Geothermal Energy Use, Country Update for Poland

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ABSTRACT

The paper presents the status of geothermal energy development in Poland in 2012 and in some previous years specially since the update report presented at WGC 2010 (Kępińska, 2010).

Poland has low-temperature geothermal resources connected mostly with Mesozoic sedimentary formations. Geothermal applications involve space heating, balneotherapy, bathing and recreation.

The activities on geothermal heating deployment were initiated in the 1980s; the experimental stage of the first geothermal plant was opened in the Podhale region in 1992. Since that time six district heating plants have been launched. In 2012 their total installed geothermal capacity was 101.9 MWth and heat sales 533.66 TJ. In recent years a growing interest has been observed in recreation and balneotherapy sector expressed by seven new centres (and two which received health resort status) opened in 2006-2012. One may estimate their total capacities as 7.45 MWth, and heat uses as 96.1 TJ/2012. In case of ten health resorts using geothermal water for curative treatments, these figures were estimated for 4.03 MWt, and 34.4 TJ/2012. Other minor uses comprised semi-technical wood drying and greenhousing, as well as heating up a football playground. These applications represented in total ca. 2 MWth, and 6.4 TJ/2012 of heat use.

In case of geothermal heat pumps sector, some faster growth has been observed in last two years. One may roughly estimate that in 2012 they reached at least 330 MWth of capacity and 1700 TJ of heat.

In 2012 total installed geothermal capacity (heat pumps including) was at least 445.38 MWth while heat sales/uses 2370.56 TJ (comparing to 281 MWth and 1501 TJ /2008 (Kępińska 2010).

In 2010-2012 twelve new geothermal wells were drilled. They will produce ca. 28-80ºC waters for bathing/recreation purposes and for space heating in some cases.

The investments were accompanied by research, technical works, feasibility studies, several projects of new drillings and implementation projects for public and private entities. Like in other countries, some R&D works on prospects for geothermal binary power generation (based on at least 90-100ºC water) and on HDR/EGS prospects were ongoing.

As the most prospective for further geothermal development one shall indicate space heating (multipurposed, hybrid systems), recreation, bathing and heat pumps sector. However – comparing with the geothermal resource base and progress in RES sector as a whole – geothermal uses development has been slow so far, specially in the heating sector.

1. INTRODUCTION

The paper presents the status of geothermal development in Poland in 2012 and in some previous years specially since the update report presented at WGC 2010 (Kępińska 2010). Geothermal uses involve space heating, balneotherapy and recreation.

Geothermal use for heating purposes in the country was initiated in the last decade of the past century. The experimental stage of the first geothermal plant was opened in the Podhale region in 1992. Since that time six plants have been launched. Space heating is a key sector for geothermal energy development.

A growing interest has been observed in recreation expressed by seven centres opened in 2006-2012. Besides, there are ten health resorts using geothermal water for treatment, several of them possessing long historical tradition while two of them were constructed and received formal health resort status in recent years (2009, 2012).

The paper presents also ongoing geothermal investments, activities and research projects in various stages of implementation. However, as mentioned in the abstract, comparing with the progress in other RES sectors, geothermal development has been rather slow, specially in the heating sector (which shall be crucial for the country).

2. GEOTHERMAL ENERGY POTENTIAL

Geothermal water and energy resources in Poland are associated with formations of various ages in the Polish Lowlands, in the Inner Carpathians (the most prospective areas) and in some locations in the Sudetes region, the Outer Carpathians and the Carpathian Foredeep (Fig. 1).

In case of the Polish Lowlands (part of the European Lowlands) sedimentary formations dominate the extensive area stretching from the Baltic Sea coast towards central and southern part of a country. They are characterized by significant thicknesses and share of sandstones and carbonates. Sedimentary formations host also geothermal aquifers in the Inner Carpathians (Mesozoic, partly Eocene carbonates – the Podhale region) and sometimes in the Outer Carpathians (Tertiary sandstones, Mesozoic carbonates) and the Carpathian Foredeep. In case of the Sudetes region geothermal aquifers occur in fractured parts of some crystalline and metamorphic formations.

The water temperatures at the outflows from the wells of (depths up to ca. 3.5 km) recorded so far vary from ca. 20 to about 90°C. The proven geothermal water reserves amount from several dm^3/s up to 150 dm^3/s. Waters are suitable for the wide spectrum of direct uses for space heating, agriculture, etc., as well as for balneotherapy and recreation. Wide opportunities are also associated with ground source heat pumps.

