SUBJECTIVITY OF ENERGY SECURITY WITH RESPECT TO USING GEOTHERMAL RESOURCES IN SELECTED REGIONS OF POLAND

PODMIOTOWOŚĆ BEZPIECZEŃSTWA ENERGETYCZNEGO W WYBRANYCH REGIONACH POLSKI PRZY WYKORZYSTANIU ZASOBÓW GEOTERMALNYCH

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Abstract: The study attempts to analyse the issues that should to create the subjective of Polish energy security in the context of rich geothermal resources being at the disposal of the various regions of our country. Adoption of these measures allows not only to increase the diversification of sources of energy supply, but also brings significant benefits in economic, social and environmental, as well as in the areas of security and defense.

This issue is presented in three aspects:

- sources and geothermal energy resources in different regions of Polish;
- advantages and disadvantages of using geothermal energy;
- examples of the use of geothermal energy in some regions of Poland.

In order to show deeper explore of the problem, it was used a research of analytical and synthetic method.

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Streszczenie: W badaniach podjęto próbę dokonania analizy zagadnienia konieczności budowania podmiotowego bezpieczeństwa energetycznego Polski w kontekście zasobów geotermalnych, jakimi dysponują poszczególne regiony naszego kraju. Podjęcie owych działań pozwala nie tylko na zwiększenie dywersyfikacji źródła dostaw energii, lecz także przynosi istotne korzyści w wymiarze ekonomicznym, społecznym, ekologicznym, jak również w obszarach bezpieczeństwa i obronności.

Zagadnienie to przedstawione jest w trzech aspektach:

- źródła i zasoby energii geotermalnej w poszczególnych regionach Polski;
- zalety i wady stosowania energii geotermalnej;
- przykłady wykorzystania energii geotermalnej w niektórych regionach Polski.

Dla głębszego ukazania problemu posłużono się badawczą metodą analityczno-syntetyczną.

Keywords: geothermal resources, geothermal sources, geothermal energy, energy advantages geothermal drawbacks of geothermal energy.

Słowa kluczowe: zasoby geotermii, źródła geotermii, energia geotermalna, zalety energii geotermalnej, wady energii geotermalnej.

Introduction

One of the significant components of the energy security strategy in Poland should be geothermal energy. Its growing importance, especially in recent years is rooted in the dynamics of economic development and political transformations in a global scope. These phenomena cause that one of the most important instruments of international influence becomes energy supply system. Ensuring its supply, economically beneficial and adequate to the needs, while minimizing the negative impact on the environment and living conditions of the population is one of the most important determinants of strategy, stability and development of each country.

By going to the Polish, you can say, that the high energy consumption of our country, inadequate level of development of the manufacturing infrastructure and transport fuel and energy, the considerable dependence on external supplies of natural gas and almost complete from external supplies of crude oil, environmental commitments which the European Union has set out for 2020 in the form of quantitative targets, so-called. „3x20", i.e. reducing greenhouse gas emissions by 20%, reducing energy consumption by 20%, (compared with forecasts for the EU by 2020), increasing the share of renewable energy sources to 20% (total energy consumption in the EU) – clearly indicates the courses of action that should be taken by the Polish Government in building up and strengthening of defensive energy security strategy.

Its expression has been noticed at the last Climate Summit (COP 21) in Paris in December 2015, during which the Minister of the Environment Jan Szyszko clearly emphasized the importance of Polish geothermal energy in the production of cheap and clean energy, saying: "We want to show the Polish geothermal energy as a success on a global scale" and further, the Minister assured that "…geothermal

energy will be able to count on a big state support, to deploy the latest technologies of extraction and use of hot water"[3].

As shown by the latest forecasts for the development of the energy sector of the world, in the XXI century geothermal energy will have a significant increase in its share in the overall balance of primary energy sources.

Thus, among others, geothermal energy may be the resource that can have a positive impact on condition of subjective Polish energy security.

