Geothermal Energy Use, Country Update for Bulgaria (2014-2018)

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ABSTRACT

The main objective of this paper is to provide an update for the development of geothermal energy use in Bulgaria by comparing the periods 2009-2013 and 2014-2018. The temperature of geothermal water (natural springs and wells) in Bulgaria varies in the range 25ºC-100ºC and the total flow rate is up to about 3,000 L/s. More than 170 geothermal fields are located all over the country: 102 of them are state-owned, the rest were conceded to several municipalities for a period of 25 years. About 72% of the total resources are of comparatively low temperature - up to 50ºC at the surface. Flow rates of most of the sources vary from 1 L/s to 20 L/s. Total dissolved solids (TDS) are in the range between 0.1 g/L and 1.0 g/L for most geothermal sources in Southern Bulgaria, while in Northern Bulgaria TDS is significantly higher - the maximum measured is up to 150 g/L. The installed capacity increased to 99.37 MWt in 2018 from 83.10 MWt in 2014 (Bojatgieva et al., 2015), excluding the low grade energy utilization by ground source heat pumps (GSHP). Geothermal energy has only direct use - in water supply, balneology, heating of buildings (including spa-centres), air conditioning, greenhouses etc. In the last more than 40 years, some geothermal (also called mineral) water sources have been used for bottling of potable water and soft drinks. Some of the hydrothermal sites are developed as mountainous or sea resorts. Electricity generation from geothermal water is not currently available in the country due to the relatively low temperatures of geothermal water.

1. INTRODUCTION

Bulgaria is located in SE Europe and covers 23% of the Balkan Peninsula (Fig. 1). The territory of the country is approximately 111,000 square kilometres and it has a population of about 7,150,000 (2015). Its thermo-mineral (geothermal) waters have been subject of exploration and exploitation since ancient times until present. Some Palaeolithic and Neolithic settlements had been built around natural thermal springs. The ancient use of thermal waters had rapidly increased during the time when the Roman Empire ruled over the territory (the period 46-395 A.D.). More than 25 site remains of buildings and bathing facilities from that time were revealed.

The capital of Bulgaria, the city of Sofia, is one of the three capitals in Europe, together with Reykjavik (Iceland) and Budapest (Hungary), which was founded around a thermal water source in ancient times – this natural spring in the city of Sofia still exists and is called Sofia-Centre Spring.

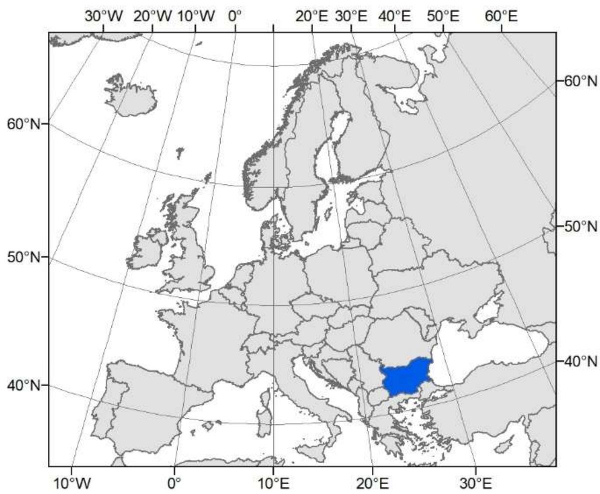

Figure 1: Location map

The natural thermal springs and thermal water, discovered in hundreds of boreholes in the country, have only direct application because of their relatively low temperature (less than 100°C). Only eleven geothermal fields have temperature higher than 75°C and the total flow rate of each of them varies between 6 L/s and 33 L/s (Hristov et al., 2018). The mineral (geothermal) water is used mainly for water-supply, balneological purposes (treatment, preventive care, relaxation, sanitary needs and pools) and only a small portion is used for heating of buildings, greenhouses etc. Most of the mineral waters are slightly mineralized and are suitable for bottling of potable water and soft drinks. Recently, thermal water from some geothermal sites is used for water supply to some relatively new spa-hotels centres.

Installation of ground source heat pumps (GSHP) is on the increase, along with the traditional installations for hydrothermal energy use. GSHP systems are assembled in family houses, blocks of flats, offices and industrial buildings. They provide heating, cooling and domestic hot water. Information about the exact number of units, their installed capacity and type (air to water, water to water) is not officially available, hence not discussed in this paper.

