Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

Aspects of Regional Geothermal Water Use in Bulgaria

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Keywords: hydrothermal basins, direct thermal water use, types of application

ABSTRACT

Geothermal water in Bulgaria has only direct applications. Major types of direct utilization include balneology, space heating and air-conditioning, geothermal heat pumps, direct thermal water supply, greenhouses, and bottling of potable water and soft drinks. Electricity generation from geothermal water is not currently available in the country.

About 72% of the total discovered flow rate of the state-owned reservoirs has a temperature up to 50^{o}C. Flow rate varies within 1-20 l/s for about 75% of these reservoirs.

The most prospective regions for geothermal application are located in the eastern part of Moesian plate (North Bulgaria, stratified horizons) and in Rila-Rhodopes massif (South Bulgaria, fractured intrusive and metamorphic rocks). The highest temperature (98^{o}C) is measured in Sapareva banja (South Bulgaria). Thermal water use is dependent predominantly on water chemical content. TDS varies between 0.1 and 1.0 g/l in most of the reservoirs in South Bulgaria, while in North Bulgaria it is much higher: from 0.1 g/l up to 150 g/l. For this reason, thermal water application is more diverse and mainly concentrated in the territory of South Bulgaria.

Most of the hydrothermal sites are developed as mountainous and sea resorts, and currently, leading applications are for balneology, direct thermal water supply for domestic needs, and space heating. Geothermal heat pumps also mark significant progress but no official summary for their use is available at present.

The focus of this analysis is on the quantity and type of thermal water use in the hydrothermal regions in Bulgaria in terms of temperature, flow rate, and application. A comparison between the quantity and type of water use in North and South Bulgaria is also made. Five leading regions are considered in more detail with respect to application. The major barriers for geothermal development are briefly presented.

1. INTRODUCTION

Bulgaria is situated on the southern part of Balkan Peninsula. Solid fuels (coal and wood) and hydro energy have dominant contributions among primary energy sources to the energy balances of the Balkan countries, as shown in Figure 1. Biomass is estimated to have the highest potential among the renewable energy sources (RES). The main domestic energy sources in Bulgaria are solid fuels , hydro energy, and nuclear energy.

According to the evaluated accessible technical potential of RES in Bulgaria, biomass and hydro energy have a dominant role, while the geothermal potential is comparable to that of solar energy. (See Figure 2.) The existing installed capacities for electricity generation operating with RES are small hydro power plants (up to 10 MWt) and wind turbines. The photovoltaic share is very small.

Electricity generation from renewables have marked progress during the last 10-15 years. Produced electricity in 2008 (excl. PSHPP) amounts to 2891.9 GWh and covers 6.5 % of the gross electricity generation in the country.

Thermal waters have an ancient tradition in the country, but only for direct applications, which include balneology (therapeutic bathing), space heating and air-conditioning, greenhouses, geothermal ground source heat pumps, direct thermal water supply, and the bottling of potable water and soft drinks.

Only nine state-owned reservoirs have temperatures higher than 76^{o}C. (See Figure 3), and the total flow rate in each of them varies between 13 and 23 l/s (Bojadgieva et al.,2007).

Thermal waters are found on all territories of the country and only six of 28 districts have no utilization. Intensive construction in mountain, sea and rural regions has been taking place during the last 20 years, which has stimulated the realization of more effective and complete thermal water applications.

The recent analysis of state-owned thermal water applications in Bulgaria is based on the officially published data by the Ministry on Environment and Water and Council of Ministers – Economic and Social Policy Directorate (Investment and Concession Department). The information on issued permits and concessions is being currently updated, presenting data on committed water quantities, types of applications for each particular site, terms of exploitation, etc. About twelve are the laws, referring to thermal water prospecting, exploration and utilization and major among them are Law on Water, Law on Energy, Law on Concessions and newly adopted one in 2008 - Law on Renewable and Alternative Energy Resources and Biofuels.

The whole legislation has been changed in the last 20 years during the transition period from planned to market economy in the country. The new laws have been amended and supplemented many times, which resulted in a delay of geothermal development. These obstacles decreasing with time and investor's interest in this activity is expected to increase in the near future.

