited. In general, making optimum use of limited energy resources, investing in renewable energy resources, reducing total energy costs, and preferring environmentally friendly technologies are essential criteria for regional and local energy policies (Bayraç, 2012).

Energy resources are crucial for developing countries like Turkey, which use energy as an intermediate input in their industry. On the other hand, while the number of energy supplier countries globally is limited, all countries require energy. In this respect, obtaining uninterrupted, safe, and cheapest energy for a country can be defined as the optimal target. Countries such as Turkey, which has scarce resources in terms of energy, should determine their energy supply security as a priority target. Turkey can easily reach this target by using the geographical advantage between energy supplying countries and energy-demanding countries. The most critical problem of Turkey is the inability to diversify its energy portfolio (Kandemir & Tuncer, 2020).

Energy deficit and foreign dependency on energy may lead to strategic political problems in the Turkish economy and increase the current account deficit problem, which threatens financial stability. In other words, the current account deficit problem, one of the central dynamics of energy imports in Turkey, disrupts the macroeconomic balances, and the concern of having problems in financing negatively affects the growth rate (Varlık & Yılmaz, 2017).

After 2001 for the Turkish economy is the 'Post-Washington Consensus' period, which constitutes the second phase of the neoliberal restructuring in which the principles of 'market regulation for sustainable growth under globalization, 'competition management' and 'strong regulatory bodies for good governance' are adopted. In this period, the establishment of the Electricity Market Regulatory Authority (EPDK) with the Electricity Market Law No. 4628 in 2001 in the energy sector and energy market legislation; The Law No. 6446, which came into force as a continuation of Law No. 4628 in 2013, the creation of secondary legislation, and the final regulations were carried out through the

restructuring of institutions with the transition to the presidential government system (Voyvoda & Voyvoda, 2019).

In the world, the increasing energy demand after the industrial revolution has affected countries in different ways. Especially after the oil crisis in 1973, the energy crisis in 1979 caused a recession on a global scale. Increasing energy demand has caused economic problems and triggered environmental problems, especially in developing countries.

The major problem in the Turkish energy sector is the foreign dependency of the sector due to the intense use of primary energy resources (petroleum, natural gas). This problem can be solved by developing investments and policies for renewable energy sources. This section discusses Turkey's energy sector performance in the 2000-2020 period with European countries. Hierarchical clustering analysis was made using the data of the countries' per capita primary energy consumption, oil, natural gas, coal consumption, renewable energy and electricity production values, carbon dioxide emission rate, and the results were interpreted.

Cluster Analysis

Cluster analysis ensures that data similar to each other according to the selection criteria are included in the same cluster in the data set whose class characteristics are unknown. As a result of the analysis, a heterogeneous structure is formed between the different clusters and a homogeneous structure within themselves (Akpınar, 2014).

In their study, Yakut et al. (2021) used hierarchical and non-hierarchical clustering analysis techniques regarding macroeconomic indicators related to energy use; they found that Turkey, Brazil, Chile, and Uruguay have a similar structure. (Yakut, Yazgan, Bacaksız, & Fikir, 2021).

