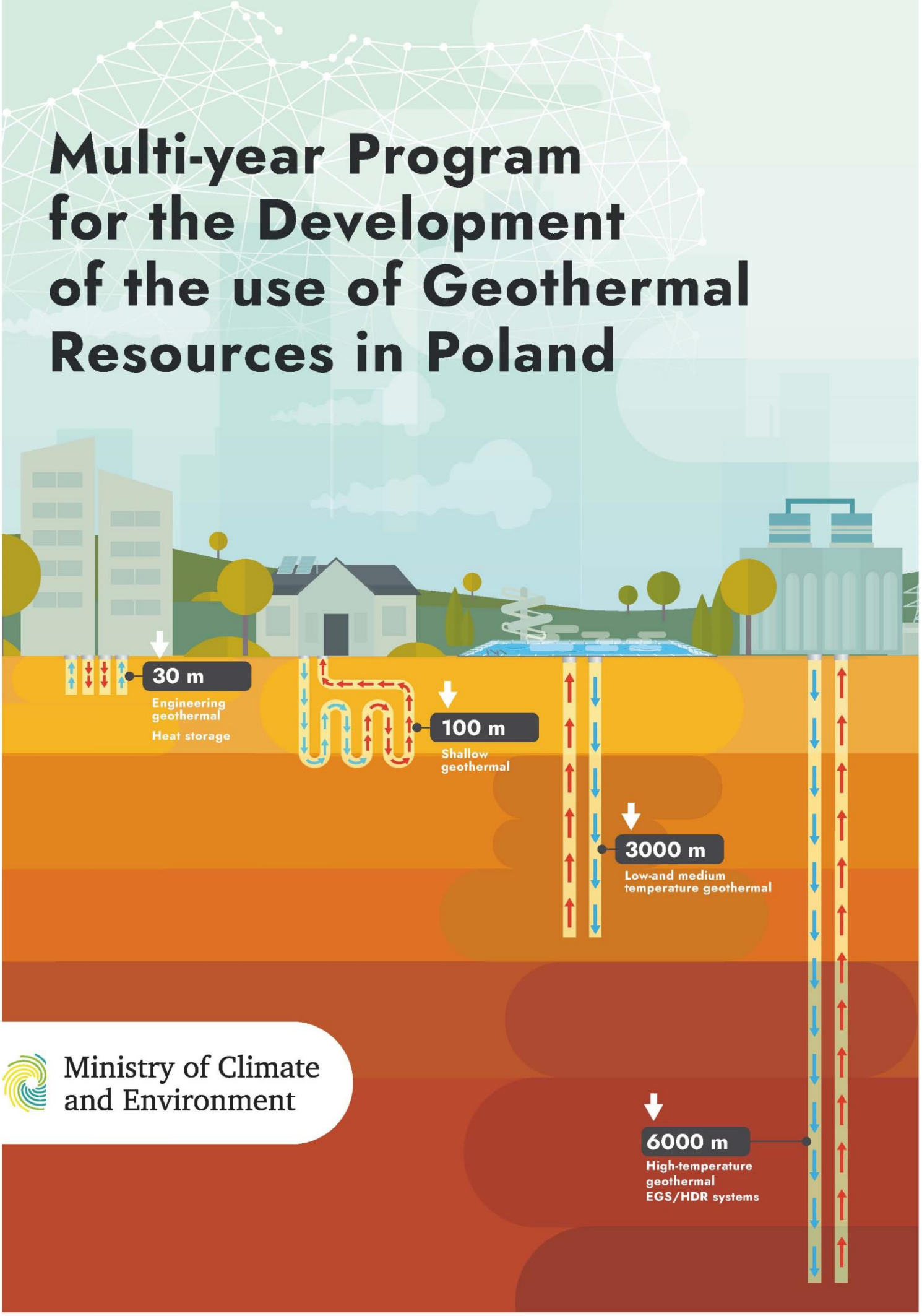
Multi-year Program for the Development of the use of Geothermal Resources in Poland



Ministry of Climate and Environment

Anna Moskwa
Minister of Climate and Environment

Renewable energy sources based on the Earth's heat are becoming increasingly important in the Polish heating sector. So far, their significance in the energy market has been relatively low, but the measures taken by the Ministry of Climate and the Environment ensure that the role of geothermal energy as an alternative to conventional fuels continues to grow.

We consistently focus on the development of renewable energy sources in Poland. Rich, natural geothermal resources are an important component of the general renewable energy sources balance. Geothermal energy provides “clean”, emission-free energy, which is of particular importance in our intense efforts to protect the climate and improve air quality in the country. At the same time, this source of energy is very stable, independent of seasons and weather conditions, and neutral for the landscape.

That is why we are enhancing the efforts for exploiting local geothermal resources and providing greater and more effective forms of support for geothermal investments. We assume that investing in geothermal energy will pay off in the future.

dr Piotr Dziadzio
Chief National Geologist, Deputy Minister in the Ministry of Climate and Environment, Government Plenipotentiary for the State's raw Material Policy

In Poland, we have taken a comprehensive approach to dynamising the use of the Earth's heat. The Multi-year Program for the Development of the use of Geothermal Resources in Poland, which was developed on the initiative of the Polish Ministry of Climate and Environment, is a holistic concept for the utilisation of geothermal energy in our country.

