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Assessment of Wind Energy Potential and Current Usage Status in Türkiye and in the World

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Abstract

While many developed countries in the world set 2050, Türkiye has determined 2053 as the year of net zero emissions target. Increase in the usage of renewable energy sources such as wind for the energy production is one of the main methods to achieve this goal. Among the renewable energy sources used for electricity production, wind energy has been the most increasing energy source in Türkiye and around the world in recent years. Today, more than 100 countries in the world generate electricity from wind energy. China, the United States of America and Germany are the top 3 countries with the highest installed capacity of wind energy for a long time. Based on 2022 data, Türkiye ranks 7th in Europe and 12th in the world with respect to the installed wind power plant capacity. Among the renewable energy sources, wind energy in Türkiye has the largest installed power and electricity production after hydroelectricity. In this study, the potential and installed capacity of the wind energy for the different countries in the world and Türkiye are analysed, the shares of the wind energy in current energy production and its contributions to the total energy consumption has been examined. The conditions that will enable the world including Türkiye to meet the energy consumption completely from renewable energy sources and the possible contribution of wind energy to all renewable resources have been estimated.

Keywords: Energy, Renewable Energy, Türkiye Wind Energy Potential, Wind Energy, World Wind Energy Potential.

1. INTRODUCTION

The rapid increase in the world population, industrialization and the intensive use of technological tools and equipment cause energy consumption to increase by 4-5% on average every year [1]. Environmental and health problems have occurred as a result of the long-term use of fossil-based energy sources, which are used to meet current and increasing energy needs. In addition, although there has not been much change in the reserve life of fossil energy resources (estimated reserve life 42-50 years for oil, 60-65 years for natural gas and 150-200 years for coal) in the last two decades, there is a concern that these resources will be depleted within 50-200 years. In recent years, this has accelerated the efforts to reduce the use of fossil-based energy sources and to find clean energy sources to replace them [2-4]. Within the scope of these studies, the use of natural gas, which is the least polluting and harmful among the other fossil fuels, has been increased as a near-term target, while the efforts to increase the use of renewable energy sources, which have no harmful emissions, have accelerated. It is known that the use of renewable energy sources such as solar, wind, geothermal and biomass for drying, grain grinding, heating and health purposes as conventional method, apart from electricity generation, is as old as human history. Today, utilization from renewable energy sources for electricity generation, which is the most effective form of their usage, is aimed to produce cleaner energy by reducing the usage of fossil resources.

The most widely engaged renewable energy sources; hydraulic, wind, solar, geothermal and biomass energies at the present time and their usage is increasing regularly. Wind energy, one of the most important renewable energy sources, occurs as a result of the different heating of the ground surfaces by the sun's rays. The difference in heating of the ground surfaces leads to a difference in the temperature, pressure and humidity of the air and the pressure differences seen between the two different regions gives rise to the movement of air from high pressure to low pressure, leading to wind formation. Some advantages of wind energy are that wind energy is renewable and clean, does not require very high technology for energy production in some systems, and is free and abundant in the atmosphere. In order to make the most effective use of wind energy, which will exist as long as the sun and the world exist, it must be converted into

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electrical energy. Wind turbines are used for this purpose [1, 2]. In wind turbines, the kinetic energy of the wind is first converted to mechanical energy by the turbine blades and then to electrical energy by the generator. In recent years, developments in propeller type wind turbine technology (such as gearless turbines, with increased unit power and efficiency) have made wind energy competitive with fossil fuel energies by reducing the cost of electricity generation from wind energy.

Many studies are found in the literature on the situation of wind energy in Türkiye and in the world. Senel et al. [1] examined the wind energy potential in Türkiye and the world, in addition to the development and usage status of wind energy systems as of the end of 2014. Kose [2] examined the formation and characteristic features of wind energy with Türkiye's wind energy potential. Köse et al. [5] performed an analysis by using the wind energy measurement data which was obtained from measurements performed at the Alaaddin Keykubat Campus of Konya Selcuk University and annual water data regarding Konya Altinapa dam. Their calculation showed that a wind power plant built in the region of Konya Akyokus and a water turbine power plant installed on the Akyokus purification plant can meet the annual electrical energy demand of the plant.

In the report published by the International Renewable Energy Agency (IRENA), the statistical information about world total and each country's separately renewable energy potentials and their current situations associated with renewable energy usage for the year 2021 and before are given [6]. In the report published by Lee et al. [7] the statistical information about world total and each countries separate wind energy potentials and their current situations associated with wind energy usage for year of 2020 and previous years are shared.

According to the BP annual statistical report, electricity generation values for all countries of the world and the world total from 1985 to the end of 2020 using wind energy use are given [8]. Kose et al. [9] investigated the most suitable wind turbine and turbine tower height that can be built in the Konya Selcuk University Alaeddin Keykubat campus region based on their wind energy measurements performed in this region. Their analysis showed that the proposed wind turbine would pay itself back in 6,5 years.

