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The Renewable Energy Sources and Technologies of Potential in Turkey

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Abstract: Turkey is a foreign dependent country in terms of non-renewable fossil fuels, but in terms of the renewable energy sources; it has a great potential to meet all its needs. Turkey's increasing energy demand because of foreign dependent fossil fuels is making country's economic conditions harsher and harsher. However, Turkey is becoming a center of attraction in the renewable energy sector. In fact, Turkey is the country which has Europe's highest solar energy potential. For example, Turkey's wind energy potential is estimated to be 48000 MW. The total potential is estimated to be 38000 MW on land and 10000 on the sea. Turkey, is also a rich country in terms of wind energy. A total of 4000 MW of capacity utilization was achieved in the wind power by the Ministry of Energy and Natural Resources in 2017 by the Renewable Energy Resource areas tender. According to the data of the Energy Market Regulatory Authority, Turkey's installed capacity of wind power is around 6621 MW. The wind power sector, which started to develop rapidly after the Law of Renewable Energy's coming into force in 2005, has grown by an average of 25-30 percent each year for the last five years. Turkey is also one of the world's richest countries in terms of geothermal energy sources. The introduction of rich geothermal energy resources in Western Anatolia will make significant contributions to the national economy. The diversification and growth of renewable energy sources will contribute significantly to the national economy as well as the positive environmental impacts (greenhouse effect).

Keywords: Engineering and energy, Energy systems, Renewable energy and applications, Turkey

Introductıon

Energy is one of the most significant means of consumption in our time and it is an indispensable tool for civilization. Energy consumption, which is one of the primary and basic needs of developed and developing countries, is constantly increasing. Today, we need energy and energy resources directly and indirectly in order to continue the technological advances we have and to continue the opportunities they contributed to our lives.

There are social, economic, environmental reasons and some major advantages of renewable energy use such as contribution to sustainable development. Therefore, energy diversification is very important in terms of energy security and continuity. Main renewable energy sources used today are; Solar, Wind, Hydroelectric, Hydrogen, Geothermal, Biomass and Marine energy (Wave, current, tide). Today, the development of countries around the world depends on the energy resources needed by the industry. In this way, increasing the social welfare of the countries and increasing their competitiveness in the global arena depend on their energy potential. Energy use directly or indirectly affects human life in many areas such as transportation, heating, communication, lighting, industry, tourism and agriculture.

The rapidly growing population and the development of technology increase the demand for energy every day. This problem causes the problem of use and distribution of energy resources. The control and distribution of energy resources can lead to geopolitical tensions, and new tensions may arise in the near future to use and obtain renewable energy sources. The rest of the energy need which is not covered by fossil fuels can be compensated by nuclear and renewable energy sources. The damage caused by the use of fossil fuel to the environment and human health is unbelievable. Environmental problems extending from air, water, soil pollution to the destruction of vegetation and animals have aroused concern for the future of societies that are affected by these problems. Due to the decrease of fossil fuel reserves in the world and carbon dioxide, sulfur and its compounds, lead and other toxic chemical compounds and gases, environmental pollution and the ozone

layer in the atmosphere and greenhouse effect, the effects of climate change and warming of the world are the problems that occur. According to the results of the last measurements; Global Warming Values should be kept below 1.5^{o}C. These values are the proofs that renewable energy sources are important for the future of the world.

Method

In parallel with the increasing technology and population growth in the world today, parallel to the rapid increase in energy consumption, it is proven a fact that traditional energy sources will be depleted in the near future. With the increase in population in the future, the energy need for production will increase. Population growth is expected to come true in developing countries. It is also observed that the energy consumption of these countries will increase rapidly. Developing countries will soon become the largest energy markets in the world. Although the energy consumption of these countries is half of the rich countries, this consumption is doubled every 15 years. One of the most striking points in this regard is the increasing need for energy in developing countries due to population growth. There will be no significant changes in the figures of population of the rich western countries and thus the energy consumption per capita will not change either. (Anderson, 1996). Today, energy, which is an indispensable part of human life, has a geopolitical importance in terms of production and consumption.Nonrenewable energy sources, in addition to negativities such as external commitment, high budget expenditures and environmental problems due to the rapid depletion of renewable energy resources, are increasing on a daily basis. With the reduction of technical and cost factors in obtaining renewable energy resources, it is accepted that it will be the most important energy source of the 21st century.

