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***Research Article***

# The Usage Status of Joetermel Energy in the World, Turkey and Djibouti

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**Abstract**

In recent years, with the increase in population and the development of technology in the world, the need for energy has been increasing day by day. With the rapid depletion of fossil fuel reserves such as oil, coal and natural gas and the increase in the population, renewable energy sources are gaining importance. Geothermal energy, one of the renewable energy sources, is currently used in various processes such as electricity generation, heating and drying. Geothermal Energy is a clean, cheap and environmentally friendly domestic underground renewable energy source. For this reason, the issue of assessing the situation of direct and indirect production and use of geothermal energy in the world, Turkey and Djibouti has gained importance.

Keywords: Renewable Energy, Geothermal energy, Environmental effects, Usage in Turkey and Djibouti

# Joetermal Enerjisinin Dünyada, Turkiye ve Cibuti'deki Kullanım Durumu

**Öz**

Son yıllarda, dünyada nüfus artması ve teknolojinin gelişmesiyle enerji ihtiyacı her geçen gün artmaktadır. Petrol, kömür ve doğalgaz gibi fosil yakıt rezervlerinin hızla tükenmesi ve nüfusun artması ile yenilenebilir enerji kaynakları önem kazanmaktadır. Yenilenebilir enerji kaynaklarından biri olan jeotermal enerji günümüzde elektrik üretimi, ısıtma ve kurutma gibi çeşitli işlemlerde kullanılmaktadır. Jeotermal Enerji, temiz, ucuz ve çevresel etkileri dostu bir yerli yeraltı yenilenebilir enerji kaynağıdır. Bu sebeple Dünya'da, Türkiye ve Cibuti'deki jeotermal enerjinin doğrudan ve dolaylı üretiminde ve kullanımının durumu değerlendirilmesi konusu önem kazanmıştır.

**Anahtar Kelimeler:** Yenilenebilir Enerji, Jeotermal Enerji, Çevresel etkiler, Türkiye ve Cibuti'de Kullanımı

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# 1. Introduction

Energy consumption is an indicator of the level of development of countries so that individuals can lead a comfortable life. Energy needs will represent 80% of energy demand in developing countries at the end of the 21st century (WEC 1993). The increase in energy consumption with the development of population and the increase in technology poses an important problem in Turkey and Djibouti as well as in the rest of the world. In the literature, energy sources are divided into two as conventional energy sources and renewable energy sources. Oil, natural gas, nuclear energy and coal are among the non-renewable energy sources. Renewable energy, on the other hand, refers to an energy source that can maintain its current status in the future as a part of the evolution of nature (Külekçi 2009).

The rapid depletion of fossil fuel resources and the damages they cause to the environment threaten the lives of future generations. Therefore, limited energy resources reserves, population growth, increasing fuel prices, negative effects on the environment and climate change (increasing carbon dioxide emissions) require the use of renewable energy resources within the framework of new energy technologies. Important renewable energy sources are solar energy, geothermal energy, wind energy, biomass (biomass; Biofuel), wave energy and hydrogen energy are used in various processes such as electricity generation, heating and drying. These resources are more advantageous than fossil fuels due to their respect for the environment, reliability and unlimited reserves (Çukurçayır and Sağır 2008).

Geothermal energy originates from the formation of the earth and the radioactive decay of materials at currently uncertain rates (Dye 2012). The high temperature and pressure on Earth causes some rocks to liquefy, and the solid mantle behaves like plastic. This also comes from the upward bending of parts of the mantle as it is lighter than the surrounding rock. Temperatures at the core-mantle boundary can exceed 4000 °C (Lay *et al* 2008).

