

CHAPTER 11

THE ROLE OF GEOTHERMAL AND HYDRAULIC ENERGY IN TÜRKİYE'S ACHIEVEMENT OF SUSTAINABLE DEVELOPMENT GOAL 7: POTENTIAL, OPPORTUNITIES, AND BARRIERS

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DOI: 10.26650/B/SS10.2024.013.011

Abstract

The United Nations General Assembly adopted the Sustainable Development Goals in September 2015 as a roadmap to be completed by 2030, aiming to eradicate poverty, protect our planet, and fight inequality and injustice. The main objective is to leave a livable and sustainable world behind for future generations. In this regard, basic goals have been established under 17 headings. SDG7, one of these goals, focuses on providing countries with access to affordable and clean energy. Renewable energy resources are considered essential for achieving this objective. Given Türkiye's geographical structure, hydraulic and geothermal energy resources play a vital role. This study aims to analyze Türkiye's situation concerning hydraulic and geothermal energy resources and assess their impact on achieving the targets set by SDG7. The share of hydraulic energy in the total installed capacity was approximately 32% in 2011 and 31% as of June 2022. The percentage of geothermal energy increased from 0.20% to 1.60% for the same period. Regarding SDG goals, Türkiye has successfully achieved the SDG7 goal, with 100% of the population having access to electricity and 95.1% having access to clean fuels and technologies for cooking. Additionally, 15.9% of the primary energy sources in Türkiye come from renewable energy. However, Türkiye fell short of the target regarding carbon dioxide emissions measuring 1.3% of such emissions per electricity generation. Based on this information, it can be concluded that Türkiye's hydraulic and geothermal energy resources have been instrumental in achieving the said targets. Nevertheless, Türkiye needs to further utilize renewable energy sources to effectively reduce carbon dioxide emissions. Policy recommendations are discussed in this paper.

Keywords: Sustainable Development Goals, SDG7, Hydraulic Energy, Geothermal Energy, Türkiye

1. Introduction

The Paris Agreement, which calls for the reduction of greenhouse gas (GHG) emissions to combat climate change, and the 2030 Agenda, especially Sustainable Development Goal (SDG) 7, which aims to “ensure access to affordable, reliable and modern energy for all,” are the two main international agendas currently influencing the development of sustainable energy systems. Minimizing environmental impacts while ensuring socioeconomic development can be broadly defined as the goal of developing a sustainable energy system (Spittler et al., 2020). The energy problem arises from the increasing global demand for energy, highlighting the crucial need for sustainable energy resources. Humans rely on energy in various areas, including industrial activities, transportation, heating, and lighting. However, most available energy resources are limited and based on fossil fuels, which cause harm to the environment. The energy problem presents a significant challenge due to its adverse environmental impacts. The combustion of fossil fuels releases greenhouse gases, contributing to issues such as global climate change and air pollution. These factors have detrimental effects on natural life, ecosystems, and human health.

Moreover, economic challenges such as dwindling fossil fuel reserves and price fluctuations further complicate the energy problem. Sustainable energy sources play a vital role in addressing this issue. Renewable energy sources, such as solar, wind, hydro, biomass, and nuclear, derive from unlimited or renewable natural resources and are environmentally friendly. These energy sources can reduce dependence on fossil fuels, mitigate greenhouse gas emissions, and enhance energy security.

Although Türkiye is a country rich in energy resources, it faces challenges regarding energy supply security. Most of Türkiye's energy resources are imported, posing a serious risk to the sustainability of its energy supply. Therefore, the country is increasing its investment in energy resources and aiming to enhance the utilization of renewable energy sources. Türkiye's energy mix comprises coal, natural gas, hydro, geothermal, and wind. Coal is the largest energy source, accounting for approximately 30 percent of the total energy supply. Natural gas is the second-largest energy source, representing around 25 percent of the total energy supply. Hydroelectric energy is Türkiye's most significant renewable energy source, contributing to about 25 percent of total electricity generation. Geothermal energy is another essential renewable energy source in Türkiye primarily used for heating. Wind energy has experienced rapid development in recent years and currently provides approximately 7 percent of the total electricity generation.

Türkiye focuses on SDG7 within the Sustainable Development Goals (SDGs) framework. This goal is to “ensure accessible, secure, sustainable and modern energy sources for all.”

Hydraulic and geothermal energy resources can play an essential role in helping Türkiye achieve this goal. Türkiye is a country rich in hydraulic energy potential. Rich in water resources, Türkiye has favorable conditions for hydraulic energy production. There are many hydroelectric power plants throughout the country, and these power plants meet a great deal of the total electricity generation. In addition, Türkiye has excellent hydraulic energy potential that has not yet been fully utilized.

Regarding geothermal energy resources, Türkiye is in a critical position worldwide. Geothermal resources can be used in heating, greenhouse cultivation, industrial use, and electricity generation. Türkiye is among the top 10 countries in the world in terms of geothermal energy potential, and most of these resources are located in Western Anatolia. More than 45 geothermal power plants are currently operating in the country, with a total installed capacity of about 1.6 GW. However, Türkiye's geothermal energy potential has not yet been fully utilized, and the country's potential should be further developed to ensure energy supply security (Republic of Türkiye Ministry of Energy and Natural Resources).

Furthermore, Türkiye's hydraulic and geothermal energy resources offer a significant opportunity to achieve SDG7 targets. Hydraulic energy resources can be used as a clean and renewable energy source in electricity generation. Geothermal energy resources can also be used in heating, greenhouse cultivation, and industrial use. Fully utilizing the potential of these resources will help Türkiye ensure the security of its energy supply and achieve sustainable development goals.

In summary, Türkiye is rich in energy resources but faces some challenges regarding energy supply security. Therefore, renewable energy sources offer an essential opportunity for Türkiye to ensure energy supply security and achieve its sustainable development goals.

The rest of the paper is organized as follows: Section 1 discusses Türkiye's energy profile, current situation, and evolution since 2000 through data. Section 2 mentions the importance of hydropower and geothermal energy in achieving the goal of clean and affordable energy. The situation of hydropower and geothermal energy in Türkiye and how it has changed over time is discussed in detail within the same section. Section 3 discusses Türkiye's performance in achieving the goal of clean and accessible energy. The final section presents the conclusion and recommendations.