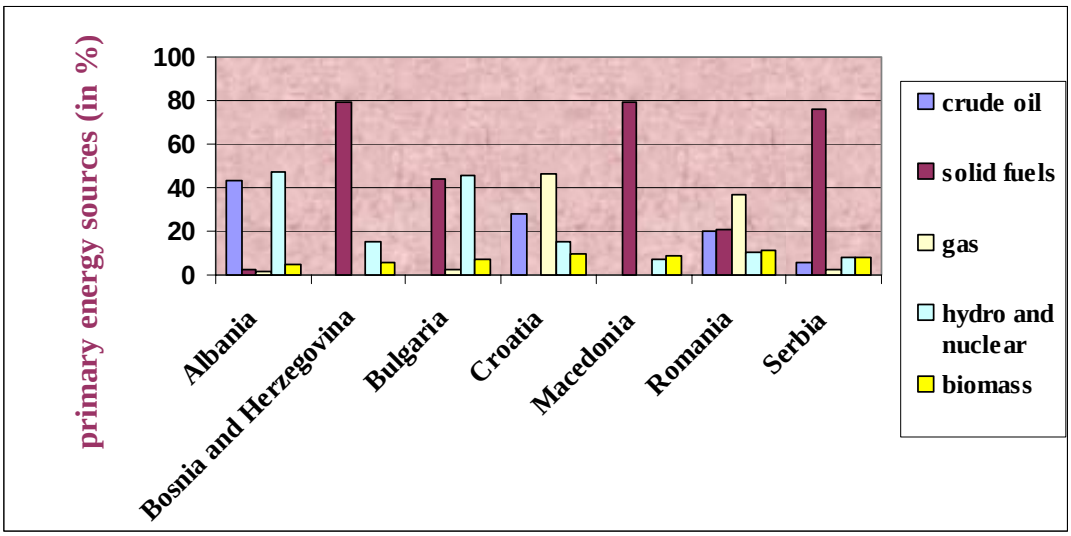


Figure 1: Major primary energy sources in the Balkan Peninsula (Data source: www.eva.ac.at)

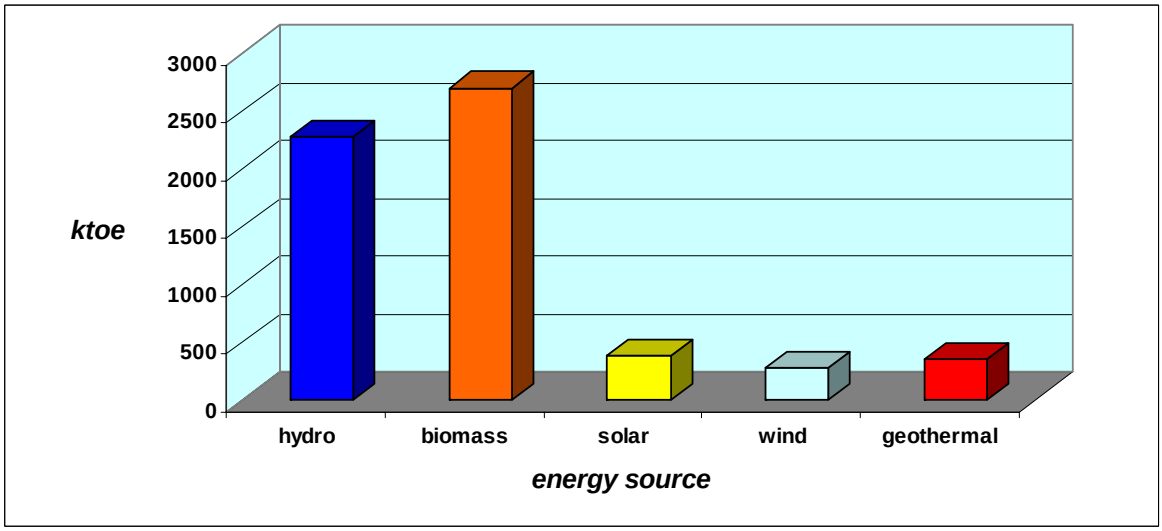


Figure 2: Accessible RES technical potential for different energy sources in Bulgaria (source: EEA)

