EnerCEE report: The potential of geothermal energy in Hungary and Croatia

Introduction

Geothermal energy has been gaining traction in Europe as a sustainable and reliable source of energy. This renewable energy source is derived from the Earth's natural heat and can be harnessed for various purposes, such as heating and electricity generation.

Europe is home to some of the world's most active geothermal regions, including Iceland, Italy, and Turkey. These countries have been leading the charge in geothermal energy production, with Iceland generating around 25% of its electricity from geothermal sources.

In addition to these countries, several other European nations are also exploring the potential of geothermal energy. The United Kingdom, for instance, has significant geothermal resources that could be used for heating and cooling buildings. The country's first deep geothermal power plant is currently under construction in Cornwall, which is expected to generate enough electricity to power 3,000 homes.

Another country that is making strides in geothermal energy is Germany. The country has over 100 geothermal plants in operation, with a total installed capacity of around 3,900 MWth. These plants provide heat to both residential and commercial buildings, as well as to greenhouses and industrial processes.

One of the advantages of geothermal energy is that it is a reliable and stable source of energy. Unlike wind and solar power, which are dependent on weather conditions, geothermal energy can be harnessed 24/7, providing a constant supply of energy. This makes it an ideal source of baseload power, which is the minimum amount of power needed to meet a country's energy demands.

Geothermal energy also has a low carbon footprint, making it an environmentally friendly source of energy. Unlike fossil fuels, geothermal energy does not emit greenhouse gases or other pollutants into the atmosphere. This makes it an attractive option for countries looking to reduce their carbon emissions and meet their climate change targets.

Despite its many advantages, there are still some challenges associated with geothermal energy. One of the main challenges is the high upfront cost of building geothermal plants. The drilling and construction costs can be significant, which can make it difficult for some countries to invest in this technology.

Another challenge is that not all areas have suitable geothermal resources. While some regions may have high temperatures and abundant water resources, others may have low temperatures or limited access to water. This can make it difficult to harness geothermal energy in some areas.

Despite these challenges, the potential benefits of geothermal energy are too great to ignore. With the right investments and policies, geothermal energy could become a major source of renewable energy in Europe and beyond. It has the potential to provide a reliable and sustainable source of energy, while also helping countries to meet their climate change targets.
Geothermal resources are a local source of energy that can cost-effectively generate renewable electricity and/or heat. Therefore, has a great, future potential for generating heat and electricity, replacing greenhouse gas emission heating systems and power plants. Geothermal reservoirs can also serve as energy and CO2 storage.[1]

Earth has unlimited heat potential – about 840 GW of electrical energy. The reservoir of geothermal energy are 10 times higher than the reserves of fossil fuels.[2] Geothermal energy allows not only to produce clean energy, but also to significantly reduce the consumption of conventional fossil resources. According to expert analysis, the generation of 10 MW of electricity in geothermal power plants is able to save about 140 barrels of crude oil per year. [3]

[1] Deep Geothermal IWG (2020) SET-Plan Implementation Working Group Deep Geothermal Implementation Plan

[2] Trutenko A., Pashkovets A., Safronova Y. (2023) The possibility of using Geothermal Energy in the Energy sector

[3] Darya Zimnukhova, Galina Zubkova and Ekaterina Kamchatova (2019) Geothermal energy for heating

There are two types of geothermal energy: near-surface and deep geothermal (from 400m).

The potential of thermal water for heating is much greater than for electricity generation. Therefore is the use of geothermal energy for heating purposes, steadily increasing across Europe. [1]

The establishment of Geothermal Global Alliance (GGA) at COP21 has significantly contributed to the political recognition of geothermal energy.
The GGA aims to increase global installed capacity for geothermal power generation by 500% and geothermal heating by 200% by 2030

EU Deep Geothermal Implementation Plan (IP) serves to support the research and innovation actions to increase renewable heat supply. Geothermal electricity generation could cover 12.5% of electricity demand of the EU and, using about 20% of the total available geothermal potential. According to a long-term decarbonization plan, geothermal electricity generation in the EU could reach up to 540 TWh per year in 2050.[1]
The current share of geothermal energy in total energy production is still very low and therefore does not play a significant role in the energy sector yet.[2]

Photo Credit: istockphoto

Advantages

The development of geothermal energy can contribute to climate neutrality and accelerate independence from fossil fuels as well as increase energy security and price stability. There are numerous possibilities for the use of geothermal energy - from balneology, industry, agriculture to district heating.

