Geothermal Energy Use - Country Update for Poland, 2013-2015

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ABSTRACT

The paper updates the status of geothermal energy development in Poland in 2013–2015 since European Geothermal Congress 2013 (Kępińska, 2013) and World Geothermal Congresss 2015 (Kępińska, 2015).

The country has low-temperature resources (connected mostly with Mesozoic sedimentary formations). Their direct applications involve space heating, balneotherapy, bathing and recreation, aquacultures, some minor uses.

At the end of 2015 six geothermal district heating plants were operating. Their total installed geothermal capacity was 76.2 MW_{th} and geothermal heat production 227.11 GWh (817.59 TJ). A growing interest has been continuing in recreation and balneotherapy: the group of 7 new centres and 2 health resorts opened in 2006–2012 and reported in 2013 was extended by 6 ones launched in 2013–2015. One may estimate their total geothermal capacities as 20 MW_{th}, and heat uses as 59 GWh (210 TJ) in 2015. In case of ten health resorts using geothermal water for curative treatments, these figures were estimated for 6 MW_{th}, and 14 GWh (50 TJ) in 2015. It is worth to point out the opening of modern atlantic salmon farm using geothermal water in 2015 (ca. 0.6 MW_{th} and 2.8 GWh at initial stage). Other minor uses comprised semi-technical wood drying, and heating up a football playground. These applications represented approx. in total 2.5 MW_{th}, and 1.9 GWh (7 TJ) of heat use.

In case of GSHP sector, its development (initiated several years ago) was persisting. One may roughly estimate that in 2015 they reached at least 500 MW_{th} and 714 GWh (2500 TJ) (comparing to 330 MW_{th} and 194 GWh (1700 TJ) in 2013). The progress of GSHPs was part of the progress of whole heat pumps' sector.

In 2015 total installed geothermal capacity (heat pumps including) was at least 705 MW_{th} while heat production and uses amounted to 1020 GWh (3 672 TJ) comparing to 445.4 and 658 GWh (2370.6 TJ) reported at EGC 2013; Kępińska, 2013).

In 2013–2015 eight new geothermal wells were drilled (one was negative). They encountered ca. 30-95ºC waters for bathing, recreation and space heating in some cases. One injection well was deepened.

Along with the investment projects various research, R&D, feasibility studies, projects of new drillings and implementation projects were conducted. Some R&D works on prospects for geothermal binary power generation, CHP (based on at least 90–100ºC water) and on HDR/EGS prospects were accomplished in 2013–2014.

However, comparing with the resource base and progress in that sector in other European countries, geothermal uses development in Poland has been moderate so far, specially in the heating sector.

1. INTRODUCTION

The paper updates the geothermal energy development in Poland in 2013–2015 since European Geothermal Congress 2013 (Kępińska, 2013) and World Geothermal Congresss 2015 (Kępińska, 2015). Geothermal uses involve space heating, balneotherapy and recreation, aquaculture and some minor uses.

At the end of 2015, 6 geothermal district heating plants were operating. Their total installed geothermal capacity was 76.2 MW_{th} and heat production 227.11 GWh. Space heating is a key sector for geothermal energy development.

A growing interest has been continuing in recreation sector: 6 new centres were opened in 2013–2015. In total, 13 geothermal recreation centres were operating in 2015. Besides, there are 10 health resorts using geothermal water for treatment, including 3 ones that were built or received formal status in 2009–2012) as reported in 2013 (Kępińska, 2013).

The paper lists also several ongoing geothermal investments, research projects etc. in various stages of advancement. However, comparing with several other countries, the development in Poland has been slow, specially in the heating sector (which shall be the crucial one for the country).

2. GEOTHERMAL ENERGY POTENTIAL

Geothermal water and energy resources are hosted by sedimentary formations of various ages in the Polish Lowlands, the Inner Carpathians (the most prospective areas) and in some locations in the Outer Carpathians, the Carpathian Foredeep and in crystalline or metamorphic rocks of the Sudetes region (Fig. 1).

The water temperatures at the outflows from the wells recorded so far vary from ca. 20 to about 95°C (depths up to ca. 3.5 km). The proven geothermal water reserves amount from several L/s up to 150 L/s. Waters are suitable for the wide spectrum of direct uses for space heating, agriculture, etc., as well as for balneotherapy and recreation.