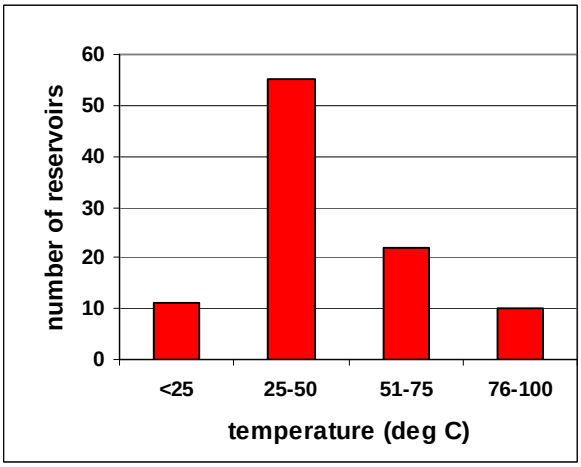


Figure3: State-owned reservoir distribution by water temperature

2. GEOLOGY AND HYDROGEOLOGY BACKGROUND

Bulgarian territory falls within the region of the Alpine-Himalayas orogen and this is the prerequisite for the relatively complex tectonic conditions. The country is divided in two parts (northern and southern) by the Balkan Mountains stretching from east to west across the whole territory. The northern part is built up mainly by sediments and includes two tectonic units: the Moesian plate and the Fore Balkan zone. The southern part consists of three major folded tectonic units: the Balkan zone, the Sredna Gora zone, and the Rila-Rhodope massif. The metamorphic and magmatic complexes are spread mainly in the southern part.

Hydrothermal zones are closely linked to the main geological structures and are present in four tectonic units: the Moesian plate (North Bulgaria), the Sredna Gora zone, the Balkan zone, and the Rila-Rhodopes massif (South Bulgaria). The Moesian plate has a Caledonian-Hercynian basement and a cover of Upper Paleozoic and Mesozoic

sediments. Their thickness decreases from about 6-7 km in the west down to several hundred meters in the east. The main geothermal reservoirs in the platform area were developed in the carboniferous strata of Malm-Valanginian, Middle Triassic and Upper Devonian age.

The Sredna Gora zone is heterogeneous hydrothermal region where unstratifed (fault-fractured), stratified and mixed hydrothermal systems are present.

The western Rila-Rhodopes massif is mainly composed of Precambrian metamorphic and granite rocks, fractured by a dense system of seismically active faults. The eastern part of the massif is not rich in thermal waters.

The different geological conditions in the northern and southern part of the country define the variety of thermal water origin, chemical content and temperature.

3. THERMAL WATERS CHARACTERISTICS

Information on state-owned thermal water characteristics for the regions of north and south Bulgaria are summarized in Table 1. Data are taken from Petrov et al., (1998), from the web sites of the Ministry of Environment and Water (www.moew.government.bg) and from the National Concessions Register (www.ncr.government.bg/app).

Higher temperatures are measured in South Bulgaria compared to the northern part. The discovered and utilized flow rates are also higher in the southern part, as shown in Figure 4. Further, about 20.5% of the discovered flow rate in North Bulgaria have been utilized, compared to 14.5% in South Bulgaria.

About 72% of the total discovered flow rate in state-owned reservoirs has a comparatively low temperature - up to 50^{o}C. Flow rate varies within 1 - 20 l/s in 75% of the reservoirs (Bojadgieva et al., 2005). The highest temperature (98^{o}C) is measured in Sapareva banja (South Bulgaria), while the highest flow rates are concentrated in the north-eastern part of Bulgaria.

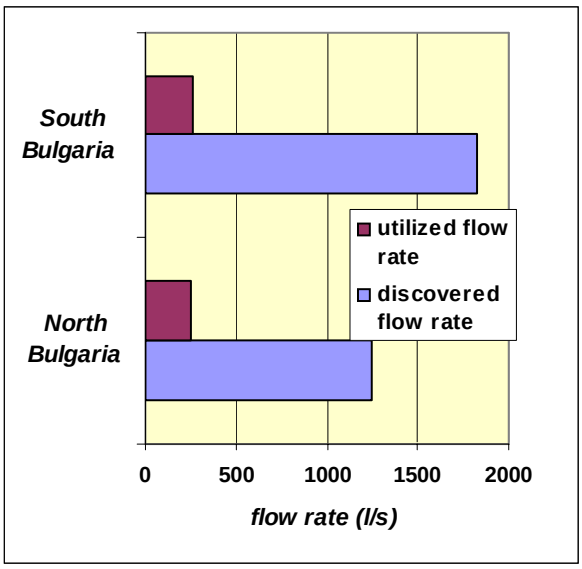


Figure 4: Discovered and utilized thermal water flow rate in Bulgaria

4. THERMAL WATER USE IN BULGARIA

The analysis of thermal water application in the country is based mainly on the information for state-owned reservoirs taken from the issued permits and concession. Some data from the concessions issued for the municipality–owned reservoirs are also available.