Turkey is a country with limited opportunities in terms of fossil fuel energy sources. However, in terms of renewable energy resources, it is a country that is rich in a size that cannot be neglected. In the near future, Turkey must take some important steps in the field of reducing the future energy dependence, technology studies that alternative sources of energy will bring, know-how (technology transfer), labor employment, and also the education and training of workers who are going to work in the production of renewable energy sources and accompanying technologies. Besides the necessary technologies and regulations to encourage Turkey to be integrated into the use of renewable energy sources and energy production also needs to improve. Turkey is an important market for renewable energy technologies. It has to create domestic and national technologies in renewable energy sources and technologies. Failure to develop renewable energy sources technologies will be higher than the cost of fossil fuels that our country is almost entirely dependent on abroad.

Findings

Renewable energy sources are produced on earth and in nature without the need for any production process, they are not fossil based (like coal, petroleum and carbon derivatives), electricity energy is produced at a minimum level, CO2 emission is at a minimum level and environmental impact and effect is much lower than traditional energy sources. It refers to energy sources such as hydraulic, wind, solar, geothermal, biomass, biogas, wave, current energy and tidal, hydrogen that are renewed in a continuous motion and available in nature.

In recent years, energy and energy resources have become very important in the world. Energy in every stage of daily life; chemical, nuclear, mechanical (potential and kinetic), thermal (heat), geothermal, hydraulic, solar, wind, electrical energy can be found in different ways and can be converted into each other by appropriate methods. According to the use of energy sources as renewable and non-renewable energy sources are divided into two; energy sources according to their convertibility; primary and secondary energy sources. Non-renewable energy sources are energy sources that are expected to be consumed in the short term and are classified in two different ways as fossil based and nucleus based sources. Renewable energy sources; refers to the resources that can be renewed in the future and can renew itself (Koç, Şenel, 2013.

Any change or non-transformation of energy is called primary (primary) energy. Primary energy sources are oil, coal, natural gas, nuclear, hydraulic, biomass, wave-tide, sun and wind. The energy obtained as a result of the conversion of primary energy is defined as secondary energy. Electricity, gasoline, diesel, coke, secondary coal, petroleum coke, air gas, liquefied petroleum gas (LPG) are among these types of energy sources (Koç, Şenel, 2013).

With the significant increase in the use of non-renewable energy resources, the rapid decline of these energy sources draws attention to the importance of renewable energy sources all over the world. In addition, the non-renewable energy sources used cause irreversible damage in the nature. It is the renewable energy that is the

obvious solution for clear air, clean energy and pollution and these are types of energies like solar, wind, geothermal etc. It is the solar energy with the highest potential among renewable energy sources. The average solar energy source in the world was 36 billion watts (3,6,106 TW), the source of wind energy was 72 TW, the geothermal energy source was 9,7 TW and the use of manpower was 15 TW.

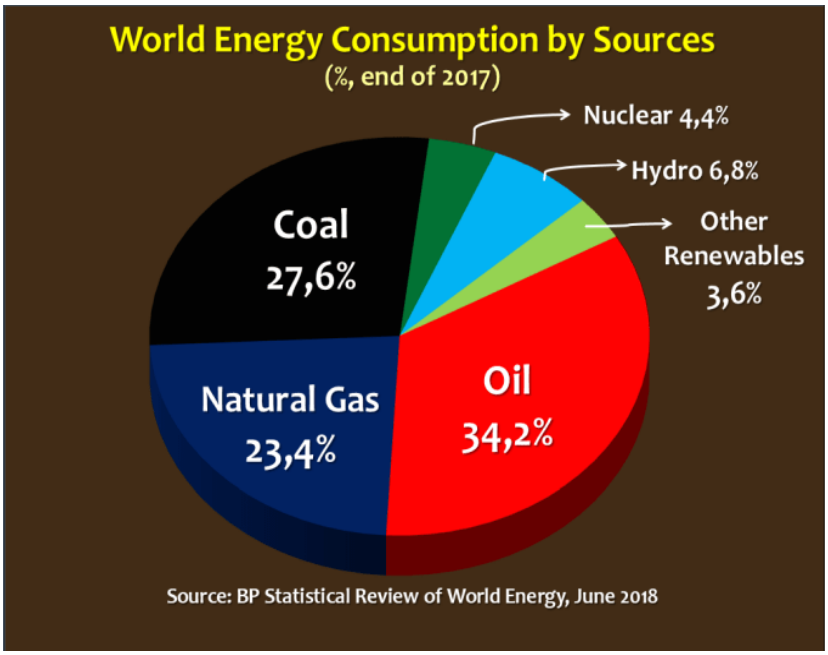


Figure 1. World energy consumption by sources, (BP statistical review of world energy, June 2018).

In 2010, the total installed capacity of 49.524 MW of electricity of Turkey has increased to 87.139 MW as of June 2018; The total installed capacity of renewable energy sources reached 40.698 MW while the installed capacity increased to 46.7 percent (EMO, Annual Report, 10.07.2018).