We have outlined a series of initiatives, which include utilising the potential of ground heat exchangers, as well as low-, medium- and high-temperature geothermal energy, storing heat in the geological formations, minimising investment risks in geothermal projects, research and implementation of innovative technologies as well as introducing the necessary legislative changes.

Such a holistic approach and systemising the development directions enables to carry out a large-scale publicly funded initiatives and pro-development actions, such as research works and pilot projects.

We want to boost geothermal energy utilisation by investing a significant funds from various sources to co-finance projects involving the construction of ground heat exchangers, new exploitation and injection geothermal wells, modernisation or construction of geothermal heating plants, implementation of new technologies to enable the efficient use of the Earth's heat.

The cost of measures planned to be implemented by 2050 was estimated at more than EUR 10 080 000 000.

Table of contents

1. Utilization of ground source heat pumps up to 30 kW and compressor heat pumps in systems of more than 200 kW.

(Implementation period: 2022-2050)

Low-temperature geothermal (so-called shallow geothermal) can be developed over most of Poland. Its application is very promising, especially for individual buildings or groups of buildings. Heat pumps can also be purposed for the production of cooling, which extends their annual operation time and increases economic viability.

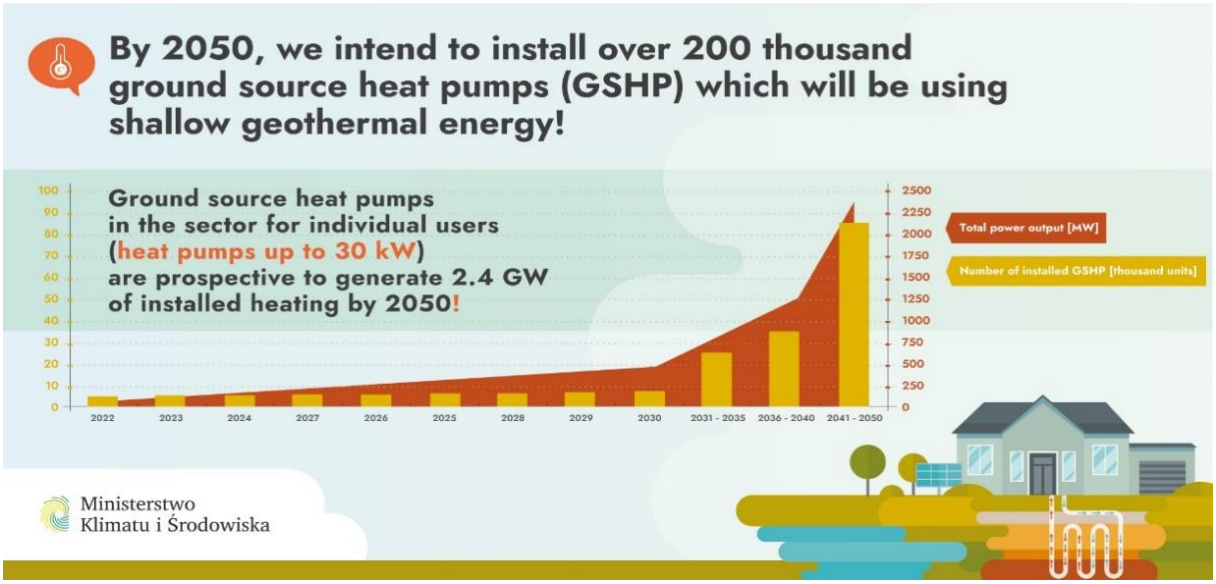


Figure 1. Increase in thermal power from heat pumps up to 30 kW to 2050.

The use of ground source heat pumps is also an important element of energy security. Their high efficiency means that they consume much less electricity than air-source heat pumps, thus avoiding large power draws from the grid (e.g., during heavy frosts, when using air-source heat pumps). When combined with photovoltaics (PV) and thermal energy storage, ground source heat pumps form a complementary and efficient district heating system.

Recommended actions:

1. Financial support specifically for large (>200 kW) and medium (30-100 kW) commercial, public, office and industrial installations.
2. Differentiation of financing rules for installations of different power: small installations (<30kW) - fixed subsidy amount; medium installations (30-100 kW) - subsidy amount dependent on the power of the installation; large installations (>200 kW) - subsidy dependent on the actual amount of energy produced.
3. Reversal of the financing scheme - a larger pool of funds will be allocated for the initial phase of investment, and over the years it will be successively reduced.
4. Increasing the degree of recognition of the thermal parameters of soils and rocks in the shallow parts of the rock mass (to a depth of 300 m).
5. To develop maps of the energy potential of shallow parts of the rock mass and maps of the risks associated with the use of ground source heat pumps, taking into account environmental (geological, hydrogeological) and anthropogenic conditions.