Although investment costs are high in the early stages of implementation, operating costs as well as system costs are low. It results in costs that are comparable to those of other renewables and low-carbon technologies. In addition, the capacity factors are much higher than most other renewables.

Deep geothermal energy can be converted into electricity or directly used for heating or cooling purposes. A further advantage is the low water consumption compared to thermal power plants, nuclear power plants and hydroelectric power plants, where the water consumption reaches up to 1000 liters per 1 kW. In the case of geothermal energy, it is only 20 liters per 1 kW. In addition, the thermal energy of the magma can also be used in the regions where it is not too deep below the earth's surface. There is easier extraction in areas

with volcanic eruptions and geysers, where hot water is at the surface.

Geothermal energy is currently used largely for heating purposes. Nearly 40% of energy demand in the EU is for space heating applications. Increased use of geothermal heating systems could therefore greatly reduce the carbon footprint of the European heating sector.[4]

Geothermal resources can play a central role in the energy transition and conversion of the economy to low-carbon and renewable energy sources.

Disadvantages

Drilling to depths of several kilometers is not feasible in all regions, under all weather and climate conditions and other environmental circumstances. The next disadvantage are large heat losses during extraction and transportation. In addition, strict geographical requirements must be met. Toxic and radioactive impurities may be present during extraction, but this does not cause pollution of the atmosphere.

There is no possibility of waste discharge into surface waters.

One of the main obstacles in the implementation of geothermal projects are the high financing costs associated with geological risks as costly drilling with unpredictable outcomes during the early exploration phase.[5]

Geothermal energy in agriculture

The Agriculture Organization of the United Nations reported on the great potential of geothermal energy for agricultural purposes in developing countries. Geothermal energy can be used for sustainable and cost-effective food production and processing in developing countries. It can serve as a source for heating of greenhouses, soils, or water for fish farming. This can significantly reduce high post-harvest costs. Geothermal energy can also contribute to improving food security, generating income and creating jobs in developing countries. 38 countries currently use geothermal energy directly in agricultural production and 24 for electricity generation. Countries such as Iceland, Costa Rica, El Salvador, Kenya, New Zealand, and

[4] Kimmo Korhonen (2023) https://www.sciencedirect.com/science/article/pii/S0960148123003270, accessed on 31.05.2023

[6] UN Report (2015) https://news.un.org/en/story/2015/04/495252, accessed on 30.05

[5] Trutenko A., Pashkovets A., Safronova Y. (2023) The possibility of using Geothermal Energy in the Energy sector

the Philippines already generate more than 10 percent of their electricity needs from natural thermal sources.[6]

Photo Credit: AgriTech Tomorrow

Hungary

Hungary has the greatest geothermal potential in Europe (installed thermal capacity of 350 MWth with 8 000 wells)[7]

The country has several geothermal fields, with the largest one located in the eastern part of Hungary, near the city of Debrecen. This field has been in operation since the 1960s and has a capacity of over 60 MW. Other notable geothermal fields are located in the cities of Szeged, Miskolc, and Szentlőrinc.

The use of geothermal energy in Hungary has been steadily increasing in recent years. In 2019, geothermal energy accounted for around 1% of the country's total energy production. The Hungarian government has set a target of increasing this share to 3% by 2030.
Hungary is located in the Pannonian Basin of Central Europe with large number of geothermal resource, which can be used directly. The geothermal potential of the Pannonian Basin is the high heat flow density (50- 130 mW/m2 with an average of 90-100 mW/m2) and the geothermal gradient of about 45 °C/km.
Geothermal district heating has been implemented in 23 Hungarian cities since 2017, with a total installed capacity of 223.36 MWth and production of 635.66 GWhth/year. Most of them are so-called “hot water heating cascade systems”, where the gas heating of public buildings has been replaced by geothermal systems. The agricultural sector plays an important role in direct use and is especially applied in the southern part of Hungary for the heating of greenhouses. About 358 MWth of installed capacity produces 803 GWhth in a year.
The government intends to promote geothermal energy in Hungary. The Ministry of Innovation and Technology is responsible for coordinating the energy sector, including geothermal energy.
The target of Hungary's National Renewable Energy Action Plan for geothermal by 2020 included 5.99 PJ (NPP), 16.43 PJ (direct use), and 57 MWe (electricity generation).
The 1345/2018. (VII. 26.) Government Decision on the Action Plan for the Utilization and Management of Energetic Mineral Resources represents an important legal act that establishes specific tasks and responsibilities of ministries for deep geothermal energy.