Geothermal water in Bulgaria has only direct application, which includes balneology (prevention, treatment and rehabilitation, bathing and swimming pools), space heating and air-conditioning, greenhouses, geothermal ground source heat pumps, direct thermal water supply, bottling of potable water and soft drinks, and for some other uses. Most of the hydrothermal sites are developed as mountainous or sea resorts. Currently leading applications in terms of water quantity are in balneology, direct thermal water supply and space heating (incl. greenhouses). Geothermal heat pumps also mark significant progress but no officially summarized information is still available.

The hydrothermal regions (defined by Petrov et al.,1998) with direct application are presented on Figure 5. The used flowrate is higher than 500,000 m^3/year (about 16 l/s) in only five regions: the Razlog, South Sredna Gora, Sandanski, Chepino, and NE Bulgaria basins. North Bulgaria combines several basins on the northern territory of the country.

The types of application for the state-owned thermal waters are presented in Figure 6. The highest water quantity (56%) is used for balneology (relaxation and sanitary needs, prevention, treatment and rehabilitation, drinking out of taps and swimming pools), followed by direct thermal water supply for domestic needs (19%) and heating of buildings and greenhouses (17 %).

The applications of thermal water use in North and South Bulgaria are shown in Figure 7. Balneology is the biggest application in both parts of the country with higher share in South Bulgaria. Other applications such as bottling, space heating and greenhouses have a larger share in the southern part than in the northern one, where bottling and greenhouses are poorly developed. The dominant application in North Bulgaria is the direct thermal water supply for domestic use in the sea resorts located on the northern Black sea coast: Golden Sands, Albena, Balchik and Kavarna. This is a solution for those regions where no alternative water sources are available. Another advantage for developing this application is the low water salinity (TDS), which makes it suitable for drinking and domestic use.

The geographic locations of the five basins of highest water quantity use (Razlog, South Sredna Gora, Sandanski, Chepino and NE Bulgaria) are shown in Figure 8. The types of applications in each region are shown in detail in Figure 9. Mountainous spa resorts have been developed in Razlog, South Sredna Gora and Chepino basins, while NE Bulgaria is famous for sea resorts.

Table 1: Characteristics of state-owned geothermal water according to region

Regions	*water temperature*	*discovered flow rate*	*used flow rate*	*TDS*
	(oC)	*(l/s)*	*(l/s)*	*(g/l)*
North Bulgaria	20-70	1241,65	254,7	0,1 - (100-150)
South Bulgaria	20-98	1823,81	263,5	0,1 - (1-15)