According to a study by Stanford University in 2010 in Turkey for 40 years in the construction of the energy mix in 2050, 183 724, 192954 and in businesses that will provide new jobs for a total of 376678 people. According to the projection of 2050, with the transition of 100% renewable energy to our country, the number of people whose deaths are prevented by the air being cleaned every year will be 19,100 and therefore the deaths will be prevented. Turkey, in order to generate electricity annually based on the average of the past 10 years engaged in importing 46.34 billion US dollars' worth of energy. According to the American Wind Energy Organization's research, 1 MW of wind energy can prevent the emission of 1500-2000 tons of carbon dioxide per year compared to conventional sources. An average of 40 MW of wind power plant prevents the emission of 60,000-80,000 tons of carbon dioxide (www.yesılıst.com).

Turkey is a rich country in terms of renewable energy sources such as solar, wind, geothermal, biomass and hydropower. The potential values of the resources they have are better than many EU members. Our country has 48000 MW wind energy potential and annual average 1315 kwh / m2 solar energy values. Turkey, which is one of the countries in Europe having a great solar energy and wind energy potential and despite this potential, it has an installed capacity very below this great potential.

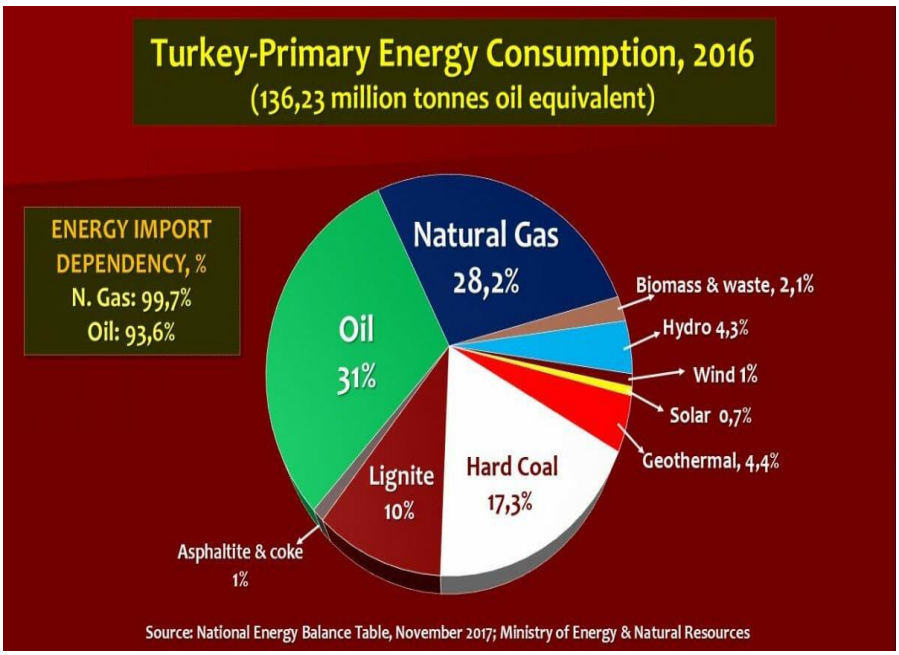


Figure 2. Turkey primary energy consumption, 2016. (National energy balance table, November 2017; Ministry of energy&natural resources)

Solar Energy

The Sun is the direct or indirect basis for all energy resources in the world. The sun rays to the world with 170 billion MW of power. This value is 15-16 thousand times the total energy used today in the world. Today, there are two ways of evaluating the solar energy reaching the world: transforming into heat and converting it into electrical energy. Solar cells are used for converting solar energy into heat energy and for converting them into direct electricity. Photo-voltaic cells (PV cells - solar cells) are the systems that convert solar energy directly into electrical energy without needing any moving mechanism without polluting the environment. Initially, solar cells, such as wristwatches, calculators, and small-scale scales, were spread over ever-wider areas of use. In the first large-scale usage area space works, solar panels were used as the most important systems for providing energy to space vehicles.

Solar energy is a renewable energy source with a constant intensity of 1370 W / m2 and a surface area ranging from 0-1100 W / m2. It can be used as control in heating and heating. The average annual sunshine duration of our country is 2640 hours (Table 1). Maximum sunbathing was seen in July with 365 hours and minimum sunshine duration was 103 hours in December. Monthly average sunshine duration is 220 hours (Yelmen, 2018). Electricity generation from solar energy is carried out by two different methods as direct conversion and indirect transformation (Alacakir F.B., 2001). Solar energy is used today for residential and business, agricultural technology, industry, transportation vehicles, communication tools, signaling and automation and electrical energy Turkey in 2018. The installed capacity of 1362.6 MW of solar energy in June, while the number of total solar energy plant; 1644 pieces.

