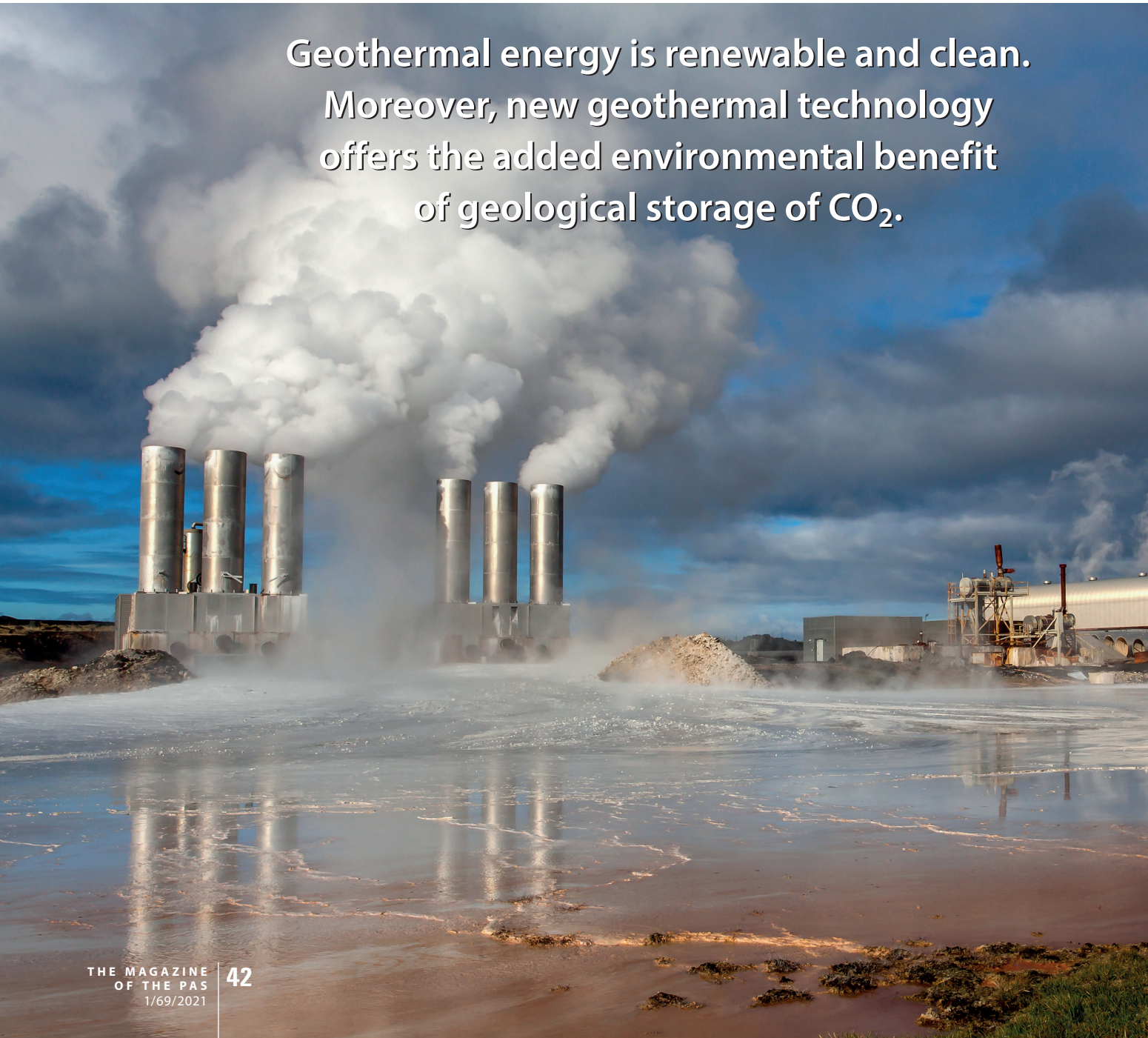
Hope for a Better Tomorrow



Geothermal energy is renewable and clean. Moreover, new geothermal technology offers the added environmental benefit of geological storage of CO_2.