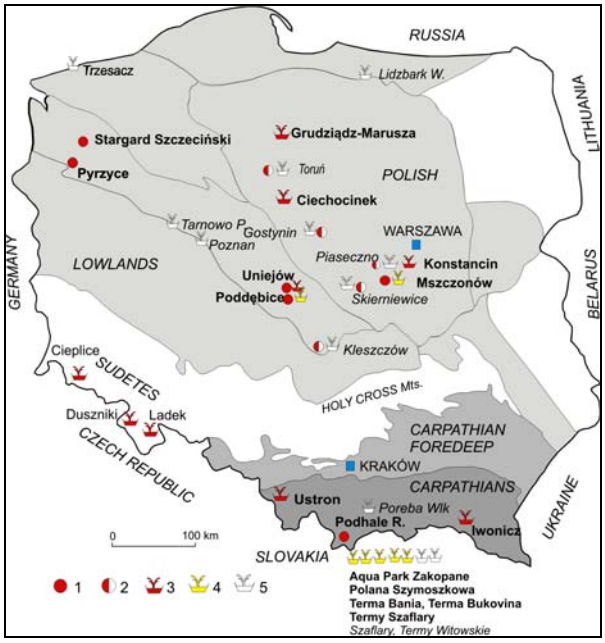

Figure 1. Poland, 2012: 1. geothermal district heating plants in operation, 2. geothermal heating systems in realization or planned (in recreation centers mostly), 3. health resorts using geothermal waters, 4. geothermal recreation centers opened in 2006-2012, 5. geothermal recreation centers under construction

3. OVERVIEW OF GEOTHERMAL USES

In 2012 geothermal energy was produced in five district heating plants (the construction of the sixth one was completed in 2012 but heat production started in 2013), used in ten health resorts (balneotherapy) and seven new recreation centers open in recent years. In the given year heat pumps (GSHP) development was marked by ca. 20% sales increase, what may indicate more dynamic development of this branch characterizing earlier by moderate growth in comparison with the leading countries.

Main data on geothermal installations described below are given in Tables C and D, their location is shown on Figure 1.

3.1 Space heating

In 2012 five geothermal district heating plants were operational: in the Podhale region and in the town of Pyrzyce, Mszczonów, Uniejów, Stargard Szczecinski (the sixth plant in Poddębice was commissioned in 2012 but heat production was started in 2013).

In addition to district heating systems, four were the heating systems in spa and recreation centers that used geothermal water for the pools and treatments and also for space heating of their objects - relevant figures are given in parts of text describing these utilities.

Podhale region. **S**ince 1994 the biggest in the country geothermal district heating project has been underway. The maximum flow rates from two production wells vary from 33 to 150 dm^3/s of 82-86°C water. The TDS are ca. 2.6 g/dm^3. In 2012 the installed geothermal capacity was 40.7 MWth (total 80.5 MWth including gas peaking boilers mostly) and heat sales amounted to 362.85 TJ/y (peak gas including, it totalled 512.94 TJ). By the end of 2012 ca. 1600 receivers were hooked to geothermal district heating grid (in case of city of Zakopane – the main heat market, it was ca. 35% of heat demand including individual, multi-family buildings, hotels and boarding houses, schools, hospital and other buildings). Since May 2008 a part of geothermal water stream cooled down in heat exchangers has supplied a new bathing centre ("Termy Szaflary"). Between December 2012 and April 2013 new production geothermal well was drilled. It will produce more geothermal heat (ca. 10 MWth) to supply new consumers via existing heating network of PEC Geotermia Podhalańska SA.

In this region, some semi-technical cascaded uses (wood drying, fish farming) have been run by MEERI PAS similar to former years (1 MWth, 2 TJ/2012).

*Pyrzyce***.** The heating plant has been operating since 1996. The maximum flow rate from two production wells is ca. 100 dm^3/s of 61°C water. The TDS are 120 g/dm^3. The plant's maximum installed capacity is 48 MWth including 35.2 MWth geothermal (14.8 MWth geothermal heat exchangers, 20.4 MWth absorption heat pumps) and 12.8 MWth from gas boilers. It supplies heat and domestic warm water to over 90% of

users of the town's population (13,000). In 2012 geothermal heat sales was ca. 52 TJ while the total heat sales was 100 TJ.

