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Geothermal Energy Use, Country Update for Serbia

Sibela Oudech[1], Ivan Djokic[1], Siniša Radomir[2].

[1] Geco-inzenjering, Vardarska 14, Belgrade, Serbia

[2] NIS ad, Narodnog fronta 12, Novi Sad, Serbia

geco.ing@gmail.com

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ABSTRACT

The territory of Serbia has favourable geothermal characteristics. Excluding Pannonian basin, there are 159 natural springs of thermal water with temperature above 15 ^{o}C, with total flow 4000 l/s. In Pannonian basin there are 81 hydrogeothermal drill holes with total average flow of about 700 l/s, and water temperature that ranges from 21 to 82 ^{o}C . According to the recent data in Serbia in 2015 **515.94 GW$_{th}$** was produced from geothermal sources with total capacity **123.89 MW$_{th}$**, where **487.75 GW$_{th}$** was in geothermal direct use with thermal capacity **111.07 MW$_{th}$**, and **28.19 GW$_{th}$** from shallow geothermal systems using heat pumps of total capacity **12.82 MW$_{th}$**. There is a growing interest in using the geothermal energy from shallow systems using heat pumps since these systems are less expensive and more secure comparing to deep hydrogeothermal systems. Republic of Serbia has as well obliged to apply EU Directives about renewable energy sources and set the scope to increase total share of all renewable energy sources in gross final energy consumption to 27%, by the end of 2020.

1. INTRODUCTION

Serbia is situated in the central part of the Balkan Peninsula (Fig 1), and covers the surface of 88361 km^2.

Systematic geothermal investigations in Serbia began in 1974, after the first world oil crises. However, the first descriptions of its geothermal resources were given in 1897 by S. Radovanovic in the book "Ground Water". Since 1974 numerous studies and projects of deep geothermal drill holes were made but only few have reached full realization.

According to the recent data in Serbia in 2015 **515.94 GW$_{th}$** was produced from operational geothermal sources with thermal capacity of **123.89 MW$_{th}$**, where **487.75 GW$_{th}$** was geothermal direct use with installed thermal capacity of **111.07 MW$_{th}$**, and **28.19 GW$_{th}$** from shallow geothermal systems using heat pumps of total capacity **12.82 MW$_{th}$**. The greatest number of objects is used in balneology, then for indoors and outdoors swimming pools, wellness and spa centres, fewer are used for spa premises and greenhouses heating, then for industrial and agriculture processes.

Nowadays Republic of Serbia is making an effort in increasing the percentage of total share of all renewable energy sources in the gross final energy consumption. It has defined the development strategy of energetic sector in order to achieve the goal set by EU of 27 % of all renewable energy sources in the final energy consumption by the end of 2020.

Figure 1: Geographical location of Serbia.

2. GEOLOGY BACKGROUND

In the territory of Serbia rocks of different age occur, from Precambrian to Quaternary age, and of all types regarding their lithology. There are 5 great geotectonic units (Fig 2): Dinarides, Serbian-Macedonian massif, Carpatho-Balkanides and Pannonian Basin, and very small part at far east of the country that belongs to Mesian Platform (Grubic, 1980).

The Dinarides occupy the large part of Serbia and they are made of Mesozoic rocks, mainly limestones and dolomite of Triassic age, then of ophiolite melange of Jurassic age and Cretaceous flysch.

The Serbian-Macedonian massif occupies the central part of Serbia and it is made of Proterozoic metamorphic rocks: gneisses, various schists, marbles, quartzites, as well as magmatic, or intrusive-granitoide and volcanic rocks of Tertiary age.

The Carpatho-Balkanides extend over the eastern part of Serbia and this unit is mainly made of limestones of Triassic, Jurassic, and Cretaceous age. At north, Serbia belongs to the great unit that extends far beyond the Serbian borders, Pannonian basin that consists of Palaeogene, Neogene and Quaternary sediments with a total maximal thickness of about 4000 meters.

