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Geothermal Energy Use, Country Update for Bulgaria (2013-2015)

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ABSTRACT

Thermal waters in Bulgaria have only direct application. The leading use is for balneology – treatment, prevention, relaxation, sanitary needs and pools. About 1 million cubic meters of thermal water were additionally put into operation in 2015 compared to 2014. Balneology retained its leading position, and in 2015 marked a growth. Two other applications - water supply (where no alternative is available) and some industrial uses (technical processes, public laundries, irrigation, etc.) also increased their share. Water use for energy purpose (space heating and greenhouses) has insignificant presence of about 2.7 % of the total thermal capacity (105.6 MWth). Currently the utilized water quantity amounts to about 29% of the discovered resource. Some administrative and legislation changes have been made to improve the development of thermal water use in the country.

1. INTRODUCTION

Thermal water and geothermal energy use are basically subject to the National Constitution and Water Law. Several other laws and regulations are also part of the thermal water legislation. There are no significant changes regarding legislation and management of thermal waters use in the period 2013-2015. This allows comparing the results of data obtained for this period to those observed in the previous one (2008-2012), (Bojadgieva et al., 2013).

The discovered thermal water in the country has only direct application because its temperature is less than 100^{o}C. Only nine state-owned reservoirs have temperature higher than 76^{o}C and the total flow rate in each of them varies between 13 and 23 l/s.

The types of use include mainly balneology (treatment, prevention, relaxation, sanitary needs and pools) and to much lesser extent energy use for space heating, greenhouses and in industrial processes. Furthermore thermal water from some deposits is used for central water supply where no alternative is available. About 70% of the discovered water are slightly mineralized (<1g/l) and are suitable for bottling of potable water and soft drinks.

The sources of information used for the current analysis of thermal water application are the updated resource registers and issued permits by the Ministry of Environment and Water as well as the data from provided concession procedures, (*http://www.moew.government.bg/?show=top&cid=81*). These data are processed, analyzed and the obtained results are compared with those from the previous periods. Particularly are considered the summarized and systemized data for the period 2010-2014 (Bojadgieva et al., 2015).

Ground source heat pumps (GSHP) are increasingly applied along with the traditional installations for hydrothermal energy use. Information on the exact number of units, their installed capacity and type (air to water, water to water) is not officially available. Partial data are found at the websites of some companies, but they are not representative for the actual application in the country. According to these sites GSHP systems are assembled in family houses, blocks of flats, offices and industrial buildings in different regions of the country. They provide heating, cooling and domestic hot water and the installed capacity varies from 5-6 to 590 kW.

The aim of this update report is to present the current status of thermal water application towards 2015 year and the main factors influencing the geothermal energy development in the country.

2. GEOLOGICAL AND HYDROGEOLOGICAL CONDITIONS FORMING THERMAL WATER DEPOSITS

Bulgaria is located in the southern part of Balkan Peninsula. Its total area is up to 111, 000 square kilometers and has a population of about 7,300,000 (towards 2011 г.).

Bulgarian mineral and thermal waters have been subject to exploration and exploitation from ancient times until present. Many Neolithic and Paleolithic settlements have been built around thermal springs. In about 25 sites remains of buildings and bathing facilities from the 2 – 4 century were revealed. Thracian tribe "Serdi" settled in 8-7 BC around a natural thermal spring (50°C) and gave the first name of our capital Sofia - Serdica. Much of the ancient city lies beneath today's public and residential buildings. Ruins of ancient baths (Roman and Medieval) were found in the city center (Bojadgieva and Hristov, 2006).

Geological and hydrogeological conditions forming hydrothermal deposits in Bulgaria are summarized in many publications (Shterev,1964; Petrov et al., 1970; Velinov and Bojadgieva, 1981; Petrov et al., 1998; Benderev et al., 2016 and others). The territory of Bulgaria is characterized by complex hydrogeological conditions. It is built of rocks of different geological structure, age and filtration characteristics. Continuous active tectonic processes have created a complex geological structure and thermal field distribution both forming the hydrothermal regime in the country. The northern part of the territory is a large artesian basin, which consists of widely distributed layered aquifers divided by water impermeable layers. The total water mineralization and temperature grow in depth for the western part of the basin. Temperature there reaches more than 100°C. The high water salinity impedes direct application due to the risk of scaling. The aquifers are reached by deep wells. The north-eastern part of the basin is currently most exploitable for different applications – balneology, space heating, greenhouses, and central thermal water supply.