2. Türkiye's Energy Profile

Developing countries need energy to ensure economic growth, improve quality of life, and support social development. However, maintaining the balance between energy supply and demand is a significant challenge these countries face. As a developing country with

rapid economic growth rates, Türkiye needs a lot of energy. Therefore, the sustainability of energy is important for meeting this need. In 2022, 34.6% of Türkiye's electricity came from coal, 22.2% from natural gas, 20.6% from hydroelectric power, 10.8% from wind, 4.7% from solar, 3.3% from geothermal, and 3.7% from other sources. As of the end of March 2023, the installed capacity reached 104,348 MW. The distribution of installed capacity by source is as follows: 30.3% hydraulic energy, 24.3% natural gas, 20.9% coal, 11% wind, 9.4% solar, 1.6% geothermal, and 2.5% other sources. In addition, the number of power plants increased to 11,845 (including unlicensed) by the end of March 2023. Of the existing power plants, 751 are hydroelectric, 67 are coal, 361 are wind, 63 are geothermal, 346 are natural gas, 9,767 are solar, and 490 are other sources (Republic of Türkiye Ministry of Energy and Natural Resources).

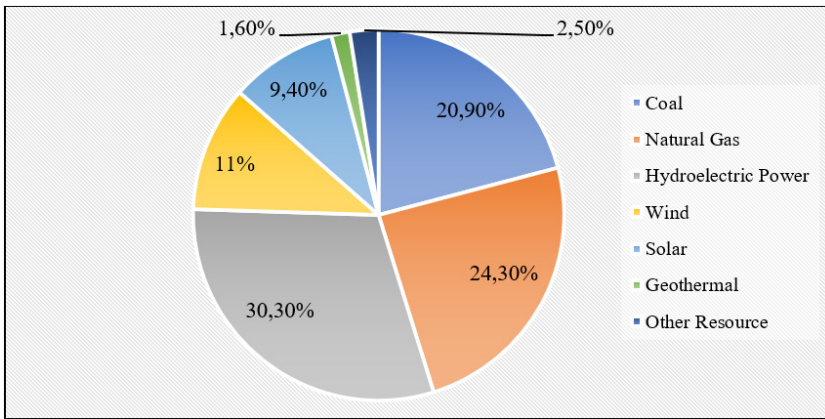


Figure 1. Share of Energy Source in Total Installed Capacity
Source: Republic of Türkiye Ministry of Energy and Natural Resources

Since Türkiye is a developing economy, its energy demand is increasing day by day. Primary energy supply represents the total amount of energy a country obtains from all energy sources. Figure 2 shows Türkiye's primary energy supply between 2000 and 2021 in tons of oil equivalent (toe). According to the data, Türkiye's primary energy supply has generally increased over the years. From 76,288 toes in 2000, the primary energy supply increased to 158,249 in 2021. The increase in primary energy supply can be realized due to various factors. For example, factors such as economic growth, increased industrial activities, population growth, changes in energy policies, and increased energy demand have contributed to the increase in primary energy supply. However, fluctuations are also observed in the data between years. For example, although the primary energy supply increased between 2000 and 2003, it followed a more stable course between 2003 and 2009. The primary energy supply

generally maintained its upward trend in the following years. These data show that Türkiye's energy demand is increasing, and the country needs to take various measures to diversify its energy supply and move towards sustainable sources. In addition, policies and strategies such as implementing energy efficiency measures and greater utilization of renewable energy sources may also be necessary.

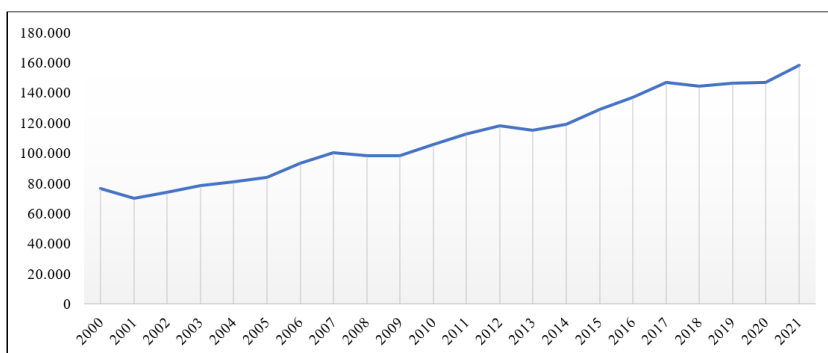


Figure 2. Primary Energy Supply (Million toe)
Source: OECD (2023a)

Figure 3 shows the renewable energy supply. According to the data, Türkiye's renewable energy production has increased over time. Although there are fluctuations in the beginning, a general upward trend is noticeable. Between 2000 and 2005, renewable energy generation fluctuated. During this period, there were ups and downs in production. Since 2005, Türkiye's renewable energy generation has grown more steadily. There was a significant increase in the period 2005-2015. By 2010, Türkiye's renewable energy generation had increased rapidly. After that year, there was a significant growth in generation in the period between 2010 and 2021. Between 2015 and 2021, Türkiye's renewable energy production increased rapidly. In 2019, there was a big leap forward, and production reached record levels. The data shows that Türkiye is increasing its investments in the renewable energy sector and focusing on the goal of sustainable energy production. However, the continuous growth trend in renewable energy generation shows that Türkiye's potential has not yet been fully realized. Continued investments and more efficient utilization of renewable energy resources could further increase generation capacity.

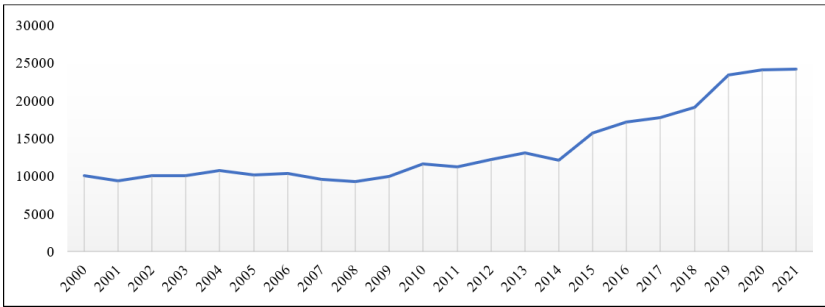


Figure 3. Renewable Energy (Thousand toe)
Source: OECD (2023b)

Since the share of renewable energy supply is only one component of the primary energy supply, it is important to consider other energy sources. Factors such as the share of fossil fuels, nuclear energy, and other energy sources can also affect a change in the primary energy supply. The increasing share of renewable energy supply reflects Türkiye's efforts to achieve its sustainable energy targets. Increased use of renewable energy sources can reduce dependence on fossil fuels, ensure energy security, and enhance environmental sustainability. Figure 4 contains data on the changes in the shares of renewable energy supply in Türkiye's primary energy supply between 2000 and 2021. According to the data, the share of renewable energy supply in Türkiye's primary energy supply varies between years. There have been increases in some years and decreases in others. Until 2007, the renewable energy supply ratio generally showed a downward trend. However, increases have started to be seen since 2007. In 2019 and 2020, there were significant increases and the renewable energy supply ratio increased substantially.