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Poland is grappling with a serious air pollution problem, resulting largely from the combustion of solid fuels, which are still the country's primary energy source. Alternative and competitive technological and systemic solutions therefore need to be actively sought and developed in order to satisfy the population's energy demand while simultaneously taking proper care of the natural environment. Boosting the use of renewable energy sources, including geothermal energy, is an extremely important and necessary element of producing energy in an ecological way.

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State support

Geothermal energy is another name for the Earth's internal heat, stored in rocks and in the groundwater that fills rock pores and cracks. Geothermal waters have been utilized since ancient times, but with the development of technology and drilling techniques this type of energy began to be harnessed on a larger scale to meet energy needs. Classical hydro-geothermal systems use existing underground water as the energy carrier, exploited via boreholes, whereas petrogeothermal systems harness hot dry rocks by using a liquid medium (typically water) introduced through boreholes.

Particularly favorable conditions for high-energy geothermal systems, potentially best suited for industrial use, are present within the plates of the lithosphere. In such zones, the geothermal vapor deposits found in reservoir rocks can be harnessed to generate electricity in geothermal power plants. Such deposits occur in areas of modern or recent volcanic or tectonic activity. Countries where such high-temperature geothermal energy is utilized include the Philippines, Mexico, New Zealand, the United States, Japan, Italy, and Iceland. However, on the global scale, such high-temperature geothermal areas are relatively scarce. Low-temperature deposits, with geothermal water deposits at temperatures below 150°C, are much more common – for them, the key sector of development is heating, with electricity production being of local importance.

Geothermal energy is a renewable energy source, and increasing the share of renewables in the national energy balance is crucial for improving the quality of the environment, and thus the health and life of Poland's residents. But despite the many advantages associated with the use of geothermal resources, geothermal energy is still in last place among renewable energy sources in Poland. However, events of recent years seem to justify a certain degree of optimism that the pace of development of the geothermal sector may pick up and the number of geothermal projects in Poland may increase. The national system of subsidies, including those provided by the Polish National Fund for Environmental Protection and Water Management, aims to increase the use of geothermal resources. Its support for geothermal drilling has led to investments located in a number of places in Poland, including Turek, Tomaszów Mazowiecki, Sieradz, Koło and Sochaczew, and more are in the pipeline, at various stages of implementation. New geothermal boreholes stand a chance of laying the foundations for the construction of more geothermal heat plants.

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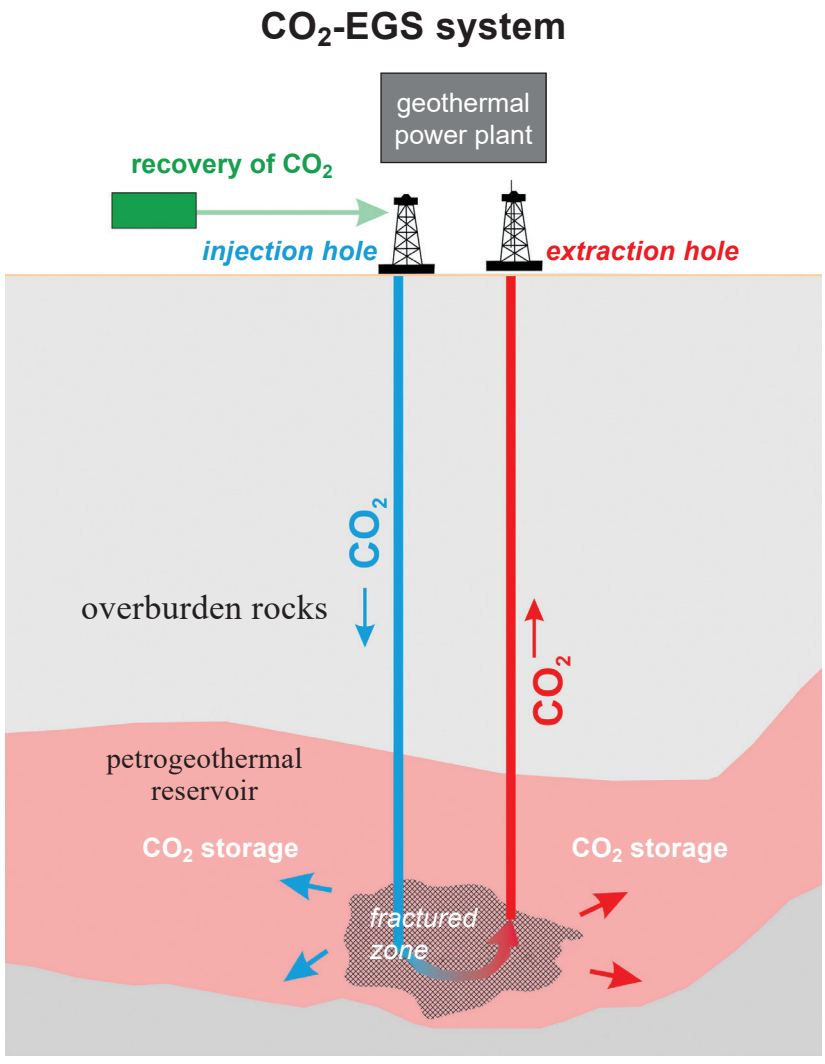
Conceptual diagram of how a CO_2-EGS system works



