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Present situation of geothermal energy development in Poland

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ABSTRACT

Poland has low-enthalpy resources predominantly found in **three** extensive geothermal Provinces: the Polish Lowland, the Fore-Carpathians and the Carpathians. Geothermal share is local, but in many places it can be important for environmental reasons. The direct **uses** are to concentrate on space heating, horticulture, fish farming, balneology and recreation. In 1999 two heating plants were on-line. In the Podhale Region, the plant supplied ca. 220 houses and cascaded **uses'** objects. The large-scale heating project has been developed there since the end of 1980s. In Pyrzyce town, the heating plant opened in 1996 served ca. 12,000 customers. **The** pilot plant in Mszczonow town was to start in 1999. In 1997 geothermal drillings began in the Sudetes Mts. In 1995-1999 numerous utilisation projects have been prepared. The growing interest was observed in geothermal heat pnmps. Basic researches and high education have been gradually developed.

KEYWORDS

Geothermal resources, direct **uses,** Poland

1. Introduction

Poland is rich in low-enthalpy geothermal resources. In 1992, the opening of the Experimental Geothermal Plant in the Podhale Region was a milestone in wider geothermal **use** in the country (SOKOLOWSKI 1993). **The** second plant started in 1996 in Pyrzyce town. During 1995-1999 the Podhale space heating project has been under constant progress, along with the works on cascaded uses. The third plant was to **start** in 1999 in Mszczonow town. Further exploration, feasibility studies and utilisation projects have been prepared. Despite of large resources, geothermal is prognosed to have local share in the Polish energetics. The main benefits of its **use are** environmental by limitation of emissions generated by coal-based heating systems. Among the main constraints of its development there are low prices of traditional energy carries and insufficient financial support. From the

other hand, it should be promoted in the view of admission to the European Community, as Poland must fulfil many preconditions, in that the practical **use** of renewables and reduction of pollutants caused by fossil fuels combustion.

The paper presents geothermal development in Poland in last several years, by 1998-1999. Previous activities were reported on international forum by e.g. SOKOLOWSKI(1995).

2. Potential geothermal resources

Over 80% of the Polish territory is built of geostructural sedimentary basins with numerous geothermal aquifers. The following geothermal Provinces and Regions were distinguished within the country (SOKOLOWSIU 1993,1995; figure 1 and table 1).

- The Polish Lowland Province (part of the Central European Province): with seven Regions (Lower Palaeozoic-Cretaceous). The reservoir temperatures range from 30 to 130°C (1-3 km of depth). The Total Dissolved Solids **(TDS)** range from 1 to 300 g/l. Geothermal resources have been estimated for over 6,225 km^3 water with thermal energy equal to 32,458 mln toe.
- The Fore-Carpathian Province: with, geothermal aquifers in Mesozoic-Tertiary formations. The reservoir temperatures range from 25 to 50°C. The TDS is variable, fiom several to ca. 100 g/l. Geothermal water resources have been estimated for 361 km^3 with thermal energy equal to 1,555 mln toe.
- The Carpathian Province: with geothermal aquifers in Mesozoic-Tertiary formations. The TDS range fiom 0.1 to ca. 100 g/l. Geothermal water resources have been estimated for 100 km^3 with thermal energy equal to 714 mln toe.
- The Sudetes-Holy Cross Region: with limited possibility of geothermal aquifers' occurence (fractured Precambrian and Palaeozoic crystallinic rocks).

For the above Provinces, the proven geothermal reserves (evidenced on the basis of flow tests from numerous wells) amount from several l/s up to 55-150 Vs of geothermal water.

Geothermal resources calculated according to the methodology recommended by the Geothermal Atlas **of** Europe (as well as the present state of geothermal exploration in Poland) will be given in its new edition (under preparation).

The terrestrial heat flow values amount to 20-90 W/m^2, while geothermal gradients **are** in the range of 1-4°C/100 m (SOKOLOWSKI ed. 1995).

Considering the prices of traditional energy, feasible geothermal plants can be built in ca. 40% of Polish area. Preference is given to the following aquifers: max. depth 3 km, min. flowrate 27-40 l/s, temperatures 65°C. Such conditions are frequent in the Polish Lowland (GORECIU ed. 1995; NEY, 1995), while in other provinces are of local character.