Mszczonów. The heating plant has been operating since 2000. Maximum geothermal water flow rate is ca. 16.6 dm^3/s of 42.5°C, while TSD are 0.5 g/dm^3. Water is produced by a single well (no injection). The plant of total installed capacity 11.2 MWth uses geothermal water for district heating, drinking and for heat and water supply to recreation centre. The district water is heated to the required temperature by heat extracted from geothermal water and gas boilers fitted with 2.7 MWth absorption heat pump (AHP) and 0.6 MWth cooler. In 2012 a 1 MWth compressor heat pump (CHP) was added to extract more geothermal heat from AHP outlet water thus supplying some lower temperature heating systems at receivers. Geothermal water cooled down by CHP is than sent to water works. Part of geothermal water stream discharged by the well is directly sent for pools in recreation centre "Termy Mszczonówskie" (opened in 2008). In 2012 geothermal heat sales was 11.84 TJ (ca. 40% of total heat sales from district heating plant in Mszczonów).

Uniejow. The heating plant has been operating since 2006. The maximum production is 33,4 dm^3/s of 68°C water and TDS are ca. 5 g/dm^3. Total installed capacity amounts to 5 MWth including 3.2 MWth geothermal and 1.8 MWth from biomass boiler (which replaced gas boiler working in former years). In 2012 about 80% of all buildings in the town were supplied by this plant and total geothermal heat sales were 15.97 TJ. The works on connecting new receivers are planned.

In 2008 new geothermal recreation centre "Termy Uniejów" was launched. It uses a part of water stream cooled down in heat exchangers for pools, curative treatments and heating the centre's facilities (ca. 8.4 dm^3/s of 42°C water; ca. 1 MWth, 7.7 TJ/2012). Some amount of spent water (ca. 5.6 dm^3/s, 28°C) is than used to heat up a lawn of football playground (ca. 1 MWth, 4.4. TJ/2012).

Further works on extension geothermal recreation facilities are underway and planned. These activities drive an economic development of that historical town, create new tourist offer attractive for many visitors. In 2012 Uniejow received a formal status of health resort.

Stargard Szczeciński. Geothermal plant was opened in 2006 but closed in 2008. In 2012 it was opened again after, among others, some rehabilitation works in wells and surface equipment. The production well discharges ca. 27.8 l/s of 78°C water. The geothermal capacity is 12.6 MWth and geothermal heat sales was 91 TJ in 2012 (K. Zabłocki – *pers. communication*, *www.pec.stargard.pl*). Geothermal heat is extracted by heat exchangers and than sold to the nearby coal-fired municipal district plant (total capacity 116 MWth serving about 75% of local population (75,000).

Poddębice. In that municipality, construction of geothermal district heating plant was commissioned in 2012. The plant of 3.8 MWth geothermal capacity bases on 71ºC water (average flow rate 32.2 dm^3/s, mineralization 0.4 g/dm^3). The plant initiated geothermal heat sales in 2013 (planned 17.5-19 TJ/y) supplying some public buildings, school, hospital, several multi-family houses. Some part of water stream is sent to swimming pools.

To sum up geothermal uses for district heating systems - in 2012 the total installed capacity of six geothermal district heating plants listed above was 161.4 MWth of which 101.9 MWth (63%) came from geothermal parts (heat exchangers, absorption, compressor heat pumps). The total heat sales by those plants were about 756.59 TJ, of which 533.66 TJ was geothermal (ca. 70%), and the rest came from peak sources (gas, fuel oil, biomass). The biggest total installed capacity (80.8 MWth) and geothermal capacity (40.7 MW) possess the plant in the Podhale region (PEC Geotermia Podhalańska SA). It acquires and sells the biggest volume of geothermal heat in the country (in 2012 there were 362.85 TJ in the total heat sales of 512.54 TJ).

3.2 Health resorts using geothermal water and energy

Geothermal waters have been used for healing treatments in ten health resorts. Eight of them have long historical tradition (centuries, dozen of years) while two youngest localities (Grudziądz-Marusza and Uniejów) received formal status of health resort in 2009 and 2012, respectively. Waters are harnessed from natural springs and wells (the Sudetes area) or wells (other areas), their approved reserves vary from ca. 2 to 200 m^3/h while maximum outflow water temperatures are in the range of 20-80°C. In single cases, iodine-bromine or cosmetic salts, and CO_2 are extracted from geothermal waters.