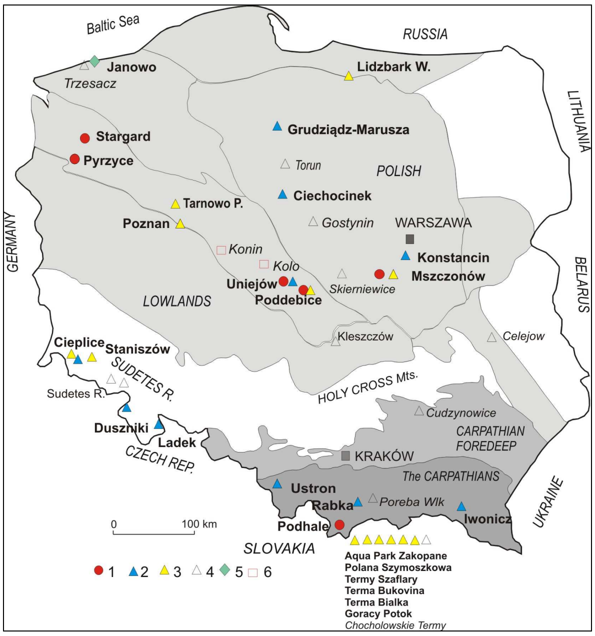

Figure 1. Poland: geothermal direct uses, end 2015: 1. geothermal district heating plants in operation, 2. health resorts using geothermal waters, 3. geothermal recreation centers in operation, 4. some geothermal recreation centers under construction, 5. aquaculture (fish farming), 6. planned CHP plants (early stages of investment projects)

3. OVERVIEW OF GEOTHERMAL USES

This chapter gives an insight into direct geothermal uses in Poland at the end of 2015. Main data on geothermal plants and installations are given in Tables A – G, their location is shown on Figure 1.

3.1 Space heating

In 2015, 6 geothermal district heating plants (geoDH) were operational: in the Podhale region and in the municipalities of Pyrzyce, Mszczonów, Poddębice, Uniejów, and Stargard.

In addition to geoDHs, in some recreation centers geothermal waters were used both for filling the pools, various treatments and for heating the objects (chapters 3.2, 3.3).

The Podhale region. The plant has been operating since 1994 (on larger scale since 2001) as the biggest geoDH in the country and one of the biggest in Europe. The total maximum water flow rates (artesian!) produced by 3 wells reach 267 L/s while average during heating season 187 L/s of 82–86°C water. A third production well was drilled in 2012–2013 and added into the geoDH system in 2014. In 2015 the installed geothermal capacity was 40.7 MW_{th} (total 82.6 MWth including gas and fuel peaking boilers). The total heat production amounted to 511.46 TJ and geothermal 462.93 TJ (90.51%). In case of heat sales it was 393.49 and 356.15 TJ, respectively (W. Ignacok, M. Pelczarska, W. Wartak – *pers. communication*). In 2015 ca. 1600 receivers were hooked to geoDH (mostly in Zakopane – the main city of that region and main heat market; geoDH met ca. 35% of its heat demand). Part of spent geothermal water is injected back while part supplies 2 recreation centres (opened in 2008 and 2015).

Pyrzyce. The geoDH plant has been operating since 1996. The maximum flow rate from two production wells is ca. 100 dm^3/s of 61°C water (spent water is injected back by two wells). After recent optimisation works the plant's maximum installed capacity is 22 MW_{th} including 16 MW_{th} high–temperature gas boilers and 6 MW_{th} geothermal heat exchangers (which cooperate with 20.4 MW_{th} absorption heat pump).

The plant supplies heat and domestic warm water to over 90% users of the town's population (13,000) meeting ca. 60% of total heat demand. In 2015 geothermal heat production was ca. 66.54 TJ and total heat production was 105.61 TJ/2015 (S. Kulik – *pers. communication*).

Mszczonów. The geoDH has been operating since 2000. Maximum geothermal water flow rate is ca. 16.6 L/s of 42.5°C, while TSD are 0.5 g/L. Water is discharged by a single well (no injection). After modernisation in recent years, in 2015 the total installed capacity was 8.3 MW_{th} (4.6 MW_{th} gas boilers, 2.7 MW_{th} absorption heat pump and 1 MW_{th} compressor heat pump). The plant uses geothermal water for district heating and than for drinking (water cooled down by compressor heat pump), and for the pools in recreation centre "Termy Mszczonowskie". In 2015 geothermal heat production was 15.698 TJ, total 41.07 TJ (heat sales 14.44 and 37.79 TJ, respectively. (M. Balcer, B. Dajek – *pers. communication*).