1. The source and geothermal energy resources in selected Polish regions

Polish **geothermal resources** based specifically on water and water vapor are **very large**, even huge. The advantage of these resources is their even distribution across 80% of the area of the country and their excellent recognition. These resources are estimated at approximately 34 billion tons of crude oil which is equivalent to approximately 36 billion tons of coal. These data demonstrate **enormous potential of energy resources** which from the technical point of view is possible to use. Research show that in some places to a depth of only 3 km their energy potential is 625 thousand PJ per year, or 387 thousand EJ per year. It should be emphasized that this potential is 99.8% of all renewable energy resources. In fact it should be also noted that one PJ is tantamount to the amount of energy contained in 23 thousands of tons of crude oil.

Generally it can be claimed that the potential of geothermal energy which can be found in the ground exceeds 154 times the annual energy needs of our country. For comparison, there are 198,000 PJ of these resources in Germany. Thus, Poland has three times more resources than our western neighbor.

An important feature of Polish geothermal resources is also their relatively **high temperature**, which, however, depends on the depth and geographical location.

For example, at the depth of 1.5-3.5 km one can find water at the temperature of 20 to approximately 80-90 degrees Celsius (with prevailing temperature of 90 degrees – at the depth of 3 km). At this temperature, one geothermal hole is able to provide the power of 1-2 MW. In some cases, there can be found water whose temperature exceeds 100 degrees Celsius; at the depth of 5 km – the temperature is 300 degrees Celsius; and at the depth of 7 km – reaches even 350-400 degrees Celsius[4].

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[3] *Toruńska geotermia w Paryżu*, „Nasz Dziennik" z dnia 3 grudnia 2015 r. – http://www.naszdziennik.pl/polska-kraj/148251,torunska-geotermia-w-paryzu.html

[4] As noted by prof. R.H. Kozłowski, Poland by having such high temperatures is "a ready-made boiler into which water needs to be poured to get vapor; geothermal vapor (i.e. hot rock energy) out of which with the use of turbine and generator, electric current is obtained". This Polish technology is recognized in the world, but not by the Polish former government (E. Kopacz's government). – Ibid.; According to the concept of **Polish Laboratory of Radical Technologies**, drilling at such depths can be used with the **multi-concentric bore technology so called Jet Stinger** brought over from the United States by prof. Bohdan M. Żakiewicz. – R.H. Kozłowski, *Geotermia to nasza specjalność*, wykład z dnia 15.11.2008 r. w Kaliszu, [w:] http://jednoczmysie.pl/artykuly/geotermia-to-nasza-specjalnosc/; Ł. Legutko, *2 Bałtyki ciepłej wody pod Polską? Energia tania, choć…*, 2003.

At this point the following question arises: What are the geothermal resources in different regions of Poland?

As a matter of fact, the distribution of geothermal resources in Poland, as mentioned before, is different depending on the geographical location and its geological structure. Referring to the division of Poland into provinces, it can be concluded that the most-favored in terms of geothermal energy are the three provinces:

- Polish Lowland Province,
- Sub-Carpathian Province,
- Carpathian Province.

Polish Lowland Province (Central European) occupies an area of approximately 222 thousand of squared kilometers and includes seven geothermal regions such as Grudziadz-Warsaw Region, Foresudetic-Swietokrzyski Region, Szczecin-Lodz Region, Pomeranian Region, Baltic Region, Podlasie Region and Lublin Region. The temperature of geothermal water in these areas ranges from 30-130 degrees Celsius at the depth of 1-3 km. The most rich in water are the Grudziadz-Szczecin and Warsaw-Lodz Regions. Both regions occupy about half of the territory of Poland, whereas the amount of water in them is approximately 90% of all geothermal resources in Poland. **The total value of the resources of the Polish Lowland Province is estimated to be more than 6225 km^2 of water whose thermal energy is equivalent to 32458 million tons of coal equivalent (about 35 billion tons of coal).**