This shows that Türkiye has made significant progress in renewable energy supply. However, continued policy measures and investments are needed to further increase the share of renewable energy supply. Incentives and regulations for sustainable energy sources can support progress in this area.

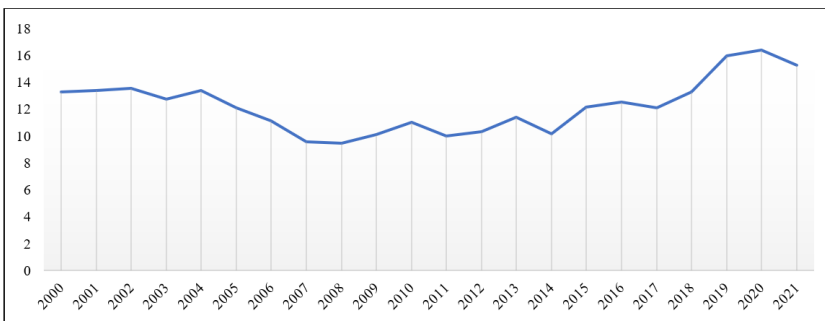


Figure 4. Renewable Energy (% of Primary Energy Supply)
Source: OECD (2023b)

3. Hydraulic and Geothermal Energy Sources Towards Sustainable Development Goals?

The diminishing reserves of fossil-based energy resources and their formation taking years raises concerns about sustainability and the need to switch to renewable energy sources rather than fossil-based ones due to their negative impact on the environment (Dincer, 2000). Renewable energy comes from ongoing natural processes that replenish it. It derives directly from the sun, wind, rain, ocean tides, biomass, and geothermal resources, which are heat sources produced deep within the earth (Mohtasham, 2015). According to the definition of renewable energy, it is “an energy source that can be available the same the next day within the evolution of nature itself.” The critical characteristics of renewable energy sources are that they contribute to environmental protection by lowering carbon dioxide emissions, lessen reliance on imported energy, create more jobs because they are domestic resources, and enjoy widespread and enthusiastic public support. In other words, accessible, available, and acceptable qualities describe renewable energy sources (General Directorate of Mineral Exploration and Research, 2023).

Due to their lack of toxic gas and particle discharges that pollute the atmosphere, their low operating costs compared to non-renewable energy sources, and their use in agriculture, hydropower and dams are considered essential. However, only a third of the potential of hydropower is currently used. This is equivalent to 17% of the electricity produced worldwide. Some argue that since large dams generate more environmental harm than small ones, they cannot be regarded as renewable energy sources. However, the World Bank, which had previously advocated against the construction of sizable dams, has begun to alter its stance. More power and energy are needed in nations where energy consumption is much lower than the global average (Republic of Türkiye Ministry of Foreign Affairs, 2023). Geothermal energy, on the other hand, is thermal energy generated naturally in the planet’s interior, primarily by the decay of radioactive potassium, uranium, and thorium isotopes (Younger, 2015). It is the only renewable energy source not dependent on solar radiation or the moon’s or the sun’s gravitational pull (McCay, 2014). Among the renewable energy sources, hydropower and geothermal energy hold a significant position. To lessen reliance on fossil fuels, ensure energy security, safeguard the environment, and combat climate change, these resources are crucial. We require both hydropower and geothermal energy for the following reasons:

Reducing dependence on fossil fuels: Hydraulic and geothermal energy replace fossil fuels and increase the diversity of our energy sources. This increases energy supply security and reduces dependence on fossil fuels.

Protecting the environment: Hydraulic and geothermal energy sources are environmentally friendly, unlike fossil fuels. The energy produced from these sources helps combat climate change by reducing greenhouse gas emissions. In addition, hydraulic energy sources do not affect natural habitats and minimize environmental impacts.

Ensuring energy supply security: Hydraulic and geothermal energy resources are important in terms of energy supply security as they are produced from domestic sources. These resources reduce the dependence of countries on energy imports and prevent the interruption of energy supply.

Providing economic benefits: Hydraulic and geothermal energy resources provide economic benefits as they are produced from domestic resources. With the use of these resources, employment is increased, local economies are revived, and energy costs are reduced.

3.1. Hydraulic Energy

Utilizing the mechanical energy of moving water, hydropower is created by forcing the water through a penstock, which turns an electrical generator to create electricity. Wave and tidal energy are two additional forms of waterpower that are still under investigation by scientists as they work to figure out how to use the energy generated by ocean currents. Compared to most other sources of electricity production, hydropower has several advantages. High levels of dependability-tested technology, high efficiency, extremely low operating and maintenance costs, and the capacity to quickly adapt to load changes are a few of these (IHA, 2023). This makes it one of the most popular renewable energy sources both in Türkiye and around the world. In general, many hydropower plants near reservoirs benefit the community by providing water, flood control, and recreational opportunities. However, hydropower has several drawbacks, including expensive initial outlays for facilities, reliance on precipitation (no control over water availability), adjustments to stream regimes (can affect fish, plants, and wildlife by changing stream levels, flow patterns, and temperature), flooding of land and wildlife habitat (creation of reservoir), and eviction of residents from the reservoir area (Mohtasham, 2015).