# 2. Material and Method

## 2.1. What is Geothermal Energy

Geothermal energy has the advantage of providing a continuous and regular flow. Also, if solar energy was stored in terrestrial biomass and in fossil energy deposits in the past, geothermal energy has the advantage of hiding a significant stock compared to other renewable energies: 140 million joules are located in the first 5 km of the earth's crust. Therefore, geothermal energy is both a flow energy and a stock energy. Therefore, this situation is also an advantage compared to other renewable energies. As the era of fossil fuels passes in this century, it is clear that no single energy source can assume the role they play. Geothermal energy will be widely used locally and will play an integrative role. For this, it is obvious that geothermal energy will play an important role in this century. Geothermal energy, on the other hand, includes all kinds of indirect or direct benefits obtained from these sources (Kendirli and Çakmak 2009).

Therefore, the work of the geothermal geologist usually consists of thermally suitable zones for searching permeable terrains, allowing high fluid flows in contact with large rock volumes (Bertanı 2015). In geothermal areas, the high temperature of hot rock and groundwater is found in shallower places than in normal areas (Figure 1). The rise of magma towards the crust and therefore heat transport, the heat flow caused by the high temperature difference in the places where the crust Decays, and the groundwater rising to the surface after a depth of several kilometers and heating were among the main reasons for this Syukri (Syukri *et al* 2018).

Historically, there have been two types of geothermal energy: the first is produced by drilling (December 150 to 350 ° C), which responds to the needs of low-temperature heating (45 to 90 ° C), which represents almost half of a country's energy demand, and the second is expanded in a steam turbine, generating electricity (in the range of 150 to 350 ° C) (Varet 2017).

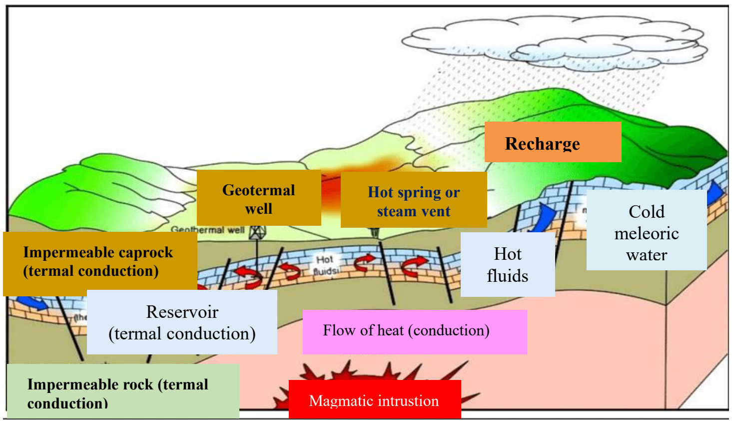


**Figure 1.** Schematic representation of an ideal geothermal system (Syukri et al 2018).

## 2.2. The State of Geothermal Energy in The World

This resource, which has been used by the inhabitants of all continents since historical periods for heating and cooking cleaning, health, entertainment and food on a primitive basis, is starting to be used in all countries with geothermal resources in the world.

In 2019, geothermal electricity production in 29 countries around the world is 16,000 MW, and the target is 250,000 MW by 2050. Ranking of the top 5 countries in geothermal electricity production in the world The United States is still the country that produces the most electricity from geothermal sources. Indonesia, the Philippines, Turkey and Kenya have greatly increased their production in recent years (Huttrer 2020). The preliminary country with the most installed geothermal energy production in 2020 is given in Table 1.

The non-geothermal electricity use in the world is 108,000 MW in 2019, which is the equivalent of about 18 million residential heating units. Global geothermal heat production (Review 2015-2020) is given in Table 2.3.

*Table 1. The front country with the most installed geothermal energy production in 2020 (Huttrer 2020].*

| Countries | MWe was founded in 2020 |
|---|---|
| *United States Of America* | 3.700 |
| *Indonesia* | 2.289 |
| *Philippine* | 1.918 |
| *Turkey* | 1.549 |
| *Kenya* | 1.193 |
| *Mexico* | 1.105 |
| *New Zealand* | 1.064 |
| *Italy* | 916 |