2. GEOLOGICHAL AND HYDROGEOLOGICAL BACKGROUND

The geology of Bulgaria comprises sediments, intrusive and metamorphic rocks of different origin with various lithologic and petrologic compositions - from Precambrian to Quaternary age (Yovchev Y. 1971, Dabovski et al, 2002, Zagorchev I. 2009). The area of the country covers parts of two major tectonic units: the northern part of the Alpine thrust belt in the Balkans, and its foreland - the Moesian plate (Zagorcev I. 1992, 1994). The Alpine belt is subdivided into three zones (Balkan, Sredna Gora, Rila–Rhodope massif). Part of the Moesian plate completely covers Northern Bulgaria. Up to 1,000 m thick artesian aquifers (Upper Jurassic-Lower Cretaceous) are found in the plate composed of extensively fractured and highly permeable limestone and dolomite. It is the biggest geothermal reservoir in the country.

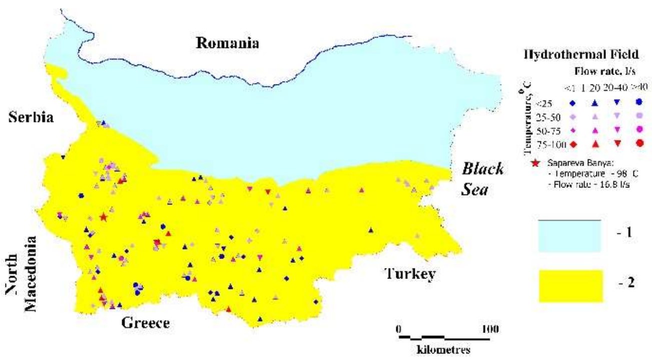

Figure 2: Schematic map with thermal sources
(1- artesian layer type geothermal waters;
2 - fracture type geothermal waters)

The geological and hydrogeological conditions forming hydrothermal fields (reservoirs) in Bulgaria are summarized in numerous publications (Shterev 1964; Pentcheva, 1968, 1984; Petrov et al., 1970, 1998; Velinov and Bojadgieva, 1981 Galabov and Stoyanov, 2011, Benderev et al., 2016 etc.). The territory of Bulgaria is characterized by complex hydrogeological conditions.

The northern part of the country (among the Moesian plate) consists of widely distributed layered aquifers (limestones and dolomites) divided by aquicludes. Groundwater temperature there reaches more than 100°C at the bottom of some boreholes (Vidin, Slanotran, Pleven sites etc.). The high salinity of the water impedes direct use due to the risk of scaling. The aquifers are penetrated by hundreds of deep boreholes (some of them deeper than 6,000 m). Most of these boreholes have been drilled for the purpose of oil and gas prospecting and exploitation. Following their exploitation, more than 2,000 of the exploration and production boreholes were decommissioned and sealed in order to prevent mixing of groundwater with very high TDS (up to 150 g/L) with fresh water from different upper aquifers. Currently, only some geothermal fields and occurrences along the Balkan and some others along the north-eastern part of Bulgarian Black Sea coast are used for different purposes (mainly for water-supply, balneology and spa-hotels). The second type of hydrothermal deposits – fractured confined systems, is found mainly in the southern part of the country. These deposits have a sporadic distribution and are attached to tectonic zones and regions characterized by higher heat flow. Most often the water there rises upward along faults and forms natural springs at the surface. More than 95% of all natural geothermal (mineral water) springs occur in Southern Bulgaria (Fig. 2). In some cases, thermal water is discharged in unconsolidated sediments (secondary reservoirs), which are deposited in graben depressions. In Southern Bulgaria, the TDS of most geothermal natural springs and in boreholes is lower than 1.0 g/L.

According to the Water Act, 102 of all hydrothermal fields in Bulgaria are specified as exclusive state property. The rest are municipal property for 25 years.

The Water Act defines three categories for thermal water utilization: water supply (where no alternative is available), treatment and rehabilitation in hospitals and specialized medical centres and the third category combines all other applications - balneology and energy.

3. UTILIZATION OF LOW ENTHALPY GEOTHERMAL ENERGY

The major factors that contribute to the geothermal development in Bulgaria are: long tradition, favourable climate, appropriate thermo-mineral water composition and developing new spa centres (Fig. 3) and bottling factories.

Figure 3: Spanchevtsi Spa-Hotel

In spite of a relatively good hydrothermal capacity of 9,957 TJ/year (2,765,855 MWh or approximately 315 MWt) (Petrov et al., 1998), the application of thermal waters is still 25-30% of the total amount. The installed thermal capacity, excluding GSHP, increased to approximately 99,37 MWt in 2018 from 83.10 MWt in 2014 (Bojatgieva et al., 2015).

Concerning renewable energy sources (RES), the national target of 16% share of the total internal energy consumption was achieved by 27 December 2013, according to the second National Report (http://www.nsi.bg) on the progress of Bulgaria - RES usage (Fig. 4). The geothermal share in RES is only 1.8% in 2013 as in 2017 (Fig. 5). Although the installed thermal capacity increased by 19,6% from 2014 to 2018, the geothermal utilization of RES has not changed due to the increase of other RES in the same period.