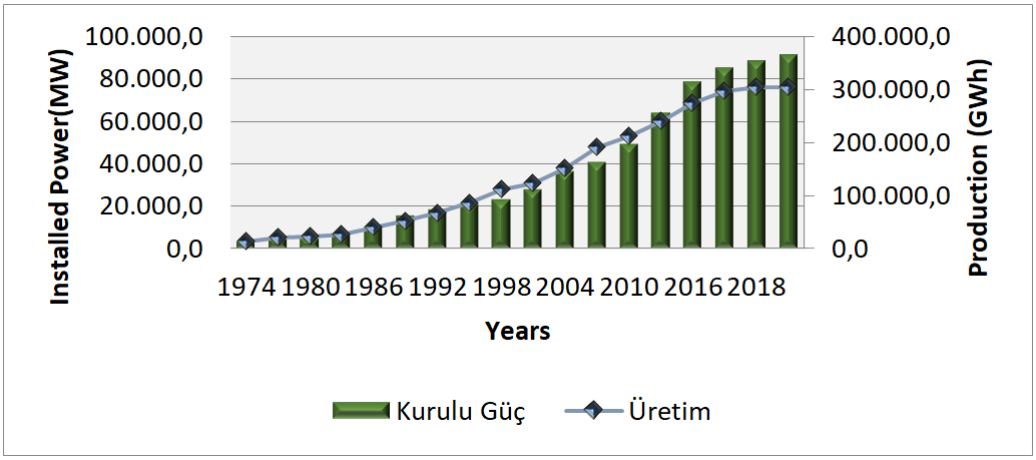
Looking at the studies made with cluster analysis, Tunalı and Aytekin examined Turkey's foreign trade in their study in 2017. In 2020, Yıldız, Aydoğan, and Kartum evaluated Turkey's international position with cluster analysis. Danacı and Koçtürk in their study in 2017 stated; free zones in Turkey were analyzed with hierarchical clustering analysis, and they determined the area and labor productivity of each free zone by using foreign trade statistics (Danacı & Koçtürk, 2017). Çelik and Kıral discussed the housing demand of foreign residents in Turkey with panel cluster analysis (Çelik & Kıral, 2018). Çekerol (2020) discussed the logistics performances of OECD countries and other selected countries with cluster analysis. Demirci and Ayan evaluated the similarities in the health infrastructure of OECD countries with cluster analysis and their performance with the TOPSIS method, one of the multi-criteria decision-making methods (Değirmenci & Ayan, 2020).

Turkey's Energy Sector Outlook

Increasing awareness of sustainable development worldwide since the 1990s has led to changes in the energy policies of countries. If the current consumption level continues, it is estimated that oil will run out in 50 years and natural gas in 200 years (Yıldırım, 2020).

According to Turkish Electricity Transmission Corporation (TEİAŞ) data, Turkey's installed power and production development over the years is given in the chart below (Figure 1). In the 2000-2019 period, we see that the installed power value in our country has increased significantly. According to Figure 1, we can state that the installed power and production in Turkey increased approximately 2.5 times in the period 2001-2019.

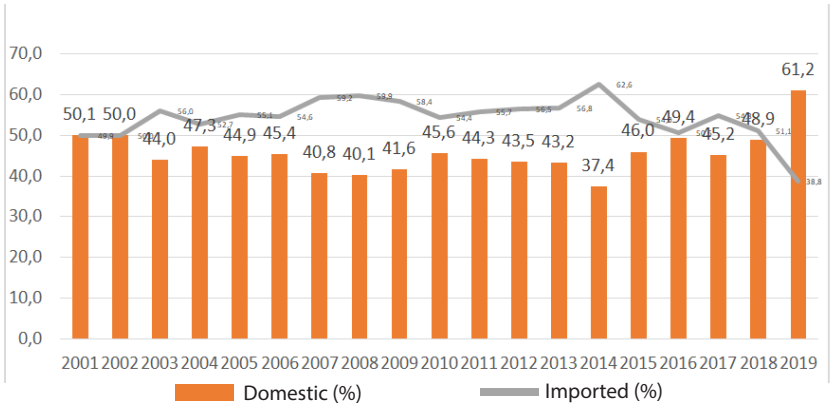
Figure 1. *Change of Installed Power and Production in Turkey by Years*



Source: (TEİAŞ, 2021)

The ratio of domestic/imported energy in Turkey's electrical energy production for 2001-2019 is given in the chart below. In 2001, the ratio of domestic-imported resources was approximately equal.

Figure 2. *Domestic-Imported Resource Rates in Electricity Production for 2001-2019 Period*



Source: (TEİAŞ, 2021)

This situation increased over the years, and until 2015, the rate of imported energy increased and reached the highest level of 62.6%. However, with the new investments after 2015, the rate of domestic resources reached 61.2% as of 2019.

According to the Electricity Markets Operation Joint Stock Company (EPİAŞ) data, 584 licensed power plants were invested in Turkey in 2003-2020, and additional installed power of 7851 MW was obtained. The values of the power plant investments are given in Table 1. Accordingly, hydroelectric and wind power plants produce approximately 60% of the 7851 MW obtained in investments.