*Table 2. Global Thermal Geothermal Production (Lund and Toth 2020)].*

| Countries | Heat Production (Mwh/Year) |
|---|---|
| *China* | 123.192.222 |
| *United States Of America* | 42.447.083 |
| *Sweden* | 17.333.333 |
| *Turkey* | 15.162.222 |
| *Icleland* | 9.332.778 |
| *Japan* | 8.534.242 |
| *Germany* | 8.094.067 |
| *Finland* | 6.500.000 |
| *France* | 4.799.899 |
| *Canada* | 4.031.111 |
| *Switzerland* | 4.009.100 |
| *Norway* | 3.500.333 |

In general, there are direct and indirect uses of geothermal energy. The direct method of use is the oldest geothermal energy. in 2019, the rates of direct use of geothermal in the world (non-electricity), geothermal area heating 74.8% (China, Iceland, Turkey, France and Germany), Spa health use 18% (China, Japan, Turkey, Brazil and Mexico), Greenhouse heating 3.5% (Turkey, China, the Netherlands, Russia and Hungary), Geothermal fishing 1.3% (China, USA, Iceland, Italy and Spain), Industrial use 1.6% (China, New Zealand, Iceland, Russia and Hungary), Cooling snow smelting accounts for 0.2% and the Other 0.2% (Lund and Toth 2020)].

## 2.3. The State of Geothermal Energy in Djibouti

It is of great importance that the Republic of Djibouti, which is currently experiencing an annual economic growth of 3.5%, uses its potential in renewable energies in order to ensure its economic growth and to save foreign currency. However, the country is experiencing the same energy situation as the sub-Saharan African countries, where energy is abundant but electricity is scarce. 97% of the population's energy needs (mostly urban, more than 85%) are met by oil production imports and 90% of Djibouti households use kerosene as domestic fuel. Electricity usage is very low, about 30%. Only 0.2% of electricity production (with a total installed power of 130 MW) is realized by solar photovoltaic energy, which is a single renewable energy source.

At the geothermal energy level, the potential is technically estimated to be between 350 and 650 MWh. The geo thermic indicators in Figure 2 show that the geothermic fields located in Djibouti are Back, Tadjourah, Gaggadé, Hanlé, Ghoubbet, Arta, Asal and Dora. In these regions, the volcano consists of eruption area (emitting smoke and gas) (Youssouf 2020).

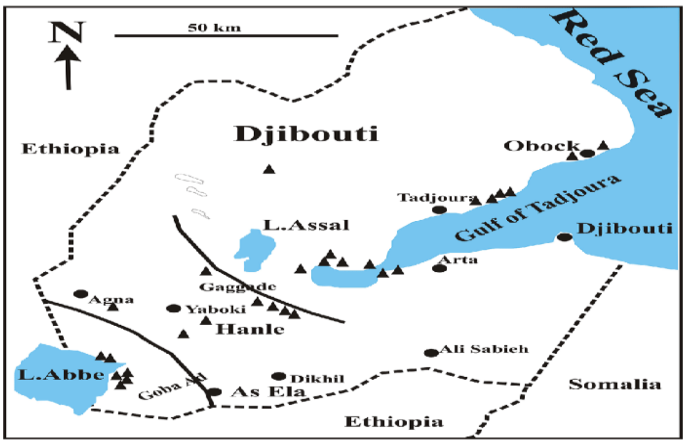


Figure 2. Geothermal sites in Djibouti (Chandrasekharam et al 2014).

There are hot water springs with a temperature of 48 °C in the Tadjourah region and regions with chimneys that emit gas and smoke at a temperature of 38 and 47 °C in the Rouéli region (Figure 3). Here, especially in the Ni'illé region, there are underground waters known as 'hot water springs-hot springs' among the people that come out sideways at the same temperature (Stieltjes 1973).

**Figure 3.** Korili hot water spring (hot spring) (Berger 2001).

According to the findings of numerous studies conducted by the CNR-CNRS and BRGM institutes, Assal-Ghoubbet, which is undeniably the most active area of the fault fracture, has the highest geothermal resource density. The Assal 1 and Assal 2 drilling experiments recorded high temperatures at depths of up to 345 ° C. Unfortunately, the high salinity of the spring (mineralization ratio of 110 g / l) causes significant deposits in the wells, reducing the likelihood of using the liquid (Youssouf 2020).

