

Development of the Polish geothermal sector in the light of current possibilities of financial support for a geothermal investment

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Abstract. Geothermal energy is an internal heat of the Earth, that is a prospective and sustainable source of renewable energy. In Poland, despite having significant amount of low-temperature geothermal resources, its share in the national energy mix remains marginal but growing. Currently, the utilisation of geothermal resources is related to hydrogeothermal resources, that are used mainly in space heating, recreation and balneotherapy. Nevertheless, the indication of potential electricity production is under research. The utilisation of geothermal resources entails a plenty of environmental benefits that are particularly important in the context of the present pollution problem. Therefore, the development of the geothermal energy sector is of relevant importance and with appropriate legal and financial conditions it may have a bearing on improvement of the environment's quality and, ipso facto, living in Poland. Thus, this paper presents numerous possibilities of obtaining a financial support for investments in geothermal energy sector. Selected funding and financial backing systems currently available in Poland are discussed. The importance of opportunity of obtaining a financial support for an investment as one of the crucial factors for the geothermal sector development is emphasised. Moreover, the examples of installations implemented in the country in the context of obtained funding are presented.

1 Introduction

Geothermal energy, as one of the renewable energy resources (RES), is considered clean, environment-friendly and independent from meteorological conditions. Generally, it is defined as the total amount of thermal energy (internal heat) accumulated inside the Earth, unequally around the globe. The most favorable conditions for the formation, and then occurrence of most prospective geothermal systems are connected to the rift and subduction zones [1]. There, the high-temperature geothermal (i.e. with temperature higher than 150°C at 1 km depth [1]) fields are located. In other cases, the term of low-temperature resources (i.e. temp. below 150°C at 1 km depth [1]) is employed. Conventionally, one can distinguish hydrothermal and petrogeothermal resources [2, 3]. Hydrothermal resources are water and/or steam reservoirs, that are categorized as liquid- or water-dominated respectively. By contrast, petrogeothermal resources are connected with hot dry (hardly dry) rock formation [2] and the utilization system of such a reservoir is called enhanced (engineered) geothermal system (abbr EGS) [4].

The development of the energy sector based on renewable energy sources is an extremely important issue of the energy policy of the European Union Member States [5]. This is due to greater care for the

protection of the natural environment, as well as an attempt to diversify internal energy sectors and improve the country's energy security. In 2016, the RES energy mix in Poland consisted mainly of solid biofuels (70.74%), wind energy (11.93%), liquid biofuels (10.16%), biogas (2.88%) and water energy (2.03%) and other (2.26%) [6]. The acquisition of geothermal energy accounted merely for 0.24% of all energy gained from RES [6]. Until now, the growth of Polish geothermal energy sector has been noticeable but insufficient considering the amount of geothermal resources and their energetic potential. Nevertheless, efforts currently taken by the government and academia might conduce to the intensification of development of geothermal energy sector in Poland [7].

2 Geothermal energy resources in Poland

Geological conditions of geothermal resources in Poland have been analyzed since the 80s of last century and geothermal waters have already found applications in heating, balneotherapy and recreation [8-11]. Those geothermal resources are related to underground waters of different stratigraphic layers (thereby various depths) within four major provinces that are subsequently: the Polish Lowlands, the Carpathians, the Carpathian

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Foredeep and the Sudetes (Fig. 1). Generally, they are natural sedimentary-structural basins filled with geothermal waters with relatively high temperature range, namely, from 20°C to about 90°C (even up to 100°C) at the depth between 1-4km [7]. Generally, the water flowrates (from a single well) vary from several to around 150dm³/s, whereas the total dissolved solids (TDS) of thermal waters differ

from 0.4g/dm³ to as many as 300g/dm³, depending on the province. The most prospective regions for a geothermal energy development in Poland are connected with areas characterized by a high value of heat flux and appropriate hydrogeological parameters, and are ascribed to the Polish Lowlands and the Podhale region, i.e. the Carpathian Geothermal Province [3].



Fig. 1. Geothermal energy provinces and installations in Poland (modified after [3]).