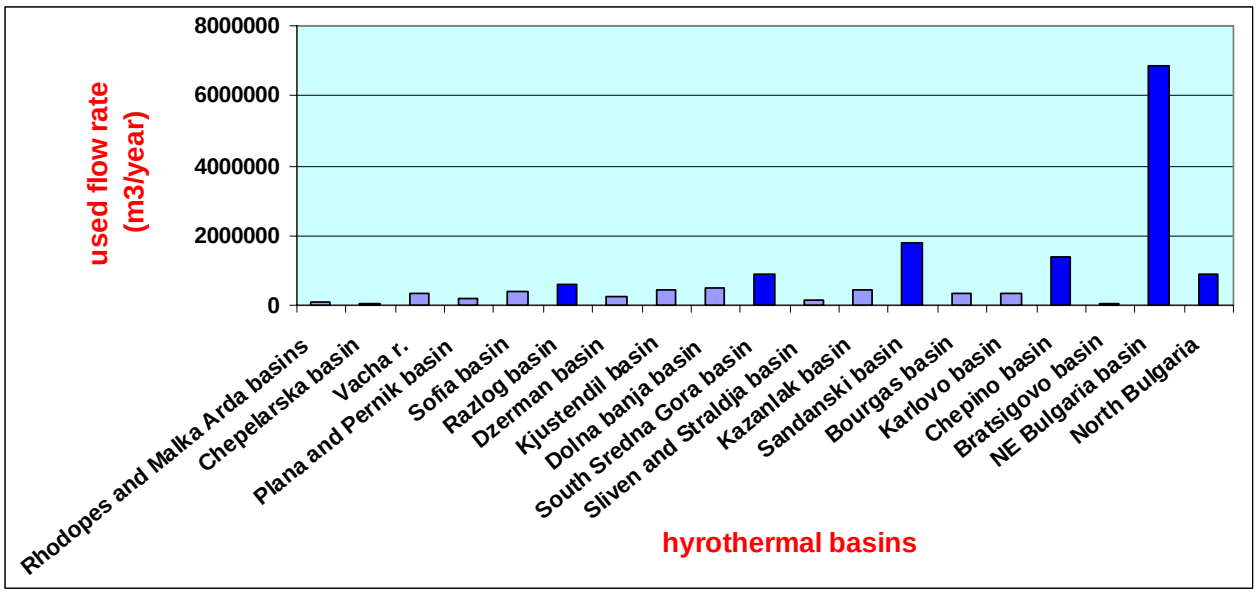


Figure 5: Thermal water use by hydrothermal basin in Bulgaria (state-owned reservoirs)

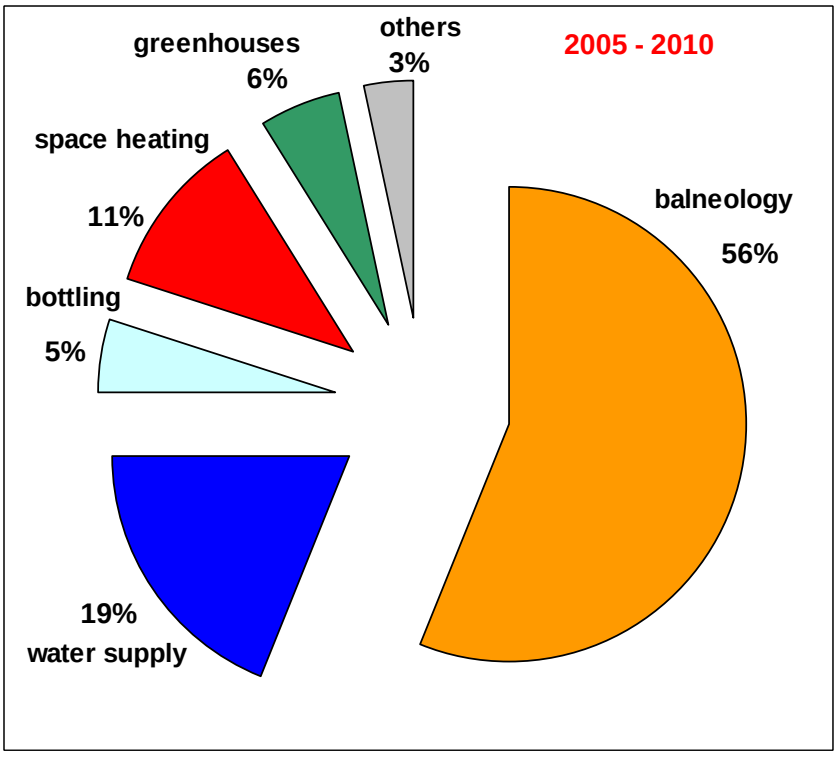


Figure 6: Percentage of flow rate used by each type of application in Bulgaria (updated 2009)

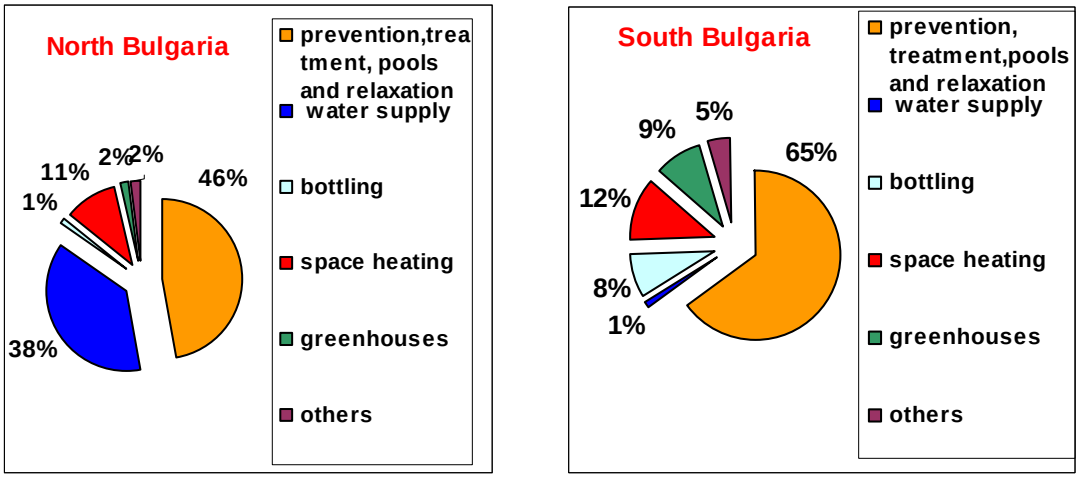


Figure 7: Percentage of flow rate used by each type of application in North and South Bulgaria