For installations in health resorts that use geothermal water due to their therapeutic properties (resulted both from chemical composition and temperature), geothermal capacities and heat uses were estimated taking into account the average annual water flow rates and temperatures at inlet and outlet from curative pools and other facilities. In some cases (e.g. „Termy Uniejów") geothermal water is also used for heating the centres' objects and warm water preparation. For seven installations of this group total geothermal capacity and heat consumed in 2012 were estimated at about 4.03 MWth and 34.4 TJ (three localities were not considered since small water flow rates from the wells imply low outflow water temperatures and cause that waters are additionally heated up before using).

3.3 New bathing and recreation centers

In several recent years (2006-2012) seven new geothermal recreation and bathing centers were constructed: five in the Podhale region and two in the Polish Lowlands (two other ones opened in 2008 and 2009: Grudziądz-Marusza, Uniejów received than the

health resort status therefore were included into the group listed above). Some of new centers use geothermal water both for supply the pools and other facilities as well as for heating their objects and warm water preparation. Some centers use waters discharged by new wells specially drilled to supply these utilities, some base on wells operating earlier for heating purposes. In 2012 some further investments oriented for bathing and recreation were either at various stages of realization or under projects' elaboration (chapt. 5).

In case of seven new bathing and recreation centres using geothermal water (in some cases also for heating the objects), their total geothermal capacity can be estimated as at least 7.45 MWth (including several compressor heat pumps in some cases /less than 2 MWth in total/) and heat consumption for 96.1 TJ.

3.4 Other uses

In addition to the-above-listed, one shall mention a semi-technical cascaded uses of wood drying and greenhouse at MEERI PAS Geothermal Laboratory in the Podhale region (ca. 1 MWth and 2 TJ/2012) and heating up of football playground (1 MWth, 4.4. TJ/2012) mentioned above as a part of multi-purposed uses in Uniejów town; even if on a small scale, this new type of use demonstrates various opportunities of geothermal applications. These remaining types of uses are estimated for total of ca. 2 MWth and ca. 6.4 TJ of heat in 2012.

In 2012, total installed geothermal capacity for all listed types of direct uses was about 115.38 MWth (bulk for GeoDH: 101.9 MWth). Total geothermal heat sales (by DH systems) and used / consumed (in case of other installations) was ca 670.56 TJ.

3.5 Heat pumps

Geothermal heat pumps (GSHP) sector has been characterized by a very moderate growth for many years while faster development occurred only recently. On the basis of available information and evaluations (Kępińska 2010; Berent-Kowalska et al. 2012) and more detailed market survey on heat pumps' sales in 2011-2012 (*www.portpc.pl;* P. Lachman, S. Kaletka – *pers. communication*) one may estimate that in 2012 heat pumps represented at least 330 MWth of installed power and at least 1700 TJ of produced heat (Table E). The number of geothermal heat pumps (various types: water/water, water/brine, horizontal, vertical loops) was evaluated for at least 30 000. GHPs have thermal capacities from less than 20 kWth up to 70-150 kW. The largest single units reach 1 MWth and some of them work in several geothermal utilities (eg. Mszczonów plant, two recreation centres).

In last years an increase in sales of various heat pump types (incl. GSHP) was observed (*www.portpc.pl;* S. Kaletka – *prs. communication*): in 2011 it was the level of 10 000 units (about 30% sales increase compared to 2010) and in 2012 – more than 12 600 units (nearly 20% sales growth compared to 2011). In those numbers were ca. 6000 GSHP units sold in 2011 and ca. 5100 GSHP units sold in 2012 (figures without installations sold to private households). However, the heat pumps sector develops with practically no support from the state (since 2013 similar situation concerns also deep geothermal). Professional and industrial entities are still waiting for the implementation of the EU RES Directive provisions recognizing the importance of heat pumps and deeper geothermal in the RES mix.

Besides GSHP one shall consider the absorption heat pumps (AHP) that have been working in two geothermal heating plants: in Pyrzyce (20.4 MWth) and in Mszczonów (2.7 MWth). These AHPs contributed significantly to total geothermal capacities and heat sales by geothermal plants in 2012. Relevant figures were included in the amount of heat produced by respective heating plants.