When Turkey geographical location due to Europe's solar energy based electricity production potential in the highest share with regard to installed capacity in the country from although one solar power, and status with an installed capacity remaining under its great potential owners. Almost all of the existing installed capacity of solar energy in Turkey is seen to consist of unlicensed stations. Sun licensed in Turkey., the first competitions for capacity allocation for energy power plants were made in 2015. The competitions were carried out for a 600 MW licensed solar power plant.

The advantages and disadvantages of solar energy can be listed as follows; Solar energy is a clean, renewable and continuous energy source, Solar powered systems can be easily moved and installed. It has the advantages of being modular (changeable), working smoothly for many years. The solar cell is durable, reliable and long-lasting. It can be more economical to use solar cells in the rural areas where there is no electricity supply line or where the network line is expensive. Thus, transportation and energy transport costs and losses are eliminated,

Solar energy has all these advantages as well as some disadvantages. These; The efficiency of solar cells is low (around 15%), photovoltaic batteries have a high cost of starting and consuming due to production, but with technological advances, energy is becoming increasingly widespread and costly. Solar energy storage as an interrupted source is limited. Disadvantages such as maintenance and life of storage units reduce the efficiency of the system and increase the cost of energy.

Table 1. The distiribution of Turkey's solar energy potential by months. (Yelmen, 2018)

Months	Monthly total solar energy (kWh/m^2-month)	Hours of Sunshine (hour/month)
January	51,75	103
February	63,27	115
March	96,65	165
April	122,23	197
May	153,86	273
June	168,75	325
July	175,38	365
August	158,4	343
September	123,28	280
October	89,9	214
November	60,82	157
December	46,87	103
Total	**1.311**	**2.640**
Average	**3.6 kWh/m^2-day**	**7.2 h/day**

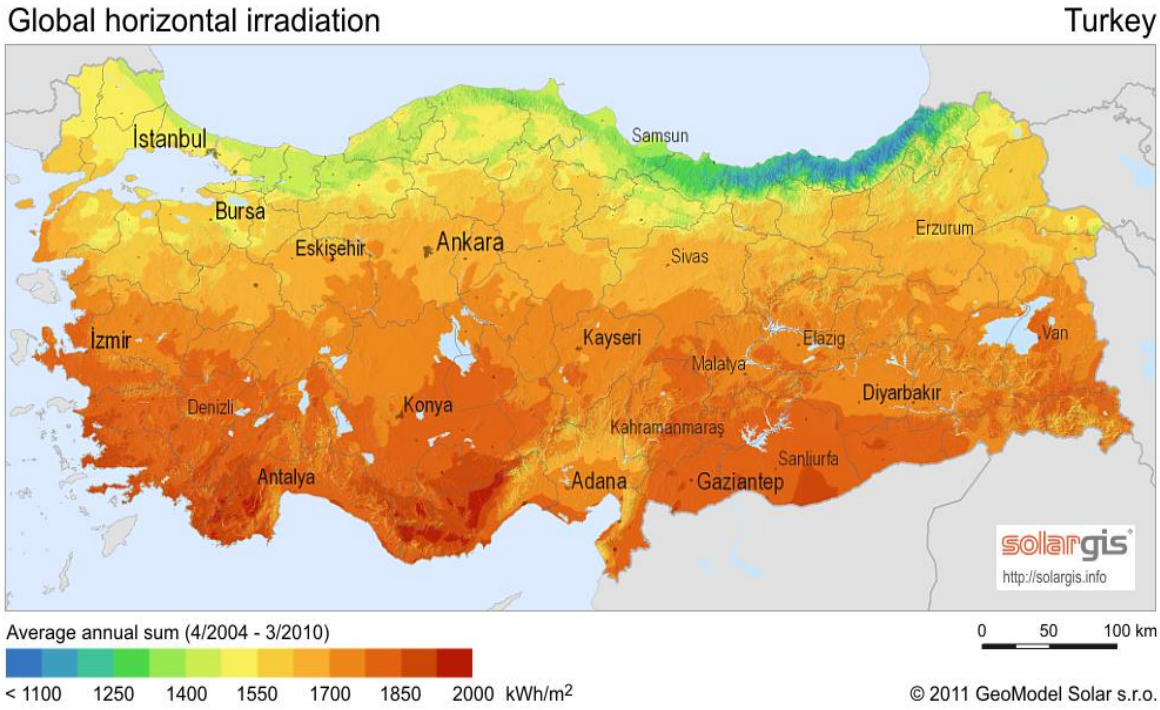


Figure 3. Average annual sum of Turkey's solar energy from 4/2004 between 3/2010 (http://solargis.info)

Wind Power Energy

It is the most renewable energy source that can be easily and quickly converted to electrical energy all over the world. The transformation from wind energy to electrical energy is the area where renewable energy technologies are the fastest progress. Wind energy is a source of energy that does not cause pollution as a completely natural source and is not likely to be exhausted. According to the International Energy Agency (IEA), the world wind energy potential is estimated to be 53 000 TWh / year (this is more than twice the amount of electricity the world needs in 2020). Wind energy is the fastest growing renewable energy source in the world for the last two decades. One of the most important factors underlying this development is the high yield (approximately 59%).