Figure 8: Locations of the five leading hydrothermal basins in Bulgarian thermal water use

Balneology has a leading role in all of them varying from 42.9% in NE Bulgaria basin up to 90 % in the Sandanski basin. Several resorts in the four selected basins in South Bulgaria are considered in greater detail in Table 2. Remains of ancient Tracian and Roman mineral baths are found in all of them. Today, they are rapidly developing spa centers, but only Hissarya and Sandanski resorts have more effective thermal water use at 66% and 82% of the discovered resource, respectively.

The widest varieties of applications exist in Sandanski and NE Bulgaria, although only three are dominant utilizations in the NE Bulgaria basin. Space heating is available in two basins in South Bulgaria (Chepino and Sandanski,) and one in North Bulgaria (NE Bulgaria) accounting for 7-22% of use. Thermal water utilization for domestic needs has a large share (42.6 %) in NE Bulgaria and a smale share (4%) in the Razlog basin.

DISCUSSION

Only about 15-20 % of the discovered thermal waters are currently used in Bulgaria. On the other hand water temperatures are relatively low and about 72% of the total discovered flow rate of the state-owned reservoirs has a temperature up to 50°C. For these reasons, the future geothermal resource exploitation will preserve the present trend of application in the existing locations.

Extremely good bio-climatic resources, combined with the existing ancient Mediterranean traditions in thermal water use, provide a base for a successful balneological activity in the country. Most of the resorts currently in use were developed in places of ancient centers. As early as Roman times, they were used on a large scale for floor heating in public baths (hypocausts). The factors mentioned above could explain the balneology's dominant share of thermal water utilization. The intensive construction of hotels in mountain and sea resorts during the last 20 years also created favorable conditions for better resource development.

Table 2

spa resort	*water temperature*	*discovered flow rate*	*used flow rate (%)*	*treatment*
Sandanski (Sandanski basin)	42 - 81	19,6	82	upper respiratory tract and lung diseases, inflammation of joints,etc.
Velingrad (Chepino basin)	27 - 88	115	42	respiratory, locomotory, neurological,cardiovasculars diseases, etc.
Dobrinishte (Razlog basin)	33 - 40	13,6	25	urologiucal, locomotory,gynecological, skin diseases, etc.
Hissarya (South Sredna Gora basin)	47	31,5	66	nephro-urological, gynecological, locomotory diseases,etc.