Uniejów. The geoDH has been operating since 2001. The maximum discharge from one production well is 33.4 L/s of 68°C water while TDS are ca. 6–8 g/L. The exploitation system includes also two injection wells. The total installed capacity of the plant is 7.4 MW_{th} including 3.2 MW_{th} from geothermal, 1.8 MW_{th} from biomass boiler and reserve 2.4 MW_{th} fuel oil peak boilers. In 2015, 80% of all buildings in that town were supplied by the geoDH. Geothermal heat production / sales were 6.82/15.89 TJ, respectively (80% of total coming from the biomass boiler) (J. Kurpik, B. Piątkowska – *pers. communication*).

Since 2008 a part of geothermal water has been used in geothermal spa and recreation centre “Termy Uniejów” for pools and curative treatments (ca. 8.4 L/s of 42°C water; ca. 1 MW_{th}, 7.7 TJ). The centre is also heated by geothermal energy. Some amount of spent water (ca. 5.6 L/s, 28°C) is than used to heat up a lawn of football playground (ca. 1 MW_{th}, 8.7 TJ) and walking paths. In 2012 Uniejów received a formal status of health resort thanks to curative geothermal water. Some new types of geothermal uses are at various stages of project preparation and planning.

Poddębice. In that municipality, construction of geothermal district heating plant was commissioned in 2012. The geoDH of 10 MW_{th} geothermal capacity is based on 71ºC water (average flow rate 32.2 L/s, mineralization 0.4 g/L). The plant initiated geothermal heat sales in February 2013 supplying some public buildings, school, hospital (and its rehabilitation part), several multi-family houses. In 2015 geothermal heat production / sales were 52.00/ 42.28 TJ, respectively. Some part of water stream is sent to swimming pools (A. Karska, A. Peraj – *pers. communication*).

Stargard. The plant was re-open in 2012 (closure in 2008–2012) after, among others, some rehabilitation works in wells and surface equipment. It is based on a doublet of production and injection wells. The maximum production is ca. 50 L/s of 87°C water. In 2015 the geothermal capacity was 12.6 MW_{th} and geothermal heat production was 213.61 TJ, entirely sold to the municipal district heating plant for heating and domestic warm water preparation (A. Biedulski – *pers. communication*). This plant is coal-fired (total capacity 116 MW_{th} serving about 75% of local population (75,000). Geothermal meets ca. 30% of total heat demand of that municipality.

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To sum up the geoDH systems: in 2015 six plants were operating. Their total installed geothermal capacity was 76.2 MW_{th} and geothermal heat production 227.11 GWh (817.59 TJ). In individual cases geothermal share in total heat production was from 38 to 100%. The biggest installed total (82.6 MW_{th}) and geothermal capacity (40.7 MW) had the geoDH plant in the Podhale region. It produced the biggest volume of geothermal heat in the country (in 2015 there was 128.59 GWh (462.93 TJ) from total 142 GWh. It is one of the biggest geoDH systems in Europe (continental).

3.2 Health resorts

Geothermal waters have been used for healing treatments in ten health resorts (. Waters come mostly from wells (in single cases from springs – the Sudetes region). 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 the iodine-bromine or cosmetic salts, and CO_2 are extracted from the 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 geothermal water is also used for heating the centers’ objects and warm water preparation. For installations of this group total geothermal capacity and heat consumed in 2015 were estimated for about 6 MW_{th} and 14.6 GWh (the evaluation was made on the basis of data from 2014 ; Kępińska, 2015).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 Recreation, balneotherapy

As reported in 2013 (Kępińska, 2013), 7 new geothermal recreation / balneotherapeutical centers were constructed in 2006–2012. Next 6 centers were opened in 2013–2015. Altogether 13 centers were operating at the end of 2015. Some of them apply geothermal water both for the pools and other facilities and for heating their objects and warm water preparation (sometimes with ca. 1 MW_{th} compressor heat pumps’ usage).

For this group of centers using geothermal water (sometimes also for heating the objects), their total geothermal capacity was roughly estimated for at least 20 MW_{th} and heat use for 59 GWh (210 TJ) in 2015 (the evaluation made on the basis of data from 2014 (Kępińska, 2015), updates and estimations for 2015).

In 2015 several further investments oriented for recreation were at various stages of realization or under projects’ elaboration (chapter 5).