4. GEOTHERMAL DRILLINGS

In 2009 – 2012 thirteen new geothermal wells were drilled. They will be serve mostly for geothermal water production for recreation and bathing purposes. Drilling works followed the licenses for exploration and prospecting issued by the minister of environment (in 2006-2011, 25 such licenses were issued /*www.mos.gov.pl*/; since 2012 the licenses are required only for the exploitation of geothermal waters and are issued by regional administration). In December 2012 drilling of geothermal production well for heating purposes started in the Podhale region and was finished in April 2013. In that year several other decisions for drilling geothermal exploration wells were issued by the regional administration. However, one may expect much less new geothermal drillings in the forthcoming time due to the termination of public financial support by the National Fund for Environmental Protection and Water Management what will have a negative impact especially for the development of geothermal heating sector.

5. WORKS IN PROGRESS AND PLANNED

In 2012 and some previous years several geothermal investment projects oriented mostly for recreation were completed or underway. Several research, R&D works were finished or in progress.

Investments works:

- The Podhale region: connecting some new receivers to geothermal DH system, works on surface infrastructure, drilling the third production well to supply more clients via district heating network (December 2012 – April 2013),

- Mszczonów town: optimisation of DH system by adding compressor heat pump to extract heat from outlet geothermal water from absorption heat pump,

- Poddębice town: in 2012 commissioning of geothermal district heating plant (supplying also water

for recreation center). Heat sales from that plant started in 2013 (as mentioned before),

- Uniejów town: extension of geothermal heating grid, extension of recreation center "Termy Uniejów",

- Stargard Szczeciński: enlargement of the geothermal plant capacity by adding ca. 4.5 MWth and project to drill new production well,

- Works on optimisation of technological schemes and increasing the efficiency of energy extraction from geothermal waters in several geothermal district heating systems and recreation centers,

- Eleven projects of geothermal bathing and recreation centers' construction: in the Podhale region two next centers ("Szaflary", "Termy Witowskie" – in addition to five already operating – they will base on wells drilled in former years; projects in the Polish Lowlands based on newly-drilled wells (Gostynin, Kleszczów, Lidzbark Warmiński, Poznań, Tarnowo Podgórne, Toruń, Trzęsacz), in some cases combination with heating of centers' facilities and with district heating system (Piaseczno, Poddębice).

Pre-investment works:

- Some pre-investment works and feasibility studies were in progress, e.g. relates to two localities in the Outer Carpathians (Sękowa, Gorlice) where former oil&gas wells may serve for geothermal water exploitation for recreation and space heating (expected water flow rates 60 – 70 m^3/h, wellhead temperatures 45ºC, and 95ºC; Hajto et al. 2011).

Research, R&D works:

Several R&D projects addressing various geothermal aspects were performed, e.g. wells and reservoirs' rehabilitation and treatment (involving as test sites two prospective wells in Skierniewice town; Kępińska, Bujakowski [eds] et al. 2011); geothermal waters' desalination (Tomaszewska 2010); wells aquifers' treatments (well in Pyrzyce; in frame of EU Program Life +).

Some projects were focused on particular wells meeting the interest of local communities or private enterpreneurs – e.g. reconstruction of well prospective for balneotherapy made in 1970s (Poręba Wlk) or feasibility study and project of adaptation of newly-drilled well as deep BHE (both cases in the Outer Carpathians area).

Two extensive research projects to define potential HDR systems, as well as areas and conditions for binary power generation (co-generation) were ongoing in 2011 – 2012 and will be completed in 2013. They have been conducted by consortia of scientific and research entities.

In 2011-2012 geothermal conditions and resource for several regions of the country were summarized in atlases of the Western Carpathians, the Carpathian Foredeep (Górecki et al. 2011, 2012) while the Atlas of Eastern part of the Carpathians will be published in 2013. Along with similar earlier works for the Polish Lowlands, the Małopolska Region and the Upper Silesia Region they cover over 80% of Polish territory and serve as comprehensive sources of data and information for scientists and potential investors.