Other support systems, such as the Polish Geothermal Plus program and the "Making Thermal Waters Accessible in Poland" program, provide opportunities for the development of geothermal projects and the harnessing of existing resources. Geothermal energy has been included as one of the renewable energy sources listed in the draft "Energy Policy of Poland Until 2040," a very important document from the perspective of the sector's development.

At present, geothermal resources in Poland are not being harnessed to a great extent. Such resources are being utilized effectively at six geothermal heat plants (in Poddębice, Stargard, Uniejów, Mszczonów and Pyrzyce in the Polish Lowlands, plus in the southern region of Podhale where the country's largest and the oldest geothermal heat plant exists) as well as in recreation and balneological centers (balneology is a branch of spa medicine that focuses on the therapeutic properties of underground waters and peloid muds). However, the potential for geothermal energy in the country, as confirmed by scientific research conducted over many years, is clearly much greater. As Poland is located in an area of low-temperature geothermal resources, it is the heating sector that is the key sector for their development. However, research work is now underway to pave the way towards building Poland's very first geothermal power plant.

Polish research

Geothermal research has been carried out in Poland since the 1980s. From the very outset, such research has aimed to identify the country's hydrogeothermal potential – the capacity to utilize geothermal waters with parameters adequate for various purposes, especially for heating, recreation, or balneology. Initial research yielded satisfactory results which led to the construction of the first geothermal installation (in Podhale) and then subsequent ones in Poland. Research on the potential for harnessing hydrogeothermal energy in Poland was summarized in a unique series of geothermal atlases published under the editorship of Prof. Wojciech Górecki in 2006–2013. This work points out possibilities of using hydrogeother-

mal resources for utilitarian purposes, especially in heat engineering, which is so far the key sector for the utilization of geothermal waters in Poland.

Potential

The technology involved in classical geothermal systems is already quite mature, enabling groundwater stored in hydrogeothermal reservoirs located at various depths below the Earth's surface to be exploited. However, there is also tremendous geothermal potential inherent in low-permeability, low-porosity rocks characterized by anomalously high temperatures. This potential can be exploited by means of unconventional systems, known as enhanced geothermal systems (EGS). EGS harness the geothermal energy associated with hot, dry rocks that have low natural permeability and low groundwater saturation. This type of system extracts energy from the rock by artificially increasing the hydraulic capacity of the geothermal reservoir, introducing a working fluid, the energy carrier, into the reservoir thus enhanced, and then channeling it to a power plant to generate electricity. These systems make it possible to harness geothermal energy when the hydrogeothermal conditions of a particular location rule out sufficiently high borehole yields, making potential locations for EGS much more plentiful than for classical hydrogeothermal systems. There are two working fluids used in EGS systems: the first and most commonly used one is water, while the second is carbon dioxide (CO_2). Although the first solution is definitely more common, EGS systems using CO_2 as a working fluid (CO_2-EGS) are very interesting due to both the thermodynamic properties of carbon dioxide and the need to reduce its emissions to the atmosphere. Such systems have indeed attracted much interest because of the added environmental benefit of geological storage of CO_2 during the power generation process. Existing research conducted worldwide has also demonstrated significant advantages of using CO_2 as a working fluid, including its favorable transport properties and low chemical activity.