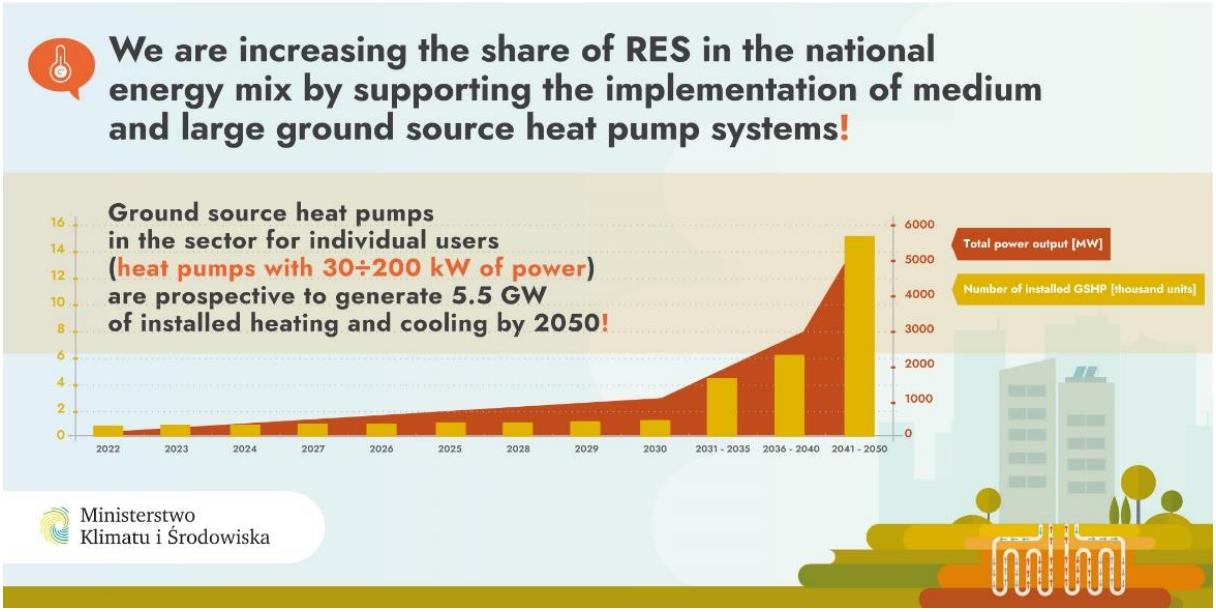


Figure 2. Increase in thermal power from heat pumps 30-200 kW to 2050.

2. Science, Technology and Business HUB - National Center for Geothermics and Heat Pumps.

(Implementation period: 2022-2026)

The Science-Technology-Business HUB is a space that integrates different areas of activities for effective support of the RES industry in Poland, especially the heat pump industry. The current stakeholders represent three areas: science and research, implementation, and government and local government institutions.

Figure 3. Resources of National Center For Geothermics and Heat Pumps.

Recommended activities:

1. Carry out research and development work in the following areas, among others: construction and implementation of high-power and high-temperature heat pumps; use of waste heat as a low-grade heat source; development of automation and control of heat pump systems, as well as integration of heat pumps with elements of building infrastructure.
2. Establishment and investment and operational financing of two experimental heat microproduction companies (distributed district heating network), based on micro heat sources, mainly heat pumps with the possibility of electricity from photovoltaic farms or other RES sources.

3. Utilization of low-temperature geothermal energy resources up to 45°C and above 45°C.

(Implementation period: 2022-2040)

Several levels of thermal water (also known as geothermal water) are present in an area of about 40-55% of the country, with temperatures in the range of 30-90°C. The indicated temperature range refers to the possibility of using geothermal energy in existing district heating systems in Poland. This would contribute to increasing the amount of heat from RES, as well as improving air quality in Polish cities.

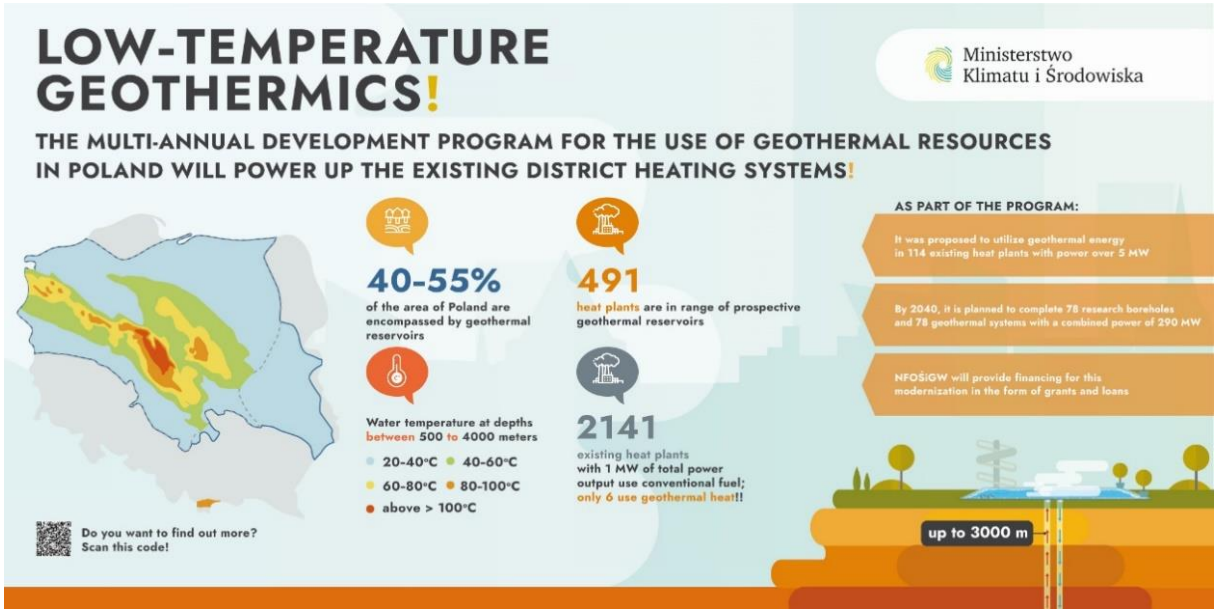


Figure 4. Geothermal potential in Poland.