Karabag et al. [10] examined the current and future status of renewable energy resources in light of large databases provided by national and international renewable energy institutions. They evaluated the latest situation in the world and Türkiye in the transition to 100% renewable energy, and made predictions about how close to the target of 100% renewable energy the transition is.

The government's purchase prices in $cent/kWh for licensed electricity produced in Türkiye from renewable energy sources according to the regulation are given in Table 1. [11]. The electricity produced by the facilities within the scope of unlicensed electricity generation activities from the same sources has been started to be purchased by the Republic of Türkiye Energy Market Regulatory Authority (EMRA) as of 10/5/2019. This purchasing is in TL kuruş/kWh based on the retail one-time active energy price of its own subscriber group. [11]. As seen in Table 1, considering the costs and efficiencies of the production systems, the electricity produced is purchased with the tariff of 7,3$cent/kWh, 7,3$cent/kWh, 10,5$cent/kWh, 13,3$cent/kWh, 13,3$cent/kWh from the electricity production facilities based on hydroelectric, wind, geothermal, biomass and solar energy respectively.

Table 1. The government's electricity purchase prices of licensed electricity produced from renewable energies sources according to the regulation in Türkiye [11]

Production Facility Type based on Renewable Energy Source	Price Tariff (US Dollar cent/kWh)
Hydroelectric enrgy generation facility	7,3
Production facility based on wind energy	7,3
Production facility based on geothermal energy	10,5
Biomass based production facility (including landfill gas)	13,3
Solar energy based production facility	13,3

Another practice in Türkiye that encourages electricity production from the renewable energy sources including wind is that an additional incentive fee is paid for each kWh electricity produced during the first 5 years of operation of the facility, if each system component used in these systems is domestically produced [11, 12]. The additional incentive fees paid for wind turbine parts by parts is given in Table 2, and the highest fee is 1.3 USD cents/kWh if all the mechanical parts in the rotor and nacelle groups are domestic production. With such additional incentives, domestic production of the entire system is aimed, starting from the parts of the turbine.

Table 2. Incentive fees to be paid depending on the parts in case the wind turbine parts are domestically produced in Türkiye [11, 12]

Domestic Manufacturing	Incentive Fees for Domestic production (US Dollar cent/kWh)
1- Blade	0,8
2- Generator and power electronics	1,0
3- Turbine tower	0,6
4- All mechanical parts in rotor and nacelle groups	1,3

The current study intends to systematically analyse the current situation of wind energy usage in the world and in Türkiye. The outline of the paper is as follows: world wind energy potential and its usage examined in detail in Section 2. Türkiye's wind energy potential and to what extent this potential is being utilized are discussed in Section 3. The conclusion is provided in Section 4.

2. WORLD WIND ENERGY POTENTIAL AND ITS USAGE

Before examining the world wind energy potential and its current usage status, the world's total current energy use and the shares of different energy sources used for energy production should be examined. In Figure 1, between 1990 and 2019, the world's total energy uses are shown at 5-year intervals [11]. Based on the data provided by the International Energy Agency (IEA), this chart shows the highest energy supply is from oil with 187.364.800 TJ in 2019; coal with 162.375.732 TJ, third: natural gas with 140.784.380 TJ, fourth: biofuel and waste with 56.813.210 TJ, fifth: nuclear with 30.461.171 TJ, sixth: hydraulic power with 13.194.639 TJ and seventh: wind and solar with 13.417.236 TJ. As a result, the sum of all of them 606.411.168 TJ, is the world's total energy consumption in 2019 [11]. The last three of these are renewable energies and they have a 14,1% share of the total, while the total of wind and solar power have a 2,21% share of the total.

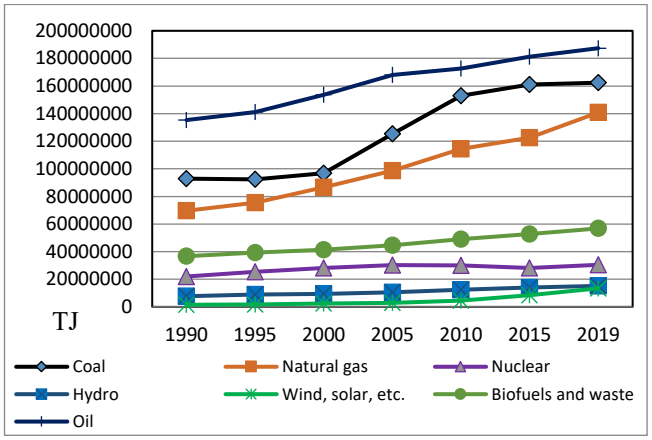

Figure 1. World 1990-2019 total energy supply (TJ) [11]

The values of the total and resource-based distribution of world primary energy consumption for 2019 and according to three different scenarios for 2050 are given in Table 3. [13]. According to this table, the total primary energy consumption, which was be 627 EJ in 2019, will have lowest value of 653 EJ based on the net zero emission scenario, 692 EJ based on the accelerated scenario, and highest value of 760 EJ based on the new momentum scenario created considering countries with new economies growing. With respect to the primary energy sources type, the lowest possible values also are obtained with net zero emissions scenario for the fossil fuels; Compared to 2019 values, it is aimed to decrease to 22,8% in oil, 43,6% in natural gas and 10,7% in coal.

