Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

Geothermal Energy Country Update Report from Poland, 2005 - 2009

Beata Kępińska

AGH – University of Science and Technology, Faculty of Geology, Geophysics & Environmental Protection, Fossil Fuels Dept. Kraków, Poland

Mineral and Energy Economy Research Institute – Polish Academy of Sciences, Kraków, Poland
E-mail: bkepinska@interia.pl

Keywords*:* geothermal energy, direct uses, country update, Poland

ABSTRACT

Poland is characterized by low-temperature geothermal resources connected mostly with the Mesozoic sedimentary formations. Since the 13th-14th centuries warm springs have been used for balneotherapy in several spas. The activities aimed at geothermal heating development were initiated in the 1980s. So far five geothermal heating plants have been operating (one of them was launched in 2006, i.e. during the period reported in this paper). It is worth to note seven new bathing centers opened in the years 2005 - 2009. Other types of uses comprise R&D greenhousing, wood drying and fish farming, salts' extraction from geothermal water. As to the geothermal heat pumps sector, further progress has been made but it is very difficult to give accurate figures since no general database has existed so far. In two heating plants absorption heat pumps have been working. In 2008 they totalled in about 23.1 MW_t and 44.5 TJ. In case of ground-source and groundwater heat pumps a constant growth has been observed; one may roughly assume that the installed capacities and heat production totalled in not less than ca. 180 MW_t and 1000 TJ/2008.

The total installed geothermal capacity (heat pumps including) at the end of 2008 was ca. 281 MW_t while heat sales about 1501 TJ (comparing to 170.8 MW_t and 838.3 TJ /2004, as presented at WGC 2005).

Five new deep geothermal wells (1.8 – 3.2 km) were drilled in 2005 – 2009. The encountered ca. 28 - 80ºC waters are planned to be applied for heating or/and for bathing. The investments were accompanied by basic research, feasibility studies, some technical works, several projects of new drillings and implementation projects for public and private entities. In some cases geothermal is proposed not only as exclusive energy source but in integration with other renewables or traditional energy sources.

Among prospective future options are: adaptation of abandoned wells; multipurposed, integrated systems; heat pumps; heat extraction from the underground mines (the latter still not in a realization stage). Like in other countries, the studies and first R&D started on possibility to produce electricity in binary schemes (using ca. 90 – 120ºC waters).

1. INTRODUCTION

The paper presents the status of geothermal development in Poland during 2005 – 2009 since the previous update report at WGC 2005 (Kepinska, 2005). In 2005 – 2009 some projects mentioned at this event were finished and some other were underway. There is also an increase of experience gained during the plants' operation as well as the growing number of new studies and projects.

Geothermal use for heating purposes in the country was initiated in the last decade of the 20th century. The experimental stage of the first geothermal plant was opened in the Podhale region in 1992 (Sokolowski et al., 1992). Since that time five other plants have been launched, including one of them in the reported years 2005 – 2009. Space heating is a key sector for geothermal. It is also worth to notice a growing interest in recreation and balneotherapy what has been expressed by seven new centres open in recent years. Wide-ranging use adequate for the reservoir potential would permit to locally limit reliance on fossil fuels and mitigate the GHGs and other emissions.

Over the last several years some general documents related to the energy policy of the country were introduced, e.g. the Strategy of Energy Policy in Poland till 2030 and in 2009 the EU Directive on RES promotion (and related documents). According to these documents the share of all RES, geothermal including, in final energy use (electricity plus heat & cold plus biofuels) shall reach 15% in Poland by 2020. These figures seem to be significant as compared to the current share of all RES in energy generation (ca. 7%). Among the main factors which hamper geothermal deployment are high up-front investment costs, weak law regulations, etc. From the other hand, as one of the main RES in Poland, geothermal should be promoted in view of the conditions the country has to meet as a member of the EU. More favorable legal regulations as well as economic and fiscal incentives shall be introduced. These would serve as the tools to facilitate the geothermal deployment. In 2007 – 2009 some changes and amendments to ease geothermal investments were introduced in the proposal of new geological and mining law as well as new provisions of economic support from the public sources. They are treated as first positive signals whereas the geothermal stakeholders expect further improvements and tools, including e.g. establishing the Geological risk guarantee fund, introducing the green certificates or lower VAT for heat prices produced from geothermal/RES.