3.4. Aquaculture

It is specially worth to point out the opening in 2015 of a large-scale modern atlantic salmon’s farm using geothermal water (Janowo at the Baltic coast). Water comes from the well drilled in 2012 and is applied both for culturing and for heating the farm’s facility. At initial stage of farm’s operation the average water flow rate is ca. 20 L/s. (K. Karapuda, M. Kowalski – *pers. communication*). Its geothermal capacity was estimated for 0.6 MW_{th} and geothermal heat use for ca. 10 TJ in 2015 (calculated on the basis on inlet – outlet temperatures and average water flowrate).

3.5 Other uses

In addition to the-above-listed, one shall mention a semi-technical wood drying at MEERI PAS installation in the Podhale region (ca. 0.2 MW_{th}, 0.17 GWh, 0.6 TJ) and heating up of football playground and walking path (1 MW_{th}, 1.4 GWh, 5 TJ) mentioned above. These uses were estimated for total of ca. 1.2 MW_{th}, ca. 1.57 GWh / 5.6 TJ of heat in 2015.

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In 2015 total installed geothermal capacity for all the-above-listed types of direct uses (except for GSHPs (see chapter 3.6 below) was about 104.9 MW_{th} (bulk for geoDHs: 76.2 MW_{th}). Total geothermal heat production (by geoDH s) and used / consumed (in case of other installations) was ca 304.48 GWh.

3.6 Heat pumps

In several recent years the constant progress of heat pumps' sector (all types) has been observed in contrast to many previous years. For instance – in 2015 it was expressed by average 14% growth of sales compared with 2014 (the most spectacular 70% growth was in air HPs in 2015; *http:// gramwzielone.pl/dom-energooszczedny/20250/ jak-rozwija-sie-polski-rynek-pomp-ciepla-wywiad*). This trend is expected to be continued. In case of GSHPs the average market growth was ca. 5% and ca. 5 000 units sold in 2014 and 2015 (information based on *www.portpc.pl*). One may estimate that at the end of 2015 the number of GSHP was ca. 45 000 pieces, while their total capacity at least 500 MW_{th} and heat production at least 695 GWh / 2500 TJ (comparing to ca. 35 000 units, ca. 390 MW_{th} 1700 TJ in 2013; Kępińska, 2013).

Typical capacities of single units vary from less than 20 kW_{th} up to 70–150 kW_{th}. The largest single units reach ca. 1 MW_{th} (some work also in several geoDHs; e.g. Mszczonów geoDH plant, two recreation centres).

4. GEOTHERMAL DRILLINGS

In 2013–2015 eight new geothermal wells were drilled (including one dry well which may serve as BHE). Two wells resulted in particular good parameters: one in the Podhale region (flow rate ca. 80L/s, wellhead temperature 85°C; included as a third producer into existing geoDH system) and one in the Polish Lowlands (Konin: flow rate min. 80 L/s, wellhead temperature 95°C; a basis for CHP plant and other uses; T. Neczyński – *pers. communication*). Other wells will serve mostly for geothermal water production for recreation. One existing injection well was reconstructed and deepened (directionally).

However, relatively less geothermal wells were drilled in the in 2013–2015 than in former years. It was mostly due to the termination of public financial support for drillings provided by the National Fund for Environmental Protection and Water Management (in 2012) what had have a negative impact especially for the development of geothermal heating sector (there are some expectations that the situation will change in the forthcoming period).

5. WORKS IN PROGRESS AND PLANNED

In 2013–2015 several further geothermal investments (oriented mostly for recreation), pre-investment, as well as research and R&D projects were at various stages of realisation or accomplished. Their general summary follows:

- Several investments oriented for recreation and balneotherapy. The opening of some of them is expected in 2016;
- Initial stages of at least two projects (Konin, Koło) aimed at CHP plants (based on above 90°C water; in one case the well was already drilled);
- Some from the operating geoDH plants were in progress or planning the optimisation and energy efficiency works (surface infrastructure, downhole equipment). Some operators were in progress or planned the extension of existing systems, some were considering or preparing for drilling new production or injection wells (drillings conditioned by the availability of sufficient financial support);
- Several pre-investment works and feasibility studies related to various sites in the country (mostly recreation, sometimes space heating, also in the systems hybridized with other RES and fossil fuels). These works included, among others, the efforts to establish a new health resort based on geothermal water and energy resources;
- The research, R&D projects addressing various geothermal aspects: in that group one shall point out the publication of the Geothermal atlas of Eastern Carpathians (Górecki [sc. ed.], Hajto M. et al., 2013) – together with earlier similar works for the Polish Lowlands, the Western Carpathians, the Carpathian Foredeep, the Małopolska Region and the Upper Silesia Region they cover over 80% of Polish territory and serve as comprehensive sources of information for scientists and potential investors;
- Another two research projects to define potential HDR systems (Wójcicki et al., 2013), as well as the prospective areas and conditions for binary power generation (Bujakowski, Tomaszewska [sc. eds] et al., 2014) were conducted;
- Since 2014 a R&D project has been ongoing on "Obtaining of drinking water, liquids and balneological substances in the treatment of cooled thermal waters" (Tomaszewska, 2015);
- The teams from Poland participated several EU projects on with various geothermal aspects, e.g.:
  - "Promote geothermal district heating systems (GeoDH; *www.geodh.eu*),
  - "Geothermal communities – demonstrating the cascading use of geoth. energy for district heating with small scale RES integration and retrofitting measures" (*www.geothermalcommunities.eu*),
  - "Geothermal energy for Transboundary Development of the Neisse Region. Pilot Project", (*www.transgeotherm.eu),*
  - The project in frame of Life+ program oriented for improvement and maintenance of sandstone aquifer's injectivity applying the soft acidizing method in the geoDH system in Pyrzyce (*http://www.geotermia.inet.pl*);

- In the reported years "The Guidelines for design, execution and acceptance of installation with heat pumps" were published – the first of its kind on the Polish market)– by the Polish Organisation for Heat Pumps Development (Lachman, Mirowski [ed] et al, 2013);

- To draw attention on geothermal potential and to enhance its practical uses deployment the Polish Geothermal Society has been presenting a concept of geothermal heating plants development in the Polish cities for several years. It is addressed to the municipalities located in areas prospective in terms of resources, possessing district heating networks, heat market, etc. where geothermal energy can be successfully introduced. In former years the concept gained recommendations of some governmental and parliamentary representatives. It is hoped that it will enter a more concrete stage (following the similar cases of other countries, e.g. Denmark).

6. PROFESSIONAL PERSONNEL ALLOCATION

In 2015 a number of professional full-time personnel at various fields of geothermal activities (scientific institutions, geothermal plants and other installations, consulting companies) might be roughly estimated for ca. 200 persons. Along with 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, but not taken here into account). The employment in other sectors related to geothermal activities is not included in these numbers.

7. INVESTMENTS IN GEOTHERMAL SECTOR

The investments in geothermal sector in 2013–2015 can be roughly estimated for min. 100–120 million million €. These sum includes drillings, related works and equipment, surface infrastructure, installments; tentative estimates of private funds. Bulk of the funds was spent for new recreation and balneotherapy centers, significant sum went also for drillings. These figures do not include the funds spent for R&D and various studies and projects made by several agencies and paid from different sources. In case of shallow geothermal the investments in 2013–2015 were estimated for min. 150–170 million € for total of ca. 14 000 new GSHPs pieces: small capacities for individual houses (heat pump plus equipment, mounting, two BHE; cost from 10 000–12 000 €).

8. LEGAL AND ECONOMIC ASPECTS

Thanks to new Geological and Mining Law since 2012 economic activity aimed at geothermal water / energy management (exploration, exploitation) has been the subject of one-staged licensing procedures. The licenses are issued by the regional administration. That Law introduced also several other provisions facilitating geothermal activities (Kępińska, 2013) like the 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); cancellation of licenses for geothermal water's exploration and prospecting – just geological works project to be approved by the regional administration; 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.

However, except for positive provisions of the Geological and Mining Law, no other proper regulations facilitating geothermal deployment have been introduced so far. For instance – the RES Law (2014) is oriented mostly for electricity and does not sufficiently deal with RES heating/cooling.

In addition – there is no public support for drillings (the program operating till 2012 was closed (as reported in the past; Kępińska, 2013; Kępińska, 2015) and was not reactivated (or replaced by a similar tool) till now (March 2016). Another important but missing tool is the Geological Risk Insurance Fund postulated to be introduced by many professionals. In case of geothermal energy (as well as other RES) no support scheme for generation / sales of renewable heat exists.

There are some expectations that better provisions for geothermal deployment will be introduced, specially in case of heating/energy sector.