There are 491 localities with commercial heating plants and company boiler plants with a capacity of more than 1 MW, and 78 localities with facilities with a capacity of more than 5 MW, which are located within the range of the most prospective geothermal water reservoirs, i.e. the Lower Cretaceous and Lower Jurassic. At least 114 geothermal plants have been selected for implementation, which could be important for the widespread use of geothermal energy.

Recommended actions:

1. Introduce mandatory systematic/annual collection of data from new geothermal boreholes and from existing and newly commissioned geothermal installations.
2. Development of an annual "Balance of water and geothermal energy resources," including, among other things, an update of exploitable, disposable resources and production volumes, and including information on, among other things, the use of geothermal energy, its share in the balance of energy generated from a given plant or the user of a geothermal heat pump.
3. Development of a "Guide to the rational management of geothermal resources", which is part of the "Balance of water and geothermal energy resources" and contains, among other things, information on the scope of the data compiled in the "Balance..." and the manner of their acquisition and use.
4. Construction of 78 test holes by 2040 and then 78 geothermal installations with a total geothermal power of 290 MW and generated geothermal energy of 9,949.6 TJ (implementation as part of the "Making thermal water available in Poland" program).
5. Application of elements of investment support in the form, for example, of reducing the financial burden of the credit part.

4. Use of high-temperature geothermal energy resources (above 100°C) - cogeneration facilities producing electricity and heat.

(Implementation period: 2022-2040)

This area is concerned with the development of binary systems, as well as EGS (*Enhanced Geothermal Systems*), including HDR (*Hot Dry Rock*) systems. Binary systems utilize thermal/hydrogeothermal water resources and the heat of dry rock, from which energy is transferred to a working medium circulating in a closed circuit in a surface plant, from which in turn electricity and/or heat is obtained. HDR systems and EGS (also referred to as induced geothermal/geothermal systems) use the heat of dry rocks or rocks with a small amount of reservoir water (brine) and water is injected into them. Studies conducted indicate three possible locations for HDR/EGS in Poland. Due to the very high costs associated with HDR/EGS technologies, development in this area may be significantly delayed. Combined systems (binary and HDR/EGS) are also possible.

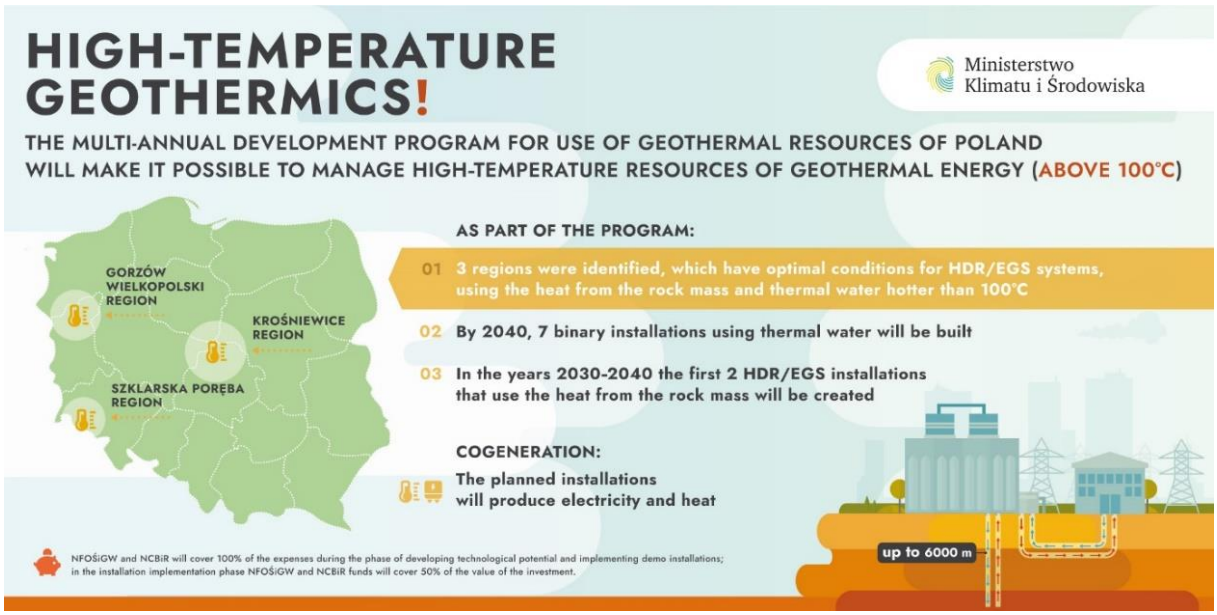


Figure 5. High - temperature geothermics potential in Poland.