2. GEOLOGICAL AND GEOTHERMAL BACKGROUND

The area of the country is built of three geostructural units: Precambrian platform of Northwestern Europe; Palaeozoic structures of Central - Western Europe covered by the Permian - Mesozoic and Cainozoic sediments; the Carpathians (part of the Alpine system). Crystalline rocks prevail within the Precambrian platform (NE-Poland) and within the Sudetes region (SW-Poland). Sedimentary formations (known as the Polish Lowlands) dominate the extensive area stretching from the Baltic Sea coast towards central and southern part of a country. Significant thickness (up to 7-12 km) and share of sandstones and carbonates characterize large sedimentary complexes. These rock types often have good hydrogeological and reservoir parameters,

creating conditions for the occurrence of ground waters, including geothermal ones.

The main geostructural units implied distinguishing of three geothermal provinces (each of them being divided into several smaller units, called geothermal regions; Sokolowski, 1993). They are formed mostly by extensive sedimentary formations and contain geothermal aquifers (Fig. 1): The Polish Lowland Province (Triassic – Cretaceous); The Fore-Carpathians (Mesozoic - Tertiary); The Carpathians (Mesozoic – Tertiary). Moreover, the Sudetes geothermal region contains aquifers in some fractured parts of crystalline and metamorphic rocks (Dowgiallo, 2002).

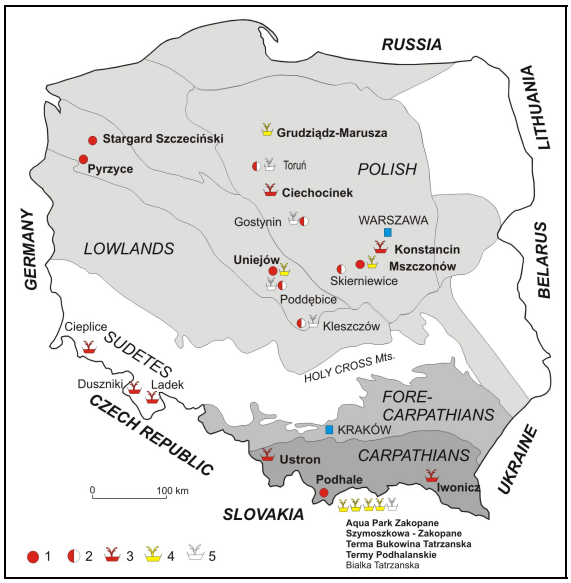

Figure 1. Poland, 2009: 1. geothermal heating plants in operation, 2. geothermal heating plants in realization (wells drilled or in drilling), 3. spas using geothermal waters, 4. geothermal bathing centers opened in 2005 - 2009, 5. geothermal bathing centers under construction (wells drilled or in drilling). Division into geothermal provinces after Sokolowski (1993)

The country is characterized by the heat flow values from 20 to 90 mW/m^2, while geothermal gradients vary from 1 to 4°C/100 m. Generally, at the depths from 1 to 4 km the formation temperatures vary from 30 to 130°C, while the TDS are from 0.1 to 300 g/dm^3. The proven geothermal water reserves amount from several l/s up to 150 l/s. The best geothermal conditions are found in the Polish Lowlands (Gorecki [ed.], 2006) and in the Podhale region (Inner Carpathians) (Sokolowski 1993).

3. GEOTHERMAL DIRECT USES

3.1 Generals

During 2005 – 2009, geothermal energy has been used in several localities mainly for heating, balneotherapy and bathing (Fig. 1, Table 3 and 5). For other purposes it was used on a semi-industrial scale in a cascaded system reported before (Kepinska, 2005) and for new application – heating up the lawn of football playground). Comparing to the data presented at WGC 2005, the installed geothermal capacity and heat sales have increased, what was caused mostly by further heat sales increase in the Podhale region, launching a new geothermal heating plant in Stargard Szczecinski as well as further heat pumps development.

Taking into account the data from particular geothermal plants, at the end of 2008 the installed geothermal capacity (heat pumps excluded) totalled 77.95 MW$_t$ and with the shallow heat pumps not less 281.05 MWt. Geothermal heat sales were ca. 501 TJ (including 456.6 TJ for space heating) - shallow heat pumps excluding - and not less than 1501.1 TJ including shallow heat pumps (Table 3). Only in case of geothermal bathing facilities where waters are used to fill pools or for curative treatment, the capacities and heat production were evaluated using the standard equations (as given in tables 3 and 5). Following the equations recommended to prepare particular tables attached to this country report, at the end of 2008 geothermal capacities and heat uses would be markedly higher in some cases. In case of heat pumps, the exact data are known for the heating plants (absorption pumps) only, while for ground-source and groundwater compressor pumps only tentative data are available (Table 4).