Considering the data in Table 3, it is estimated that energy production from renewable energy sources will increase 1.71 times in hydroelectricity and 5,65 times in renewable energies including biomass in 2050 compared to 2019. In the same period, it is aimed that nuclear energy production will increase by 2 times and 82% of the total primary energy can be produced from nuclear and renewable energies.

Table 3. World primary energy by fuel, consumption level for 2019 and demands of 2050 with different scenarios, EJ [13]

Primary energy by fuel	2019 (EJ)	Accelerated	Net Zero	New Momentum
Total	**627**	**692**	**653**	**760**
Oil	193	87	44	154
Natural gas	140	94	61	181
Coal	158	25	17	103
Nuclear	25	40	49	27
Hydro	38	61	65	48
Renewables (incl. bioenergy)	74	384	418	247

Various studies have been carried out by the International Energy Agency (IEA) in order to determine the world wind energy potential. In these studies, the world technical wind potential was calculated as 53.000 TWh/year, based on the prediction that 4% of the regions with a wind capacity above 5,1 m/s would be used due to practical and social constraints [1]. In Figure 2, the wind speed values for the places which have 80m above the ground are given in m/s and miles/h units. [14]. Likewise, Figure 3, the comparison of technical wind potentials of world continents are illustrated [1]. Wind energy potential is highest in North America with 14.000 TWh/year and lowest in Oceania with 3.000 TWh/year. These data show that North America, Eastern Europe, Russia and Africa have 66% of the world wind energy potential.

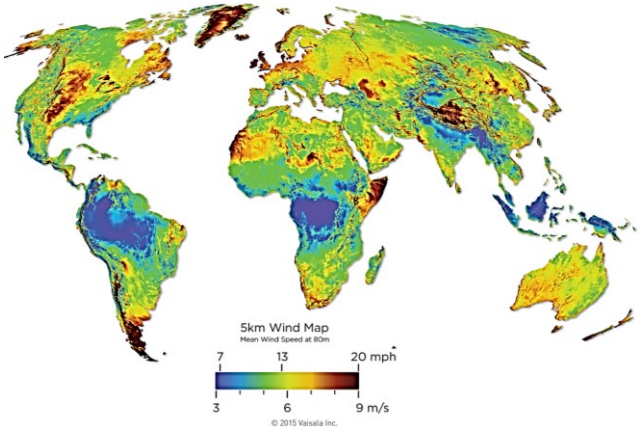

Figure 2. Technical wind potentials of world continents [14]

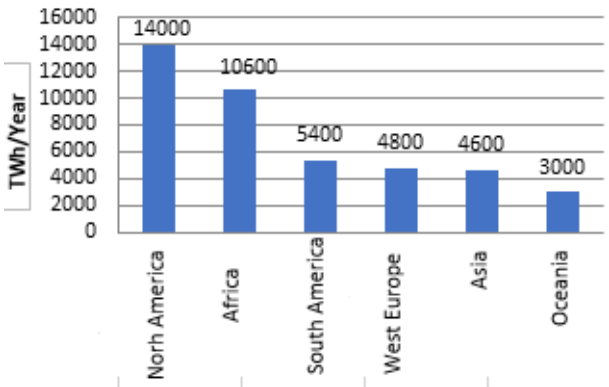

Figure 3. Technical wind potentials of world continents [1]

According to Lee et al. [7] as can be seen in Figure 4 a), by 2050, % 50 increases in global energy consumption is expected due to non-OECD economic growth and population increases. Furthermore, they claim that although liquid fuels are the largest primary source for energy production in the reference state, energy production from renewable sources also reaches about the same levels. In Figure 4 (b), electricity generation from renewable sources has been converted to Btu at a rate of 8.124 Btu/kWh. When the total energy consumption of OECD member and non-member countries is analysed as it can be seen in Figure 4 (a), it is noticed that energy consumption of non-OECD countries will increase tremendously due to increasing population and industrialization.