To draw attention on geothermal potential and to enhance its practical uses deployment the Polish Geothermal Society presented a concept of geothermal heating plants development in the Polish cities. It is addressed to the municipalities located in areas prospective in terms of resources, possessing heating networks, heat market, etc. where geothermal energy can be successfully introduced. The concept has gained recommendations of some representatives of the government and the parliament, and one shall believe that it will enter into implementation stage.

6. PROFESSIONAL PERSONNEL ALLOCATION

In 2012 a number of professionals working at various fields of geothermal activities (scientific institutions, geothermal plants and other installations, consulting companies) might be estimated for ca. 100 persons (Table F). Along with putting on line new geothermal bathing and recreation centres significant growth of number of various technical personnel took place (ca. 20 – 100 prs/centre, depending on its size).

7. INVESTMENTS IN GEOTHERMAL SECTOR

The investments in geothermal sector in 2010 – 2012 can be roughly estimated for at least 300 million euro (Table F). These sum includes public support for drillings, related works and equipment, some R&D works and regional publications; funds from several regional EU-programs (surface infrastructure, installments); tentative estimates of private funds. Bulk of these funds was spent for construction and equipment of new recreation and balneotherapy centers (not for district heating systems), significant sum went also to cover parts of drilling costs (some drilling were not supported). These figures do not include the funds spent for some R&D and various studies and projects made by several agencies and paid from different sources.

8. LEGAL AND ADMINISTRATION PROCEDURES

By 2011 economic activity aimed at geothermal water management (exploration, exploitation) was the subject of two-stage licensing procedures. The licenses were issued by the minister of the environment. The new Geological and Mining Law (put into force in 2012) has simplified some procedures by, among others, introducing a single system of licensing and transfer it to the competences of regional administration. Other provisions facilitating geothermally-oriented activities include:

- exemption from royalties for geothermal water exploitation,

- exemption from fees for the geological information used for project purposes,

- reduction of fees for the use of geological information in order to exploit geothermal water (up to 1% of its value to 31/12/2020, then 5%),

- cancellation of licenses for exploration and prospecting of geothermal water – just geological works project to be approved by the regional administration (no need to prove the funds to operate, no license fee, no contract for mining operation /only the stamp duty for a decision/),

- shortening the exploitation license procedures by a significant reduction of the duties of cooperation with other bodies while issuing the decision on concession.

Some of the above simplifications are mentioned in Table G.

A very important factor for the development of geothermal energy is an access to public support for the projects. By 2012 such role was played by the National Fund for Environment Protection and Water Management, NFEP&WM (program "Energetic use of geothermal resources"). That program supported, among others, geothermal exploration wells. However, it did not apply to exploitation wells. In 1995-2012 that support resulted in a dozen of geothermal projects, including several exploration wells, R&D projects, and other works (e.g. series of geothermal atlases). In 2010 – 2011 the public support for several projects from the NFEP&WM (program "Energetic use of geothermal resources" /up to 50% of eligible costs/ and other programs of the Ministry of Environment) amounted to ca. 17 million €; base: www.nfosigw.gov.pl).

Unfortunately, since 2013, this program was closed, which – as mentioned – may result in significant slowdown, or even complete suppression, of investments especially in the heating sector. The more that no other relevant sources of public support are proposed (some shall come with new EU- financing perspective 2014-2017).

Another important tool which has been missing so far is the Geological Risk Insurance Fund postulated to be introduced by many professionals (Kępińska, Tomaszewska 2010).

In case of geothermal energy (as well as in case of other RES) no support scheme for generation / sales of renewable heat exists. It is neither envisaged by the NREAP nor by government project of Law on RES (despite many demands by the professional organizations and experts).

In the light of the above, one shall state that better provisions of the new geological and mining law introduced in 2012 have been not accompanied so far by other relevant provisions and support tools which should create proper circumstances facilitating geothermal development.