3.2 Space Heating

In 2009, five geothermal space heating plants were operational (Tables 3 and 5): in the Podhale region (since 1992/1993), in Pyrzyce (since 1996), in Mszczonow (since 1999), in Uniejow (since 2001) and in Stargard Szczecinski (since 2006). A heating installation in Slomniki (open late 2002) and reported in 2005, was not in operation.

Podhale region. In that region, since 1994 the biggest in the country geothermal heating project has been underway. The main geothermal aquifer – a subject of exploitation, is hosted by the Triassic and Eocene carbonates (depths of 1 – 3.5 km). Reservoir temperatures reach up to 80 - 90°C. The maximum flow rates vary from 50 to 150 l/s of 82 - 86°C water. The TDS are 0.1 – 2.5 g/l (Kepinska, 2000).

In 2008 the installed geothermal capacity was 41 MW$_t$ (not fully used yet) and heat sales amounted to 267.00TJ/y (peak gas including, it totalled 324.25 TJ). By the end of 2008, 1298 receivers were connected to geothermal heating grid (incl. 57% individual houses, 17% multi-family buildings, 17% hotels and boarding houses, 3% schools and other buildings). The target heat sales 600 TJ/y are expected to be achieved by 2011.

In May 2008 a part of geothermal water cooled down in heat exchangers started to supply a new bathing centre ("Termy Podhalanskie").

Along with the heating system (operated by PEC Geotermia Podhalanska SA) the basic research and R&D works on cascaded uses have been run by the PAS MEERI. The system comprises the installations given in previous report (Kepinska, 2005): wood drying, greenhouse, fish farming and foil tunnels with heated soil (Table 3, Table 5).

Thanks to the geothermal heating the annual average concentrations of particulate matter PM_{10} and SO_2 have dropped by about 50% in comparison to the period before this heating type was put on-line. In 1998 – 2008 the CO_2 emissions were reduced by 197 000 tons.

*Pyrzyce***.** The heating plant was open in 1996. The aquifer is situated within the Jurassic sandstones at the depths of 1.5 – 1.6 km. It is exploited by two production and two injection wells. The maximum flowrate is 100.1 l/s of 61°C water. The TDS are 120 g/l. The plant's maximum installed capacity is 48 MW$_t$ including 14.8 MW$_t$ geothermal, 20.4 MW$_t$ from absorption heat pumps and 12.8 MW$_t$ from gas boilers. It supplies heat and warm water to over 90% of

users of the town's population (13,000). The network water parameters: 95°C/40°C (winter) and 60°C/45°C (summer).

In 2008 geothermal heat sales was ca. 60 TJ/y including ca. 30 TJ extracted directly by exchangers and 30 MWt from two absorption heat pumps (Tables 3 and 4) while the total heat sales was 100 TJ/y. Basically, the exploitation and technical parameters of the plant remained similar as during the past years. However, one noticed the drop in heat sales (in 2005: 72 TJ from geothermal) despite of connecting some new consumers. It was caused by lower heat demand thanks to the thermomodernisation of many buildings.

Mszczonów. The heating plant was launched in 1999. In 2008, maximum 16.6 l/s of 42.5°C water is produced from the Cretaceous sandstones by a single well. The plant of the total installed capacity of 10.2 MW_t uses geothermal water both for heating and drinking. The heating part of the plant operates as an integrated system: the district heating water is heated to the required temperature by the heat extracted from geothermal water and gas boilers fitted with 2.7 MW_t absorption heat pump and 0.6 MW_t cooler. When cooled down, it is supplied to the consumers as potable water (TDS 0.5 g/l). In heating season, ca. 30% of the total heat sales come from geothermal water (14.5 TJ in 2008; Table 4).

In June 2008 the geothermal bathing centre was opened ("Termy Mszczonów"). It uses a part of water stream discharged by the well and sent directly to pools.