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

According to official commitments and documents ("Directive 2009/28/EC", "The Energy Policy of Poland until 2030", "The National Renewable Energy Action Plan") 15% of gross final energy consumption in Poland will come from RES by 2020. Just as now, biomass will dominate, with a significant share of wind energy. In case of heating/cooling sector itself, by 2020 the final RES energy consumption is expected for 5921 ktoe, also dominated by biomass (86%) while the share of geothermal is prognosed for 3% only (without GSHPs) and 2.5% for heat pumps (all types).

Taking into account the 2014 share of geothermal energy ("deep") in RES' heat production, i.e. approx. 0.35% and 0.5% for the heat pumps (Berent-Kowalska et al., 2015), it is clear that in order to achieve even this low assumed geothermal share (3%, 2%) by 2020, many actions and investments would be needed resulting in putting on-line at least several geothermal heating plants by 2020.

Although the official prognoses predict a very low geothermal share in the RES mix, it should be noted that Poland has the resources suitable for wider applications especially for heating (district heating), as well as for bathing and balneotherapy. As mentioned above, in certain cases one may also consider the binary systems (CHP).

10. CLOSING REMARKS

In the conclusion of the reported years 2013–2015 it can be stated that some progress has been made in Poland in the field of geothermal direct uses in comparison to the previous period until 2013, specially in recreation/balneotherapy (6 new centers) and in the GSHPs' sector (as part of the growth of the whole HPs' sector). This was expressed as a 30% increase in the total installed geothermal capacity and 25% of the produced / consumed heat since 2013.

It is also worth noting that just in Poland are some from the largest heating installations on European continent, both in case of "deep" and "shallow" geothermal: the Podhale region geoDH system (geothermal installed capacity 40.7 MW_{th} and heat production 463 TJ/ 128.6 GWh in 2015) and GSHP installation (hospital) in Szczecin town (2.6 MW_{th} installed capacity of low heat source; *www.portpc.pl*).

However, the stagnation of geothermal uses for heating (no new geoDH systems) was noticeable in 2013–2015 despite the country has the appropriate reservoir potential and many other arguments in favor of geothermal deployment for that purposes (even if coal is and will remain the primary energy source).

The situation was largely the result of lack of public support system for geothermal drillings, missing other measures and provisions as well as the lack of a clear conducive state policy (or at least treating geothermal in a comparable way with other RES).

The author of this paper and many members of geothermal community expect the change of the conditions for geothermal deployment for the better ones (following the declarations of government officials in recent period) as to missing to the present legal provisions, financial decisions and necessary measures to support and stimulate the development of this sector, like in other European countries. Then one can expect more dynamic development of geothermal applications both for recreation centers, and – first of all – for space heating on a scale larger than presented in this country update for 2015.

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

	Geothermal Power Plants*		Total Electric Power in the country**		Share of geothermal in total electric power generation	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2015	-	-	40 273	164 380	0	0
Under construction end of 2015	-	-	~ 3 800	~13 000	0	0
Total projected by 2018	~ 1 – 2 MW_e (B, CHP)	~ 2 – 3	est. ~ 43 000	est.~174 000	<0.001	<0.001
Total expected by 2020	~ 2 – 4 MW_e (B, CHP)	~ 3 – 6	est. ~ 44 000	est. ~176 000	<0.001	<0.001
In case information on geothermal licenses is available in your country, please specify here the number of licenses in force in 2015 (indicate exploration/exploitation, if applicable):						

* conservative estimations based on information available end 2015, early 2016
** acc. to: ARE – Informacja Statystyczna o Energii Elektrycznej, (2015); Fakty: Węgiel – Energetyka w Polsce (elaborated by Z. Grudziński; *www//min-pan.krakow.pl/zaklady/zrynek/cf_we.htm*, access 9.03.2016); Gawlik [ed] et al., (2013); estimations based on historical data 2009–2014.
The numbers given consider both the additions of new installed capacity and termination of some old units by 2020.