In addition to the above features, the advantages of hydraulic energy can be summarized as follows (Erdogan et al. (2018), Wasti et al. (2022)):

- Long economic life
- Widespread worldwide
- Environmentally friendly
- Low operating and maintenance costs

- No fuel costs
- Short payback period
- High efficiency
- Ability to meet peak demands by providing flexibility and convenience in business
- Providing economic and social contributions to the local people
- It is a domestic resource that is not dependent on foreign sources and ensures energy production
- Potential to generate hydrogen

Figure 5 contains data on installed capacity based on hydraulic energy in Türkiye between 2011 and 2022. In 2011, Türkiye's installed capacity based on hydraulic energy was 17,137 MW. In 2012, this amount increased to 19,609 MW, showing an increase. In 2013, the installed capacity was recorded as 22,289 MW. This trend continued in 2014 and increased to 23,643 MW. In 2015, the increase gained momentum and reached 25,868 MW. In 2016 and 2017, the installed capacity based on hydraulic energy was 26,681 MW and 27,273 MW, respectively, and reached 28,291 MW in 2018. In 2019, Türkiye's installed hydraulic energy resource capacity was 28,503 MW. In 2020, there was a significant increase, reaching 30,984 MW. This upward trend continued in 2021 and reached 31,493 MW. Finally, as of June 2022, Türkiye's installed capacity based on hydraulic energy was determined as 31,558 MW. Based on these data, it can be said that Türkiye's installed capacity based on hydraulic energy has been increasing over the years and has shown a continuous growth trend from 2011 to 2022.

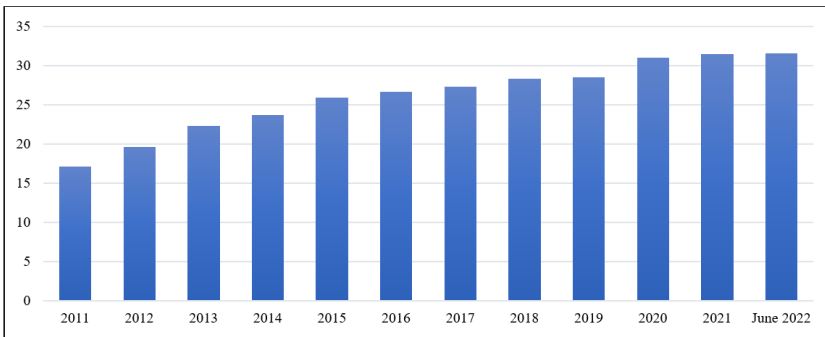


Figure 5. Amount of Installed Power Based on Hydraulic Energy (MW)

Source: Republic of Türkiye Ministry of Energy and Natural Resources

Figure 6 shows Türkiye's hydraulic energy share in total installed capacity. According to the data, in 2011, hydraulic energy accounted for 32.3 percent of Türkiye's installed capacity, while this share increased to 34.2 percent in 2012 and 34.8 percent in 2013. However, after a decline in 2014, the percentage of hydraulic energy fell to 34.0 percent. In the following years, the share of hydraulic energy in installed capacity fluctuated. While it increased to 35.2% in

2015, it decreased to 34.0% in 2016 and remained constant at 32.0% in the years 2017 and 2018. In 2019, the percentage decreased to 31.2% and then increased again in 2020 to 32.2%.

The data show that the share of hydraulic energy in installed capacity has generally followed a stable course. No significant increase or decrease is observed in this period. These data suggest that Türkiye should continue its energy-generation and utilization diversification efforts. Steps such as investing more in renewable energy sources, developing sustainable energy policies, and increasing energy efficiency can help improve the share of hydraulic energy as well as other renewable energy sources in the energy portfolio.

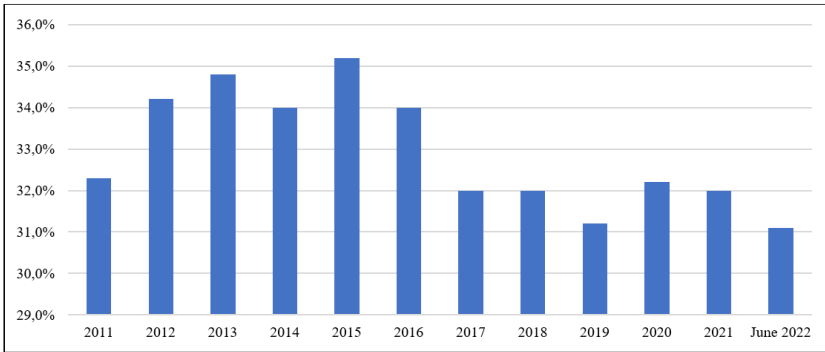


Figure 6. Share of Hydraulic Energy in Total Installed Power (%)
Source: Republic of Türkiye Ministry of Energy and Natural Resources

3.2. Geothermal Energy

Sustainable development has become a critical issue for humanity due to the rapid growth of the world's population and increasing environmental concerns. In many regions of the world, geothermal resources have the potential to make a significant contribution to sustainable energy use. Sustainable use of geothermal energy means producing energy at a rate that can be sustained for a very long time (100-300 years). International organizations have classified geothermal energy as a renewable energy source. This classification has been in use for a very long time. Still, it is occasionally claimed that geothermal energy is not strictly a renewable energy source on human time scales because the thermal depletion of geothermal reservoirs would take a long time to recover (Ledingham, 1998). Depending on their geological setting and nature, different geothermal systems have various production capacities and respond to production differently. The sustainable use of all geothermal resources requires comprehensive management. In other words, effective management is needed to prevent overexploitation, which typically results from ignorance and lack of understanding, as well as from situations where multiple users exploit the same resource without coordinated

management. Sustainable development requires careful monitoring and modeling, as well as energy-efficient use. Sustainable use of closed geothermal systems, which have little recharge, also depends on injection (Hepbasli & Özgener, 2004).

The geothermal process involves storing energy below ground and releasing it as heat as it rises to the surface. This heat is captured and used to turn a steam turbine to produce electricity when it naturally has hot water or steam. Geothermal energy is very considerate of the environment as a result. It provides a consistent, effective clean energy supply with little negative environmental impact (Geothermal Engineering Ltd.). Geothermal energy can be directly used for various purposes, including industry, greenhouses, fish farming, health spas, and space heating and cooling. It mostly makes use of current technology and simple engineering. The direct use of geothermal energy has been proven to be technologically feasible, dependable, economically viable, and environmentally acceptable worldwide (Fridleifsson, 2001).