The second type of hydrothermal deposits – fractured confined systems, is found in the central and southern part of the country. These deposits have an interrupted distribution and are attached to tectonic zones and regions characterized by higher heat flow values. Most often water in them moves upward along faults and forms natural springs at the surface. In some cases part of thermal water is discharged in young unconsolidated sediments, which are deposited in graben depressions. More rarely, there are cases where karstified limestone and marble become secondary collectors for thermal water. Additional boreholes are drilled to increase the water quantity in many of these fields.

3.WATER MANAGEMENT AND LEGISLATION

Water management in Bulgaria is implemented at national and basin level. Four river basins – Danube, Black sea, East Aegean and West Aegean are identified and managed by Basin Directorates, Fig.1.

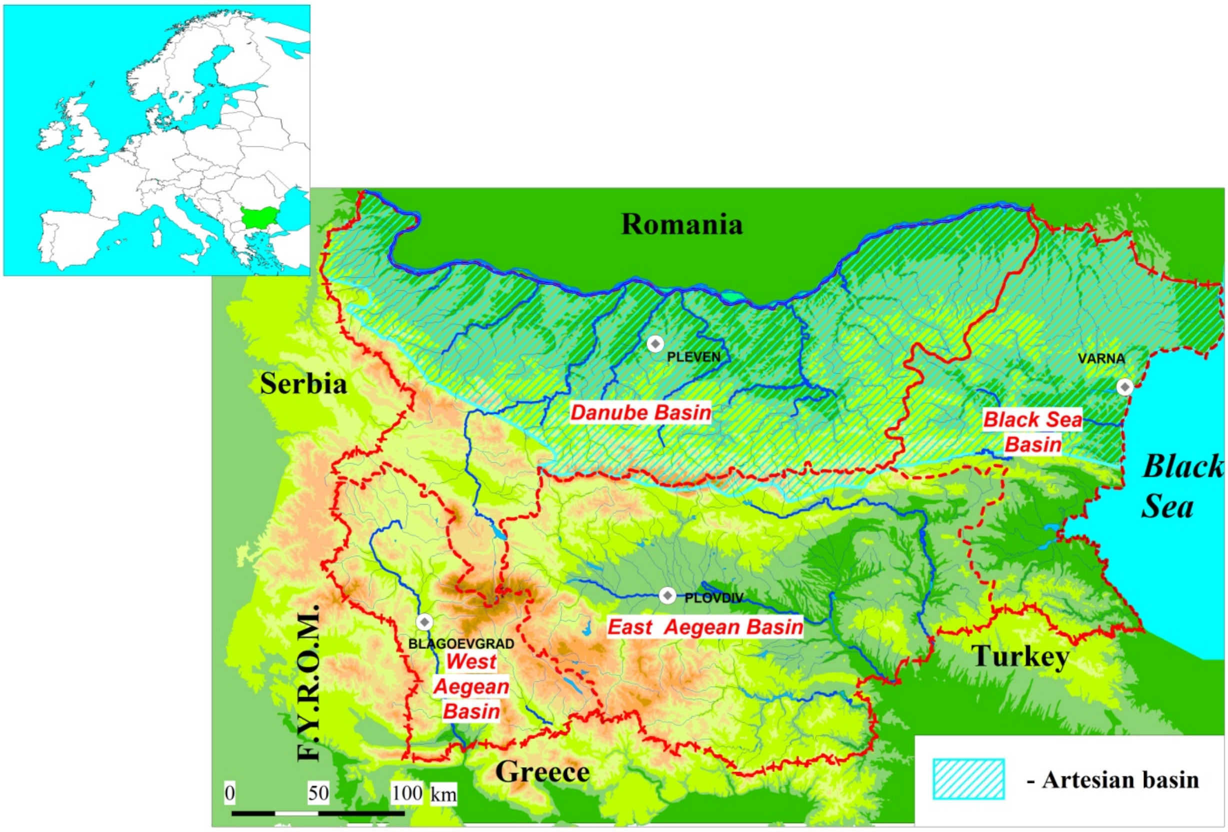

Figure 1: River basins in Bulgaria.

Thermal water is an integral part of the total water resource in Bulgaria but due to its particular qualities is treated separately by the legislation.

According to the Water Act, 102 of all hydrothermal deposits are specified as exclusive state property. The rest are municipal property. State-owned thermal deposits are administered by the Council of Ministers according to the Concession Law (1995) through concession regime and by the Ministry of Environment and Water (MOEW) – according to the Water Law (1995) through permit regime. The Municipalities carry out the management of local thermal water according to the Municipality Property Law (1996).