The Polish Lowlands is the largest (about 87% of the country) among geothermal fields within the country and it is characterized by the geothermal gradient varying from 2-3°C/100m. The highest capacity for a single well is 300m³/h, whereas the TDS of thermal waters amounts even to 300g/dm³. The major resources of geothermal waters are accumulated within the Mesozoic groundwater horizons – primarily in the Lower Jurassic and Lower Cretaceous formations but significant importance is ascribed also to the Upper Jurassic, Middle Jurassic, Upper Triassic and Lower Triassic formations [8]. Considering the Podhale region, the hydrothermal resources are assembled in the Mesozoic sedimentary formations – the most prospective aquifers occur within the Middle Triassic limestones and dolomites, as well as in overlying Eocene carbonates [3, 12]. The maximum temperature of reservoir is set as 90-95°C at the depth between 2 – 3.2km, and the (artesian) flow rates varies from several to even 500m³/h for a single well. The TDS of thermal waters are measured as 0.1-3.2g/dm³. The Fore-Carpathian Geothermal Province is less prospective in the context of possible utilization in heating but might find the successful application in recreation and/or balneotherapy. In the Carpathian Foredeep, low discharges (several m³/h) of single wells (in vast majority of aquifers) are observed, except from the Cenomanian reservoir (sandstones). In this case, the water capacity is expected to reach even 250m³/h and the temperature of geothermal waters varies from 30 to 100°C [3]. The TDS rises from the East to the West of the province, presenting values from 1-150g/dm³. Last

but not least – the Sudetic Geothermal Province differs from aforementioned areas, as geothermal waters occur only within the crystalline formations. The temperature of geothermal waters vary between 20 and 87°C, whereas, the average well capacity is about 10m³/h. Thus, this province is rather insignificant for a space heating sector, but has an important application in curing and therapeutic issues [12].

Poland is endowed with low-temperature hydrothermal resources, thus primary applications involve three fields: space heating, bathing and recreation as well as balneotherapy (Fig. 1). Nonetheless, the geothermal waters are also used in agriculture (e.g. production of pickled cucumbers in Uniejów), aquaculture (e.g. fish farming in Janowo) and for different industrial applications (e.g. production of cosmetics in Poddębice or wood drying in Podhale). In 2018, six geothermal district heating plants were operating: in Podhale region and municipalities of Pyrzyce, Mszczonów, Poddębice, Uniejów and Stargard. The total installed capacity amount to 76.2MWth, which gives production of 868TJ of geothermal heat [7]. Moreover, 17 recreation centers are located within the country, where geothermal water is used both for swimming pools and other facilities as well as for preparation of hot domestic water. Geothermal water is also utilized in 12 health resorts for curing and rehabilitation purposes. It is worth to be highlighted that numerous projects concerning distinctive geothermal aspects have been under development, including an indication if the utilization of

existing geothermal potential is feasible and sufficient for electricity production [13-15].

3 Geothermal energy in the Polish legislation

Currently, for the successful development of the geothermal energy sector in Poland, it is necessary to introduce a coordinated system of actions, namely the symbiosis of legal and administrative regulations with the simultaneous possibility of obtaining financial support for geothermal investments [16, 17].

Generally, Polish legislation regarding the use of energy from renewable sources, including geothermal energy, is strongly determined by the conditioning derived from the European Union [5, 18, 19]. Such regulations allow not only for proceeding the efficient, sustainable exploitation and utilization of geothermal energy, but also urge our country to take the following steps essential for the dynamic development of the broadly understood renewable energy sector. The most important internal legal act that regulates principles of the exploration, recognition and exploitation of geothermal reservoirs is the Geological and Mining Law [20], however, supported by numerous ministerial regulations. An extremely important step for the development of geothermal energy was the introduction of modifications in the Geological and Mining Law, aimed at facilitating the potential entrepreneur to conduct geothermal investments with simultaneous care for the natural environment [21, 22]. The fundamental changes concern the way of obtaining a concession—since 2012 acquiring the concession has been simplified from 3-stages long (subsequently for exploration, recognition and exploitation) to 1-stage long (only for exploitation) [20]. What is worth noting, the single-step licensing not only makes it easier for a potential entrepreneur to pursue legal and administrative proceedings, but also reduces the related costs. What is more, according to Ministry of the Environment's Announcement, the operating (zero) rate for extracting thermal waters has been maintained [23].

The important factor for the development of the geothermal energy sector in our country is also ongoing work on the strategic document State Resource Policy [24], which began in 2017. The paramount objective of the work is to secure the long-term economic and social needs of the country, resulting from the adopted priorities of Poland's economic development [24]. Geothermal energy was included in the second pillar of the project, i.e. Acquisition of raw materials from mineral deposits and the heat of the Earth [25]. The utilization of thermal water potential for heat production requires the introduction of a stable system for the noncurrent development of geothermal energy sector [25]. The State Resources Policy initiates activities aimed at the compilation of appropriate legal regulations, procedures for the assessment of geothermal installations' projects in terms of: optimal location, rational use of heat resources, avoidance of conflicts of interest and estimation of geological and economic risk

[25]. It is a fundamental document to intensify the development of the geothermal energy sector in Poland [7].