Sub-Carpathian Province covers an area of approximately 16 thousand km^2. On this area geothermal waters reach the temperature of 25-50 degrees Celsius. **The total value of these local resources is estimated at more than 362 km^2 of water whose thermal energy is equivalent to 1555 million tons of coal equivalent (1.7 billion tons of coal).**

Carpathian Province covers an area of approximately 12 thousand km^2. Geothermal waters in the area reach the temperature of 60-90 degrees Celsius. **The total value of geothermal resources in the region is estimated at over 100 km^2 of water whose thermal energy is equivalent to 714 million tons of coal equivalent (0.8 billion tons of coal).**

Another regions of Poland which have interesting geothermal prospects are **Sudety** where geothermal waters can be found in crevices of rocks, and **the area of Podhale**[5].

At the regional level, according to the Polish Geothermal Association, temperatures of approx. 100°C **are in the Mazowieckie Province, Wielkopolska Province, Lubuskie Province, Malopolska Province and Zachodnio-Pomorskie Province** and locally in other parts of the country[6].

[5] R. Tytko, *Odnawialne źródła energii*, Eurogospodarka, Warszawa 2011, p. 267.
[6] Wiśniewski p. 67.

2. Advantages and disadvantages of using geothermal energy

The use of geothermal waters to produce energy depends mainly on their **heating medium temperature**. Research confirmed by numerous experiments show that both power plants as well as heat and power plants based on geothermal waters are a great opportunity for Poland in the economic and ecological dimension. This is the result of such **advantages of geothermal energy** as[7]:

- renewability;
- ecological character – no pollution of the natural environment: the atmosphere, hydrosphere, lithosphere, and biosphere;
- prevalance;
- decentralization, i.e. obtaining energy from the sources that are close to potential users, which allows to reduce the losses associated with the transmission of energy at a distance and the independence of small regions and local populations;
- independence of climactic and weather changes;
- possibility to use existing wells, which guarantees economic justification for creating geothermal heating installations;
- constant flux of thermal energy for several decades;
- independence of energy costs from energy source prices;
- independence from the supplies of fossil fuels;
- lower cost per unit for acquiring geothermal heat as compared with conventional heating plants;
- lower cost of geothermal energy as compared with other fossil fuels because of the automatic outflow of hot water onto the surface by means of a closed duct system followed by their reinjection into the reservoir after dissipating heat;
- possibility to use source energy directly without the conversion to another energy – when groundwaters are confined; however, when energy comes directly from rocks there is a need to use surface water or other liquids as a carrier;
- impossibility of transporting geothermal energy over long distances, which prevents the monopolization of energy solutions.

As far as the advantages of geothermal resources are concerned, it must be emphasized that the energy sourced from them is environmentally friendly. The amount of pollution emissions that get into the environment from the geothermal plants is to a large extent smaller than in case of the heating plant. A meaningful example of such a situation is a geothermal plant in Konin. Taking it as an example, it turns out that the geothermal plant with a nominal capacity of 12 MW largely eliminates gaseous and dust pollutants, as shown in the Table 2 below.

[7] Ł. Legutko, *2 Bałtyki...*, op. cit.

Table 1. Pollution emissions from the heating plant and the geothermal plant in Konin

Element	Pollution Emissions from the Heating Plant E_1 (kg / year)	Pollution Emissions from the Geothermal Plant E_2 (kg / year)	Percentage Reduction in Emissions 100% x ($E_1 - E_2$) / E_1 (%)
Benzo(a)pyrene	18,85	–	100,00
Soot	848,25	–	100,00
Dust	530 156,36	17,01	100,00
CO_2	24 700 630	2 303 639,10	90,69
CO	117 812,52	316,69	99,73
NO_x	47 125,01	2252,03	95,22
SO_2	188 500,04	–	100,00
Aliphatic hydrocarbons	23 562,50	105,09	99,55
Aromatic hydrocarbons	23 562,50	45,04	99,81

Source: T. Tytko, *Odnawialne źródła energii*, Eurogospodarka, Warszawa 2011, s. 282