Table 1. Data of 2003-2020 Licensed Power Plants

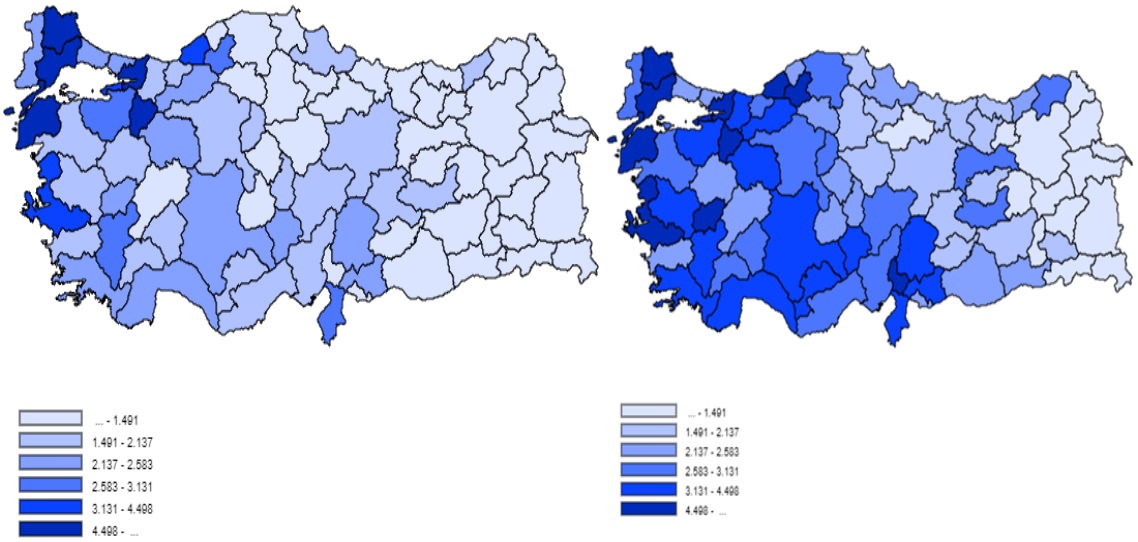
Fuel Type	Number	Total Additional Installed Power (MW)	Total Additional Power, Ratio %
Waste Heat	1	9	0,11
Bio Mass	141	440,591	5,61
Natural gas	23	948,448	12,08
Solar energy	56	386,878	4,93
Hydro Electric	95	2749,291	35,02
Wind power	237	1926,65	24,54
geothermal	22	365,77	4,66
Coal	9	1024,604	13,05
Total	584	7851,232	100

Source: (EPİAŞ, 2021)

Energy in Turkey is increasing depending on the demand. With the investments made in recent years, energy production has been increasing and diversifying. Electricity consumption is mainly directly affected by population growth and industrial production.

The increase in energy demand in Turkey also increases energy imports. Therefore, the effect of foreign dependency on energy causes the current account deficit to be triggered. In this case, the creation of national and renewable energy resources is of great importance both in terms of the country's economic performance and supply security and continuity (Alpdoğan, 2021).

Figure 3 *Electricity Consumption in Turkey 2007-2019*



Source: (TUIK, 2021)

Figure 3 shows the electrical energy use of the provinces in 2007 and 2019. When Figure 3 is examined, it can claim that while there are significant increases in the use of electrical energy in the western and central regions on a regional basis, there is no significant increase in the eastern region.

Turkey's Energy Performance

Primary energy consumption decreased by 4.5% in 2020 due to the effects of the Covid-19 pandemic conditions worldwide. This situation was recorded as the most significant decline after the Second World War. In addition, carbon emissions from energy use fell by 6.3% to the lowest level since 2011. It can be said that there is a significant decrease in oil demand to the reduction of Primary Energy consumption. In general terms, oil and natural gas prices have decreased, while the global energy demand has increased in China, it has decreased significantly in other countries, especially in the USA, India, and Russia. On the other hand, there has been an increase in production based on renewable energy sources (wind, solar, hydroelectric) (Energy, 2021).

Data set

Data were obtained from the bp Statistical Review of World Energy report. The data were organized according to the criteria in Table 2 of the European countries for 2000 and 2020 and analyzed with the hierarchical k-means method in the R program. The aim is to include the carbon dioxide emission rate among the criteria and reveal which countries in the data set adopt more environmentally friendly and sustainable development policies in the worldwide drift towards renewable energy.