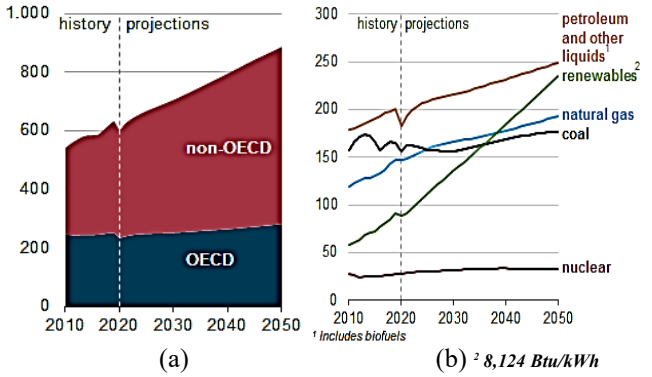

Figure 4. 2010-2050 (a) world energy consumption, (b) world primary energy consumption by energy source, (quadrillion BTU) [7]

Total world electricity generation from wind power by the end of 2020 was 1591,2 TWh/year [6]. This value is approximately 3% of the world wind capacity given in Figure 3 and 5,3 times the electricity consumption of Türkiye, which was 305 billion kWh/year in 2020. World total renewable energy production between 1999 and 2019 is given in Figure 5. Accordingly, it is seen that energy production from wind power has exceeded 50% of total renewable energy production in recent years.

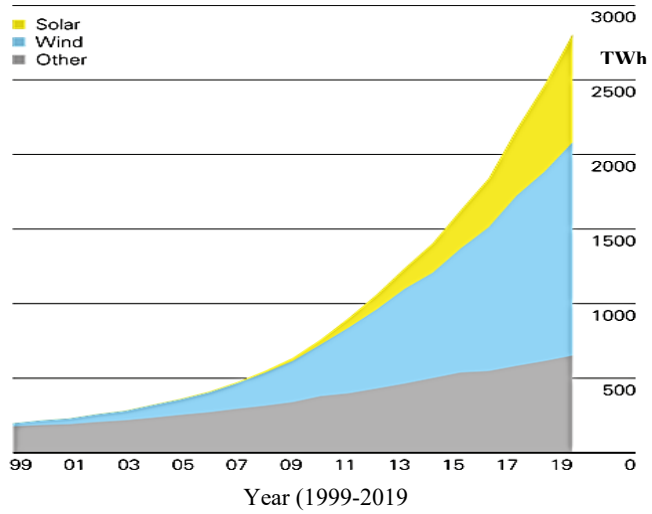

Figure 5. Renewable energy generation by source between 1999-2019, (TWh) [8]

For the global wind industry, 2020 was the best year in history with 53% annual growth. More than 93 GW of wind power was installed in a challenging year disrupting both the global supply chain and project processes [7]. World total wind power increased to 743 GW with 93 GW of new installations in 2020. This equals 1.1 billion tons of CO_2 reduction per year.

The installed wind energy capacity of the world has increased 3 times in the last 10 years, reaching from 283 GW to 837 GW as illustrated in Figure 6 [13], which has made wind energy one of the most cost competitive and durable energy sources.

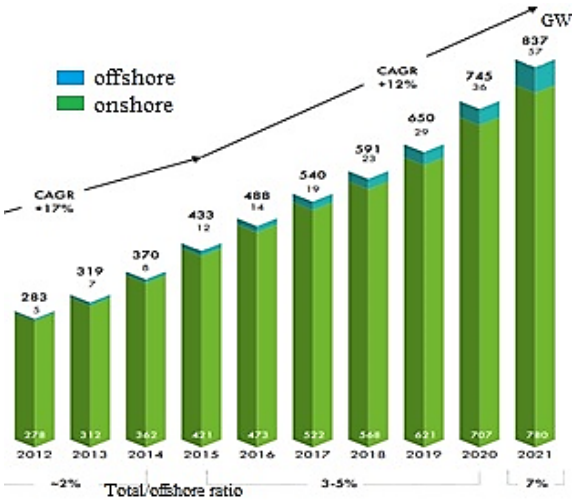

Figure 6. Development in the world total wind installed power over a 10-year period (2012-2021) [13]

Regionally, records have been performed in terms of onshore installations in Asia Pacific North America and Latin America in 2020-2021. As of 2022, a total of 55 GW of new onshore wind energy capacity has been gained from these three regions [13].

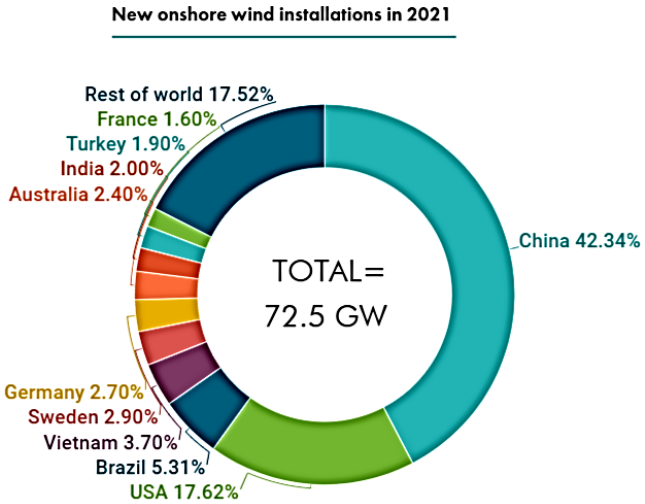

Figure 7. New onshore wind power installation rates by countries for 2021 [13]