9. THE SHARE OF GEOTHERMAL IN CURRENT RES MIX AND IN OFFICIAL PROGNOSES

In 2011 the total RES energy acquisition in Poland achieved ca. 325 234 TJ, i.e. 11,2% of total primary energy acquisition (Berent-Kowalska et al. 2012). Polish energy sector is dominated by coal (hard and brown) with growing contribution of natural gas. The dominant share in RES mix came from solid biomass (85.57%). The next were: liquid biofuels (5.54%), wind (3.55%), hydro (2.58%), biogas (1.76%), biodegradable municipal wastes (0.41%), solar (0.13%) while geothermal energy was 0.16% only and heat pumps (all types) – 0.29% (installations in private households are not included in this latter share). Final brutto RES energy consumption was 303 698 TJ (7253 ktoe) including 218 141 TJ (5210 ktoe) for heating sector (cooling being a small portion), 46 479 TJ (1110 ktoe) for electricity generation and 39 078 TJ (933 ktoe) for transport. The domination of heating sector in RES mix is striking but the geothermal contribution to it is very small; this is because the fact that this energy source so far has been not developed accordingly to the resources' potential, market and social interest. Geothermal energy is used mainly to meet the heat demand of households (in 2011 about 80% of energy sales) while the trade and services sector accounted for about 20% (Berent-Kowalska et al. 2012).

According to the "Energy Policy of Poland until 2030" and National Renewable Energy Action Plan, in 2020 RES shall reach 15.5% in final energy consumption. The largest share will go to biomass and wind energy. In the case of the heating and cooling sector, final energy consumption in 2020 is expected to be 5921 ktoe, with the dominance of biomass – 86% share of all RES. The share of solar energy is set at 8.5%, while the forecasted share of geothermal energy is very low: 3% (without heat pumps), similar as heat pumps' share – 2.5% (including geothermal, hydrothermal and aerothermal ones). The NREAP does not include geothermal electricity generation (binary systems), even on a small scale (single devices with a capacity of tens-hundreds of kWe), as postulated by the experts. However, government project of RES Law involves introduction of factor 1.4 in case when such generation will develop.

Although the official prognoses predict a very low share of geothermal in the RES mix, it should be noted that Poland has prospective resources especially for heating sector (district heating), as well as for bathing and balneotherapy. As mentioned above, in certain cases one may also consider the binary systems (usually co-generation of power and heat).

10. CLOSING REMARKS

In Poland, there are circumstances conducive to the geothermal uses deployment: prospective water and energy resources, potential receivers of geothermal

heat and water, as well as high level and scientific commitment, the Polish and European experience of servicing companies (drilling, geophysics), contractors of installations, etc. One shall add the need to implement EU- and national documents to increase the RES use and follow sustainable energy development. Operating geothermal plants, associated environmental effects and social benefits along with the growth of some investments observed in past few years, suggest that more dynamic geothermal energy development is possible. Particularly prospective is the heating sector (space heating, DH, agriculture, aquaculture, other). In some locations the prospects exist for binary electricity and heat cogeneration (based on ca. 90-100ºC water). The promising branch represents also recreation and balneotherapy (attracting especially private investors). Further GSHPs' development is expected, following the progress observed in 2011-2012.

To facilitate the geothermal deployment some regulations and faster administrative procedures were introduced in new geological and mining law. It was expected that they would effectively work thanks to introduction of complementary relevant provisions in e.g. new law on RES (including incentives for renewable heat), and at least by maintaining the current measures of public support for the projects (drillings), surface infrastructure, etc. However – as mentioned before, the expected measures and incentives have not been introduced and the support from NFEP&WM was completed. According to the author of this article and other experts these may significantly limit or even stop the development of geothermal energy, specially for energetic purposes.

Last but not least one shall point out significant role of geothermal education and promotion addressed to various groups of professionals, students, teenagers and wide circles of common public. This is an indispensable condition to create awareness of public and decision makers on geothermal energy resources and create better conditions for it wider uses. Some relevant activities have been conducted in the country but they shall be done at more regular and wider basis (Table G). Important is also the participation in international initiatives and cooperation, transfer of know-how and best practices. In this respect, some teams and experts have been participating projects co-funded by EC, e.g. Geothermal Communities; www.geothermalcommunities.eu) and GEODH; www.geodh.eu).

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Tables A-G

Table A: Present and planned geothermal power plants, total numbers*

*Geothermal power plants are not available in the country.

Table B: Existing geothermal power plants, individual sites*

*Geothermal power plants are not available in the country.