Recommended actions:

1. Perform an update and assessment of resource potential for binary systems technology and HDR and EGS systems nationwide.
2. Develop assumptions for the use of HDR and EGS and binary systems.
3. Develop a feasibility study for HDR and EGS, including simulations of fracturing processes, preferably under reservoir conditions.

5. Use of shallow groundwater, mine water, surface water and waste water.

(Implementation period: 2022-2050)

Utilizable and non-utilizable aquifers, occurring at depths of up to about 100 m, whose temperature at the outflow of the intake exceeds 4°C, may play a significant role in this Area. The possibility of effective development of low-temperature energy from such waters depends on geological conditions, among other things. It is also possible to use water from mine drainage or submerged mine workings. A prospective solution is also the development of hydropower on process lines used, for example, for cooling of thermal power systems.

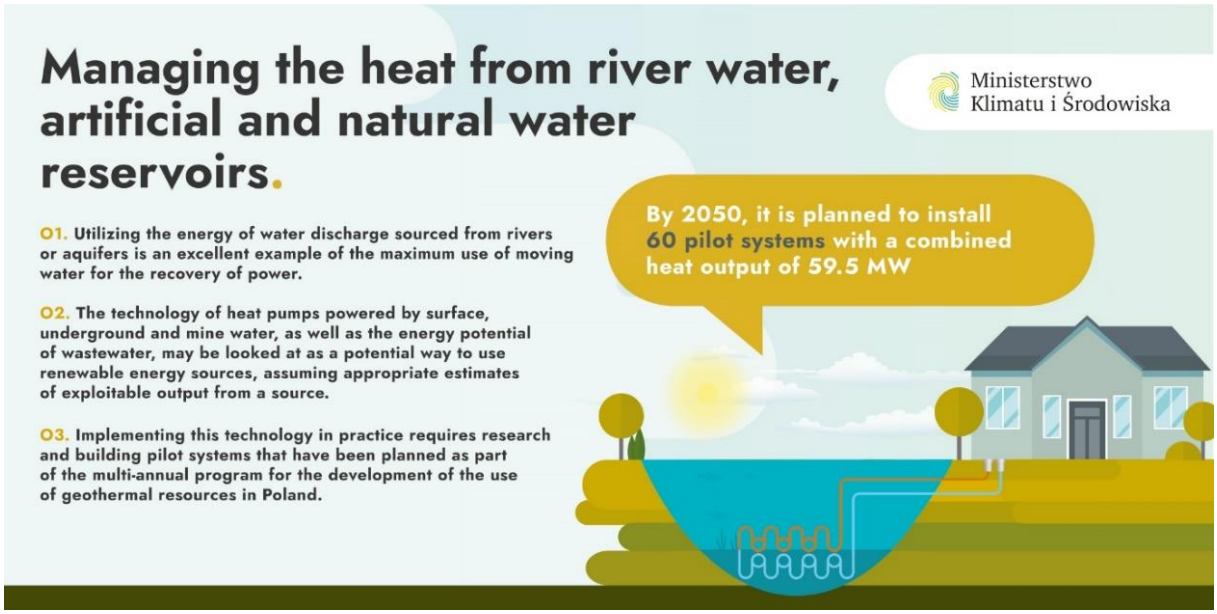


Figure 6. Pilot systems for usage heat of water reservoirs.

Recommended actions:

1. Estimate exploitable resources of water sources that can be used as renewable energy sources.
2. Conduct energy recovery (heat and electricity) from waste waters, including on process lines.
3. Locate water sources for heating purposes in the immediate vicinity of the heat consumer.
4. Promote the implementation of investments in the area of shallow groundwater heat utilization and to introduce preferential rules for the use of the Central Hydrogeological Data Bank.
5. Develop a guidebook on the use of the potential of surface water, groundwater (from unused aquifers) and mine and waste waters for heat recovery, together with the identification of the best locations for the implementation of pilot work in this area.
6. Carry out an experimental installation at the selected location for prototype research and dissemination of research results.
7. Introduce incentives for citizens and entrepreneurs interested in RES installations, including, among others, water-to-water heat pumps in the form of, for example, tax breaks or lower VAT rates for selected investments.
8. Streamline legal procedures related to the use of water heat.
9. Waive fees for the use of water for energy purposes.

6. Development of Deep Borehole Heat Exchanger Technology.

(Implementation period: 2023-2040)

Deep borehole heat exchanger (DBHE) technology uses existing boreholes for energy production purposes. Approximately 640 boreholes, each more than 1,000 meters deep, have been inventoried in Poland, and that can be considered for use with DBHE technology. In Poland, the technology has been used on a trial basis in the Jachówka 2K borehole in Malopolska province. The first DBHE project is being prepared.

Currently, DBHEs can work in cooperation with biogas, natural gas or fuel oil. In the near future, cooperation with solar energy may also be beneficial.