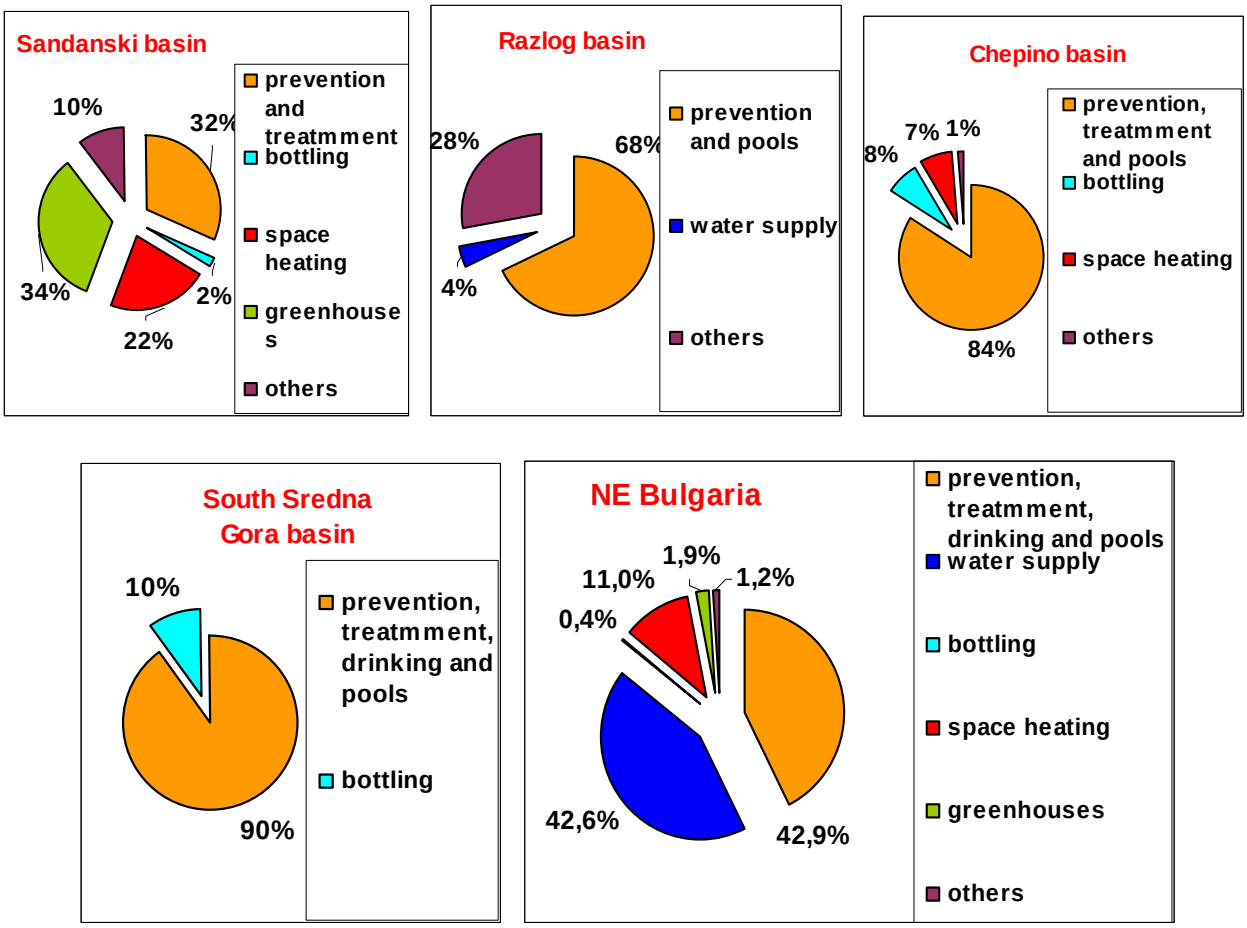


Figure 9: Percentage of thermal water flow rate used by each type of application for leading regions in Bulgaria (updated 2009)

The application of thermal water for space heating hasn't marked a significant progress for several reasons. These barriers are related to the harmonization of new legislation governing this activity, the complicated and time consuming procedure for obtaining permits or concessions, and the lack of investment interest in constructing new heating systems. Most of the existing installations are old and not in good technical condition.

The application of ground source heat pumps and air-to-water pumps continue to grow particularly in private and business buildings. It is difficult to assess the share of their contribution, as only a few companies publish information on their systems.

Great progress has been made in the policy related to promotion of renewable sources development in Bulgaria, but it is focused mainly on wind and solar energy.

Specific policy support for producers of thermal energy is in place. It concerns replacement of conventional fuels for heat production with renewables, complex utilization of renewable energy sources, and issuing of certificates corroborative to the origin of the produced thermal energy.

ACKNOWLEDGEMENTS

The authors would like to express their thanks to V.Toshev and K.Barokov from the Ministry of Environment and Water for data discussion.

REFERENCES

Bojadgieva,K.,Hristov,V., and Benderev,A.: General overview of geothermal energy in Bulgaria. J.Acta Montanistica Slovaca, vol.**12,** 86-91, (2007).

Bojadgieva,K., Hristov,H.,Hristov,V., Benderev,A. and.Toshev, V: Geothermal update for Bulgaria (2000-2005). *Proceedings*, World Geothermal Congress'2005, Antalya, Turkey, 24-29 April2005, (2005).

Petrov,P.(ed.) et al.: Reassessment of hydrogeothermal resources in Bulgaria, Report for the Ministry of Environment and Waters, National Geofund, Sofia, Bulgaria (1998). (in Bulgarian).

Phare Project BG 9307-03-01-L001-Report Writing: Technical and Economic Assessment of Bulgarian Renewable Energy Resources. Ministry of Energy and Mineral Resources, Sofia, Bulgaria, (1997).

Vladeva,L. and Kostadinov, D. - Bulgarian Potable Mineral Waters,I part, M-8-M, S.pp.175, (1996). (in Bulgarian)