Up to date about 70 state-owned fields have been identified for being granted to the Municipalities for a period of 20 years.

The Water Act defines three categories for thermal water utilization: water supply (when no alternative is available), treatment and rehabilitation in hospitals and specialized medical centers and the third category combines all other applications - balneology and energy, Table 1.

Table 1: Fees for thermal water use State Gazette, 2011) (http://www3.moew.government.bg/)

№	Application	Fees (EUR/cub.m)		
		t ≤ 30 °C	30 °C < t ≤50 °C	t > 50 °C
1.	Direct water supply	0.02	0.02	0.01
2.	Treatment in specialized hospitals and rehabilitation centers	0.02	0.02	0.03
3.	All other types	0.08	0.18	0.26

Priority in setting thermal water fee is given to the needs of water supply and treatment and rehabilitation in medical centres. These fees are applied to the activity under permit regime. Bottling and extraction of minerals from thermal water are under concession regime and their fees are set for each individual site. The Municipalities are entitled to adopt their own tariffs for water use in order to attract developers of renewable energy sources.

According to the strategy for development of renewable energy sources in the country at least 15% of total thermal energy should be produced from renewable sources for heating and cooling buildings. This will be done through the introduction of central heating using biomass or geothermal energy (Bulgarian Ground Water Association).

4. THERMAL WATER CHARACTERISTICS

Presently about 250 hydrothermal fields and occurrences have been discovered on the territory of Bulgaria. The water temperature varies between 20°C до 98°C, and the flow rate is in the range of 1 to 20 l/s for 75% of the deposits (Petrov et al.,1998). According to the data from chemical geothermometers, the maximum predicted temperatures might reach 150°C, (Hristov, 1993). About 70% of discovered thermal waters are slightly mineralized (less than 1g/l) and suitable for drinking. The exploitable part of the resource hasn't significantly altered within the period 2004 - 2016, varying between 25 and 29%.

The changes in the water temperature and operational flow of the deposits in the four river basins are shown in Table 2. The highest temperature values are measured in the West Aegean basin (87°C, Velingrad-Kamenitsa) and East Aegean basin (98°C, Sapareva banja). The exploitable resource of a single deposit reaches the highest value in the Black Sea basin (2512 l/s, South-East Bulgaria, Upper Jurassic-Lower Cretaceous Reservoir). The highest number of hydrothermal reservoirs currently discovered is in the East Aegean basin – 59.

Table 2: Water characteristics by basin

Basin	**Number of reservoirs**	**Water temperature (deg C)**	**Exploratory resource (l/s)**
Danube	33	15 - 52	1 - 58
Black sea	19	24 - 75	2 - 2512
West Aegean	27	23 - 87	1 - 67
East Aegean	59	29 - 98	0.5 - 62

5. THERMAL WATER USE

Thermal water use is concentrated mainly in the southern and north-eastern part of the country. The highest water quantity is under exploitation in the Black Sea basin, followed by the East Aegean basin, Fig.2.

Balneology has always had a leading role in the use of thermal water in the country. The following activities are part of it – treatment, rehabilitation, prevention, relaxation, sanitary needs and pools. Utilized water for relaxation and sanitary needs has the highest share in balneology due to the intensive application in spa hotels located in the mountain and seaside resorts. Permits issued for one thermal source include one or more of the above mentioned categories.

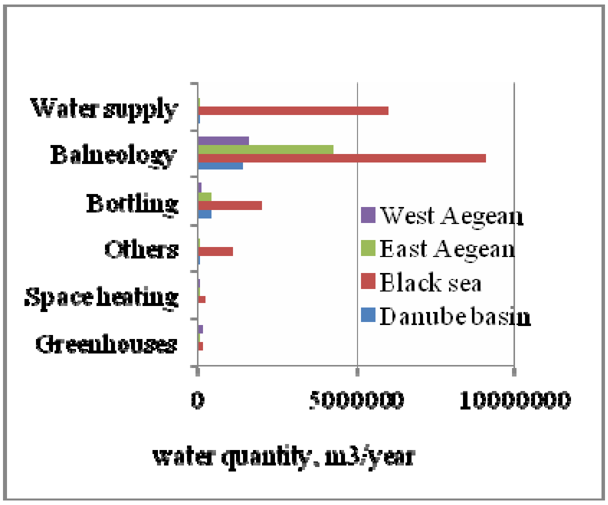

Figure 2: Thermal water use by river basin (towards 2015)

The state of thermal water use in 2015 is shown in Fig.3. The share of balneology is 59.3%, followed by water supply – 26.6%, while the space heating and greenhouses totaled 3.1%. Heating is provided only to individual buildings not connected in a district heating system.