Table 2 Criteria

Number	Criteria
1	Primary energy: Consumption per capita**
2	Carbon Dioxide Emissions
3	Oil: Total liquids consumption in thousands of barrels per day*
4	Natural Gas: Consumption *
5	Coal: Consumption*
6	Renewables: Consumption*
7	Electricity Generation*

***per capita, *EJ*

Source: (BP, 2021)

We can summarize the processing steps of K-means clustering methods as follows (Kassambara, 2017).

1. Compute hierarchical clustering and cut the tree into k-clusters

2. Compute the center (i.e the mean) of each cluster

3. Compute k-means by using the set of cluster centers (defined in step 2) as the

initial cluster centers

Note that, k-means algorithm will improve the initial partitioning generated at the step 2 of the algorithm. Hence, the initial partitioning can be slightly different from the final partitioning obtained in the step 4.

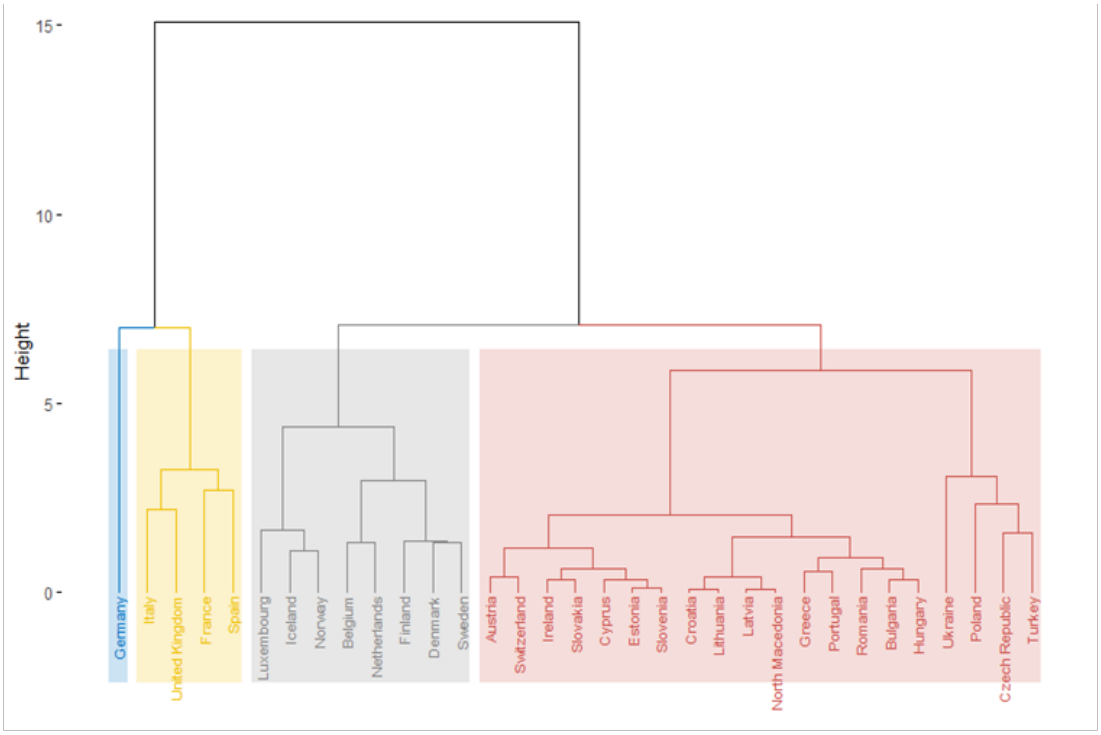
Table 3. Energy consumption data for the year 2000