The EnerGizerS Project

Studying the effectiveness of this innovative technology is the aim of the EnerGizerS project (CO_2-Enhanced Geothermal Systems for Climate Neutral Energy Supply), launched in October 2020 under the framework of the POLNOR 2019 Polish-Norwegian research projects, funded by the Norwegian Financial Mechanism Programme 2014–2021. The operator of the program is Poland's National Center for Research and Development, and it is co-financed from the state budget. It will be carried out until 2023 by a consortium led by the AGH University of Science and Technology in Kraków, partnered with three research institutions – the PAS Institute of Mineral and Energy Economy, SINTEF Energi AS and the NTNU Norwegian University of Science and Technology – as well as the company Exergon.

Researchers from Poland and Norway have thus joined forces in the EnerGizerS project to analyze the efficiency of unconventional geothermal systems using CO_2 as working fluid. The proposed solution aims to help protect the climate by harnessing clean and green geothermal energy while also reducing CO_2 emissions from burning fossil fuels. Unconventional geothermal systems are attracting ever more interest worldwide, mainly due to the possibility of geological storage of CO_2 in tandem with the process of electricity and heat production. This technology has the potential to become a new sustainable renewable energy source of great importance for the implementation of international efforts aimed at mitigating anthropogenic climate change. These solutions are innovative on global markets and have not yet come into widespread use.

Under the EnerGizerS project, our consortium of scientists is working to identify and characterize in detail the potential of various geological structures in Poland and Norway to serve as locations for CO_2-EGS systems, satisfying combined requirements for geothermal and CO_2 sequestration technologies. Due to the differing geological, legal, and environmental circumstances in the partner countries, each of the cases considered will be characterized by different parameters. This research work will lay the basis for a technical, economic, and environmental assessment of the potential for the proposed technology to be brought into use in the Polish and Norwegian energy systems. Comprehensive laboratory tests will be carried out on samples of drill cores taken from relevant geological structures, evaluating their petrophysical, thermal, and mechanical properties. The obtained results will serve as the basis for advanced mathematical modeling, including structural modeling of the reservoir, modeling of the fracturing process in the rock medium, and 3D multivariate simulations of CO_2 injection and production with forecast projections of reservoir behavior over time. The project also involves experimental determination of the properties and behavior of CO_2, as well as mathematical modeling of CO_2-based surface systems for heat and power production.

Overall, the findings of the project will help determine the viability of combining two technologies, EGS and CO_2 sequestration, to both reduce CO_2 emissions and generate energy in an environmentally friendly as well as economically viable manner. Another key benefit from the project will be the exchanging of experience and deeper cooperation between Polish and Norwegian partners, helping to determine the best framework for the analyzed technology and thus reduce risks for future geothermal investments. The final results of the project will be publicized in 2023. ■

Further reading:

Atlas of Geothermal Resources in the Polish Lowlands – Mesozoic Formations, ed. W. Górecki, Kraków 2006.

Atlas of Resources of Waters and Geothermal Energy in the Western Carpathians, ed. W. Górecki, Kraków 2011.

Geothermal Atlas of the Carpathian Foredeep, ed. W. Górecki, Kraków 2012.

Geothermal Atlas of the Eastern Carpathians, ed. W. Górecki, Kraków 2013.

Ocena potencjału, bilansu cieplnego i perspektywicznych struktur geologicznych dla potrzeb zamkniętych systemów geotermicznych (Hot Dry Rocks) w Polsce [Evaluation of the Potential, Thermal Balance, and Promising Geological Structures for the Needs of Closed Geothermal Systems (Hot Dry Rocks) in Poland], ed. A. Wójcicki, A. Sowiżdżał, W. Bujakowski, Warszawa – Kraków 2013.