Today, with the development of new technology and new materials as well as control technology, wind turbines are used to produce the cleanest electric energy people need for lighting, heating, cooling and other household appliances. At present, electricity is being produced with an increasing wind turbine in the world. They operate as wind turbine groups producing electricity at a higher capacity in the form of wind farms. There is no fuel cost during the wind farm's production life and operating costs are almost non-existent. The wind turbines are modular (part-changeable) and can be manufactured in any size and can be used individually or in groups.

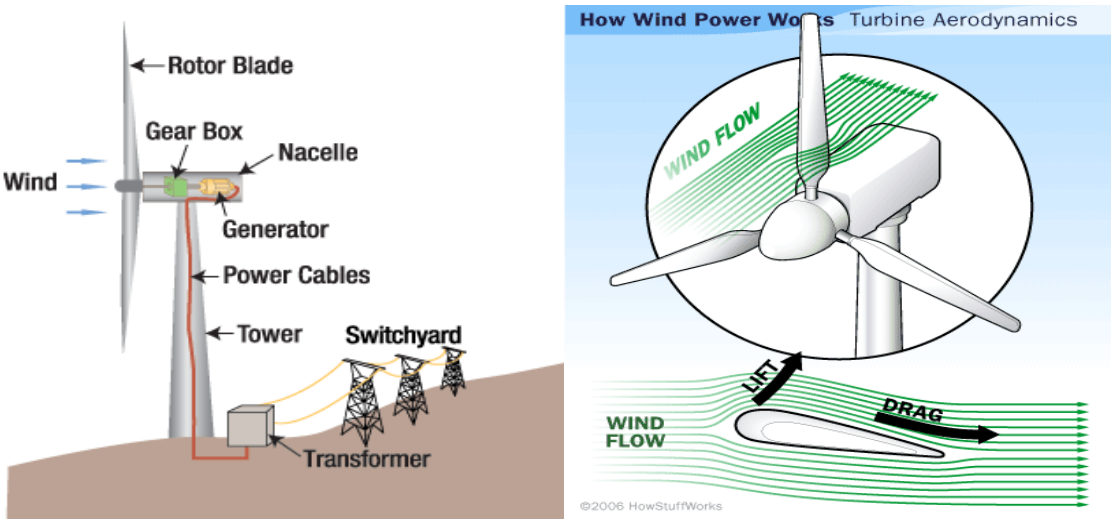


Figure 4. Wind power energy conneting switchyard (on the left), wind turbine aerodynamics (on the right)

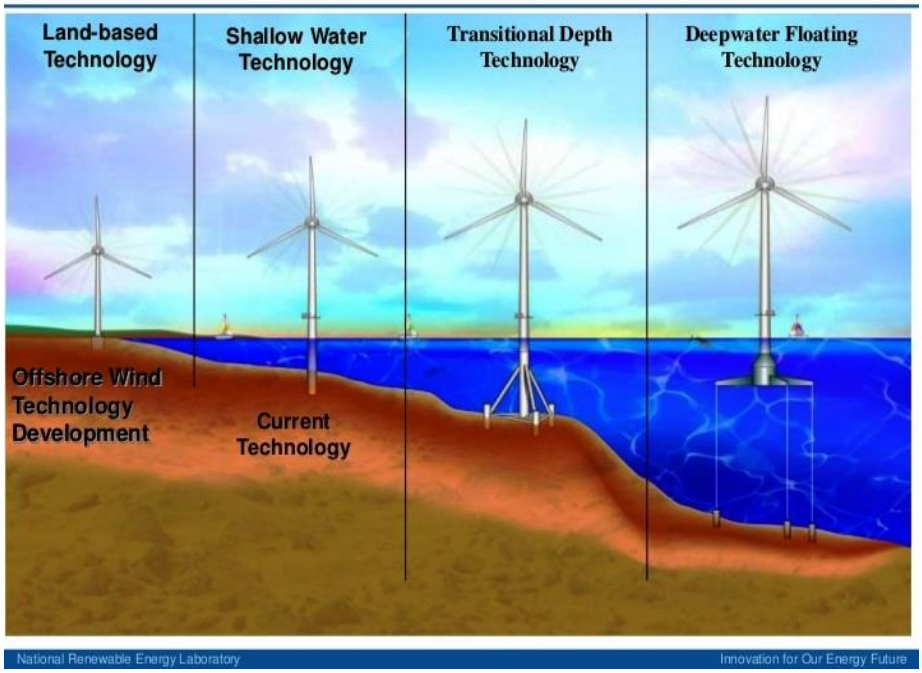


Figure 5. Future research on offshore wind technology, (www.nrel.gov/about)