Uniejow. The heating plant was opened in 2001. Geothermal aquifer is situated within the Cretaceous sandstones at the depth of 1.9 – 2 km. The maximum production is 18.8 l/s of 68°C water (without pumps) and 33.4 l/s (using the submersible pump), and the TDS are 5 g/l. Water is exploited in one doublet system. The installed capacity of the plant is 5.6 MW_t, including 3.2 MW_t from geothermal and 2.4 MW_t from peak oil boilers. In 2008 about 80% of all buildings in the town were supplied by this plant. In 2008 the total heat sales were ca. 14 TJ (entirely from geothermal water; Table 3). The works on connecting new consumers are planned.

In June 2008 the geothermal bathing centre was opened ("Termy Uniejów"). It uses a part of water cooled down in heat exchangers (ca. 8.4 l/s of 42°C water) for pools, curative treatments and heating the centre's facilities. Spent water from bathing centre (ca. 5.6 l/s of 28°C water) is used to heat up a lawn of football playground.

Stargard Szczecinski. The plant was open in 2006. It is based on a doublet of deep production (2672 m) and deviated injection (2960 m) wells. The aquifer is situated in the Jurassic sandstones. The production well discharges 27.8 l/s of 78°C water on average (max flowrate was 69.4 l/s of 87°C water). The geothermal capacity is 10 MWt and heat sales were ca. 86 TJ in 2008. Geothermal heat is extracted by heat exchangers and than sold to the nearby coal-fired municipal district heating plant (total capacity 116 MW_t) serving about 75% of local population (75,000).

Initially the plant was planned to distribute ca. 300 TJ/y of geothermal heat to the town's consumers via the existing municipal network. It had to cover the total heat demand for warm tap water in summer while during the heating season it would be supported by existing coal-fired plant. (However, due to economic situation mostly, in fall 2009 the geothermal plant was in liquidation).

3.3 Balneotherapy and Other Uses

Geothermal waters from springs or wells, with temperatures from 20°C to 62°C, have been used for medical treatments in seven spas. Some by-products, like iodine-bromine medical and cosmetic salts, and CO_2 are extracted from geothermal waters. In one locality (Iwonicz), the cosmetics based on geothermal brine are produced (Table 3, 5).

It is worth to note seven new geothermal bathing centers constructed in the reported years (2006 – 2008). Four of them were opened in the Podhale region (Aqua Park Zakopane, Szymoszkowa, Terma Bukowina tatrzanska, Termy Podhalanskie) and three in the Polish Lowlands :(Grudziadz-Marusza /2005/, Termy Uniejów and Termy Mszczonów /both in 2008/). Five of them use water produced mostly for heating whereas two base on waters discharged by new or reconstructed wells that supply only these centres. Some further investments are either at the final stages of realization or under projects' elaboration.

Moreover, a semi-technical cascaded uses have been operated by the Mineral and Energy Economy Research Institute PAS in the Podhale region (Kepinska, 2005): wood drying, greenhouse, fish farming and foil tunnels with a heated soil (Table 3, Table 5). In case of Uniejow town, outlet geothermal water from the bathing centre started to be used to heat up a lawn of football playground. Even if on a small scale, this new type of use demonstrates various opportunities of geothermal applications in the so-called cascaded mode.

3.4 Geothermal Heat Pumps

As given before, the absorption heat pumps have been working in two geothermal plants (Table 4; chapter 3.2): in Pyrzyce two pumps of 20.4 MW_t total capacity produced about 30 TJ in 2008. In Mszczonów, geothermal heat production is entirely based on AHPs: the installed capacity is 2.7 MWt and heat sales were ca. 14.5 TJ in 2008. For these installations one can give the exact data on their capacities and heat production: 23.1 MW_t and 44.50 TJ in 2008 (Table 4), contributing significantly to the total geothermal capacities and heat sales by all plants in 2008.

The market for shallow geothermal heat pumps, GHPs, has been constantly growing. However, no detailed statistic data exist. On a basis of available data and market analyses (e.g. Joniec, 2007) one may very roughly assume the total installed capacity at least 180 MW_t and heat production 1000 TJ/2008 (Table 4). About half of newly installed GHPs has capacities less than 70 kW, larger capacities (70 - 110 kW) form ca. 30% of installations while bigger ones (110 - 150 kW) are not common.