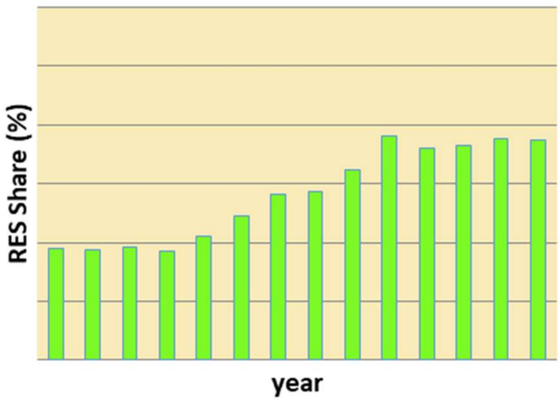

Figure 4: Share of renewable energy sources in the total energy use

Because of the relatively low temperatures (<100°C), thermal waters have only direct application. According to 2018 data from the River Basin Directorates (Fig. 6), the variety of uses includes: water-supply (33%), balneology (14.6%), space heating and air-conditioning (0.5%), greenhouses (4.1%), bottling of potable water and soft drinks (3.7%), and others (44.1%, including sport, swimming pools, spa procedures, bathing in local public baths laundering, dish washing, etc.). The relative share of balneology in thermal water use dropped from ca. 60% in 2014 (Bojatgieva et al., 2015) to less than 15% because of the different way of reporting – the water used for sports, pools, public baths, etc. is no longer included in the share of balneology.

In the last five years the situation changed significantly since mineral water of 32°C temperature is being supplied to several sea resorts along the northern Black Sea coast: Sv.Sv. Konstantin & Elena, Zlatni Pyasatsi, Albena, Rusalka and others. Thus the water supply reached up to 33.0 % (2018) of the total use of mineral water (Fig. 6). Direct supply is typical for many new spa resorts among mountain areas as Chiflika, Velingrad, Ognyanovo, Sapareva Banya and many others as well in some sea resorts.

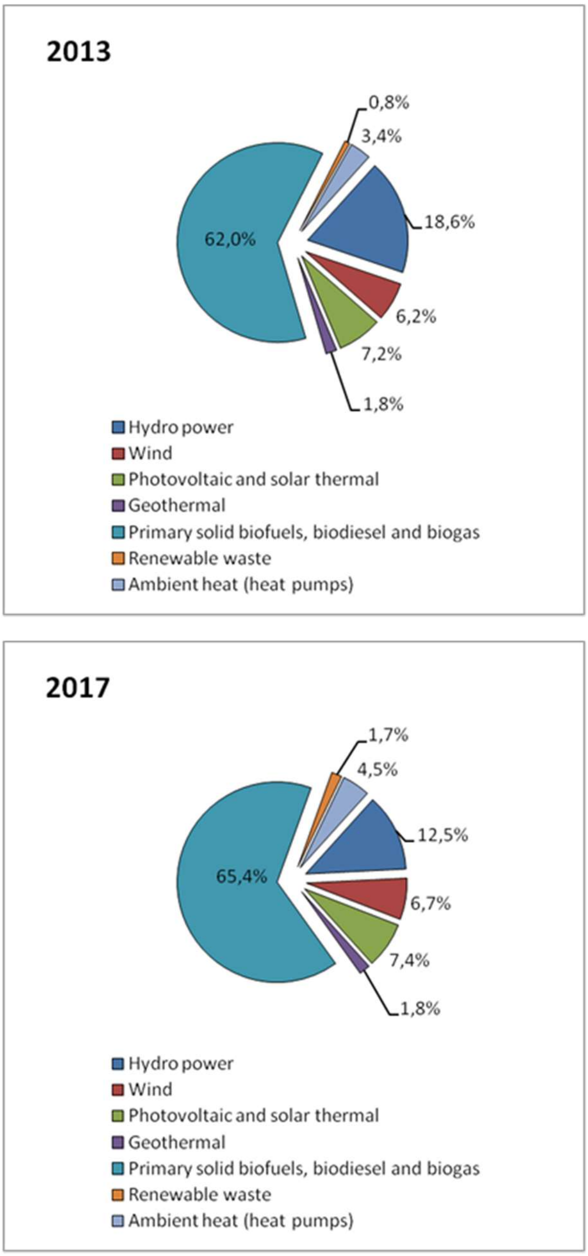

Figure 5: Comparison between 2013 and 2017 of share RES application in Bulgaria

Drinking mineral water on tap is free of charge all over the country.