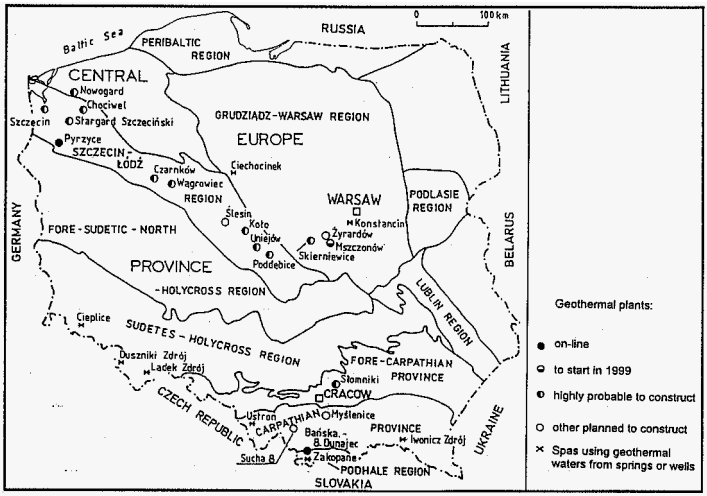

Figure 1: Geothermal resources in Poland (based on SOKOLOWSKI, 1995)

3. Exploration activities

The major work on geothermal resources in Poland was conducted in 1980s. It was based on data fiom over 7,000 wells, extensive geological, hydrogeological and geophysical survey during former decades (SOKOLOWSKI, 1995). In 1995-1999 new data were obtained fiom drillings and other works. Detailed exploration focused on the most prospective areas of the Polish Lowland Province and on the Podhale Region. In 1997, geothermal successful drilling started in Cieplice Resort (the Sudetes Mts.; geothermal prospection was initiated there in 1970s; DOWGIALLO, 1991). Further production drillings are planned to start in 1999. Generally, in 1995-1999 three deep (2.5-3.5 km) production wells were drilled; *two* wells in the Podhale Region and one well in Skierniewice town (the Polish Lowland). One well drilled in 1970s was tested and adapted for geothermal exploitation (Mszczonow town).

One well was deepened fiom 660 m to 2002 m and tested (Cieplice Spa, the Sudetes Mts.). Apart from the listed works, in 1995-1999 there have been prepared several estimations of thermal potential and utilisation projects for the wells previously drilled which revealed geothermal aquifers. The adaptation of the abandoned wells will result in saving

Geothermal provinces and regions	Surface (10^3 km^2)	Water resources (km^3)	Thermal energy in waters (10^6 toe)*
POLISH LOWLAND PROVINCE (CENTRAL EUROPE)	222	6,225	32,458
1. Grudziadz-Warsaw Region	70	2,766	9,835
2. Szczecin-Lodz Region	67	2,854	18,812
3. Fore Sudetic-North Holy Cross R.	39	155	995
4. Pomorze Region	12	21	162
5. Lublin Region	12	30	193
6. Peribaltic Region	15	38	241
7. Podlasie Region	7	17	113
FORE-CARF'ATHIAN PROVINCE	17	361	1,555
CARPATHIAN PROVINCE	12	100	714
TOTAL	251	6,687	34,727

4. Geothermal direct use

In 1995-1999, geothermal direct use in Poland was on very limited scale. It focused on space heating, balneology\bathing, while other **uses** (greenhousing, drying, fish farming) were conducted on semi-technical scale. Two heating plants were on-line: in the Podhale Region and in Pyrzyce town. The third plant in Mszczonow town was expected to start in 1999. In eight localities warm waters from springs or wells were used for bathing and balneology (figure 1). At the end of 1998 the installed geothermal capacity totalled ca. **36** MW_t and the energy use was 162 TJ/yr, including ca. 120 TJ/yr for space heating purposes (table 2).

What concerns geothermal heat pumps, in Pyrzyce Plant two such devices (20.4 MW_t) produced 40 TJ/yr of thermal energy. In the Podhale Plant, the heat pump operated on experimental scale only. In 1997, in the Upper Silesian Coal Basin it was installed the first 0.06 MW_t heat pump based on **16-19°C** ventilation air from the underground mine. The

raising interest was observed in the ground and groundwater heat pumps. In 1998 over 400 devices were on-line, with the capacity ca. 6.4 MW_t and heat production 65 TJ/yr.

The total investments in geothermal sector in Poland in 1995-1998 can be estimated as 50 mln US$. They were financed fiom the Polish means (National Fund for Environmental Protection and Water Management, Ecofund, Committee for Scientific Researches, counties, cities, geothermal companies) and fiom the foreign sources (PHARE, World Bank, Danish, Italian, German means).