4. GEOTHERMAL DRILLING

In 2005 – 2009 five new geothermal wells were drilled (Table 6): two production ones in the Podhale region (ca. 1.8 – 2.2 km of depth) and three exploration ones in the Polish Lowlands (ca. 2.0 - 3.3 km). They gave a total depth of ca. 12.5 km. Besides, the drilling of next deep well was initiated in August 2009. Several projects for new geothermal drillings had been issued the licenses and awaited for realisation in 2009. They were oriented at geothermal water exploitation for heating and/or recreation. Moreover, some projects on reconstruction of old wells have been prepared and expected to be executed soon.

5. PROFESSIONAL PERSONEL ALLOCATION

In 2005 – 2009 a number of professional full-time personnel (with university degrees) working at different fields of geothermal activities can be given as about 90 persons (Table 7). This is similar figure as given in 2005, however some employees' movements took place. It was also some growth in the number of technical personel.

6. INVESTMENTS IN GEOTHERMAL SECTOR

The investments in geothermal sector in 2005 – 2009 can be estimated for at least 130 million USD (Table 8). This evaluation refers to the field development (drilling, surface equipment) and utilization according to the information provided by the operators of the heating plants and bathing centers in operation and underway. Prevailing amount was spent for bathing centers' constructions. These figures do not include the funds spent for R&D and many different types of studies and projects by several agencies and paid from several sources (public and governmental mostly but also by private entities). .

7. PROJECTS UNDERWAY AND PLANNED

Different stages of geothermal investment projects were underway in 2009:

- The Podhale region: the heating project planned to achieve the target heat sales ca. 600 TJ/y. The drilling of a new deep well is planned. Besides, further geothermal recreation centre has been in construction. It was also initiated the project to update the reservoir model and re-evaluate geothermal resources of this region;

- Uniejów: extension of geothermal heating grid to all potential clients in the town, connecting new large clients in recreation centre (under construction and planning);

- Realization of different stages of the projects oriented mostly for bathing /and heating in some cases/ in several localities where wells were recently drilled (Gostynin, Torun, Kleszczów) or rehabilitation of wells drilled several years ago was initiated (Skierniewice);

- Drillings: several licenses issued in 2008 – 2009; e.g. Poddebice – drilling started in fall 2009, beginning of several further drillings expected;

- Several R&D projects addressing various geothermal problems and aspects, e.g. reconstructions of some old exploration/oil wells for geothermal exploitation; well and reservoir rocks rehabilitation and treatment; desalination of geothermal waters/brines for drinking purposes; possibility on binary power generation (based on 90 - 120ºC waters).

Apart from the investments underway and planned, several geothermal assessments and projects have been prepared over the reported period 2005 - 2009. They focused on heating sector and /or bathing and included i.e.: adaptation of abandoned wells; heat pumps; integrated and distributed systems, advanced research methods to explore deep geothermal aquifers; legal and regulatory aspects, etc. The area being a subject of growing interest is bathing and recreation. Another important concept still awaiting practical realization is the use of heat from the underground mines (Malolepszy, 2003). Recently, the possibilities of binary power generation using over 80 – 90°C waters tapped in some deep wells or expected to occur in some areas (theoretical studies, R&D works).

It shall be also noticed that in recent years the geothermal conditions and resource assessments for prevailing area of Poland were presented in the "Atlas of geothermal energy resources in the Polish Lowlands" (Gorecki et al. 2006), "Atlas of geothermal water resources of Malopolska Region" (Bujakowski et al., 2006) and in "Atlas of geothermal resources of the Upper Silesia Region" (Solik-Heliasz et al. 2009). These comprehensive works are useful tools also for the investors as they indicate prospective areas for geothermal development. Similar works for other regions of the country are in progress.

8. CLOSING REMARKS

During the reported period of 2005 – 2009, some further progress in geothermal direct applications in Poland has been made. One geothermal heating plants was open which joined four other launched in 1992 – 2004. Seven new geothermal bathing and balneotherapeutical centres were put online. The construction of next such facility is underway. Further GHPs' development has been recorded expressed by at least 180 MW_t and 1000 TJ. These facts resulted in the total level of ca. 281 MW_t of installed geothermal capacity and 1501 TJ/2008 of heat use for the whole country at the end of 2008 as compared to the level of 170.81 MW_t and 838.35 TJ in 2004 (Kepinska, 2005).