Another important feature is that wind turbines can also be installed at sea. Wind farms can be easily dismantled and their land can be easily restored. In Turkey, this new technology will find application in the Western Black Sea and the Aegean Sea. Wind energy is an energy source that does not have any emission, does not consume natural resources, does not contribute to global warming, does not cause acid rain and is a source of energy that is sensitive to local environment. The noise that wind energy gives to its immediate surroundings, its interaction with TV and radio broadcasts, the dangers and visual impacts on birds are known environmental impacts (Kumbur, Özer, et al. 2005). Turkey is a country rich in wind. The highest value in terms of annual average wind speed and power density at a height of 10 m was 3.29 m/s and 51.91 W/m^2 in the Marmara Region. The lowest value is in Eastern Anatolia with 2.12 m/s speed and 13.19 W/m^2 power density. Turkey has 64.5% of the max wind power density of 20 W/m^2 (Alacakir FB, 2001). Today there are two wind farms in Alaçatı and Bozcaada, and an autoproducer plant in Germiyan, consisting of 3 turbines. In addition to a total of 16 wind farm projects, which were approved, there were demands for small-scale private use, while small-scale turbine production was also started (Tavman İ.H., 2001). Turkey's potential investments of the last 15 years to evaluate the major part of the potential hydropower together with the effect it has in the wind, however, and have solar energy assessment shows lags behind the developed countries. Turkey, in 2016 new wind power plants (WPP), installation of 1387 megawatts (MW) was the third in Europe. With this figure, Turkey's place in the global league RES installation is seventh. The establishment of a new wind power plant of is a 54600 MW all over world in 2016.

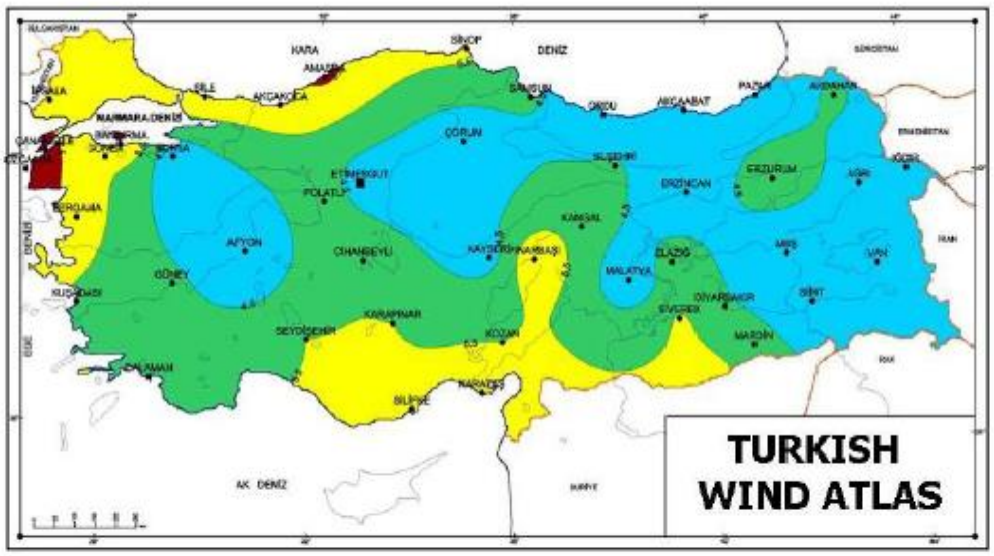
Turkey's wind energy potential is estimated to be priced at 48,000 megawatts. The total production potential of 48 thousand megawatts is estimated to be 38,000 megawatts on land and 10,000 megawatts on the sea. Turkey today can only use the land owned 15.1% of the wind potential.

In terms of total wind potential, this rate is only 12%. Wind power plants account for 7.3% of the total installed capacity. Turkey's natural gas in electricity generation, coal and hydroelectric wind power ranks after the 4th. Approximately 5.6% of the total electricity generated in 2016 was obtained from wind power plants.

It is possible to talk about the negative environmental effects of wind power plants such as visual and aesthetic pollution, causing noise, causing bird deaths, causing birds to change their migration paths and creating parasites in radio and television receivers (within 2-3 km).