The first electricity generation in geothermal energy applications was started in 1975 with the Kızıldere Power Plant established by the General Directorate of MTA with a power of 0.5 Mwe. The geothermal potential of Türkiye is relatively high, and 78% of the potential areas are located in Western Anatolia, 9% in Central Anatolia, 7% in the Marmara Region, 5% in Eastern Anatolia, and 1% in other regions. 90% of our geothermal resources have low and medium temperatures and are suitable for direct applications (heating, thermal tourism, various industrial applications, etc.). In comparison, 10% are ideal for indirect applications (electrical energy generation). The installed capacity of geothermal energy in the world is 16.1 GWe, according to data taken at the end of 2022. The top 5 countries in electricity generation from geothermal energy are the USA, Indonesia, Philippines, Türkiye, and New Zealand. Non-electricity utilization has exceeded 107,000 MWt, and the top 5 countries in the world in direct utilization applications are the USA, China, Sweden, Türkiye, and Germany (General Directorate of Mineral Exploration and Research, 2023).

With the support of the Ministry of Energy and Natural Resources, the available heat capacity, which was 3100 MWt as of the end of 2004, increased to 5000 MWt with an additional 1900 MWt heat energy increase as of the end of December 2022. In addition, the number of discovered geothermal fields, which was 173 by MTA, has increased to 243 fields with the discovery of new fields, 16 of which are suitable for electricity generation, and a total of 658 exploration works with 447.000 meters of drilling have been carried out to date. As a result, approximately 5000 MWt of heat energy has been obtained with the wells drilled, including natural outlets (General Directorate of Mineral Exploration and Research, 2023).

Figure 7 shows Türkiye's geothermal energy-based installed capacity data by years, and an analysis of this indicates significant trends and developments. In 2011, the installed capacity of geothermal energy was 114 megawatts (MW), which increased rapidly to 162 MW in 2012. In 2013, this amount increased significantly and reached 311 MW. In 2014, the amount of geothermal energy-based installed capacity increased to 405 MW and continued to increase. In the following years, this increase gained momentum and was recorded as 624 MW in 2015, 821 MW in 2016, and 1064 MW in 2017. The amount of geothermal energy-based installed capacity reached 1283 MW in 2018 and displayed a continuous growth trend. In 2019, the amount of geothermal energy-based installed capacity increased to 1515 MW and continued to increase compared to the previous year. In 2020, this amount increased to 1613 MW. The data shows that it maintained its upward trend in 2021, reaching 1676 MW. In addition, data for June 2022 is also available, and the amount of installed capacity from geothermal energy is determined as 1686 MW on this date. Overall, Türkiye's geothermal energy sector is developing rapidly with a continuous increase in the data. This rate of increase has gained momentum over time, and significant growth has been achieved in the amount of installed capacity from geothermal energy. These data show that Türkiye's investments in renewable energy resources are increasing, and with this, the potential of the geothermal energy sector is also increasing. Geothermal energy is essential in Türkiye's energy portfolio as a sustainable and environmentally friendly energy source.

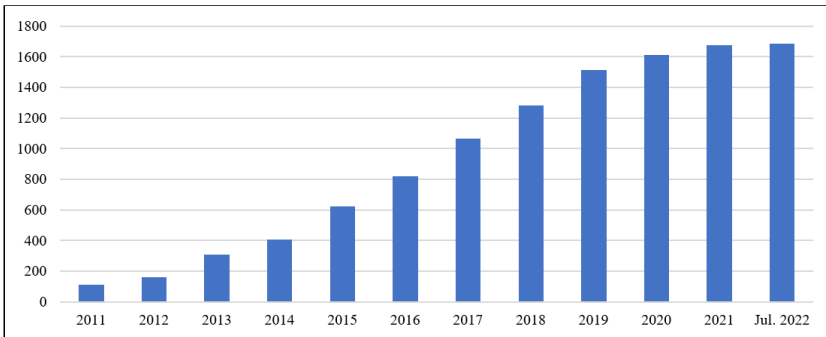


Figure 7. Geothermal Sourced Installed Power (MW)

Source: Republic of Türkiye Ministry of Energy and Natural Resources

Figure 8 shows the ratio of geothermal energy in Türkiye's total installed capacity between 2011 and 2022. In 2011, the percentage of geothermal energy in Türkiye's total installed capacity was only 0.22%. However, this ratio showed a significant increase in the following years. In 2012, the ratio improved slightly to 0.28 percent. An even more remarkable development took place in 2013. The proportion of geothermal energy increased to 0.49 percent,

showing a significant increase, and achieved a rapid growth momentum. This upward trend continued in 2014, and the ratio increased to 0.58 percent. According to the data, it increased to 0.85 percent in 2015 and continued to grow. Then, an even more significant increase was recorded in 2016, reaching 1.05 percent. The share of geothermal energy resources in total installed capacity increased steadily, reaching 1.25% in 2017. In 2018 and 2019, the ratio of geothermal energy was 1.45% and 1.66%, respectively. Investments in geothermal energy resources and the increase in installed capacity continued in these years. In 2020 and 2021, the geothermal energy ratio remained constant at 1.68%. According to the July 2022 data, the geothermal energy ratio decreased to 1.66%.

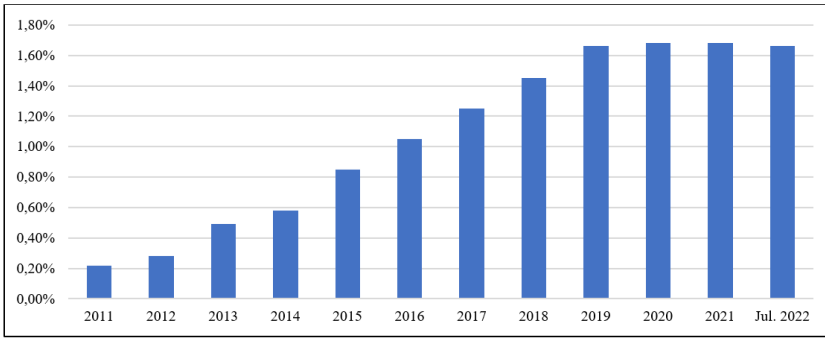


Figure 8. Share of Geothermal Energy in Total Installed Capacity
Source: Republic of Türkiye Ministry of Energy and Natural Resources

Comparison of Geothermal Applications in Türkiye for the Years 2002-2022 (General Directorate of Mineral Exploration and Research)

- The number of sites suitable for electricity generation increased from 16 in 2002 to 25 in 2022.
- Greenhouse heating increased from 500 acres in 2002 to 4052 acres in 2022, an increase of 710%.
- Residential heating increased from 30,000 houses in 2002 to 125,820 houses equivalent in 2022, an increase of 319%.
- Installed capacity in electricity generation increased from 15 MWe in 2002 to 1691 MWe in 2022, an increase of 11,000%.
- The country's apparent heat capacity increased from 3000 MWt in 2002 to 40,000 MWt in 2019 (together with the private sector), an increase of 1230%.
- In addition, 350 thermal facilities in our country are utilized for treatment and thermal tourism purposes.