Space heating belongs to the most important types of geothermal energy uses at present and in the future. Growing interest has been observed specially in geothermal bathing sector which attracts private investors. Systems based on deep hydrothermal resources, as well as on shallow groundwater and rock formations, are successfully exploited. The variety of reservoir conditions proves the variety of possibilities in which geothermal energy can be used, adjusted to local conditions and needs. For further real progress in geothermal implementation, it is indispensable to introduce better legal and economic conditions which will facilitate such development, to limit investment costs so as to make geothermal more competitive and marketable than the heat coming from other sources both fossil and other renewables.

ACKNOWLEDGMENTS

The author is grateful to all persons who kindly provided data presented in this paper: M. Balcer (Geotermia Mszczonow), W. Bujakowski and L. Pajak (PAS MEERI), Cz. Slimak (PEC Geotermia Podhalanska SA), J. Kurpik (Geotermia Uniejow), S. Kulik (Geotermia Pyrzyce), A. Niewiarowski (PUC Geotermia Stargard), A. Krawiec (UAM Torun), operators of spas and bathing centers.

REFERENCES

Bujakowski W., Barbacki A., Pajak L. (2006). Atlas of geothermal water resources of Malopolska Region. PAS MEERI. Krakow.

Dowgiallo J. (2002). The Sudetic geothermal region of Poland. Geothermics 31, pp. 342-359.

Gorecki, W. [ed.] et al. (2006). Atlas of geothermal energy resources in the Polish Lowlands. 1. Mesozoic formations. 2. Palaeozoic formations. AGH. Krakow.

Joniec W. (2007). The heat pumps' market. Rynek instalacyjny. No. 11. (in Polish)

Kepinska, B. (2005). Geothermal energy country update report from Poland, 2000 – 2004. Proceedings of the World Geothermal Congress 2005. Paper 0135 (CD).

Krawiec A. (2009). Thermal waters in the vicinity of Grudziądz. Proceedings of the II Polish Geothermal Congress, 23-25 September 2009. CD.

Malolepszy, Z., 2003: Man-made, low-temperature geothermal reservoirs in abandoned workings of underground mines on example of coal mines, Poland. Proceedings of International Geothermal Conference Reykjavik, 2003.

Solik-Heliasz E., Karwasiecka M., Kurowska E., Krieger W., Bula Z., Chybiorz R., Warzecha R. (2009). Atlas of geothermal resources of the Upper Silesia Region. GIG. Katowice. (In Polish).

Sokolowski, J. (1993). Geothermal resources in Poland and possibility of their utilization in environmental protection. Exploration Geology, Geosynoptics and Geothermal Energy. No. 5-6. pp.67-80.

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2008 (other than heat pumps), POLAND

[1] I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish farming
K = Animal farming
S = Snow melting
H = Individual space heating (other than heat pumps)
D = District heating (other than heat pumps)
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
O = Other (please specify by footnote)

[2] Enthalpy information is given only if there is steam or two-phase flow

[3] Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (^oC) - outlet temp. (^oC)] x 0.004184 ($MW = 10^6 W$)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

[4] Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.1319 ($TJ = 10^{12} J$)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

[5] Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% of capacity all year.

Note: please report all numbers to three significant figures.

Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization		
		Flow Rate	Temperature (^oC)		Enthalpy[2] (kJ/kg)			Ave. Flow	Energy[4]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5]
Podhale - Geotermia Podh.	D (+G+F+A)*	125	87	55			41	91	267.0	0.21
Pyrzyce	D	100.1	61	28			14.8	44.2	30.0	0.07
Uniejow	D	33.4	68	42			3.2	13.9	14.0	0.14
Stargard Szczecinski	D	69.8	87	64			10.0	27.8	86.0	0.27
Aqua Park-Zakopane/Podhale	B	13.9	37	28			0.46	6.9	8.8	0.61
Szymoszkowa-Zakopane/Podhale	B	22.2	27	23			0.37	11.0	5.0	0.43
Terma Bukowina Tatrzanska/Podhale	B+D	11.2	64.5	28			0.38	11.2	3.2	0.27
Termy Podhalanskie/Podhale	B	4.2	38	32			0.14	4.2	2.5	0.56
Geotermia Grudziadz-Marusza**	B	5	20-22				0.04	0.1	ng	ng
Termy Uniejow	B+D	8.3	42	28			0.50	8.4	7.7	0.49
Uniejow***	O	8.3	28	20			0.28	8.3	4.4	0.50
Termy Mszczonów	B	4.2	32	28			0.07	4.2	1.1	0.50
Cieplice	B	7.5	36-39	26			0.4	6.0	10.0	0.79
Ladek	B	13.8	20-44	30-34			0.7	9.8	12.0	0.54
Duszniki	B	5.5	19-21	19			0.05	5.5	0.7	0.44
Ciechocinek	B	56.8	27-29	20			1.9	4.2	2.8	0.05
Konstancin	B	2.5	29	12			1.8	0.1	0.2	0.01
Ustron	B	0.9	28	11			0.6	0.4	0.6	0.9
Iwonicz****	B+O	3.0	21	10			1.4	0.4	0.6	0.02
TOTAL		495.6					77.95	257.3	456.6	