As can be seen from Figure 7, when we look at the new wind installations, Türkiye is seen among the top 10 countries on a global scale. In Türkiye, there was a new wind capacity

increase of 686 MW in 2019, and the increase in 2020 almost doubled the previous year with 1224 MW. The total wind capacity in Türkiye increased to 9.559 MW in 2020 and then in 2021 10.681 MW. As an offshore wind farm, 21,1 GW of worldwide capacity was commissioned last year, making 2021 the best year ever as shown in Figure 8. China has broken the record, achieving 80% all new world offshore wind power installations. Steady growth was recorded in Europe. The United Kingdom took the lead, followed by Denmark and Netherlands. The remaining new offshore wind installations in 2021 were made by the Vietnam and rest of the world. World offshore wind installation exceeded 57 GW in 2021 and represents 7% of total world wind capacity [13].

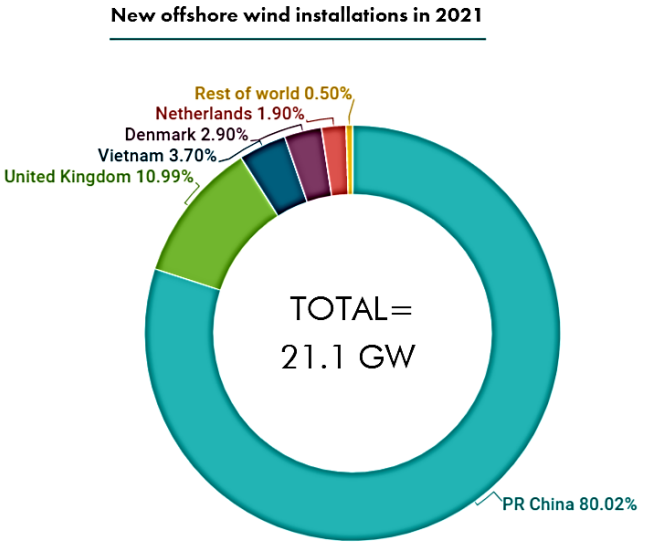

Figure 8. New offshore wind power installation rates by countries for 2021 [13]

The world and European wind installed power rankings taken into account considering 2022 values, China, USA and Germany are in the first three places in the world, respectively, and Germany, Spain and England are in the top three rankings in the European ranking. Türkiye ranks 7th in Europe and 12th in the world with its 10.681 MW of installed power as presented in Table 4 [3, 6, 7, 13].

Table 4. World and European wind installed power ranking

Rank	World Ranking Country	Installed Power (MW)	European Ranking Country	Installed Power (MW)
1	China	338.309	Germany	64.542
2	US	134.396	Spain	27.089
3	Germany	64.542	England	26.586
4	India	40.084	France	19.131
5	Spain	27.089	Sweden	11.915
6	England	26.586	Italy	10.839
7	France	21.580	**Türkiye**	**10.681**
8	Brazil	19.131	Netherland	6.992
9	Canada	14.255	Denmark	6.840
10	Sweden	11.915	Portugal	5.239
11	Italy	10.839	Belgium	2.843
12	**Türkiye**	**10.681**	Ireland	2.830
	Total	**719.407**	**Total**	**195.527**

Some scenarios and plans have been made by some international organizations such as IRENA, IEA and EWEA to produce the world's energy need from clean and renewable energy sources instead of fossil-based sources that disrupt the ecological balance and harm human health. Some of these are based on the 2015 Paris agreement targets, some are based on 2030 and some are based on 2050 [6-8]. According to IRENA's Energy Transition Scenario, world wind additional annual capacity increase would need to reach approximately 180 GW to meet the Paris agreement targets [6]. According to the IEA's Net Zero scenario by 2050, it needs to increase to 160 GW by 2025 and to 280 GW by 2030. This value corresponds to 3 times the increase in 2020 as illustrated in Figure 9. Total annual global investment in clean energy and efficient systems infrastructure should increase from US$380 billion in 2020 to US$1,6 trillion in 2030, according to the IEA [15].

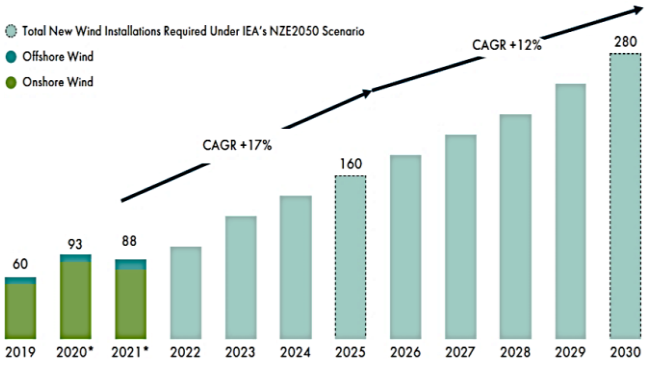

Figure 9. New global wind energy installations required by 2030 (GW) (CAGR: compound annual growth rate) [8]