In addition to the positive features of geothermal resources, there are also **some negative ones** namely[8]:

- possibility of causing environmental problems during the exploitation of geothermal energy in case of release of geoliquid – harmful gas, i.e. Hydrogen sulfide H_2S which should be absorbed in the appropriate systems, and Radon – the product of disintegration of radioactive uranium, which can be released along with vapor out of a geothermal well;
- high initial investment;
- strong dependence of the economic results on the heat sales;
- problem of corrosion of the system and clogging of deposits;
- limitation to the areas where geothermal water can be found.

3. Examples of the use of geothermal energy in some regions of Poland

In Poland, geothermal waters are most frequently used for heating – in heat engineering, spa treatment sector, recreation and balneotherapy, and in the case

[8] W. Górecki, *Wody geotermalne Polski*, AGH, Kraków, 1999, p. 32.

of high temperature water – in energy production. Figure 1 shows these data in percentages.

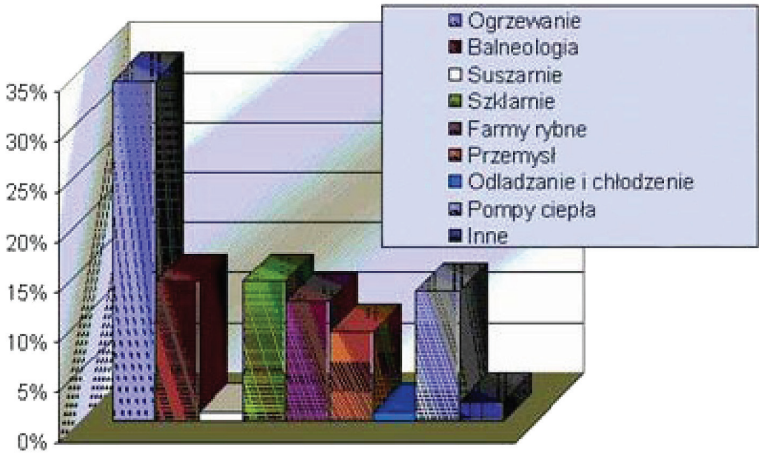

Figure 1. Use of geothermal resources
Source: *Potencjał energetyki geotermalnej i kierunki jej wykorzystania*, in: www.plan-rozwoju.pcz.pl/wyklady/ener_srod/rozdzial4.pdf

In the years 2012-2013, in Poland there were more than 20 systems using water and geothermal energy[9], i.e.:

- **six geothermal plants** – in Podhale (PEC Geotermia Podhalańska SA); in Pyrzyce (Geotermia Pyrzyce Sp. z o.o.); in Mszczonow (Geotermia Mazowiecka SA); in Uniejów (Geotermia Uniejów Sp. z. o.o.); in Stargard (G-Term Energy – former name PUC Geotermia Stargard Sp. z o.o.); in Poddebice (Geotermia Poddębice Sp. z o.o.);
- **ten spas** – in Cieplice Slaskie Zdroj, in Ladek Zdroj, in Duszniki Zdroj, in Ciechocinek, in Konstancin, in Ustron, in Iwonicz Zdroj, in Maruszy near Grudziadz, in Rabka Zdroj and in Uniejow;
- **eight recreation centers and swimming pools** – in Podhale (Aqua Park Zakopane, Termy Szaflary – former name Termy Podkarpackie, Kapielisko Geotermalne Szymoszkowa w Zakopanem, Terma Bukowina, Terma Białka – former name Terma Bania); in Polish Lowlands (Termy Mszczonowskie, thermal swimming pools in Poddebice and Termy Maltanskie in Poznan);
- **other applications** – wood drying, thermophilic fish farming, in winter heating football fields, sidewalks, airport runways, highways, intersections, etc.

Below, in tables, there are given the main parameters of the above geothermal systems.