Noise from wind turbines affects the human ear at close points, one of which is aerodynamic or broadband noise, which occurs when air passes through the machine's wings and the other is tonal or single frequency noise; It consists of rotating mechanical and electrical elements such as gearbox and generator.

In recent years, the efforts to produce electricity from wind power have increased in our country. The wind power plants that can be designed and installed with domestic sources have to be established based on importation, a significant contribution should be made for the formation of technological accumulation related to the subject. In addition to fully supporting the generation of electricity from wind power, technological accumulation and production must be supported by domestic resources.



Wind resources at 50 m above ground level for open plains (roughness class 1)

v (m/s)	> 7.5	6.5 – 7.5	5.5 – 6.5	4.5 – 5.5	< 4.5
P (W/m²)	> 500	300 - 500	200 - 300	100 - 200	< 100

Figure 6. Turkey's wind atlas, (http://www.geni.org/globalenergy/library/renewable-energy)

Geothermal Energy

Geothermal energy is the energy obtained by the heat of the hot rocks and fluids in the depths of the earth's crust, passing through the weak layers and reaching the earth. again to earth. In other words, the rain water or other water resources that go underground are warmed up to the hot rock and magma layer in suitable places and they are warmed up again.

In order not to cause the environmental pollution of the ions and gases passing through the minerals dissolved by water and steam, these waters are passed through the heat exchanger and the sulfur dioxide, hydrogensulfide, carbon dioxide and nitrogen oxides they contain are sent back to the ground again with the residual water used in the energy (Reenjection). If the water produced during the production of geothermal energy is pumped back into the ground again, the molten mineral, which is more polluted than the surface waters, is eliminated due to various salts and gases; becomes clean and renewable. Thus, the negative impact on the environment can be prevented. Geothermal energy; According to the temperature of the source water generation, heating (regional, residential, greenhouse, etc.), chemical material production, drying, plant and aquaculture, agriculture, greenhouse, snow melting. The efficiency of the geothermal source is very high and because it can be obtained directly, it is a low cost, good, renewable, uninterrupted, environmentally friendly, domestic power source.

The cost of unit power derived from geothermal energy is much cheaper than that obtained from thermal and other plants. With the development of reinjection applications, the environmental problem is almost never left. With the new technologies developed in recent years, it is possible to generate electricity in the lower temperature areas and the unit energy cost is further reduced by increasing the plant cycle efficiency. With the systems developed integrated with electricity generation, it is possible to obtain more thermal power and other uses (integrated) than geothermal fluid. This cost, even for integrated (integrated) uses, It decreases. So geothermal resource can be used at the same time for more than one purpose. Although geothermal energy is recognized as an environmentally friendly source, the fluid causes corrosion, decay, calcification (crusting), contaminates the surface water that will be disposed of by the boron, the presence of CO_2, H_2S and B, and requires some technological measures in practice.

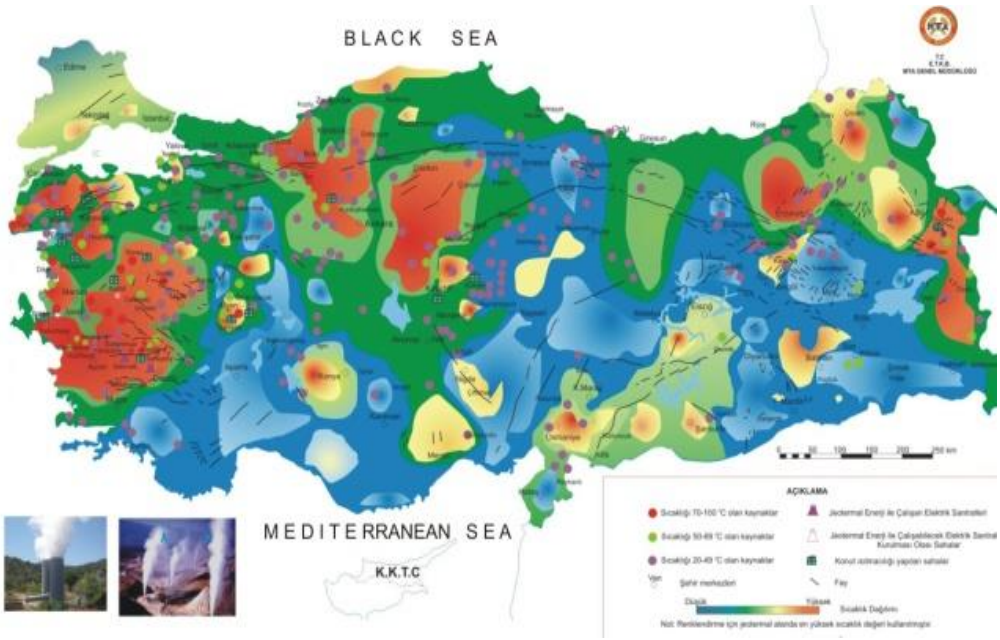


Figure 7. Turkey's geothermal resources and applications map (Cetin A., Paksoy H., 2013).