Country	PrimaryEnergy*	Co2Emission	Oil *	NaturalGas	CoalConsumpt	Renewable *	ElectricityGenerati
Austria	171,00	63,55	0,51	0,28	0,15	0,0167	61,80
Belgium	259,15	136,29	1,29	0,56	0,32	0,0058	84,01
Bulgaria	97,18	43,43	0,18	0,12	0,26	0,0000	40,92
Croatia	77,55	17,47	0,17	0,09	0,02	0,0000	11,28
Cyprus	115,49	7,98	0,11	0,00	0,00	0,0000	3,37
Czech Republic	165,54	124,10	0,34	0,31	0,89	0,0077	73,47
Denmark	158,54	57,53	0,44	0,18	0,17	0,0554	36,05
Estonia	138,88	17,23	0,05	0,03	0,12	0,0001	8,51
Finland	244,24	58,87	0,46	0,14	0,21	0,0867	70,47
France	187,24	381,50	4,10	1,50	0,59	0,0435	539,95
Germany	175,76	854,43	5,65	2,99	3,57	0,1523	576,56
Greece	120,94	102,60	0,85	0,07	0,38	0,0045	53,84
Hungary	98,38	55,32	0,29	0,40	0,16	0,0007	35,19
Iceland	410,95	2,78	0,03	0,00	0,00	0,0132	7,68
Ireland	164,16	43,59	0,36	0,14	0,11	0,0034	23,98
Italy	132,74	434,38	4,05	2,44	0,52	0,0668	276,63
Latvia	56,24	6,95	0,05	0,05	0,01	0,0001	4,14
Lithuania	79,64	10,89	0,10	0,09	0,00	0,0000	11,43
Luxembourg	306,82	9,04	0,10	0,03	0,00	0,0005	1,17
Netherlands	227,30	216,20	1,75	1,48	0,33	0,0285	90,18
North Macedonia	54,20	8,74	0,04	0,00	0,06	0,0000	6,81
Norway	444,05	33,94	0,38	0,15	0,04	0,0029	142,98
Poland	94,96	299,78	0,87	0,42	2,35	0,0023	145,18
Portugal	101,64	61,35	0,68	0,08	0,16	0,0155	43,76
Romania	67,87	88,86	0,42	0,57	0,31	0,0000	51,93
Slovakia	144,31	36,33	0,15	0,24	0,18	0,0000	31,16
Slovenia	140,59	14,00	0,10	0,03	0,06	0,0007	13,62
Spain	133,79	309,32	2,97	0,64	0,88	0,0654	224,47
Sweden	251,38	57,74	0,69	0,03	0,11	0,0456	145,58
Switzerland	179,31	43,11	0,53	0,10	0,01	0,0085	67,33
Turkey	48,90	205,69	1,34	0,50	0,94	0,0027	124,92
Ukraine	116,38	335,91	0,51	2,67	1,61	0,0001	171,45
United Kingdom	162,25	566,37	3,44	3,65	1,54	0,0483	377,07

Source: (BP, 2021)

Data for the year BP 2000 are given in Table 3. As can be seen in the data set, renewable energy sources are not widespread compared to other sources, and the consumption value is relatively low. Turkey ranks 11th in electricity generation, 20th in renewable energy consumption, 25th in carbon dioxide emission rate, and lasts in primary energy resource consumption per capita. Germany is differentiated from other countries by ranking first in electricity production, renewable energy sources, coal, oil use, and carbon dioxide emission rates (Figure 4).

Figure 4. *Cluster Dendrogram-year 2000*



Turkey is in the largest cluster in terms of energy consumption performance, although the Czech Republic, Ukraine, and Poland are familiar. Developing countries come to the fore in the cluster where Turkey is included. We can express the countries with similar structures as follows: (Austria, Switzerland),(Ireland, Slovakia) (Cyprus, Estonia, Slovenia) (Croatia, Lithuania, Latvia, North Macedonia) (Greece, Portugal) (Bulgaria, Hungary).

As stated earlier, Germany, which has the highest value in many criteria, differed from other countries.

Italy, the United Kingdom, France, and Spain were included in a similar and different cluster. When we look at the other cluster (Luxembourg, Iceland, Norway), (Belgium, Netherlands), (Finland, Denmark, and Sweden), they have a similar structure and are included in the same cluster.