4 Financial support for a geothermal investment

The recognition of geothermal energy as one of the Polish Government's priorities in national energy and economic development has translated into the launch of a financial backing programs for geothermal investments, by the Ministry of the Environment [7]. The financial support for the Polish geothermal energy sector is provided mainly by the National Fund for Environmental Protection and Water Management (abbr NEEP&WM) [26]. The NEEP&WM is the pillar of the Polish system of financing distinctive projects aimed at effective and efficient environmental protection [26]. In the context of geothermal energy the main goal is set as utilization of geothermal energy resources for heating purposes and generation of electricity, for the period from 2014 to 2025 [26]. Three relevant programs are available for entrepreneurs in case of geothermal energy sector, namely: Geology and Mining – Part 1) *Recognition of the geological structure of the country and management of mineral deposits and groundwater resources*; Improvement of Air Quality – Part 1) *Energy use of geothermal resources*; Operational Program Infrastructure and Environment – Activity 1.1. *Supporting the production and distribution of energy from renewable sources* (co-financed from the Cohesion Fund) [26]. These priority programs of the NEEP&WM fit into the national energy policy that is aimed at increase the share of RES in the energy mix and promote green energy, including geothermal resources, simultaneously, reducing or even covering the costs of potential geothermal investment.

4.1 Geology and Mining Program

The Geology and Mining program – Part 1) *Recognition of the geological structure of the country and management of mineral deposits and groundwater resources* [26] is aimed at the exploration and recognition of geothermal resources within the country – both hydrothermal and petrogeothermal resources. The program is addressed to private entrepreneurs (from micro to large businesses) and territorial self-government units. In this priority program, grant is the form of financing, however its amount depends on the kind of beneficiary. Projects implemented by the territorial self-government units may apply for a subsidy of up to 100% of eligible costs, whereas enterprises may receive 50% of eligible expenditure. Nevertheless, there is the possibility to increase the co-financing value for entrepreneurs by 10%, in the case of medium-sized enterprises and by 20% for small and micro-businesses. The obtainment of the financial backing is conditioned by accomplishment of formalities, submitting an application as well as appropriate documents. The basic conditions that are put before the applicant for the

financial support from the NEEP&WM include having an approved Project of Geological Work (consistent with the Geological and Mining Law), analysis of the conditions for the use of geothermal resources and tenure of land. It is also essential to obtain a positive opinion regarding the project issued by the Ministry of the Environment and do not begin the implementation of the geothermal investment before submitting the application for the financial support. Call for proposals is on a continuous basis until 11/30/2018 or when the funds are exhausted.

4.2 Improvement of Air Quality Program

The Improvement of Air Quality program – Part 1) *Energy use of geothermal resources* [26] is aimed at the construction of a new and/or extension of the existing geothermal Heat and Power Plant and District Heating Plant, revitalization of an old borehole as well as drilling an injection well (with the proviso that the construction of the test hole is not possible). In the case of this program, there are two different ways of financial backing, namely, loan or capital investment. The co-financing in the form of loan can amount to 75% of eligible costs, while in the case of capital investment it can cover up to 85% of eligible expenditure. In the first case, the loan can amount to 1-90 million PLN in two forms of lending rate: market conditions or preferential terms (with reserve of maintaining the value not lower

than 2% p.a.). The loan is allocated for a period of 15 years without the possibility of remission. The financial support in the form of capital investment is available only for owners of private limited company or joint-stock company. It should be noted that the share of funds raised from the NEEP&WM should not exceed 49% of nominal capital. Also, the capital investment ought to transcend 3 million PLN. As in the case of loans, the co-financing period cannot be longer than 15 years. Call for proposals is on a continuous basis until 12/28/2018.

4.3 Operational Program Infrastructure and Environment

Operational Program Infrastructure and Environment – Activity 1.1. *Supporting the production and distribution of energy from renewable sources* [26] comprises the construction of a new geoDH Plant (together with connection to the DH network) or enhancement of thermal power of yet operating geoDH (thermal capacity higher than 2MWth). The chance for getting financial support for electricity production has been excluded. The highest co-financing possible to obtain is 85% of eligible costs, and single entrepreneur can receive maximally 15 million PLN. Submitted projects are to be evaluated in terms of decrease in the level of carbon dioxide (CO₂) emission per unit of the financial backing and the economically justified rate of co-financing amount to the obtained capacity. Call for proposals finished in 2017.

Table 1. Geothermal projects financed from the NEEP&WM funds, within the Geology and Mining Program (based on [7, 26-31]).