To reach the net zero targets, the wind market expects the addition of new onshore and offshore wind power with a capacity of over 469 GW in the next five years. That indicates around 94 GW of new installations per year by 2025, according to current policies [8]. Governments are expected to significantly increase their targets following COP26 (26th UN Climate Change Conference of the Parties) [17]. Combined with China's net zero target by 2060 and the United States' intention to reach net zero by 2050 are extremely important in terms of reducing the emissions of greenhouse gases because these countries adopt two-thirds of the global economy and represent 63% of global greenhouse gas emissions. By 2030, according to IRENA, the average LCOE (levellised cost of electricity) of both onshore and offshore wind electricity generation costs is projected to decrease by 25% for onshore and 55% for offshore, from 2018 levels. Annual wind installations must increase significantly to reach net zero by 2050 [6, 8, 18].

3. TURKIYE WIND ENERGY POTENTIAL AND ITS USAGE STATUS

There are different power estimations about the installed power of wind energy in Türkiye depending on the annual average wind speeds at which power plants can be established. According to the Wind Energy Potential Atlas (REPA) [16] prepared by the Ministry of Energy and Natural Resources in 2007 (Figure 10), the wind power plant that can be installed has been determined for the total country,

regions and provinces based on the lands which is suitable for the establishment of a wind power plant having an altitude of 50 m with wind speed of 7,0 m/s and above as shown in Table 5 and Table 6. According to these tables, the total capacity for terrestrial areas is 37.836 MW, and for offshore 10.013 MW, a total of 47.894 MW, which is approximately 48.000 MW. Among the regions, the Ege region has the highest value with 18.975 MW, followed by the Marmara region with 12.704 MW, which shows that there are too many wind farms established in these two regions today.

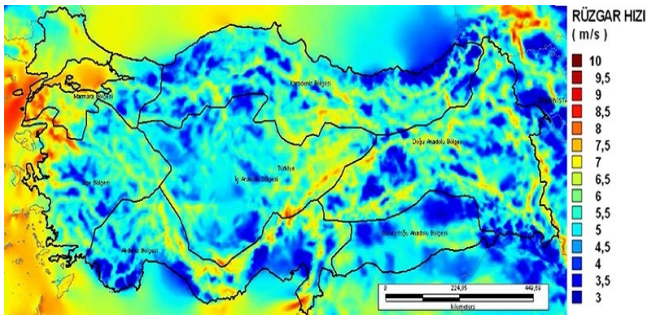

Figure 10. Türkiye 70 m wind speed potential map [16]

Table 5. Türkiye's wind farm capacities for 50 m altitude and annual average wind speed of 7,0 m/s and above [16]

Wind Classification	Annual Power Density, W/m²	Annual Average Wind Speed, m/s	Total Capacity, MW
4	400-500	7,0-7,5	29.259,36
5	500-600	7,5-8,0	12.994,32
6	600-800	8,0-9,0	5.399,92
7	>800	>9,0	195,84
Total Capacity			**47.894,44** terrestrial: 37.836 above the sea: 10.013

Table 6. Wind plant capacities of regions of Türkiye for 50 m altitude and annual average wind speed of 7,0 m/s and above (MW) [16]

Region Name	Capacity (MW)
Marmara	12.704,0
Aegean	14.975,0
Mediterranean	5.335,0
Central Anatolia	914,0
Black Sea	2.472,0
Eastern Anatolia	986,0
Southeast Anatolia	0,0
Total Capacity	37.386,0

Although Türkiye's wind potential values are determined as 48.000 MW based on the lands having 50 m altitude and wind speed of 7,0 m/s and above according to 2007 REPA values, when 100 m altitude and wind speed of 6.0 m/s and above areas are taken into consideration, the potential is 83.000 MW appears to be out. In recent city-based potential studies for larger powerful and more efficient wind turbines, it has been determined as 115.129 MW. Considering the rate at which this potential is used, the usage rate is 8,3% for the installed power of 9.559 MW according to the values of 2020, and 9,2% for the 10.585 MW power in October 2021. In Table 7, the 5 cities with the highest potential and current capacity utilizations status are given. The city with the highest potential is Balıkesir with 13.827 MW, followed by Çanakkale with 13.013 MW [1].