Table 2: Summary of geothermal direct uses in Poland (end of 1998)

Type of use	Installed thermal power (MW_t)	Energy use (TJ/yr)
Space heating	21	120
Bathing and swimming	8	34
Greenhouses, fish farming, drying	1	7
Other - extraction of CO_2, salts	6	1
SUBTOTAL	36	162
Heat pumps (geothermal, groundwater)	27	110
TOTAL	63	272

4.1 Space heating

THE BANSKA-BIALY DUNAJEC PLANT (THE PODHALE REGION)

The construction of a large-scale geothermal heating network has been developed since the end of 1980s (SOKOLOWSKI, 1993, 1995). It will benefit in elimination of 300,000 t coal/yr and over 80% of the gas and dust emissions generated in the Region due to coal burning. The main artesian aquifer occurs in the Eocene and Mesozoic carbonates (depths of 2-3.5 km). The reservoir temperatures reach up to 80-100°C (at the wellheads up to 82-93°C); flowrate ftom a single well 55-150 l/s; TDS of 0.1-3 g/l; wellhead static pressure 27 bar. In 1993 several houses started to be supplied with geothermal heat from the PAS Experimental Geothermal Plant Banska-Bialy Dunajec. In 1994, the Geotermia Podhalanska Co. was established in order to further construct the heating service. In the end of 1998 it served over 220 houses (16 TJ/yr). So far, the network bases on a doublet of the production and injection wells. The flowrate amounts 8-16 l/s of 76-80°C water. The maximum power is ca. 9 MW_t geothermal (water cooled down to 20°C). Geothermal heat is transmitted to 65-78°C district heating water via the heat exchangers. In 1996-1998 there have been completed by the Geotermia Podhalanska Co.: two exploitation wells (2.5-3.2 km deep; 150 l/s artesian flow of 86°C water); 50 MW_t geothermal base load plant; central peak heating plant in Zakopane (22 MW_t fiom gas, increased to 50 MW_t after geothermal heat will be provided); part of transmission pipeline (total lenght 14 km) linking these two

plants. Heat supplies will base on geothermal (gas boilers in peak periods). By the end of 1998 ca. 25% of all customers in Zakopane (30,000 population) were linked to new central peak heating plant. To the year 2001 geothermal will be delivered to ca. 4,200 individual houses and 170 large-scale receivers in the central part of the Podhale. The project is financed by the Polish and foreign means. The semi-teclmical cascaded **uses** have been conducted by the PAS MEERI Geothermal Laboratory. The system consists of the heating network (operated by the Geotermia Podhalanska Co.); space heating and domestic water service in the Laboratory objects; wood drying; greenhouse; fish fanning; foil tunnels for plants' growing on heated soil. In 1996-1998 two R&D projects on geothermal use to vegetable growing, fish farming, and monitoring system were completed (financed by the Committee for Scientific Research).

THE PYRZYCE PLANT

The plant in Pyrzyce town (13,000 population) was opened in 1996. It replaced 68 traditional heating plants (20,000 tonnes of coal/yr). The aquifer (Lower Jurassic sandstones at the depths of 1.5-1.6 km) is tapped in two production and two injection wells. The maximum flowrate is **103** kg/s of 61°C water. The TDS amounts to **120** g/l. The maximum installed power is 50 MW_t, including 13 MW_t geothermal while the rest (37 MW_t) comes from heat pumps and condensation gas boilers. It operates as an integrated system: heat exchangers-absorption heat pumps-gas boilers. The plant supplies central heating (95/45°C) and domestic warm water to 12,000 customers (SOBANSKI, 1998). In the coming years geothermal will be also used for recreation and agriculture.

MSZCZONOW: THE PLANT UNDER CONSTRUCTION

For many localities in the Polish Lowland, the utilisation projects were elaborated in 1980/90s. The most advanced is the project for Mszczonow town (6,000 population). The geothermal aquifer is located in the Lower Cretaceous sandstones, TDS is below 1 g/l. In autumn 1999 the pilot plant was to be put into operation. Its novelty lies in the **use of** 40°C water discharged by a single well both for heating and drinking water production: the extracted heat (by the heat exchangers and absorption beat pump) will be used for heating, while cooled geothermal water will be used as potable **one.** In 1996-1997, a 4.1 km well drilled in 1970s was tested and adapted for exploitation. The project was financed by the Committee for Scientific Research and the Mszczonow county; the R&D works conducted by the PAS Geothermal Laboratory.

4.2 Balneology/bathing, *other uses*

In 1998, eight out of 36 Polish spas used 20-62°C waters from springs or wells for balneology and bathmg (figure 1). **In** Duszniki Resort (the Sudetes Mts.) there is on-line an installation for CO_2-extraction from 20°C water discharged by shallow well. **In** Iwonicz Resort (the Carpathian Province), a 21°C brines produced by two wells *are* used for extraction of iodine-bromine medical and cosmetic salts.