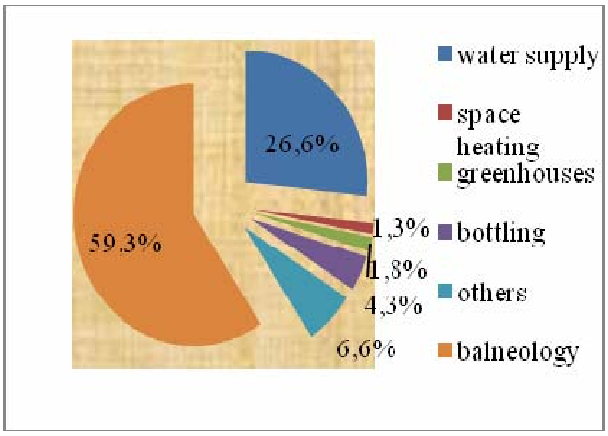

Figure 3: Thermal water use by type of application (towards 2015)

The trend of utilized water quantity during the period 2006-2015 is presented in Fig.4. A growth of about 1 million cubic meters is observed in 2015 compared to 2014. Balneology preserves it leading role as in 2015 a growth is marked compared to 2014. The water quantity used for water supply and other purposes like technical processes, public laundries, irrigation, etc. also increases. Bottling shows a slight decrease. Thermal water used for space heating and greenhouses remains with a small share and not changed during the discussed period. Heating is provided only to individual buildings not connected in a district heating system.

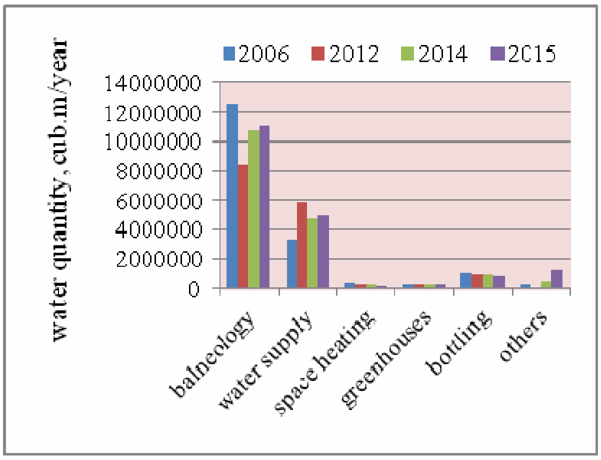

Figure 4: Thermal water use by type within the period 2006-2015.

In Fig.5 is presented the location of hydrothermal sites and changes that have occurred in water quantity use within the period 2013-2015. About 15 new geothermal sites are put in exploitation in 2015 mainly for relaxation, water supply and technical purposes. A reduction in water quantity use is observed in the West Aegean basin, while an increase is realized in the Danube and Black sea basins.

Thermal energy use is shown in Fig.6 and Fig.7. Balneology is practically the only significant application, while the other three amount totally to about 5% (Fig.6) Although the calculation of thermal capacity for balneology is not enough representative for objective reasons, the trend of rapid development of this application within the period 2004-2015 is clearly outlined, Fig.7. The decline of space heating and greenhouses development is due to closing of old, uneconomical installations which have not been replaced by new ones. The installed capacity of the operating systems is less than 500 MWth.

At present legal framework has created enough good conditions for the implementation of both the permit and concession regimes. The main problem in implementation is the lack of new investments in times of economic crisis, not the conditions for energy development (Bulgarian Ground Water Association). The reduction of fees for water use and the opportunity for the Municipalities to administrate their locally available resource granted by the state are good prerequisites to better resource utilization.