Figure 2: Tectonic map of Balkan Peninsula (Martinovic and Milivojevic, 2010).

3. GEOTHERMAL RESOURCES AND POTENTIAL

Territory of Serbia is featured with greater geothermal potential than it is in use nowadays. According to M. Milivojevic, (1989) there are 4 geothermal provinces within the 4 great geotectonical units.

Excluding Pannonian basin, there are 159 natural springs of thermal water with temperature above 15 ^{o}C. The thermal springs with the highest temperature are in Vranjska spa (96^{o}C), then Josanicka Spa (78 ^{o}C), Sijarinska Spa (76 ^{o}C), Kursumlijska Spa (68 ^{o}C) and Novopazarska Spa (54 ^{o}C). The total flow of all natural springs is about 4000 l/s. The thermal springs with highest flow are draining the karstified limestones of Triassic age, and the next highest are those from Tertiary granitoides and volcanic rocks. The most of thermal springs occur in the Dinarides then in Carpatho-Macedonian Massif.

In Pannonian basin there are 81 hydrogeothermal drill holes with total average flow of about 700 l/s, and water temperature that ranges from 21^{o}C 1 to 82^{o}C.

There are 60 convective hydrogeothermal systems in Serbia. Of this number, 25 are in the Dinarides, 20 in the Carpatho-Balkanides, 5 in the Serbian-Macedonian Massif, and 5 in the Pannonian Basin under Tertiary sediments (Fig 3). Conductive hydrogeothermal systems are developed in basins filled with Paleogene and Neogene sedimentary and as such they mainly occur in the Pannonian Basin in Vojvodina, northern Serbia (Martinovic and Milivojevic, 2010).

3.1 Pannonian basin

Within this geotectonic unit 4 groups of hydrogeological systems were defined according to the depth.

The first hydrogeological system encompasses sediments from the surface to the basement of the upper Pontian with maximal thickness of 2000 m in central part of the basin and reaches several dozen meters in the bordering zones of the Pannonian basin. The collectors are sands and gravel. Maximal strata temperature is 120 ^{o}C. The average flowing well yields are 1-13 l/s, with water temperature at well-heads from 40 to 55 ^{o}C, maximum 82 ^{o}C (Martinovic et al, 2010). Chemical composition displays water of HCO3-Na type and mineralization 1-9 g/kg.

The second hydrogeological system is located immediately under the first one and is consisted of the lower Pontian and Pannonian rocks. The collectors in this system are sandstones. Maximal strata temperature in this system is 160 ^{o}C. The average flowing well yields are 2.5-5 l/s, with water temperature at well-heads from 50 to 65 ^{o}C (Martinovic et al, 2010). Chemical composition displays water of HCO3-Cl-Na type and mineralization 4-20 g/kg.

The third hydrogeological system is formed at the base of Neogene or Palaeogene sediments, where collectors are made of Miocene limestones, sandstones, basal conglomerates, and basal breccias. The average flowing well yields are 5-10 l/s. Water temperature at well-heads ranges from 40 to 50 ^{o}C (Martinovic et al, 2010) and according to the chemical composition thermal waters are of HCO3-Na type and mineralization up to 50 g/kg.

The fourth hydrogeological system encompasses magmatic, metamorphic and sedimentary rocks of the Triassic and Palaeozoic age underlying the Palaeogene and Neogene sediments. The most significant collectors are fractured and karstified Triassic limestones and dolomites. In the central parts of the basin these rocks are at the depth of about 1500 m, while in the basin borders the depth is about 1000 m. The average well yield is 12 l/s in central parts and up to 40 l/s in the border zones. Water temperature at well-heads is 40-60 ^{o}C (Martinovic and Milivojevic, 2010). In the border zones due to the active water-exchange thermal waters are of HCO3-Na type and mineralization up to 1 g/kg, while in central part thermal water belongs to the Cl-Na type.

3.2 Dinarides

Different groups of reservoirs have been formed within this geoteconic unit as a result of complex geology (Fig. 3).