## 2.4 The State of Geothermal Energy in Turkey

The use of geothermal resources is quite common. In these places, the geothermal energy currently produced in Turkey is used for electricity generation, heating (for greenhouses and houses), thermal and health tourism, industrial mineral extraction, fishing, drying and other purposes. Kizildere Power Plant, which was established by the General Directorate of MTA in 1975 and has a power of 0.5 MWe, started the first electricity production in geothermal energy applications.

According to the end of 2021 data, there are 15,854 MWe of installed geothermal energy capacity worldwide, an increase of 246 MW compared to 2020. The USA, Indonesia, Philippines, Turkey and New Zealand are the top 5 countries in the world for geothermal energy electricity generation (Figure 4). Turkey, which has an 11.5 percent share in the global geothermal energy installed capacity, ranks fourth in the world in terms of installed capacity and first in Europe (Richter 2022).

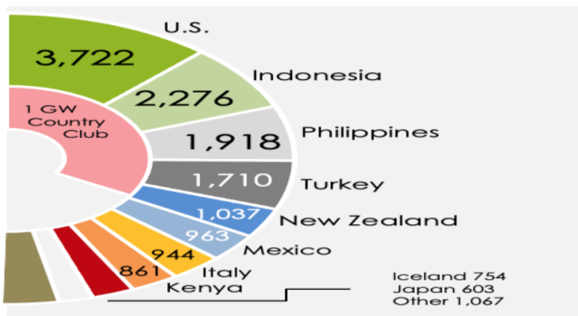


**Figure 4** ThinkGeoEnergy Top 10 Geothermal Countries by installed power generation capacity (MWe) in 2021 (Richter 2022)..

While there are more than 600 hot water (geothermal energy) sources in Turkey, some sources have increased this number to 1000. Turkey has the second largest geothermal energy resource in Europe after Italy, and these resources are more concentrated in the Aegean Region in Western Anatolia than in other regions due to the geological structure of the country.

Turkey is located in a region with active tectonic activity. Geothermal resources in the form of natural outlets and at various temperatures are widely distributed throughout Turkey. Geothermal energy is therefore an important renewable energy source for Turkey (Zaim and Çavşi 2018).

Electrical energy is generated using high enthalpy fields (temperatures> 180 ° C). Medium enthalpy sites (70 to 180 ° C) are used for heating houses and greenhouses and other drying processes. Low enthalpy zones benefit from facilities such as swimming pools, balneological baths and fish farms (temperatures from 20 to 70 ° C). Depending on the local conditions and the fluid temperature, geothermal energy sources can be used in many different places. The use of geothermal energy in places close to the fluid source is important in terms of its efficient and cost-effective evaluation. Kizildere (Denizli), Tuzla (Anakkale), Salavatl (Andy), Germencik (Andy) and Einar-Simav (Kütahya) regions of Turkey (Table 3) were excellent for generating electrical energy, classified as high enthalpy locations according to their temperatures (Şimşek 1998).

Turkey is located in a geography where tectonic movements are intense. Turkey There are many geothermal resources scattered all over the world in the form of natural outlets and at different temperatures. Therefore, geothermal energy is an important renewable energy source for Turkey. The areas of use of geothermal energy resources vary greatly depending on the regional conditions and fluid temperature. In order for geothermal energy to be evaluated efficiently and economically, it is necessary to use it in areas close to the source of the fluid.

Geothermal power plants with an installed capacity of 820.86 MW account for 1.58% of Turkey's total installed energy power. As of 2000, the direct use capacity of geothermal energy in the world such as thermalism, cooling, heating has reached 17174 MWT. Turkey, on the other hand, is the 5th in the world thanks to its 820 MWt direct use capacity. it is in the position of the country. With an increase of 246 MW compared to 2020, the total installed geothermal energy production capacity in our country was measured as 15,854 MW at the end of 2021 (Anonymous 2022). In Table 3, the areas where geothermal energy can be produced in Turkey are given.