Table B: Existing geothermal power plants, individual sites

Locality	Plant Name	Year commis-sioned	No of units **	Status	Type	Total capacity installed (MW_e)	Total capacity running (MW_e)	2015 pro-duction (GWh_e/y)
-	-	-	-	-	-	0	0	0
total						0	0	0

Key for status:		Key for type:			
O	Operating	D	Dry Steam	B-ORC	Binary (ORC)
N	Not operating (temporarily)	1F	Single Flash	B-Kal	Binary (Kalina)
R	Retired	2F	Double Flash	O	Other

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 for individual buildings		Geothermal heat in balneology and other *	
	Capacity (MW_{th})	Production (GWh_{th}/yr)	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 2015	76.2	227.11	3.1	3.7	-	-	26	73
Under constru-ction end 2015	-	-	-	-	-	-	~ 10–20 (*est.* for 6 centres)	~ 25
Total projected by 2018	~100–120	~ 300	~ 6	~ 8	?	?	~ 45–50	~110
Total expected by 2020	~130–150	~ 450	~ 9	~ 12	?	?	~ 70–80	~ 140–150

* Note: spas and pool are difficult to estimate and are often over-estimated. For calculations of energy use in the pools, be sure to use the inflow and outflow temperature and not the spring or well temperature (unless it is the same as the inflow temperature) for calculating energy parameters, as some pool need to have geothermal water cooled before using it in the pools.

Table D1: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commis-sioned	CHP *	Cooling **	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2015 produc-tion (GWth/y)	Geoth. share in total prod. (%)
Podhale Region	PEC Geotermia Podhalańska SA	1993	-	Y (RI)	40.7	82.6	128.59	90.51
Mszczonów	Geotermia Mazowiecka SA	2000	-	N	3.7	8.3	4.358	38.2
Poddębice	Geotermia Poddębice Sp. z o.o.	2014	-	N	10	10	14.44	100
Uniejów	Geotermia Uniejów Sp. z o.o.	2006	-	N (RI)	3.2	7.4	1.89	80
Pyrzyce	Geotermia Pyrzyce Sp. z o.o.	1994	-	N (RI)	6	22	18.483	63.0
Stargard	Geotermia Stargard Sp. z o.o.	2012 (re-open)	-	N (RI)	12.6	12.6	59.336	100
total					76.2	142.9	227.11	

* If the geothermal heat used in the DH plant is also used for power production (either in parallel or as a first step with DH using the residual heat in the brine/water), please mark with Y (for yes) or N (for no) in this column.

** If cold for space cooling in buildings or process cooling is provided from geothermal heat (e.g. by absorption chillers), please mark with Y (for yes) or N (for no) in this column. In case the plant applies re-injection, please indicate with (RI) in this column after Y or N.

Table D2: Existing geothermal direct use other than DH, individual sites

Locality	Plant Name	Year commis-sioned	Cooling *	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2015 produc-tion (GWh_{th}/y)	Geoth. share in total prod. (%)
10 localities** (Ladek, Cieplice, Duszniki, Ustron, Rabka, Iwonicz, Ciechocinek, Konstancin, Grudziadz/Marusza, Uniejów)	Health resorts	13th c. - 2012	-	6	6	14	100
13 localities** (Zakopane Aqua Park, Zakopane Szymoszkowa, Bialka, Bukovina, Szaflary (2x), Mszczonow, Poddebice, Cieplice, Staniszów, Poznan, Tarnowo Podgórne, Lidzbark)	Recreation/ balneotherapy	2006-2015	-	ca. 20	20	59	100
Bańska Niżna (MEERI PAS)	Wood drying	1993	-	0.5	0.5	0.5	100
Uniejów	Heating up of football playground, walking path	2008	-	2	2	1.4	100
Janowo	Atlantic salmon farm	2015	-	0.6***	0.6	2.8	100
total				29.1	29.1	77.7	

* If cold for space cooling in buildings or process cooling is provided from geothermal heat (e.g. by absorption chillers), please mark with Y (for yes) or N (for no) in this column. In case the plant applies re-injection, please indicate with (RI) in this column after Y or N

** The evaluation for all localities in the group was made on the basis of data from 2014 (Kępińska, 2015), updates and estimations for 2015. Capacity calculated (not installed) for almost all other cases

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

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2015 *		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2015 *	~ 45 000	~ 500	~ 714.3	~5 000	~ 55	**
Projected total by 2018* (2016-2017)	~55 000	~ 600	~ 850			

* Numbers given and estimations made on a basis of data provided by Polish Organisation for Heat Pumps Development (*www.portpc.pl*; access 4.03.2016) and data for 2014 (Kępińska, 2015)

** Difficult to evaluate. However, some surveys and estimations made for all heat pumps' types indicate that heat pump (of various type) is installed at ca. 10% of newly-constructed individual houses (*http://www.budujemydom.pl/pompy-ciepla/12662-dlaczego-40-budujacych-dom-chce-pompe-ciepla*; access 15.03.2016), so some of them can be GSHPs.