Hydrogeothermal systems have been formed in terrains of: (1) Neogene sedimentation basins with reservoirs in Triassic limestones underlying them; (2) peridotite massifs and ophiolitic melange with reservoirs in Triassic limestones; (3) granitoid intrusions and respective volcanic rocks with reservoirs in the same rocks; and (4) Palaeozoic metamorphic rocks with reservoirs in marbles and quartzites. The most significant aquifers are Triassic limestones with spring flows up to 400 l/s, and well yields up to 60 l/s. The maximal temperatures of water at well-heads are 80 ^{o}C. The thermal waters are of HCO3-Na or HCO3-Ca-Mg type and have low mineral content (<1 g/kg). The second important reservoirs are those in granitoid intrusions and thermo metamorphosed fractured zones at their borders. The maximal yield is up to 15 l/s and the highest temperature of waters at well-heads is 78 ^{o}C The contained thermal waters are also low in total mineralization (>1 g/kg), of HCO3-Na type. There are few occurrences of thermal water in Palaeozoic metamorphic rocks. Such springs have low flows (<1 l/s), low water temperatures (<20 ^{o}C), mineralization rates 5-7 g/kg, HCO3-Na in type, and high concentrations of free CO_2 gas.

3.3 Serbian-Macedonian Massif

There are two types of hydrogeothermal systems in this geothermal province. One is in the Proterozoic metamorphic complex, with the reservoir in marbles and quartzites up to 1500 m in thickness, (Fig. 4). Thermal waters in this reservoir are of HCO3-Na-Cl type and total mineralization of 5-6 g/kg with high concentration of free CO_2. This gas is formed by thermolysis of marble at temperatures above 100 ^{o}C in the presence of water. Thermal water temperature at springs is 24-72 °C and springflow is of gas-lift type due to the high CO_2 gas content. The second type of hydrogeothermal system is formed in contact with and in the marginal zones of the Neogene granitoid intrusions. The reservoir rocks are granitoids, metamorphic and contact-metamorphic rocks, heavily fractured as a result of heating and cooling. The thermal springs of Vranjska Spa belong to this system type and have the water with highest temperature in Serbia, 80-96 °C, (Table 3). Its mineral content varies from 0.1 to 1.2 g/kg. The water type is HCO3-Na-SO4-Cl. Springflows are up to 80 l/s.

3.4 Carpatho-Balkanides

There are many hydrogeothermal systems within this unit and most of them have been formed in the regions of isolated Neogene sedimentary lake basins with reservoirs in karstified Triassic, Jurassic or Cretaceous limestones. Thermal karst springs have flows of 60 l/s, with water temperatures to 38 °C. In chemical composition thermal waters are of HCO3-Ca type and mineralization of 0.7 g/kg. Another type of hydrogeothermal systems is formed in the Upper Cretaceous paleorift of Eastern Serbia, where Mesozoic limestones were penetrated and thickly covered with andesite lavas and pyroclastics. Water temperatures at thermal springs are up to 43 °C, and springflows are up to 10 l/s. Thermal waters are of SO4-Na-Cl or HCO3-Na-SO4-Cl type and mineralization of 0.8 g/kg.

4. GEOTHERMAL UTILIZATION

The commonest use of geothermal energy in Serbia is the traditional ones: balneology and recreation. In Serbia nowadays at over 50 locations the thermal water is being used for balneology, sport and recreation. Geothermal energy utilization for heating, as well as in agriculture and industrial processes is present but only on few locations. Usually the geothermal energy utilization for heating is connected with systems used for spas and balneology. District heating systems based on geothermal energy are rather rare. Usually those are old systems from the era before 1990, working only partially.

There are 128 hydrogeothermal drill holes, of which 81 are in Pannonian basin and 47 in other provinces. The total heat capacity of all hydrogeothermal drill holes in Serbia is about 188 MW_{th}, where 80.3 MW_{th} are in Pannonian basin. So far, 24 hydrogeothermal systems had been constructed in Pannonian basin and all were put in operation before 1990, when the highest production was reached of about 1.6 million m^3 of thermal water, that was used for heating, balneology, agriculture and industrial processes.