Table 4. Energy consumption data for the year 2020

Ülke	Primary Energy	Co2Emission	Oil	Natural Ga	Coal	Renewable	Electricity Generatic
Austria	153,63	55,27	0,48	0,31	0,09	0,14	64,36
Belgium	189,03	88,74	0,93	0,61	0,11	0,23	85,62
Bulgaria	99,29	35,82	0,19	0,11	0,17	0,05	45,84
Croatia	79,58	15,28	0,13	0,10	0,01	0,03	13,05
Cyprus	84,09	6,98	0,09	0,00	0,00	0,01	4,65
Czech Republic	143,58	85,12	0,37	0,30	0,49	0,09	84,36
Denmark	101,93	26,49	0,26	0,08	0,03	0,21	45,60
Estonia	140,49	14,76	0,05	0,02	0,10	0,02	9,73
Finland	197,86	39,00	0,35	0,07	0,13	0,19	82,66
France	133,35	250,91	2,68	1,46	0,19	0,68	574,87
Germany	144,55	604,84	4,21	3,12	1,84	2,21	639,57
Greece	95,97	58,24	0,51	0,21	0,11	0,14	60,79
Hungary	100,20	45,48	0,33	0,37	0,07	0,06	35,86
Iceland	601,83	2,59	0,03	0,00	0,00	0,05	9,92
Ireland	124,56	32,78	0,27	0,19	0,03	0,12	27,50
Italy	96,97	287,10	2,13	2,44	0,21	0,67	314,09
Latvia	76,93	7,28	0,07	0,04	0,00	0,01	4,89
Lithuania	91,31	11,91	0,13	0,08	0,01	0,03	12,48
Luxembourg	229,41	8,79	0,10	0,03	0,00	0,02	4,33
Netherlands	196,82	175,83	1,51	1,32	0,18	0,33	98,83
North Macedonia	48,90	7,22	0,04	0,01	0,04	0,00	7,01
Norway	355,97	31,71	0,37	0,16	0,03	0,11	121,40
Poland	106,03	279,49	1,28	0,78	1,67	0,27	161,74
Portugal	91,46	41,27	0,41	0,22	0,02	0,17	49,04
Romania	69,19	66,25	0,44	0,41	0,15	0,10	62,70
Slovakia	114,11	26,43	0,16	0,18	0,08	0,03	31,23
Slovenia	129,06	11,58	0,08	0,03	0,04	0,01	15,12
Spain	106,35	220,24	2,21	1,17	0,07	0,77	299,45
Sweden	217,78	45,41	0,55	0,04	0,07	0,41	143,30
Switzerland	124,55	32,41	0,37	0,12	0,00	0,05	63,86
Turkey	74,58	369,45	1,82	1,67	1,66	0,45	176,30
Ukraine	75,77	177,20	0,45	1,06	0,98	0,09	193,38
United Kingdom	101,56	317,15	2,39	2,61	0,19	1,20	397,28

Source: (BP, 2021)

According to 2020 data, Turkey ranked 2nd in carbon dioxide emission rate, 3rd in coal consumption, 4th in natural gas consumption, 6th in oil consumption, 7th in primary electricity production and renewable energy consumption per capita, and 32nd in primary energy use.