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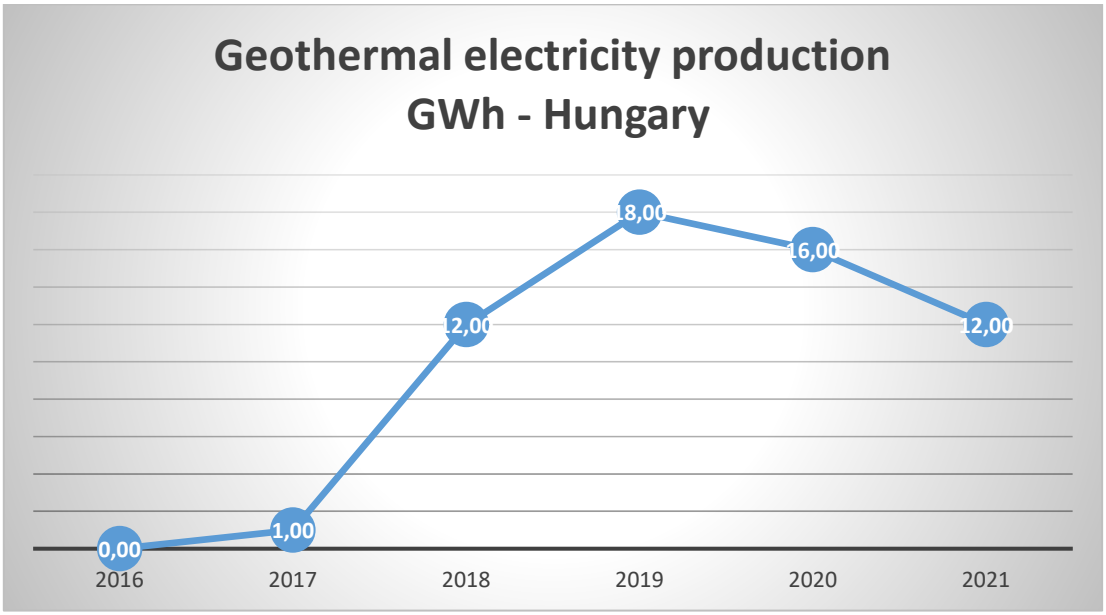
[7] Enerdata (2022): Country report, Hungary, September 2022, https://global-energy-data.enerdata.net/database/, accessed on 30.05.2023



Source: Enerdata Design: AEA

The graph indicates that the geothermal energy generation has increased since 2016 up to 18GWh in 2019, which is the peak, and has been gradually decreasing until 2021.

Although Hungary has very favorable natural conditions for geothermal energy production, energy production and utilization is not progressing as fast as desired. Nevertheless, the implementation has already started and the first steps have been taken. For a successful future development of Hungarian geothermal energy, a well-elaborated energy policy as well as supportive legal and financial framework conditions are necessary.
Due to the fact, that Hungary is 83% dependent on imported energy, renewable energy sources, including geothermal energy, represent opportunities for increasing its energy security, especially in the heating sector.[8]

Croatia

Just like Hungary, the north of Croatia is located in the Pannonian Basin, which has particularly suitable conditions for geothermal energy generation.

Geothermal energy is a promising source of renewable energy in Croatia. The country has abundant geothermal resources, with an estimated potential of 1,000 MW. The use of geothermal energy in Croatia dates back to the Roman times, where hot springs were used for bathing and heating. Today, geothermal energy is used for district heating, electricity generation, and industrial processes.

The largest geothermal power plant in Croatia is located in the town of Ciglena, near Bjelovar. The plant has a capacity of 16.5 MW and produces electricity for around 25,000 households. The plant also provides heat for the local district heating system. Other geothermal power plants in Croatia include the Velika Ciglena and Legrad plants, with capacities of 10 MW and 1.5 MW, respectively.