Table 7. 5 cities with the highest wind potential in Türkiye [1]

City	Theoretical Potential MW	In operation MW	Under constr. MW	Licenced MW	Sub-license MW	Total Process MW	Process/ Theory Ratio
Balıkesir	13.827	1.294	87	0	0	1.382	10 %
Çanakkale	13.013	797	256	40	162	1.255	10 %
İzmir	11.854	1.680	55	0	23	1.758	15 %
Manisa	5.302	691	11	10	0	712	13 %
Samsun	5.222	48	4	9	0	61	1 %

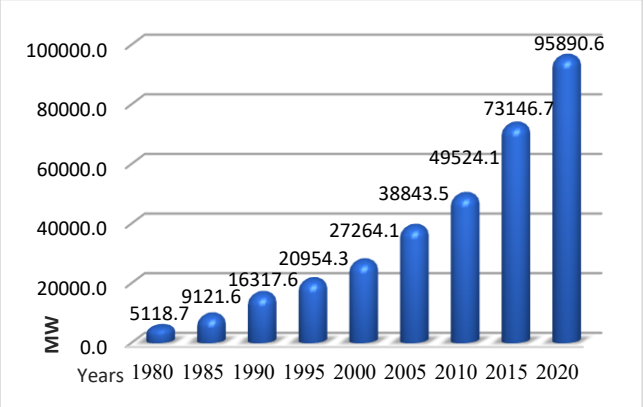

Figure 11. Development of Türkiye's installed power over the years [15, 20]

The development of Türkiye's electrical installed power between 1980 and 2020 is given in Figure 11, and the power which was 5.118 MW in 1980 increased approximately 19 times and reached 95.890 MW after 40 years. The first wind farm in Türkiye was established in 1998 in Izmir. Türkiye's total electricity installed power values and electricity generation from renewable sources in 2020 are given in Table 8 and Table 9 respectively. As of the end of 2020, Türkiye has 8.832 MW of installed wind power and the ratio of this power to the installed electricity is 9,21% and the energy produced with this power is 24.828 GWh and its ratio to the total energy generation is approximately 8,1%. Some of the 269 power plants that have been commissioned have not yet reached the installed capacity of the license and their construction is still on going. With the full capacity commissioning of these power plants, an additional wind turbine with a capacity of 2.091 MW will be commissioned and the installed power will reach 11.650 MW. In addition, the license capacity of 60 power plants, of which no units have been commissioned yet but progress has been made in their installation, is 165 MW. When all of these projects are completed, the installed capacity of Türkiye's wind power plants will be 11.814 MW.

Table 8. Türkiye's total electricity installed power values in 2020 [20]

Source	Installed Power MW	Ratio, %
Import Coal	8.841,9	9,22
Bituminous Coal	782,5	0,82
Lignite	9.988,7	10,42
Liquid Fuels	189,4	0,20
Multi-Fuel	4.889,1	5,10
Waste Heat	397,5	0,41
Natural Gas	21.599,4	22,53
Renewable Waste + Waste	1.105,3	1,15
Wind	8.832,4	9,21
Solar	6.667,4	6,95
Water Dam	22.925,0	23,91
Water Stream, Lake	8.058,9	8,40
Geothermal	1.613,2	1,68
TOTAL	**95.890,6**	**100**

The share of wind energy in Türkiye's total electricity installed power is approximately 10 percent, while wind energy has 19,3 percent of the total renewable energy installed power. When the wind energy capacity is evaluated on a city basis, İzmir has the highest capacity with approximately 1700 MW, followed by Balıkesir with 1300 MW, Çanakkale with approximately 850 MW, Manisa with 750 MW and Istanbul with 420 MW. In addition, Hatay and Kırklareli with 415 MW each, Aydın with 400 MW, Afyonkarahisar with 325 MW, Kayseri with 272 MW (10th), Osmaniye with 260 and Konya with 242 MW (12th), Muğla with 220 MW, Bursa with 205 MW and Mersin with approximately 200 MW installed wind capacity are among the 15 cities with the highest energy installed capacity.

The installed power shares of different energy sources in Türkiye's electricity production for the years 2010 and 2020 are given in Figure 12. These energy sources used for electricity production are hydroelectric, natural gas, coal (stone, lignite and imported coal), wind, diesel, liquid fuels, geothermal, biogas and solar the values given in Table 8 is direct agreement with the 2020 values of Figure 11.

Table 9. Türkiye's electricity generation from renewable sources in 2020 [19, 20]

Source	Generation (GWh)	Contribution (%)
Renewable Waste+Waste	4.459,9	3,47
Wind	24.828,2	19,34
Solar	10.950,2	8,53
Water Dam	57.463,9	44,77
Water Stream, Lake	20.630,4	16,07
Geothermal	10.027,7	7,81
Total Renewable	**128.360,4**	**100,00**
Renewable (%)	**----**	**41,85**
Türkiye Total	**306.703,1**	**100**

Furthermore, the fact that the energy produced by hydroelectric power plants is higher than all the energy obtained by the use of fossil fuels in 2020 values, the rate of renewable energy approaching 50% and the rate of electricity generation from wind energy approaching 50% in renewable generation shows the importance of renewable and wind energy (Table 9).