4. Türkiye's Achievements in Line with SDG7 Goals

At a time when EU member states have started to concentrate on efforts to increase the share of renewable energy sources in their energy consumption, Türkiye, as a country that aspires to EU membership as a national policy, attaches increasing importance to renewable energy sources. Türkiye continues its efforts to encourage the use of renewable energy resources and to establish the necessary administrative structure for this purpose, both in terms of international commitments and European Union membership targets and national needs and interests. In this framework, in the revised “National Program of Türkiye for the Adoption of the European Union Acquis”, which entered into force on July 24, 2003, increasing the share of renewable energy resources in total energy production is stated among the short-term priorities. The National Program also states that increasing the use of renewable energy in the energy supply balance constitutes an important part of the energy policy and that the use of renewable energy should be supported in order to reduce energy import dependency and ensure the security of supply. In the Eighth Five-Year Development Plan, it is emphasized that necessary measures should be taken to support the use of renewable energy resources for the protection of the environment. Within the framework of policies to ensure greater utilization of renewable energy resources, preparations are underway to submit a “Draft Law on the Utilization of Renewable Energy Resources” to Parliament. Furthermore, with “Electricity Market Law” No. 4628, efforts are being made to take the necessary measures to encourage the use of renewable energy resources in electricity generation. In this framework, a World Bank loan amounting to 200 million dollars was made available to the private sector through the Industrial Development Bank of Türkiye and the Development Bank of Türkiye for renewable energy investments (Republic of Türkiye Ministry of Foreign Affairs, 2023).

Figure 9 provides data on the access rates of the Turkish population to electricity. Based on the data in the figure, it can be said that the access rates to electricity in Türkiye were generally high and stable between 2000 and 2020. Indeed, the access rate to electricity has been consistently above 99%, reaching 100% in 2020. These data show a positive development in line with the sub-target of access to electricity within the framework of the United Nations Sustainable Development Goals (SDG7). SDG7 aims to ensure everyone can access reliable, sustainable, and modern energy by 2030. Therefore, Türkiye's high access rate to electricity can be considered an indicator of progress toward this goal.

The rate of access to electricity, which was 99.99 percent in 2004, showed a slight downward trend in the years that followed, as can be seen by looking at the figure in more detail. However, the access rate to electricity has generally remained above 99 percent, and it should

be noted that this downward trend has only been very slight. This demonstrates how steadily and largely successfully Türkiye's electrification process has gone.

The steady increase in Türkiye's access to electricity can be attributed to infrastructure developments, investments, and policy measures in the energy sector. Electrification supports economic growth, increases access to health services, and promotes social development. Therefore, Türkiye's progress in this area indicates its efforts toward the energy sector and sustainable development. As a result, it is clear that Türkiye has achieved its target of population access to electricity under SDG7.

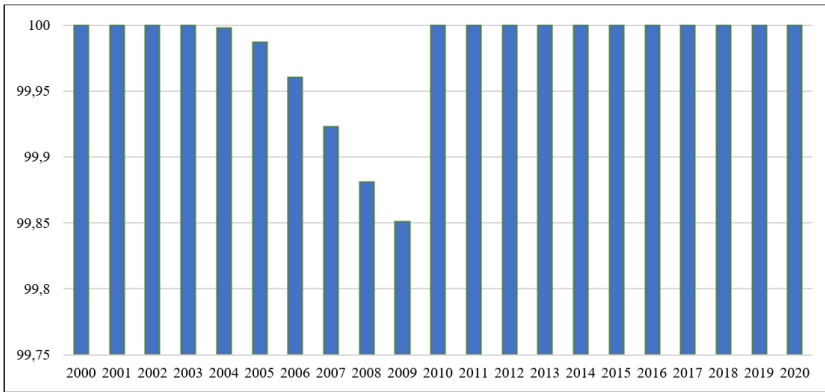


Figure 9. Türkiye's Access to Electricity (% of Population)

Source: Sustainable Development Report

Figure 10 includes data on the percentage of the population that has access to clean fuel and technology for cooking. Based on the data in the figure, we can observe that Türkiye's access rate generally increased between 2000 and 2020. These data point to a positive development when evaluated in the context of SDG7 targets. While the access rate was 90.1 percent in 2000, this rate increased to 95.2 percent in 2020. This shows an improvement in the access that Türkiye's population has to clean fuels and technology.

Access to clean fuels and technology, among the SDG7 targets, is essential for a healthy and sustainable life. Using clean fuels and technology can help reduce air pollution, improve indoor air, and prevent health problems. Increasing the access rate of Türkiye's population can be attributed to developments in the energy sector, policy measures, and awareness-raising efforts. A high rate shows Türkiye's steps toward achieving sustainable development goals in this area. However, it can also be observed that there has not been a significant increase in the data over the years. Since 2010, the access rate has ranged between 94.2 percent and 95.2 percent. This shows that progress has been slower in recent years.

In conclusion, the data shows that Türkiye's access rate to clean fuels and technology for cooking increased between 2000 and 2020. This indicates that Türkiye is making progress toward the SDG7 targets. However, it is important to take further steps to accelerate progress in this area and to continue efforts to provide access to clean fuels and technology to a broader segment of the population.