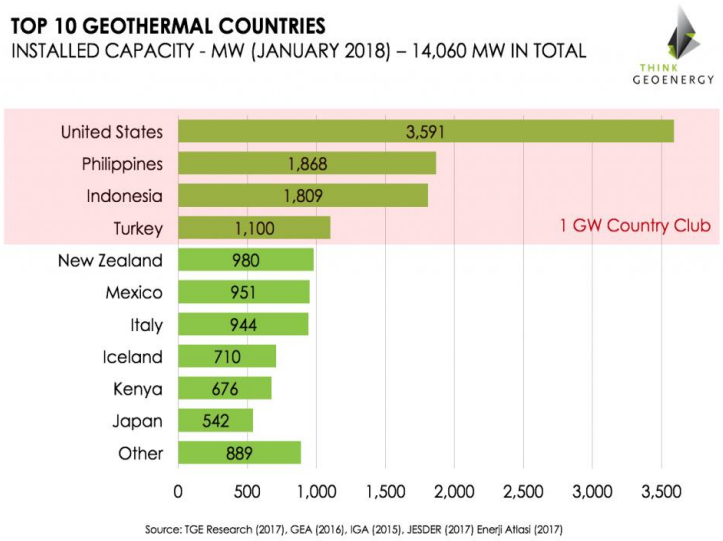


Figure 8. Top 10 geothermal countries ınstalled capacity, (TGE Research 2017)

One of the world's richest countries in terms of geothermal resources, geothermal energy between Turkey should put the priority of renewable energy sources. Naturally, geothermal resources in Western Anatolia should be put into use in order to search, operate and use these resources.

Result and Conclusıon

Turkey, is an energy-dependent country. It is determined that the energy need will gradually increase due to the insufficient fossil resource structure and low energy efficiency, and the development of the developing structure and sustainable development. Turkey, the impact of fossil maximum efficiency from renewable energy sources to minimize the lack of resources should be obtained. With the laws enacted, it is desired to attract investments of domestic and foreign investors and increase the energy diversity and investments in the domestic market.

When Turkey's economic growth and increasing energy needs considered, depending on the increase in welfare; In the 2025s, almost half of this potential comes from Renewable Energy sources. Turkey, refresh fossil energy

sources it is a country dependent on foreign terms, but has almost all of its energy needs with renewable energy sources in terms of the potential itself may encounter. The external budget can provide significant deficits every year with imports of fossil fuels at an average of $ 47 billion. These significant amounts paid to fossil fuels can be evaluated within the country in order for the wheels of the national economy to return successfully. Turkey is becoming a center of attraction in renewable energy today and for the near future. It should be kept in mind that renewable energy sources have an important contribution to climate change and environmental factors. When the issues you mentioned are evaluated together, it can be seen that renewable energy investments have superior public interest.

When Turkey geographical location due to Europe's solar energy based electricity production potential in the highest share with regard to installed capacity in the country from although one solar power, and status with an installed capacity remaining under its great potential owners. In recent years, the efforts to produce electricity from wind power have increased in our country. The wind power plants that can be designed and installed with domestic sources have to be established based on importation, a significant contribution should be made for the formation of technological accumulation related to the subject. In addition to fully supporting the generation of electricity from wind power, technological accumulation and production must be supported by domestic resources. Moreover, Turkey is one of the world's richest countries in terms of geothermal resources, geothermal energy should be put between the priority of renewable energy sources. Also; Biomass energy is an important energy potential for Turkey. As is the case in many countries, the expansion of anaerobic treatment methods in our country will provide significant contributions to the national economy as well as the environmental values, and will constitute an important step of a sustainable energy policy in line with the realities of our country.

Today, the countries of the world can realize their sustainable development moves, increase their social welfare and increase their competitiveness on a global scale. The ability to meet energy needs from renewable energy sources will also facilitate the solution of global problems such as the destruction of the ozone layer due to the emission of harmful and toxic gas from conventional energy sources. The use of renewable energy sources is becoming increasingly widespread in the world. Diversification of renewable energy sources will significantly reduce foreign dependency in terms of supply of energy resources. The dissemination of renewable energy resources and increasing the amount of production will contribute significantly to world peace and security. On the other hand, the need for human fossil fuels will partially diminish, which will be an important factor in reducing the oil and oil-related disagreements that are the cause of all wars on earth.

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