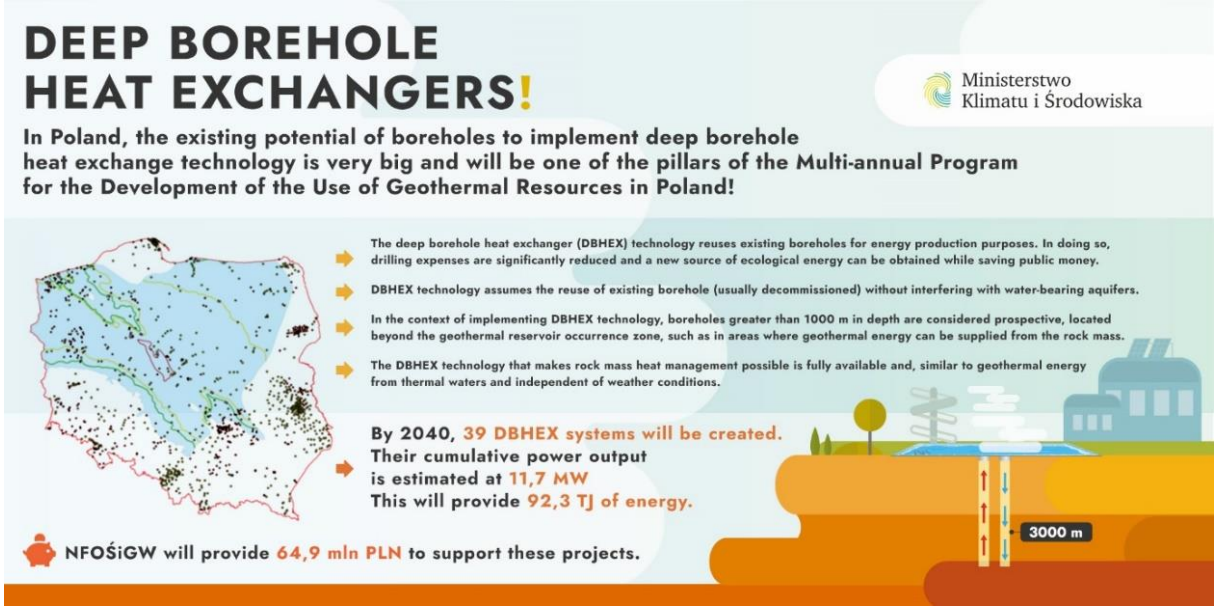


Figure 7. Localization of deep borehole in Poland (more than 1000 m depth).

Recommended actions:

1. Use of existing boreholes, usually decommissioned (this proposal requires legislative changes).
2. Fulfill the technical conditions of the boreholes and of existing potential heat consumers, regarding the criteria of: location, depth, design to allow for internal piping, completeness of documentation on the method of decommissioning and the results of tests conducted in piping, mainly in the direction of the technical condition of the pipes, assessment of their tightness, cementing conditions, degree of corrosion and other borehole geophysics tests.
3. Develop an assessment of the energy potential of existing boreholes for their initial selection and identification of up to 100-200 boreholes that meet the criteria of adequate technical condition. The study will include a multi-criteria assessment to identify the most promising locations for the implementation of DBHE technology (ultimately for about 50 locations).
4. Implement a DBHE pilot plant in a selected well to obtain the necessary empirical data required for the dissemination of DBHE technology.

7. Innovative technologies for storing heat in the rock mass.

(Implementation period: 2022-2050)

Heat and cold energy storage can balance the seasonal demand for heating and cooling power. A promising method is *Underground Thermal Energy Storage* (UTES), with some of the technologies developed based on it already in the commercial stage.

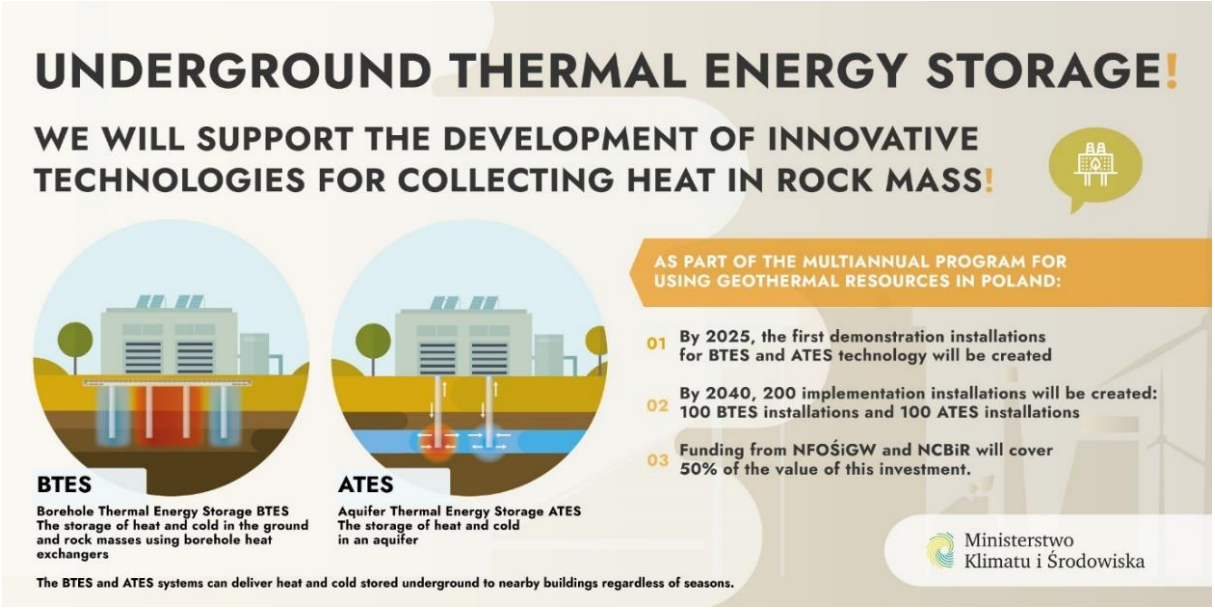


Figure 8. Energy storages for delivering heat and cold.