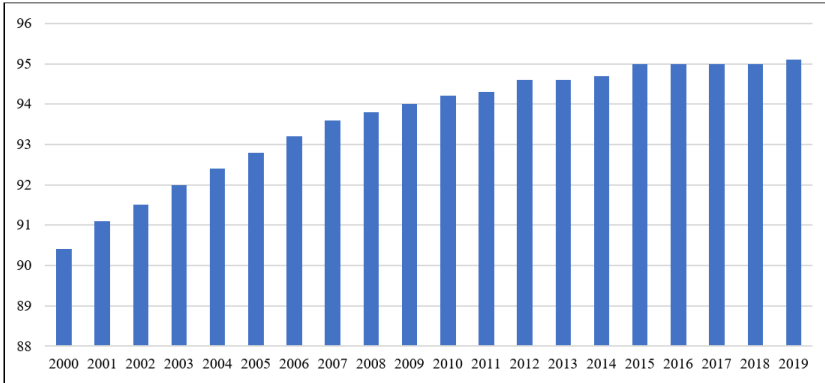


Figure 10. Population with Access to Clean Fuels and Technology for Cooking
Source: Sustainable Development Report

Figure 11 contains the data on carbon dioxide (CO₂) emissions per total electricity generation in MtCO₂/TWh. Based on the data given, it is seen that Türkiye has been in a general downward trend between 2000 and 2019. While in 2000, the amount of emissions was 1.68, it decreased to 1.26 in 2019. This shows that there is a decrease in Türkiye's emission amount. Reducing carbon dioxide emissions is important in combating climate change, using clean energy, and sustainable development. Moreover, lower CO₂ emission amounts can help mitigate the effects of global warming by reducing the greenhouse gas concentration in the atmosphere. Therefore, reducing CO₂ emissions in Türkiye is a positive development in terms of environmental sustainability and combating climate change. This observed decrease in Türkiye's CO₂ emissions per total electricity generation can be attributed to various factors. These include increased energy efficiency, increased use of renewable energy sources, adoption of cleaner technologies, and the impact of policy measures. The combination of these factors is a tangible sign of Türkiye's steps toward reducing carbon dioxide emissions. However, despite the downward trend in the data, there was an increase in 2017 and 2018. These increases may reflect a temporary situation that requires further analysis or specific impacts in certain sectors. Therefore, monitoring such fluctuations and maintaining efforts to reduce emissions continuously is essential.

As a result, the data show that Türkiye's CO₂ emissions per electricity output decreased between 2000 and 2019. This indicates that Türkiye is progressing towards reducing carbon

dioxide emissions in line with the SDG7 targets. However, further efforts to reduce CO₂ emissions should be made, including increasing renewable energy sources, improving energy efficiency, and investing in clean technologies.

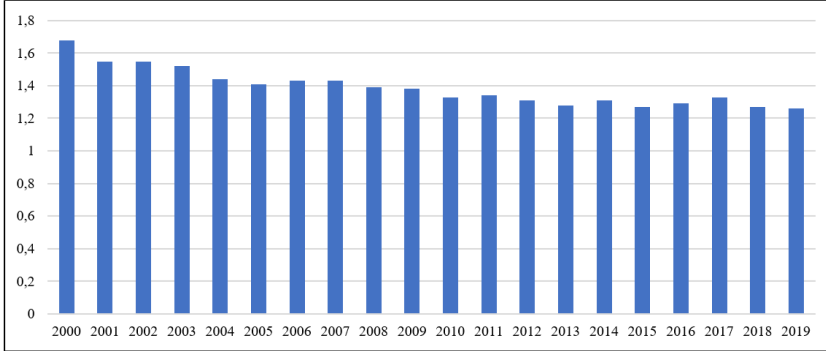


Figure 11. CO₂ Emissions from Fuel Combustion Per Total Electricity Output (MtCO₂/TWh)
Source: Sustainable Development Report

The Sustainable Development Report 2022 summarizes Türkiye's performance against the goals. The report also provides information on where Türkiye has achieved its targets, where it has not achieved them, and the direction in which the situation is heading. Data on Türkiye's performance on SDG7 issues are given in Table 1.

Goal	Score	Situation
Population with access to electricity (%)	100.0	SDG Achieved
Population with access to clean fuels and technology for cooking (%)	95.1	SDG Achieved
CO ₂ emissions from fuel combustion per total electricity output (MtCO ₂ /TWh)	1.3	Stagnated
Share of renewable energy in total primary energy supply (%)	15.9	SDG Achieved

Source: Sustainable Development Report (2022)

According to the report a detailed evaluation of the goals is as follows:

Population with access to electricity: Türkiye's electricity access rate reaching 100% in 2020 and achieving the SDG7 target can be considered a positive development. Electricity is a basic necessity of modern life, and the achievement of this target indicates the strengthening of Türkiye's energy infrastructure and the inclusiveness of its population. Indeed, it can affect the development of a country's energy sector and society's welfare. Furthermore, electricity is essential in many areas, such as lighting, heating, healthcare, education, communication, and industrial production. Therefore, the completion of access to electricity can improve the

living standards of citizens and contribute to economic development. SDG7 includes targets such as promoting access to sustainable energy, increasing energy efficiency, and expanding the use of renewable energy sources. Türkiye's 100% electricity access rate shows that these targets have been achieved, and steps are being taken toward sustainable energy. However, electricity access is not only measured by the access rate. Other factors such as energy security, energy efficiency, diversification of energy sources, and environmental sustainability are also important. Therefore, Türkiye needs to continue and advance its efforts in the energy sector in areas such as sustainability and using renewable energy. Türkiye's electricity access rate reaching 100% and meeting the SDG7 target is a positive development. This achievement shows the impact of investments and policies in the country's energy sector.

Population with access to clean fuels and technology for cooking: Access to clean fuels and technology for cooking is essential for environmental sustainability and human health. Traditionally, food is cooked in low-income areas using wood, charcoal, and other polluting fuels. This can cause indoor air pollution, which has environmental impacts (air pollution, deforestation, etc.) and negative impacts on human health. This development can reduce environmental impacts and improve health by providing a cleaner and more efficient way of cooking. Türkiye's 95.1% access rate indicates that households are progressing in switching from traditional fuels to clean energy sources. However, an access rate of 95.1% still does not mean that the SDG7 target has been fully achieved. Instead, it shows that policies and projects tackling fuel poverty and promoting the transition to clean energy are succeeding, but inclusivity needs to be further increased. To summarize, it is a positive development that Türkiye's population with access to clean fuels and technology for cooking has reached 95.1%. This is an important step towards environmental sustainability and human health. However, it is essential to make further progress on access to clean energy and increase inclusiveness.