[9] B. Kępińska, *Wykorzystanie energii geotermalnej w Polsce, 2012-2013*, „Technika Poszukiwań Geologicznych. Geotermia. Zrównoważony Rozwój", nr 1/2013, p. 7-10.

Table 2. Main parameters of geothermal systems in Poland in the years 2012-2015

System	Application	Parameters of geothermal water		Installed / estimated power		The use / sale of heat	
		max. capacity	max. temperature	total	from geothermal energy	total	from geothermal energy
		m^3/h	°C	MW_t	MW_t	TJ/r	TJ/r
Podhale – heating plant	heat engineering, recreation	670	86	80,8	40,7	512,94	362,85
Mszczonow – heating plant	heat engineering, recreation	60	41	112	3,7	33,02	11,84
Uniejow – heating plant	heat engineering, recreation	120	68	5,0	3,2	19,625	15,97
Stargard Szczecinski	heat engineering	100	78		12,6		91,0

Source: B. Kępińska, *Wykorzystanie energii geotermalnej w Polsce, 2012-2015*, „Technika Poszukiwań Geologicznych Geotermia, Zrównoważony Rozwój", nr 1/2016, [w:] https://www.min-pan.krakow.pl/.../TPG2013/01-(I)-14-kepinska-pol.pdf

Table 3. Main health resorts using geothermal systems in Poland in the years 2012-2015

System	Application	Parameters of geothermal water		Installed / estimated power		The use / sale of heat	
		max. capacity	max. temperature	total	from geothermal energy	total	from geothermal energy
		m^3/h	°C	MW_t	MW_t	TJ/r	TJ/r
Cieplice Sląskie Zdroj	balneotherapy	27	36-39	0,3	0,3	10,0	10,0
Ladek Zdroj	balneotherapy	50	20-44	0,7	0,7	12,0	12,0
Ciechocinek	balneotherapy	204,5	27-29	1,9	1,9	2,8	2,8
Duszniki Zdroj	balneotherapy, other, CO_2 recovery	20	19-21	0,05	0,05	0,7	0,7

Source: ibidem

Table 4. Other aplications using geothermal systems in Poland in the years 2012-2015

System	Application	Parameters of geothermal water		Installed / estimated power		The use / sale of heat	
		max. capacity	max. temperature	total	from geothermal energy	total	from geothermal energy
		m^3/h	°C	MW_t	MW_t	TJ/r	TJ/r
Podhale	other: wood drying, fish farming, heating airport runways, sidewalks, air-conditioning			1,0	1,0	2	2
Uniejow	other: heating football fields	20	28	1,0	1,0	4,4	4,4
Lubatowka	other: recovery of mineral salts from geothermal water	11,0	24,5				

Source: ibidem

Conclusions

Poland is one of the European countries with the largest geothermal resources of diversified temperatures depending on the geographical location of a particular area of the country. Therefore, nowadays, waters and geothermal energy are a great opportunity and also a challenge for energy security and self-sufficiency of communes, districts, provinces, and the entire country. Awareness of this fact shows more and more pronounced increase in interest in the use of these resources (national wealth) – compared to previous years.

Geothermal resources can be an important element of Polish energy security. The use of geothermal technology should be more widely distributed in the structures of the army and be used for heating infrastructure. These elements can be either residential areas of military garrisons, as well as operating infrastructure as plates of airports, objects in ports, warehouses, fuel or ammunition dumps.

Official forecasts assume a very favorable local share of geothermal energy in the energy market in Poland. Main benefits resulting from its use are connected with the supply of heat to the local consumers and the protection of the environment due to the limited amount of pollution produced by traditional heating systems based on coal. Geothermal energy should be promoted due to the benefits previously mentioned in the article as well as due to the fact that Poland

has adopted greater commitments in the use of our country's renewable energy sources (RES), which was confirmed by the declarations of representatives of the Polish Government during the Climate Summit organized in December 2015 in Paris (COP21). Thus, by the year 2030 there should be created tens of geothermal plants in our country.

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