Bottling of mineral potable water is regulated by the Concessions Act. The main reasons for the development of bottling include the generally low TDS (<1 g/L) and the wide variety of chemical compositions of the mineral waters in Southern Bulgaria. Bottling of mineral potable water (3.7 % in 2018) is one of the very fast developing businesses in the last 30 years. The number of bottling factories increased from 3 to more than 40 in three decades only.

The share of water used for greenhouses is about 4.1% (2018) of the total use of thermal water. The geothermal water application in some relatively large greenhouses (the villages of Levunovo, Kazichene etc.) decreased.

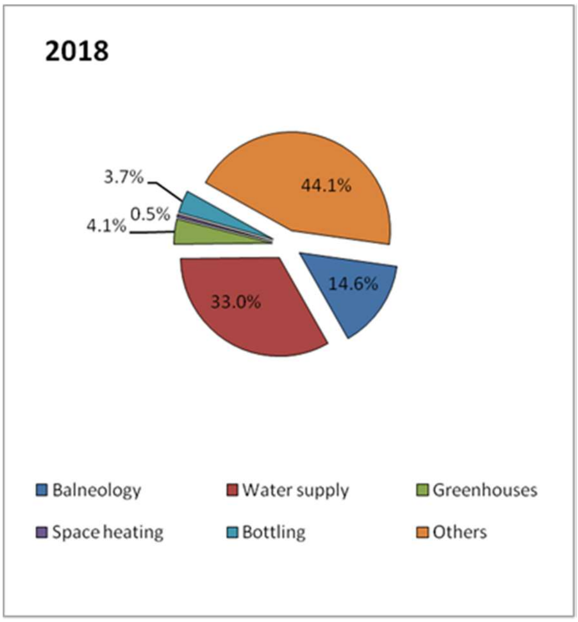

Figure 6: Thermal mineral water utilization in Bulgaria for 2018

The thermal water potential in the country is suitable mostly for low temperature floor heating or for systems assisted by convectors. Such installations need high initial investment and, at this stage of economic development, they are not competitive to the air-conditioning systems widely available on the market.

Heating is provided only to individual buildings (up to 1% of the total geothermal water used) and it is not connected in a district heating system. Heating installations are assisted by plate heat exchangers (Sapareva banya, Varna etc.). In addition, they heat domestic water and are in operation for about 200 days/year.

4. CONCLUSIONS

The utilization of geothermal water in Bulgaria for the periods (2009-2013) and (2014-2018) could be summarised as follows:

- The installed thermal capacity increased by 19.6% from 83.10 MWt in 2014 to 99,37 MWt at the end of 2018; GSHP excluded.
- Water supply of mineral water of approximately 32°C temperature to several sea resorts along the northern Black Sea coast has increased rapidly.
- Currently there are only a few balneological sites where thermal water is used for building space heating and domestic hot water. Many old heating installations in poor technical condition were abandoned and only a small number of new installations have been constructed.
- The renewable geothermal resources in the country have the potential for future direct use development. Currently only about 30% of the resources are being utilised.
- The major factors promoting geothermal development in Bulgaria are the long existing tradition in thermal water use, favourable climate, and appropriate thermal water composition for therapy; as well as for bottling of potable water and soft drinks and a well developed spa system. There has been a significant growth in building of hotels in the mountains and in the seaside resorts. Most of them use water for small pools and relaxation areas.
- Electricity generation from geothermal water is not currently available in the country but some binary cycle power plants could be built. Obviously, such systems would be of local importance only, because of the very limited geothermal potential for this kind of activity.

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Tables A-G

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

*Geothermal power plants are not available in Bulgaria.

Table B: Existing geothermal power plants, individual sites*

*Geothermal power plants are not available in Bulgaria.

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

	Geothermal DH plants		Geothermal heat in agriculture and industry		Geothermal heat for 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 2018			3.48	15.70	82.30	586.08		
Under constru-ction end 2018								
Total projected by 2020								
Total expected by 2025								

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

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2018 *		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2018	8	5.52	14.746			
Projected total by 2020						

Table F: Investment and Employment in geothermal energy

	in 2018		Expected in 2020	
	Expenditures (million €)	Personnel (number)	Expenditures (million €)	Personnel (number)
Geothermal electric power	No available		It is not expected.	
Geothermal direct uses				
Shallow geothermal				
total				

Table G: Incentives, Information, Education

	Geothermal electricity	Deep Geothermal for heating and cooling	Shallow geothermal
Financial Incentives – R&D		Reduction of taxes paid for geothermal water use.	
Financial Incentives – Investment			Direct investment support
Financial Incentives – Operation/Production	Not at all	Promotion in the media	Widely promoted - by press, media, internet sites
Information activities – promotion for the public	Insufficient	Well studied	Well studied
Information activities – geological information	a short	explanation	
Education/Training – Academic	available	yes	available
Education/Training – Vocational	available	available	available