Table F: Investment and Employment in geothermal energy

	in 2015		Expected in 2018	
	Expenditures * (million €)	Personnel ** (number)	Expenditures * (million €)	Personnel ** (number)
Geothermal electric power	0	0	10	10
Geothermal direct uses	*est.* 100 – 120	~ 200 – 300	*est.* 100 – 120	ca. 300 – 400
Shallow geothermal	50 – 60	?	50 – 60	?
total	**> 150 – 180**	**> 200 – 300**	**> 150 – 180**	**> 300 – 400**

* Expenditures in installation, operation and maintenance, decommissioning: minimum estimations / for small GSPH units, with equipment, mounting, two BHE). Larger GSHPs are not included (see chapter 7).

** Personnel, only direct jobs: Direct jobs – associated with core activities of the geothermal industry – include "jobs created in the manufacturing, delivery, construction, installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration". For instance, in the geothermal sector, employment created to manufacture or operate turbines is measured as direct jobs.

The Table gives mainly the number of personnel with academic degrees, employees in geoDH, geothermal health and recreation centres (not number of full time job positions, and without technical personnel working seasonally mainly in recreation centres. For shallow geothermal it is difficult to estimate the number of personnel (it would require separate survey, such data are not available yet)

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	-	O: public support /grants for R&D projects /national, EU- sources/	O: public funds for R&D projects /national, EU- sources/
Financial Incentives – Investment	-	O: - No fee for geological information aimed at exploration project LIL: Lower interest loans from regional environment funds (for surface heating infrastructure like for other RES) DIS: Some subsidies /grants for the-above-surface parts of installations /in general support schemes as for other RES/ However: main support tools missing so far: - risk guarantee fund - public support /subsidy for drilling first geothermal exploration well, - lack of provisions facilitating RES/geothermal heat in RES Law (put in force Feb 2015)	Yes: DIS/LIL 2014-2022: Program of the National Fund for Environmental Protection & Water Management. „Support of dispersed RES sources. *Prosument* – LIL loans/credits, partial grants for purchasing and installing micro-installations producing heat (up tp 300 kW_{th}), electricity (up to 40 kW_e) or co-generation. Heat pumps are in the group with biomass boilers, solar collectors, pV, small hydro, micro-co-generation. Program oriented for electricity, worser conditions for heat (heat pumps; 20% of support / 40% for electricity/pV). Beneficiaries: natural prs, local administration units, housing cooperatives and communities

Financial Incentives – Operation/Production		O: - reduced fee for geological information used for geothermal water exploitation (1% of its value by 2020, 5% after 2020) - no fee for geothermal water exploitation	-
Information activities – promotion for the public		Yes, but occasional not regular ones More systematic activities needed No regular all-country activities so far, some occasional information in mass media, at events for some professionals, local authorities, etc.	Yes, but occasional not regular basis More systematic activities needed No regular all-country activities so far, some occasional information in mass media, at events for some professionals, local authorities, etc.
Information activities – geological information		Yes, Geological information is available Basic information: - State Geological Survey data base; some others data bases, - Geothermal atlases covering ca. 80% of the country (funded by public sources), - Several other published and archival data sources In case of information activities – more systematic activities needed	Yes, Geological information is available, but more detailed recognition of geological conditions/parameters of ground/groundwater as low heat source for GSHPs in particular areas/localities are recommended In case of information activities – more are needed More systematic activities needed
Education/Training – Academic		Yes – in several cases some series of lectures, but regular courses only at one university (AGH – UST Kraków) as part of wider courses on RES,	Yes – in several cases some series of lectures, but regular courses only at some universities as part of wider courses on RES
Education/Training – Vocational		Yes, but in single cases geothermal is among several subjects tought not as individual subject of specialisation	Yes, but still not on a regular basis. However, the growing number od trainings is organised by professional organisations (for installers, etc. to obtain certificates, etc.)

Key for financial incentives:

DIS	Direct investment support	FIT	Feed-in tariff	A	Add to FIT or FIP on case the amount is determined by auctioning
LIL	Low-interest loans	FIP	Feed-in premium		
RC	Risk coverage	REQ	Renewable Energy Quota	O	Other (please explain)

SOURCES OF SOME DATA AND INFORMATION GIVEN IN TABLES A–G:

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