*Table 3. Areas where Geothermal Energy Can be Produced in Turkey (Anonim 2022)*

| Field Name | Reservoir Temperature (°C) |
|---|---|
| Germencik, Aydın | 232 °C |
| Kızıldere, Buharkent, Aydın | 242 °C |
| Kurudere, Alaşehir, Manisa | 184 °C |
| Göbekli, Alaşehir, Manisa<br>Tuzla, Çanakkale | 182 °C<br>174 °C |
| Salavatlı, Aydın | 171 °C |
| Simav, Kütahya<br>Seferihisar, İzmir | 162 °C<br>153 °C |
| Caferbey, Salihli, Manisa | 150 °C |
| Yılmazköy, Aydın | 142 °C |
| Balçova, İzmir | 136 °C |
| Dikili, İzmir | 130 °C |

## 3. Results and Discussion

Geothermal resources in the world may supply 8% of the world's electrical energy needs in the near future. Rising oil prices will improve the economics of energy production from supported geothermal systems in the near future and may double electricity production from geothermal systems. The use of low-grade geothermal resources in the world and in Turkey will replace fossil fuels in direct use locally. It will reduce social costs by controlling the use of geothermal resources instead of fossil fuels and controlling CO2 levels. The technically decontamentable geothermal potential of the Republic of Djibouti is currently estimated to be between 350 and 650 MW.

## 4. Conclusions and Recommendations

On the temporal horizons of technology and social systems, geothermal resources can be seen as renewable because they do not have the same geological lifespan as fossil fuel reserves such as coal, oil and gas. At the same place where the liquid or heat is withdrawn, high enthalpy reservoirs are recovered. In October, heat pump systems can be used to produce truly sustainable food. The environmental impacts of geothermal energy production and direct consumption are typically modest, manageable or negligible. Environmental laws, which may differ from one country to another, should be strictly adhered to. In any case, the effects should be monitored, recorded and, if necessary, mitigated (sometimes for extended periods of time).

In the foreseeable future, geothermal resources may meet 8% of the world's electrical energy requirements. Rising oil prices may soon make supported geothermal energy production more economically viable and perhaps triple electricity production from these systems. Fossil fuels will be replaced by low-grade geothermal resources both globally and in Turkey for local direct use. By limiting CO2 levels, the use of geothermal resources instead of fossil fuels will reduce social costs.

Turkey's energy production seems economically viable and more projects are underway. With the current financial model and heating rates, the economy of central heating systems in Turkey does not look healthy, and given this economic situation, it does not seem realistic to compete with natural gas in the short and medium term. Turkey's geothermal resources seem to be a good place to get process heat. The industry needs to be aware of this scenario and take it into account. The industry has already recognized that it makes economic sense to use Turkey's geothermal resources to heat greenhouses.

The technically Decontamentable geothermal potential of the Republic of Djibouti is currently estimated to be between 350 and 650 MW. The Asal-Ghoubbet plant alone has an economic operational potential of over 150 MW, far beyond the current requirements of the country. During the drilling operations, the exploration of most of the places with geothermal resources was very simple due to the small area of the country. The only remaining task is to move to the operational stage after twenty years of exploration in this area.

The Assal plant is a promising area and the initial 30 MW phase, gradually followed by modular units of 5-10 MW, should be considered near the country's existing plants. The current Iceland project in this region can be completed with an initial capacity of 50 MW, which is expected within the next three years. After completing these tasks, a 5 MW pilot geothermal power plant should be built.

## 5. Acknowledge

The authors would like to thank the many people who contributed to the country update articles who provided data that is often difficult to find or calculate. In most cases, these numbers had to be estimated by the country update authors or the authors of this article. We hope that our estimates of geothermal capacity and utilization are quite accurate, but we welcome suggestions for changes or corrections. This research was carried out within the scope of the Doctoral program.

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