4.3 Allocation **of** professional personel, researches, education

In the end of 1998, over 100 Polish professional personel was working in geothermics. In 1995-1998, it was supported by some 50 foreign specialists and consultants.

To the broadest extent, geothermal researches and R&D activities are developed by the PAS MEERI, Cracow, the University of Mining and Metallurgy, Cracow, then by the Technical University, Szczecin, the Silesian University, the Polish Geological Institute. The investments are realized mostly by the commercial companies.

The lectures on geothermics were introduced at the University of Mining and Metallurgy, Cracow, the University in Lodz and at Postgraduate Environmental Studies. The courses of the Polish Geothermal School are organized by the Polish Geothermal Association.

5. Future activities

In 1995-1999 there were prepared feasibility studies, R&D and utilisation projects for many Polish voivodeships, regions and localities. They often make use of the abandoned wells, cascaded and integrated systems. Their realization is conditioned by financial factors, ownership and legal-regulations. There also exists the perspective of being financed from the European Community and other funds.

In the coming years, the major geothermal investments are foreseen as follows.

- Mszczonow town: in 1999 opening the pilot plant (water production from a single well for heating and drinking purposes); construction of the recreation centre.
- The Podhale Region: further construction of the geothermal heating network; construction of two big recreation and balneological centres.
- Pyrzyce town: development of other uses along with the space heating system on-line.
- Uniejow town: in 1999 beginning the construction of the recreation centre and heating network (in autumn 1998 there were made the flow tests, technical works on surface equipment and monitoring system of geothermal well drilled in early 1990s).
- Slomniki town: construction of the recreation centre (supplied with geothermal water from the abandoned well adapted for exploitation purposes).

Several other space heating-oriented projects are probable to start in the towns located mostly within the Polish Lowland Province (figure 1). Among other activities to be undertaken there are drillings in Cieplice and Duszniki Resorts (the Sudetes Mts.) followed by utilisation of hot waters for balneology; works on adaptation of the abandoned wells for geothermal purposes; the geothermal heat pumps' development, R&D works on the borehole heat exchangers; studies on potential and utilisation of geothermal energy stored in the Upper Silesian Coal Basin.

6. Sustainable energy policy

The Polish energetics is based on coal (70% of primary energy production) and hydrocarbons. The share of all renewables including geothermal in energy production is prognosed to reach several percentages in the years 2015-2020 as compared to the maximum 15-20% for European Community countries assumed by the ALTENER Programme. Such a situation has been predicted despite large geothermal resources of Poland. Among the key reasons which influence the prognosis there are low oil, coal and gas prices. In some places, however, the scope of geothermal use can achieve considerable sizes, being significant factor for the local energy market and environmental protection. Geothermal progress should be enhanced by the new Energetics Law which makes the local administrationsresponsible for managing the space heating sector, also with the use of local energy sources. Moreover, geothermal should be preferred in Poland in the View of admission to the European Community, because the country is obliged to use the renewable energy and to reduce the present level of the dust and gas emissions.

Recently, geothermal started to be treated as an important agent of the sustainable regional development strategies. It is perceived as an attractive factor stimulating new trends in horticulture (especially in the terms of variable climatic conditions in the country), agrotourism and recreation sector, local employment market.

And, last hut not least, geothermal energy should he developed in the view of necessity to limit the traditional resources' mining and their preservation for future generations.

7. Conclusions

1. In 1995-1999 further progress was made in Poland in exploration and utilisation of rich low-enthalpy geothermal resources. Although prognosed as a local energy source, their use will benefit in reduction of pollutants generated by traditional heating systems.

2. Geothermal use was on limited scale. It focused on space heating and balneology, while other uses were on semi-technical size. In 1998 the installed geothermal capacity totalled ca. 36 MW_t and yearly heat production ca. 162 TJ/yr. Two geothermal heating plants were on-line (the Podhale Region and Pyrzyce town) serving ca. 13,000 customers (120 TJ/yr). In 1999, the third plant was to be put into operation in Mszczonow town.

3. In 1997, the successful1 geothermal deep drillings started in the Sudetes Mts. The research and first attemps to extract heat stored in underground mines in the Upper Silesian Coal Basin were initiated.

4. Many feasibility studies, R&D and utilisation projects has been prepared for regions and localities. They often make use of the abandoned wells, cascaded and coupled systems.

5. Future activities comprise continuation of the investments on-line, realization of several new projects along with the progress in exploration, R&D works and education.