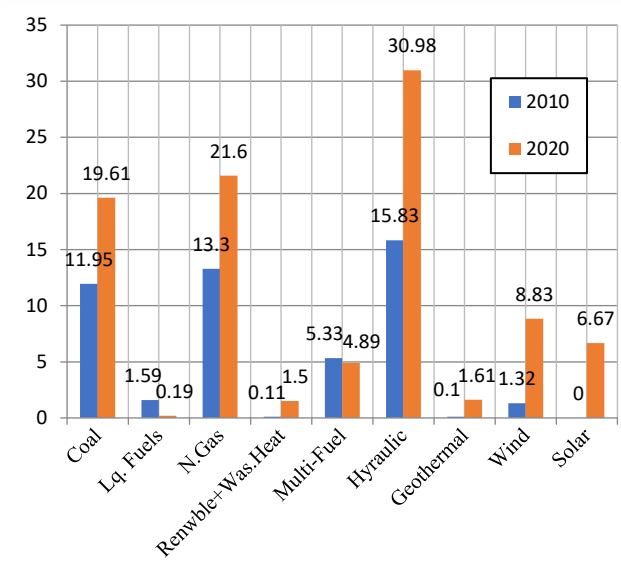

Figure 12. Electricity installed capacity of Türkiye from primary energy sources in 2010 and 2020 (GW) [19, 20]

When the graph of Türkiye's wind total installed power and annual installation amounts between (1998-2020) given in Figure 13 is examined, it is seen that the total installed power has increased approximately 7 times in the last 10 years and 2 times in the last 5 years. Annual installation amounts have grown rapidly after 2012, after reaching the highest value in 2016, it decreased slightly until 2018 and started to increase rapidly as of 2019.

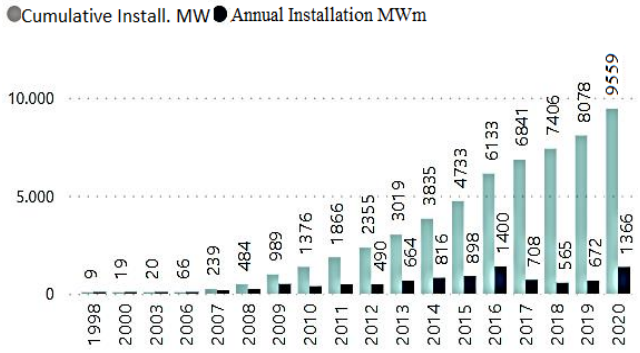

Figure 13. Development of Türkiye's wind power over the years [15, 20]

In recent years, there have been significant developments in the technologies of wind turbines used to convert wind energy into electrical energy. The first of these developments has been achieved by the widespread use of turbines without gearbox and their getting cheaper. The second important development has been achieved by increasing the rotor diameter that is directly related with the turbine power, by constructing turbines with a power over 10 MW. While the first of these developments will increase the efficiency of the turbines, the second will increase the tower height of the turbine and increase the power coefficient value with higher wind speeds.

4. CONCLUSION

In this study, first the energy needs and current energy usage status of the world and Türkiye were determined, then the wind energy potentials were obtained and by using these wind energy potentials, it has been investigated to what extent the energy demands can be met. In addition, measures and scenarios were analysed to reduce the use of fossil-based energy, which has harmful effects on the ecological balance of the world and living health, and to increase the use of wind and other renewable energy resources to replace them. The results obtained in the study are summarized below.

Currently, 80% of the world's general energy needs and 85% of Türkiye's total energy needs are met from fossil fuels. The share of wind energy in Türkiye's total electricity installed power is approximately 10 per cent, while wind energy has 19,3 per cent of the total renewable energy installed power.

The world technical wind potential is 53000 TWh/year, with the highest being North America with 14000 TWh/year from the continents and Oceania having the lowest 3000 TWh/year. In addition, North America, Eastern Europe, Russia and Africa have 66% of the world's wind energy potential. The total installed wind power of the world in 2021 is 837 GW, and the installed power of Türkiye is 10,7 GW. With this power value, Türkiye ranks 12th among world countries and 7th among European countries. As of the end of 2021, Türkiye has 10.681 MW of wind power, which is 9,2% of the country's electrical installed power, and the energy generation by using this power is 24.828 GWh and its ratio to the total energy production is approximately 10%.

While the world's total electrical energy production in 2020 is 26.823,2 TWh/year, Türkiye's production is 305,5 TWh/year. Energy production from renewable sources was 3.147,0 TWh/year for the world and 49,8 TWh/year for Türkiye.

According to IRENA's Energy Transition Scenario, additional annual wind capacity increase would need to reach approximately 180 GW to have a chance to meet the Paris targets. According to the IEA's Net Zero scenario by 2050, it needs to increase to 160 GW by 2025 and to 280 GW by 2030. This value is 3 times the increase in 2020.

Developments seen in turbine technologies and the production of domestic turbines in Türkiye will increase the use of wind energy, making wind electricity cheaper both in the world and in Türkiye. As a result, it is estimated that it will be possible to reach the target of 100% zero emissions and 100% renewable energy production by using all renewable energy sources, even if not only with wind energy, until 2053 or 2070.

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