Borehole Thermal Energy Storage (BTES) technology uses borehole heat exchangers to store heat and cold, and involves alternating the storage and extraction of heat from the rock mass. The cycle of energy storage and extraction is seasonal, and the heat storage expiration period in BTES technology can last from 3 to 5 years.

Using ATES (*Aquifer Thermal Energy Storage*) technology, the system of low-temperature storage of heat and cold in the aquifer consists of drilling a minimum of one pair of boreholes, providing access to a selected aquifer, with one of these boreholes acting as a "cold" hole for cold storage, and the other as a "warm" hole - for heat storage. Poland has some of the best conditions in the world for implementing ATES technology in most areas.

Recommended actions:

1. Adaptation of current or creation of new formal and legal regulations enabling the development of underground heat storage, especially in the context of ATES technology.
2. Carry out a detailed analysis of geological, spatial, hydrogeological and climatic conditions, as well as technical and economic models for the cooperation of underground heat storage with the heat source, transmission network and potential heat consumers, taking into account different types (energy characteristics) of consumers.

8. Risk insurance program for geothermal projects.

(Implementation period: 2022-2050)

Geothermal work may be subject to investment risks, due, for example, to the failure to obtain geothermal resources with the designed parameters (resource risk) and other risk factors during exploration, drilling, testing and confirmation of these resources.

Financial instruments are already available in Poland - grants, loans and subsidies from public programs that mitigate or eliminate the financial impact of the risks that the investor bears or could bear at the investment stage. They are intended for investments at the beginning of development (investment stages: drilling, confirmation of resources) and for long-term geothermal heat installations.

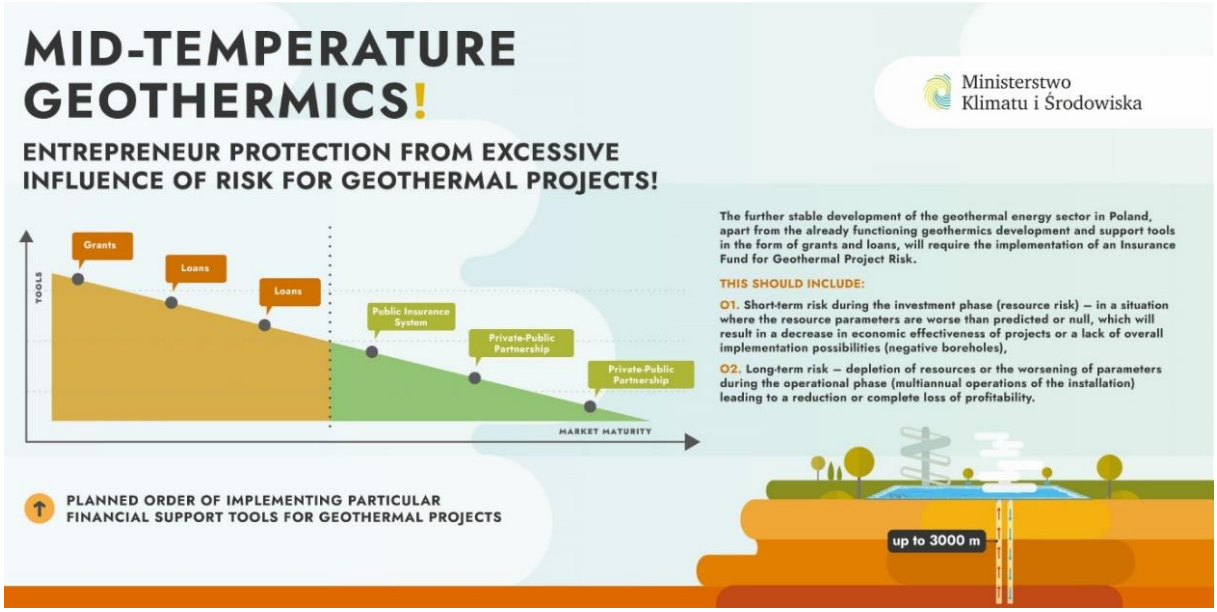


Figure 9. Protection of geothermal projects.

Recommended actions:

1. Establishment of a Fund for Risk Insurance in Geothermal Projects, which will take into account short-term risk at the investment stage (resource risk) and long-term risk - with depletion of resources or deterioration of their parameters at the operational stage.
2. Develop programs for insurance against short-term and long-term risks in geothermal projects, which will determine, among other things, the detailed organizational structure, sources and principles of financing the funds, formal aspects, legal aspects, management, assumptions, eligibility criteria for applications and payment of compensation.

9. Legislative changes, promotion and education.

(Implementation period: 2022-2050)

The conduct of work related to the exploration and extraction of thermal waters and the use of the Earth's heat, is regulated by the provisions of laws: *Geological and Mining Law, Energy Law, Water Law*, on renewable energy sources and energy efficiency.