* Podhale: (G+F+A) - cascaded uses in PAS MEERI Geothermal Laboratory (ca. 1 MWt, 4 TJ/2008)
** Uniejow - O: heating up a lawn of football playground
*** Geotermia Grudziadz-Marusza - uses limited amount of water (max. 20-22oC, usually less than 20oC) thus not all parameters are given. Water is often heated up. ng - negligible
**** Iwonicz: O - extraction of iodine-bromine salts, production of cosmetics
In case of bathing and swimming (B) tentative capacity factors are given.
Termy Bukowina were opened in Dec. 2008, Termy Uniejów, Termy Mszczonów were opened in June 2005 - the given data on energy utilization relate to their real operation periods in 2008.

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2008, POLAND

This table should report thermal energy used (i.e. energy removed from the ground or water) and report separately heat rejected to the ground or water in the cooling mode. Cooling energy numbers will be used to calculate carbon offsets.

[1] Report the average ground temperature for ground-coupled units or average well water or lake water temperature for water-source heat pumps

[2] Report type of installation as follows: V = vertical ground coupled (TJ = 10^{12} J)
H = horizontal ground coupled
W = water source (well or lake water)
O = others (please describe)

[3] Report the COP = (output thermal energy/input energy of compressor) for your climate

[4] Report the equivalent full load operating hours per year, or = capacity factor x 8760

[5] Thermal energy (TJ/yr) = flow rate in loop (kg/s) x [(inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.1319
or = rated output energy (kJ/hr) x [(COP - 1)/COP] x equivalent full load hours/yr

Note: please report all numbers to three significant figures

Locality	Ground or water temp. (^{o}C)[1]	Typical Heat Pump Rating or Capacity (kW)		Number of Units	Type[2]	COP[3]	Heating Equivalent Full Load Hr/Year[4]	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
Pyrzyce*	40	10200	20400	2	W	3.0	5400	30	
Mszczonów**	42	2700	2700	1	W	3.5	5200	14.5	
Groundsource and groundsource heat pumps**	(-7) - 20	10 - 200	> 180 000	> 11 000	V. H	2 to 6	3800	> 1000	ca. 30% devices used for cooling; exact data not known
TOTAL			> 203100					>10 44.5	

* Pyrzyce heating plant: absorption heat pumps working in an integrated layout (see Table 3 and chapters 3 - 4)
** Tentative data (see chapter 4)

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2008, POLAND

[1] Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

[2] Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

[3] Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10^6 W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]			
District Heating [4]	68.0	393.0	0.19
Air Conditioning (Cooling)			
Greenhouse Heating + Fish farming + wood drying	1.0	4.0	0.13
Fish Farming			
Animal Farming			
Agricultural Drying[5]			
Industrial Process Heat[6]			
Snow Melting			
Bathing and Swimming[7]	8.67	55.2	0.20
Other Uses - heating football playground	0.28	4.4	0.50
Subtotal	77.95	456.6	0.18
Geothermal Heat Pumps	>203.10	>1044.5	0.16
TOTAL	>281.05	>1501.1	

[4] Other than heat pumps
[5] Includes drying or dehydration of grains, fruits and vegetables
[6] Excludes agricultural drying and dehydration
[7] Includes balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2005 TO DECEMBER 31, 2009 (excluding heat pump wells), Poland

[1] Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1]	(all)					
Production	>150^o C					
	150-100^o C					
	<100^o C		5			12.5
Injection	(all)					
Total			5			12.5

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees), Poland

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2005						
2006						
2007						
2008						
2009	10	35	30			15
Total	10	35	30			15

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2009) US$, Poland

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	5.6	8.10	40.8		5	95
2000-2004	0.3	11.36	37.91		5	95
2005-2009	15.0	15.0	100.0		80	20