Table C: Present and planned geothermal district heating (DH) plants and other direct uses, total numbers

	Geothermal DH Plants		Geothermal heat in agriculture and industry		Geothermal heat in balneo-therapy, recreation and other	
	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)
In operation end of 2012	101.9	148.4	2.0	1.8	11.5	36.3
Under construction end of 2012*	~20	-	-	-	~10	-
Total projected by 2015	~130	~265	?	?	~25	~70

* mainly extensions of operating plants

Table D: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commiss.	Is the heat from geo-thermal CHP?	Is cooling provided from geo-thermal?	Installed geotherm. capacity (MW_{th})	Total installed capacity (MW_{th})	2012 geo-thermal heat prod. (GWh_{th}/y)	Geother. share in total prod. (%)
Podhale Region	PEC Geotermia Podhalanska SA	1993	no	no	40.7	80.8	100.9	70.7
Pyrzyce	Geotermia Pyrzyce SA	1996	no	no	35.2	48.0	14.5	52
Mszczo-nów	Geotermia Mazowiecka SA	2000	no	no	6.4	11.2	3.1	40
Uniejow	Geotermia Uniejów Sp. z o.o.	2006	no	no	3.2	5.0	4.4	80

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Table D (continued):

Locality	Plant Name	Year commiss.	Is the heat from geo-thermal CHP?	Is cooling provided from geo-thermal?	Installed geotherm. capacity (MW_{th})	Total installed capacity (MW_{th})	2012 geo-thermal heat prod. (GWh_{th}/y)	Geother. share in total prod. (%)
Stargard Szczecin-ski	G-term Energy Sp. z o.o.	2012*	no	no	12.6	12.6	25.3	100
Podde-bice**	Geotermia Poddebice Sp. z o.o.	2012	no	no	3.8	3.8	-	-
Total					**101.9**	**161.4**	**148.4**	

* re-launch, geothermal plant sales geo-heat to Municipal DH Company, ** - heat sales started in 2013

Table E: Shallow geothermal energy, ground source heat pumps (GSHP)*

	Geothermal Heat Pumps (GSHP), total			New GSHP in 2012		
	Number	Capacity (MW_{th})	Production (GWh_{th}/y)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2012	> 30,000	> 330	> 470	> 5100	> 50	Info not available
Projected by 2015	> 50,000	> 550	> 780			

Table F: Investment and Employment in geothermal energy

	in 2012		Expected in 2015	
	Investment (million €)	Personnel (number)	Investment (million €)	Personnel (number)
Geothermal electric power	-*	-	?	-
Geothermal direct uses	ca. 300 (rough estimate)	ca. 100 prs**	150 – 200 (?)	? > 100 prs (expected growth in number of technical personnel)
Shallow geothermal	No data available	No data available		
total	-*	-	?	-

* - some R&D installations may be constructed (<1 MWe),
** - number of personnel with academic degrees (not number of full time job positions, and without technical personnel working mainly in new recreation centres (see chapter 6)

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D		Yes (support by some national and int. programs), By 2012 support from Ministry of Environment/NFEP&WM (closed in 2013) - exemption from fees for the geological information used for project purposes (provision in Geological&Mining Law facilitating R&D projects' procedures; see chapter 8)	-
Financial Incentives – Investment		DIS: not since 2013 (yes by 2012 from NFEP&WM) LIL – yes RC – no - reduced fee for the use of geological information in order to exploit geothermal water (up to 1% of its value to 31/12/2020, then 5%), - reduced fee for geological information used for geothermal water exploitation (1% of its value by 2020, 5% after 2020) (provisions in Geological&Mining Law; chapt. 8)	Yes – public support from some regional Funds for Environment Protection and Water Management for purchase and installation but for public entities only and larger installations, not for private individual houses
Financial Incentives – Operation/Production	FiT: no *	No fee for exploited geothermal water (provision in Geological&Mining Law; chapt. 8)	-
Information activities – promotion for the public		No regular all-country activities so far, some occasional information in mass media, events for some professionals, local authorities, etc.	
Information activities – geological information		Yes: - Basic information available (State Geological Survey data base), - Geothermal atlases covering of the country (funded by public sources), other published sources	
Education/Training – Academic		Yes – but in several cases only (+ single post-graduate courses aimed at RES, not geothermal exclusively)	
Education/Training – Vocational		Single cases only (in some secondary schools geothermal included into wider topics (not separate) No all-country program so far	

Key for financial incentives:					
DIS	Direct investment support	RC	Risc coverage	FIP	Feed-in premium
LIL	Low-interest loans	FIT	Feed-in tariff	REQ	Renewable Energy Quota

* Factor 1.4 for binary generation in government proposal of RES Law