In order to accelerate the development of geothermal energy in Poland, it is necessary to further adapt the laws governing it. Legislative work is currently underway on a draft law amending the *Geological and Mining Law* (UD280). The proposed changes include:

1. the jurisdiction of the geological administration bodies in matters related to the drilling of boreholes for the use of the Earth's heat,
2. use of existing boreholes for geothermal purposes,
3. adjustment of the scope of geological authorizations to conduct research work on the thermal potential of land and rock.

Figure 10. Promotional activities.

Recommended actions:

1. Introduce a zero or "symbolic" price for the purchase of geological information on deep boreholes planned for development for thermal purposes.
2. Maintain a 0 PLN extraction fee for thermal water until at least 2050.
3. The fee for the extraction of non-thermal waters including waters from open streams and reservoirs and from aquifers should be 0 PLN/m^3, provided that they are used for energy purposes and introduced after cooling into the aquifer/stream/reservoir.
4. Introduce a surcharge for the reduction of CO_2 emissions (expressed in the unit of energy GJ) on a similar basis to the currently applied fee for CO_2 emissions.
5. Require mandatory submission of geological and energy information by commercial geothermal system operators and private users of geothermal energy seeking a surcharge for CO_2 reduction.
6. Regulate the Law on the use of waste energy as RES.
7. Simplify the procedure for accessing data from the Central Hydrogeological Data Bank.
8. Facilitate the procedure for obtaining the relevant water permits.

9. Simplify the legal procedures under the *Geological and Mining Law* and the *Water Law* and others, also in terms of supplementing or updating existing laws of various ranks and adapting them to the specifics and needs of geothermics, which have been formulated and reported in recent years by the communities of specialists and practitioners from the geothermal industry.
10. Develop a guidebook recommended by the Ministry of Climate and Environment (MoC) to identify technical and technological solutions and constraints to the development of investments based on heat pumps.
11. Organize training courses and develop guides on heat pump installation for potential individual investors.

10. Summary.

The total estimated subsidy costs for **pts. 1-9** in the period 2022-2050 will amount to about **EUR 2,620.5 million**. Financing of the described tasks takes into account the funds of the Ministry of Climate and Environment, National Environmental Protection and Water Management, NCBiR, BOŚ, the Treasury, NPO, sources of the new financial prospects, e.g. FENIKS and modernization fund.

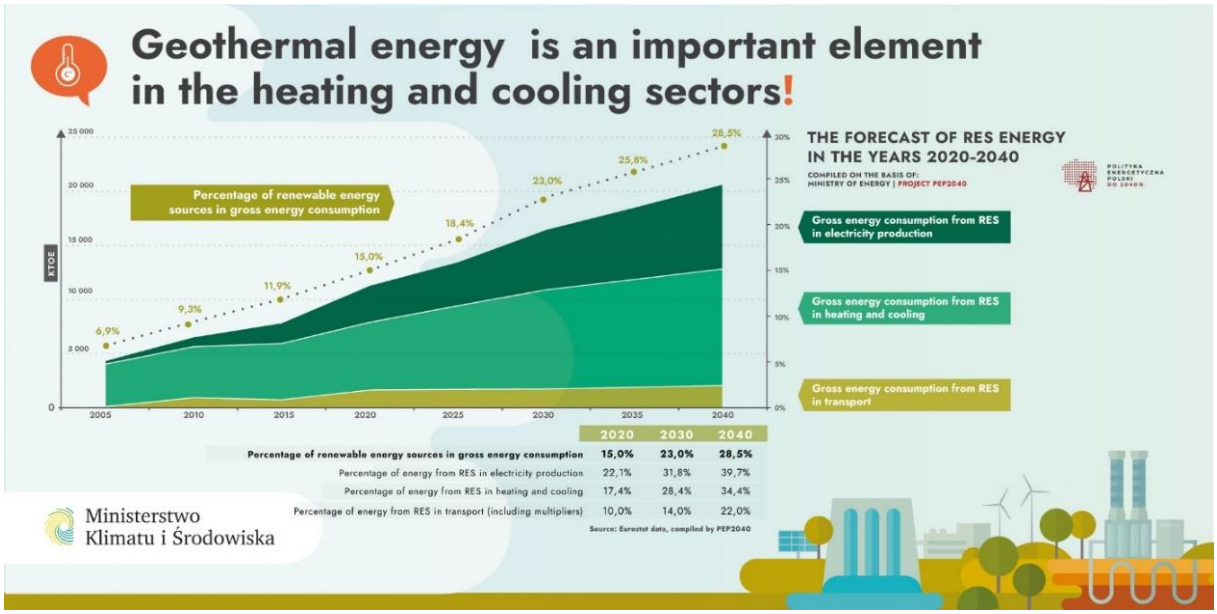


Figure 11. Assumed increase in geothermal energy.

The development of geothermics broadly based on private capital, taking into account the level of co-financing, may reach a value of **EUR 10,080 million** by 2050. Support in the form of co-financing for the investments listed in items 1-9 amounts to about 26% of the total value of capital involvement in the development of geothermal broadly based in Poland.

Total projected installation capacity: 8,559.5 MW_t and 7.6 MW_{el}.