	SZAFLARY	ŁĄDEK-ZDRÓJ	SOCHACZEW	SIERADZ	KOŁO
Subject matter	Exploitation of geothermal resources	Recognition and exploitation of geothermal resources	Recognition and exploitation of geothermal resources	Recognition and exploitation of geothermal resources	Recognition and exploitation of geothermal resources
Planned scope of operation	Generation of electricity; space heating	Space heating; balneotherapy; agriculture; and other	Space heating; drinking water	Space heating; balneotherapy	Generation of electricity; balneotherapy
Depth of well	5.3 km	2.5 km	1.4 km	1.5 km	3.6 km
Expected temperature	130°C	80°C	40°C	62°C	100°C
Reservoir formation	Eocene (nummulite) and Mesozoic	Metamorphic of Łądek and Śnieżnik	Lower Cretaceous (sandstones)	Lower Jurassic (sandstones)	Lower Jurassic and Lower Cretaceous (sandstones)
Investment costs	45 M PLN	19 M PLN	11 M PLN	10.6 M PLN	22.15 M PLN
Financial support	45 M PLN	19 M PLN	11 M PLN	10.6 M PLN	22.15 M PLN
Predicted completion time (year)	2021	2019	2020	2018	2018

4.4. Effects of Financial Support from the NEEP&WM

The rational effect of the programs implemented by NEEP&WM [26] is the implementation of new

geothermal investments and increase in the efficiency of existing installations in Poland.

Until now, 30 applications for the financial support for geothermal investments have been received under the Geology and Mining program, 17 have received a

positive opinion and 6 of them (towns of Szaflary, Łądek-Zdrój, Sochaczew, Sieradz, Koło, Tomaszów Mazowiecki) have signed agreements with NEEP&WM, the others are still waiting for the decision of the Main Geologist of the Country. The five aforementioned beneficiaries were given acceptance and financial support covering 100% of eligible costs – summarily 107 million PLN. Among the approved geothermal investments (Tab. 1), there are projects aimed at the realization of: research and exploitation borehole Bańska PGP-4 (Szaflary), explorative well Koło GT-1 (Chojny), exploratory well LZT-1 (Łądek-Zdrój), explorative borehole Sochaczew GT-1 (Sochaczew) as well as recognition and documentation of thermal water resources in Sieradz.

Within the program implemented by the National Fund for Environmental Protection and Water Management and financed from the Cohesion Fund, a positive evaluation were given to 14 projects – 9 of them were recommended for obtaining a financial support, including 4 concerning the utilization of geothermal energy. This group of beneficiaries includes Geotermia Toruń with the project *Construction of a geothermal DH plant in Toruń using the existing TG-1 and TG-2 wells*, Geotermia Podhalańska which plans to increase the operating capacity, G-Term Energy with application for proceeding geothermal wells’ drilling (4 pcs.) in Stargard and the last project concerning the extension of the Bania tourist complex together with the construction of a geothermal DH plant (Tab. 2).

Table 2. Geothermal project co-financed from the NEEP&WM within the Operational Program Infrastructure and Environment (based on [7, 26, 27, 32, 33]).

	GEOTERMIA TORUŃ	GEOTERMIA PODHALAŃSKA	G-TERM ENERGY	BANIA TOURIST COMPLEX
Town/Region	Toruń	Podhale	Stargard	Białka Tatrzańska
Subject matter	Construction of a geoDH plant, connection to the distribution grid	Extension of the geothermal system (+10MWth)	Geothermal wells’ drilling (4 boreholes)	Construction of a geoDH plant, with pipelines and distribution equipment
Planned scope of operation	Space heating; balneotherapy	Space heating	Space heating	Space heating/cooling
Investment costs	40.3 M PLN	32.7 M PLN	-	-
Financial support	19.5 M PLN	12.2 M PLN	40.1 M PLN	2.1 M PLN

5 Conclusion

Geothermal energy, being one of RES, is considered clean, abundant and reliable source of energy that can be utilized in numerous manners – heat and electricity production, recreation, balneotherapy and various industrial applications. Poland, besides being endowed with low-temperature (<150°C) geothermal resources, geothermal energy is a marginal contributor to the national energy mix (0.24%). Nevertheless, due to the implemented changes within the internal legislation (i.e. the Geologic and Mining Law, the State Resources Policy) and introduction of financial support (provided by the National Fund for Environmental Protection and Water Management, abbr NEEP&WM) for geothermal investments, the increased development of the geothermal energy sector can be observed. So far, financial support from the NEEP&WM – within programs Geology and Mining (Part 1) and Operational Program Infrastructure and Environment, has been allotted to 10 beneficiaries, among which there are communes: Szaflary, Koło, Łądek-Zdrój, Sochaczew, Sieradz, Tomaszów Mazowiecki and investors: Geotermia Toruń, Geotermia Podhalańska, G-Term Energy and Bania tourist complex. The total amount of currently granted funding exceeds 180 million PLN.

The increase in the utilization of geothermal energy resources and technologies’ development might help to fulfill important economic, environmental and social objectives in Poland. It can also reduce the dependence

on fossil fuels, providing the country with the energy security and conducing to the diversification of internal energy resources. What is more, geothermal energy resources might be an efficient way for the sustainable development of our country with simultaneous economic growth.

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