CO₂ emissions from fuel combustion per total electricity output (MtCO₂/TWh): Türkiye's CO₂ emissions from fuel consumption per total electricity output, a target of SDG7, was 1.3 in 2020, indicating that the situation is not at the desired level. This shows that progress has not been made in the energy sector regarding environmental sustainability, and CO₂ emissions are still high. SDG7 includes sustainable energy targets, including reducing CO₂ emissions and promoting the transition to clean energy sources. CO₂ emissions from fuel consumption per total electricity output is an indicator that reflects the efficiency and environmental impact of the energy sector. Lower CO₂ emission values indicate cleaner and more sustainable energy production. Indeed, the value of 1.3 indicates that Türkiye still has a high amount of fuel consumption in energy production and the CO₂ emissions associated with this

consumption. This highlights the importance of taking measures in the energy sector, such as energy efficiency, transition to renewable energy sources, and adoption of low-carbon technologies. This assessment shows that Türkiye needs to work towards further sustainability goals in the energy sector. Steps such as increasing the use of renewable energy sources, implementing energy efficiency measures, and investing in low-carbon technologies can contribute to reducing CO₂ emissions and improving environmental sustainability. This situation indicates challenges to environmental sustainability in the energy sector. Therefore, it is essential to take further measures to remedy this situation and increase the use of sustainable energy sources.

Share of renewable energy in total primary energy supply: Türkiye's share of renewable energy in the total primary energy supply was 15.9% in 2020, indicating that it has successfully achieved a target of SDG7. This shows that Türkiye has made progress in investing in renewable energy sources and diversifying its portfolio. Increasing the share of renewable energy in the total energy supply is important for environmental sustainability. Renewable energy sources produce fewer greenhouse gas emissions than fossil fuels and play an important role in combating climate change. In addition, renewable energy sources can also offer advantages regarding energy security, as their sources are local and sustainable. In recent years, Türkiye has increased its investments in renewable energy sources such as wind, solar, hydroelectric, and biomass. This helps the country to diversify its energy portfolio, increase energy security and support environmental sustainability. However, the 15.9% share of renewable energy shows that further progress is needed. In line with the SDG7 targets, Türkiye needs to increase its use of renewable energy and reduce its dependence on fossil fuels for electricity generation. Therefore, investments in renewable energy sources must be continuously encouraged, and renewable energy potential needs to be further exploited. Overall, the 15.9% share of renewable energy in Türkiye's total primary energy supply is a positive development and shows progress towards the SDG7 targets. However, continued efforts are needed to further increase the use of renewable energy and further diversify the energy portfolio. This is important for environmental sustainability and energy security.

5. Conclusion and Recommendations

Hydraulic and geothermal energy is vital among sustainable energy sources in line with Türkiye's SDG 7 targets. In addition, these energy sources contribute to Türkiye's energy transformation with their environmentally friendly features and renewable nature. Therefore, geothermal energy is becoming increasingly crucial in Türkiye's energy portfolio. Türkiye has rich geothermal resources in various fields, such as electricity generation, heating, and greenhouse heating. In addition, geothermal energy is considered a sustainable energy source

as it is derived from natural resources that are continuously renewed. Therefore, increasing the use of geothermal energy is essential to ensure Türkiye's energy security by diversifying its energy supply. Türkiye's investments in and utilization of hydraulic and geothermal energy have significantly contributed to sustainable energy production. However, various challenges are faced in exploring the potential and utilizing these energy resources more effectively. These challenges include technical and financial barriers, infrastructure deficiencies, and improving regulatory measures.

The proportion of the population with access to electricity is 100%, indicating that Türkiye has achieved the SDG target. This means that everyone in Türkiye is powered by electricity and has full access to modern energy. The proportion of the population with access to clean fuels and technology for cooking is 95.1%. This indicates that the SDG target has been achieved. Türkiye has provided clean and healthy cooking methods to the vast majority of the population. CO₂ emissions from fuel combustion per total electricity generation (Mt CO₂/TWh) is 1.3, below the SDG target. This indicates that Türkiye needs lower carbon dioxide emissions from power generation for less environmental damage. The share of renewable energy in the total primary energy supply is 15.9%, meeting the SDG target. Therefore, Türkiye has obtained a significant percentage of its energy supply from renewable sources.

Overall, Türkiye has primarily achieved the SDG7 targets through hydro and geothermal energy. In addition, significant progress has been made in areas such as access to electricity, clean fuels, low carbon dioxide emissions, and the use of renewable energy. These achievements reflect Türkiye's commitment to transition to sustainable energy and its steps towards achieving environmental goals.

Considering Türkiye's current situation, some policy recommendations regarding sustainability and climate change issues can be listed as follows.

Focus on Renewable Energy Targets: Türkiye should focus more on renewable energy targets by increasing the potential and expanding the use of geothermal and hydraulic energy resources. In addition, investments in renewable energy sources and infrastructure development should be encouraged.

Research and Development Investments: Türkiye should invest more in research and development activities in geothermal and hydraulic energy. Developing new technologies and innovative solutions is essential for increasing energy efficiency and reducing carbon dioxide emissions.

Assessment of Geothermal Potential: Türkiye's geothermal energy potential is relatively high. Therefore, policies should be established to identify, explore, and develop geothermal areas to utilize geothermal resources more effectively. In addition, sustainability principles should be observed by considering the geographical and environmental impacts of geothermal energy utilization.

Hydraulic Energy Management and Water Resources: A sustainable approach to managing hydraulic energy resources should be adopted. Policies should be established for the sustainable use of water resources, evaluation of the impacts of hydroelectric potential, and protection of aquatic ecosystems. In addition, water conservation and effective water management measures should be encouraged.

Energy Efficiency and Transformation: Besides geothermal and hydraulic energy utilization, energy efficiency is also essential for sustainability. Therefore, Türkiye should strengthen energy efficiency policies and promote energy transition. Guidelines should be developed in areas such as energy efficiency measures in buildings, innovative technologies in industry, and the transformation of energy-intensive sectors.

International Cooperation and Financing: Türkiye should effectively utilize international cooperation and financing resources to increase geothermal and hydraulic energy use. Applications should be made to international funds for sustainable energy projects, and cooperation should be developed to transfer renewable energy technologies.

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