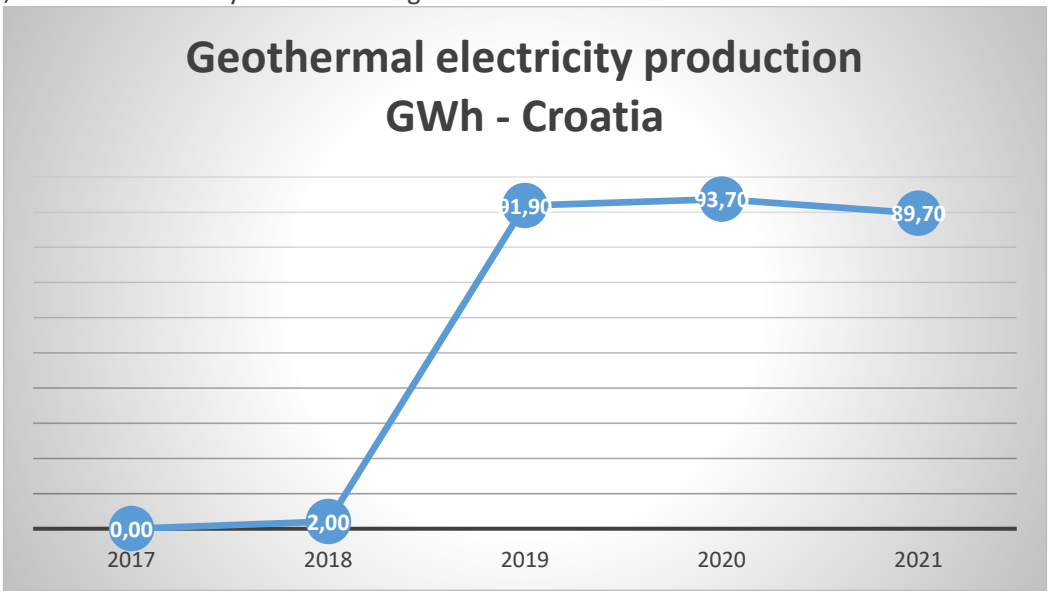
In addition to electricity generation, geothermal energy is also used for direct heating and cooling applications. The town of Koprivnica has a geothermal district heating system that provides heat to over 3,000 households and several public buildings. The system uses water from a geothermal well with a temperature of around 80°C.

The use of geothermal energy in Croatia is supported by the government through various incentives and regulations. The country has a feed-in tariff system that guarantees a fixed price

[8] Annamária Nádor (2019) Geothermal Energy Use, Country Update for Hungary

for electricity generated from renewable sources, including geothermal energy. The government also provides grants and loans for the development of geothermal projects.
Due to oil and gas exploration and production, in the second half of the 20th century in the northwestern part of Croatia, the information of deep geology, geophysics, hydrodynamics, etc. have been collected and more than 4000 deep wells were drilled. This has significantly contributed to the current development of geothermal energy in this region.
Interest in geothermal power generation projects focuses mainly on well-known geothermal sites such as Velika Ciglena and Kutnjak-Lunjkovec, but there are also other sites that already have exploration licenses such as Draškovec, Kotoriba, Legrad, and Ferdinandovac.

The most famous project represents Velika Ciglena, where after 20 years of drilling and testing, a geothermal power plant was put into operation at the end of 2018. The installed capacity is >16.5 MWe, but supply is currently limited to the local power grid capacity of 10 MWe.
A unique innovative project has been started in Draškovec, where the hybrid system uses the direct heat of the geothermal water as well as the unconventional hydrocarbon gases dissolved in the water to generate electricity. 98% of the resulting CO2 is captured and reinjected into the aquifer.
The interest in district heating projects especially in the northern Pannonian region of Croatia in the cities of Zagreb, Karlovac and Križevci as well as in other industrial and agricultural areas is increasing constantly.



Source: Enerdata Design: AEA

The graph shows that geothermal energy production increased from 2 GWh in 2018 to over 90 GWh in 2019 and 2020.[9]

Conclusion

Geothermal is just entering the early stages of implementation, and the ongoing research, pilot work, and case studies are very important to its further development. In order to promote geothermal energy, costs must be reduced and performance as well as technologies must be improved. Geothermal energy can make a great contribution to the transition to a more sustainable energy system. It can promote local and sustainable economic developments and increase the energy security and diversification.[10]

[9] Sanja Živković (2019) Geothermal Energy Use, Country Update for Croatia

[10] Deep Geothermal IWG (2020) SET-Plan Implementation Working Group Deep Geothermal Implemenation Plan