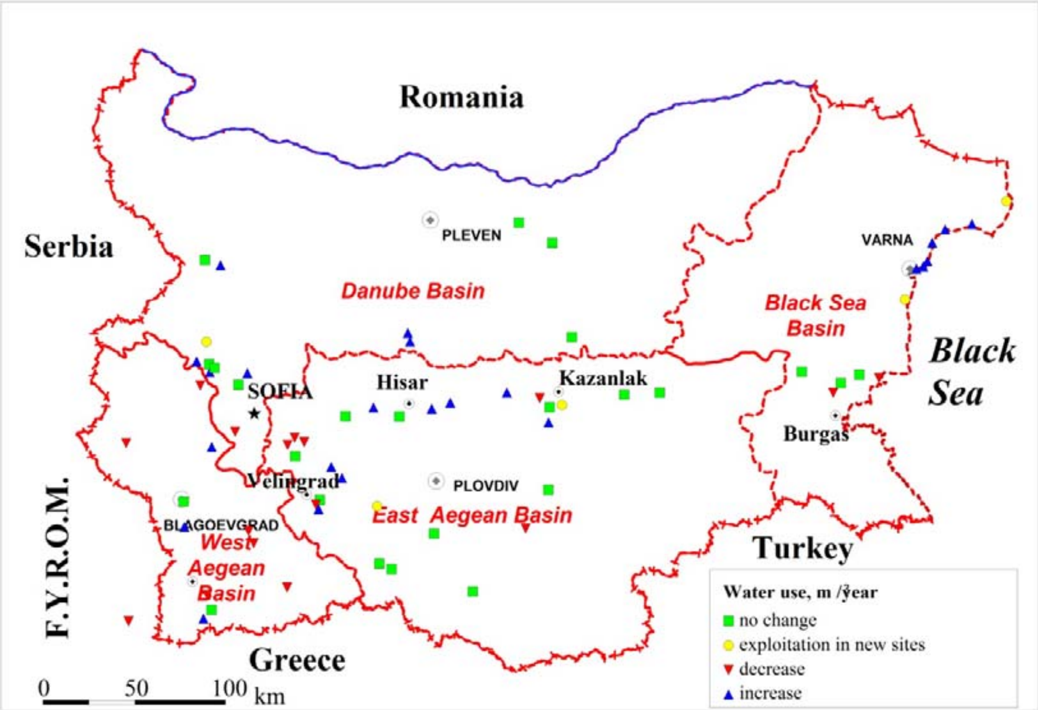

Figure 5: Distribution of hydrothermal sites and indicators for their development in the period 2013-2015

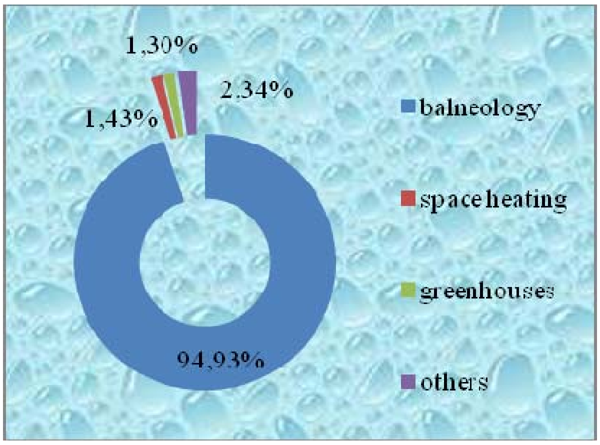

Figure 6: Installed capacity by application (towards 2015)

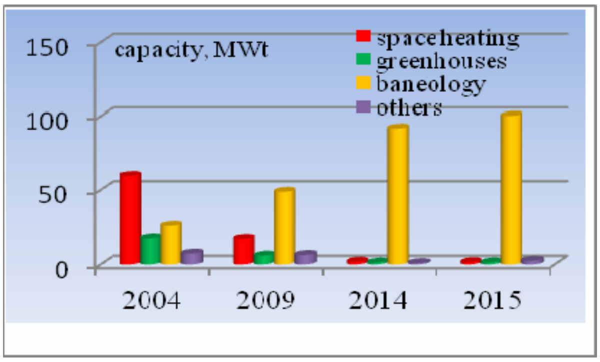

Figure 7: Capacity change by type in the period 2004-2015

3. CONCLUSIONS

The major factors promoting geothermal development in Bulgaria are the existing long tradition in water use, favorable climate, appropriate thermal water composition for healing and bottling of potable water and soft drinks and a well developed spa system. A progress in balneological application in the past 20 years has been achieved due to the big growth of hotels construction in the mountain and seaside resorts. In most of them water is used for relaxation and small pools. The thermal energy use showed advance in some industrial processes and public services in 2015. No progress has been observed in applications like space heating and greenhouses. The greenhouses are very energy consuming systems and their operation under existing climatic conditions and available market are not presently cost effective. Thermal water potential in the country is suitable mostly for low temperature floor heating or for systems assisted by convectors. Such installations have high primary investments and at this stage of economical development are not competitive to the widely available at the market air-conditioning systems.

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http://www.moew.government.bg/?show=top&cid=81

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

	Geothermal heat in agriculture and technological processes		Geothermal heat for individual buildings		Geothermal heat in balneology	
	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 *	3.8416	13.2205	1.5114	6.0664	100.2689	379.5292