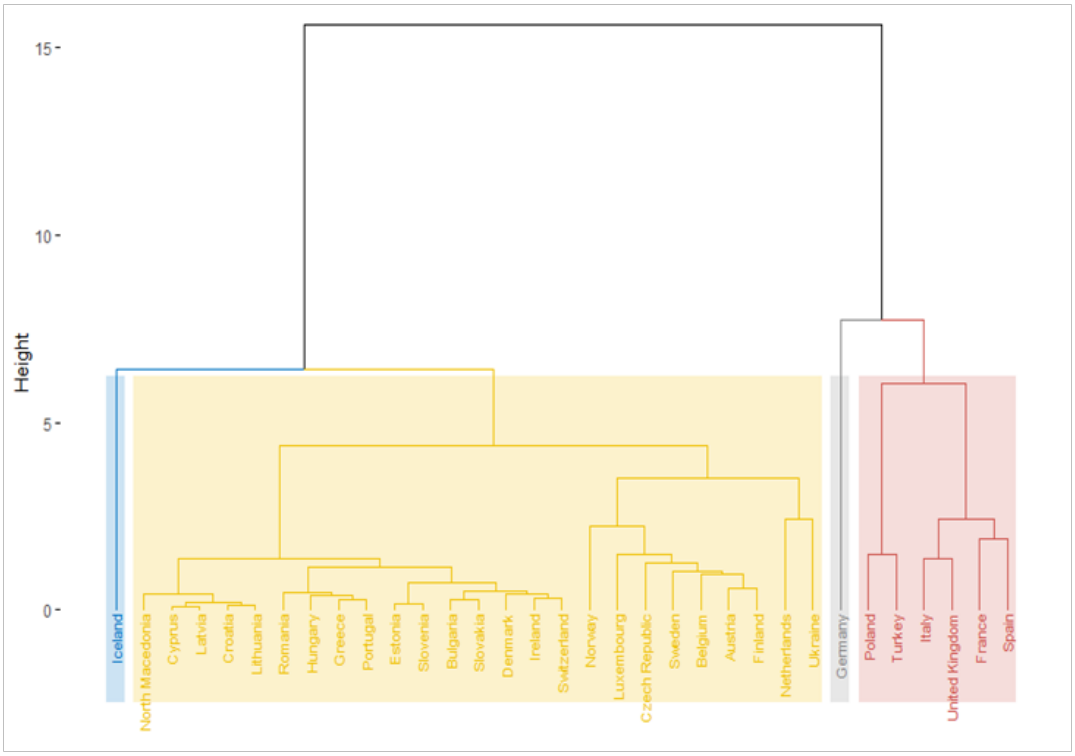
The development of Turkey in the period of 200-2020 is given in the table below. We can state that the energy consumption rate of renewable energy sources has increased at a record level. While a negative increase was observed in the carbon dioxide emission rate, significant improvements were achieved in other criteria.

Table 5. Change rates in the Turkish energy sector for the period 2000-2020

Year	Primary Energy	Co2Emission	Oil	NaturalGas	Coal	Renewables	Electricity Generation
2000	48,90	205,69	1,34	0,50	0,94	0,00275	124,92
2020	74,58	369,45	1,82	1,67	1,66	0,45	176,30
increase rate %	152,50	179,61	136,10	332,45	176,38	16248,29	141,13

The dendrogram of the cluster analysis is given below.

Figure 5. *Cluster Dendrogram-year 2020*



The cluster structure has changed in the dendrogram obtained by hierarchical clustering analysis with the data of 2020. Turkey has a similar structure to Poland and approaches developed countries such as Italy, United Kingdom, France, and Spain. Iceland, which ranks first in primary energy consumption per capita, is separated from other countries. In 2000, Germany was separated from other countries by taking first place in electricity production, renewable electricity production, coal, natural gas oil consumption. In the cluster formed by other countries, respectively (North Macedonia, Cyprus, Latvia, Croatia, Lithuania), (Romania, Hungary, Greece, Portugal),(Estonia, Slovenia, Bulgaria, Slovakia, Denmark, Ireland, Switzerland), (Norway, Luxembourg, Czech) Republic, Sweden, Belgium, Austria, Finland, Netherlands, Ukraine).

CONCLUSION

Energy deficit and foreign dependency on energy are among the leading causes of the current account deficit problem in the Turkish economy. In order to eliminate this problem, the Turkish energy sector has undergone structural changes in the 2000-2020 period. Investments made in the field of renewable energy continue to increase.

According to hierarchical clustering analyses for 2000-2020, Turkey has positively differentiated from countries with a similar structure (the Czech Republic, Ukraine, and Poland) in 2000, especially renewable energy consumption and electricity production indicators. With this transformation, it can be said that although it has a similar structure to Poland according to 2020 data, it approaches Italy, the United Kingdom, France, and Spain. In this period, Turkey's energy performance has been positively affected by investments in renewable energy. It can claim that foreign dependency has partially decreased as domestic energy resource use in the Turkish energy sector has reached 61%. However, it is not considered sufficient when this situation is evaluated in terms of carbon dioxide emissions. In addition, according to the Ember Energy report, Turkey is among the countries that are adversely affected in terms of SO2 (sulfur dioxide) and NOx (azote) pollution originating from electricity generation from coal (Alpaslan, 2021).

Energy consumption is an indicator associated with development. More energy is required for more investment. The global expansion of the use of environmentally friendly renewable energy for "Sustainable Development" entered our lives in the 1970s and is the critical concept of today. Just like the global reaction to the Covid pandemic, reactions to global warming and carbon dioxide emissions should be shown, and precautions should be taken.

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