In other geothermal provinces thermal waters are mainly used for balneology and sport and recreation while less were in use for spa premises heating and in agriculture. In Vranjska spa thermal waters with temperature 96 °C have already been used for 40 years for heating the rehabilitation centre and accompanying objects using heat exchangers, then for heating the flower greenhouses located downstream of the spa. In Sijarinska Spa thermal water of 76 °C is used for heating the hotel and recreation centre. Thermal water from one of the wells in Ribarska spa with temperature 44 °C is in use over heat exchanger for heating the rehabilitation centre, while another well with water temperature of 48 °C is used for balneotherapy. Thermal water in Lukovska Spa is used for heating the hotel and balneotherapy. Geothermal energy in Debrc (Macva region) is used for drying wheat and other cereals. Another use of geothermal energy at Debrc is for premisses heating.

Most of these systems and drill holes were constructed before 1990. After 1990 due to the economic and political situation in country and surroundings geothermal energy use decreases. The budget funds for realization of programmes of geological exploration were cut down and almost all the interest in further investments in geothermal resource development was lost. Furthermore, decreased financial solvency of final users of energy, as well as unsolved property issues after privatization process led to abandonment of the existing projects and caused transfer back to use of electric power and fossil fuels (oil, mazut, gas etc.). The great number of existing objects are temporarily closed and protected, while on other the thermal water is freely flowing out.

As the result of this situation total available heat capacity of geothermal resources that were in operation in 2015 was **111.07 MW_{th}**, of which **30.81 MW_{th}** in Pannonian basin. Total installed capacity of heat pumps in Serbia in 2015 was about **12.82 MW**.

However, in last decade the interest in use of geothermal energy have been revoked caused by petrol energy products misbalance and permanent growth of demand on one side and deficit, on another, of fossil organic and nuclear fuels, then by growth of transport costs, regional separation, environmental degradation due to the global, regional and local influences and increased costs of environmental protection.

The highest interest is in geothermal utilization for aqua parks and wellness centres, where the investors start recognizing the benefits of using the thermal water not only for recreational purposes but for the heating the premises and sanitary hot water as well.

Recreational centres and wellness centres in two towns in Vojvodina (Pannonian basin), Senta and Becej are under construction and they were planned to be put into operation by the end of 2014. Those will use thermal waters from the new hydrogeothermal wells that were drilled in 2011 and 2012. Hydrogeothermal well in Becej is 1100 m deep with free outflow yield of 20 l/s of water temperature 65 °C and it will be included in the heating system and for recreational use in newly designed wellness centre. The most recent drilled is hydrogeothermal drill hole in Senta, 920 m deep with over 20 l/s of free outflow and water temperature of 55 °C. It is planned to be used for heating, outdoor pools and wellness centre. Unfortunately investments in such projects are rather high and exploitation licence procedure is complicated and slow, therefore the commencement dates for these two projects are postponed. It is expected they would be put into operation by the end of 2018.

Macva region is considered as one of the highest prospects for multipurpose use of geothermal energy and has been the subject of many detailed geothermal investigations. The prospect of Municipality of Bogatic to use hydrogeothermal energy from the existing well BB-1 for district heating was also recognised by the Project "Promotion of Renewable Energy Sources and Energy Efficiency", EuropeAid/129768/C/SER/RS", where it was chosen with 2 more locations (Vrbas and Mataruška spa) as the most prospective location for geothermal energy utilization. Municipality decided to follow this path and set up the project of reconstruction of the existing drill hole BB-1 and its connection to the district heating system of Bogatic. After revitalization of this well the free outflow at the well head was 25 l/s and water temperature 75 °C. Projected capacity of the system is **5.75 MW_{th}**. Planned commencement date is in 2018.

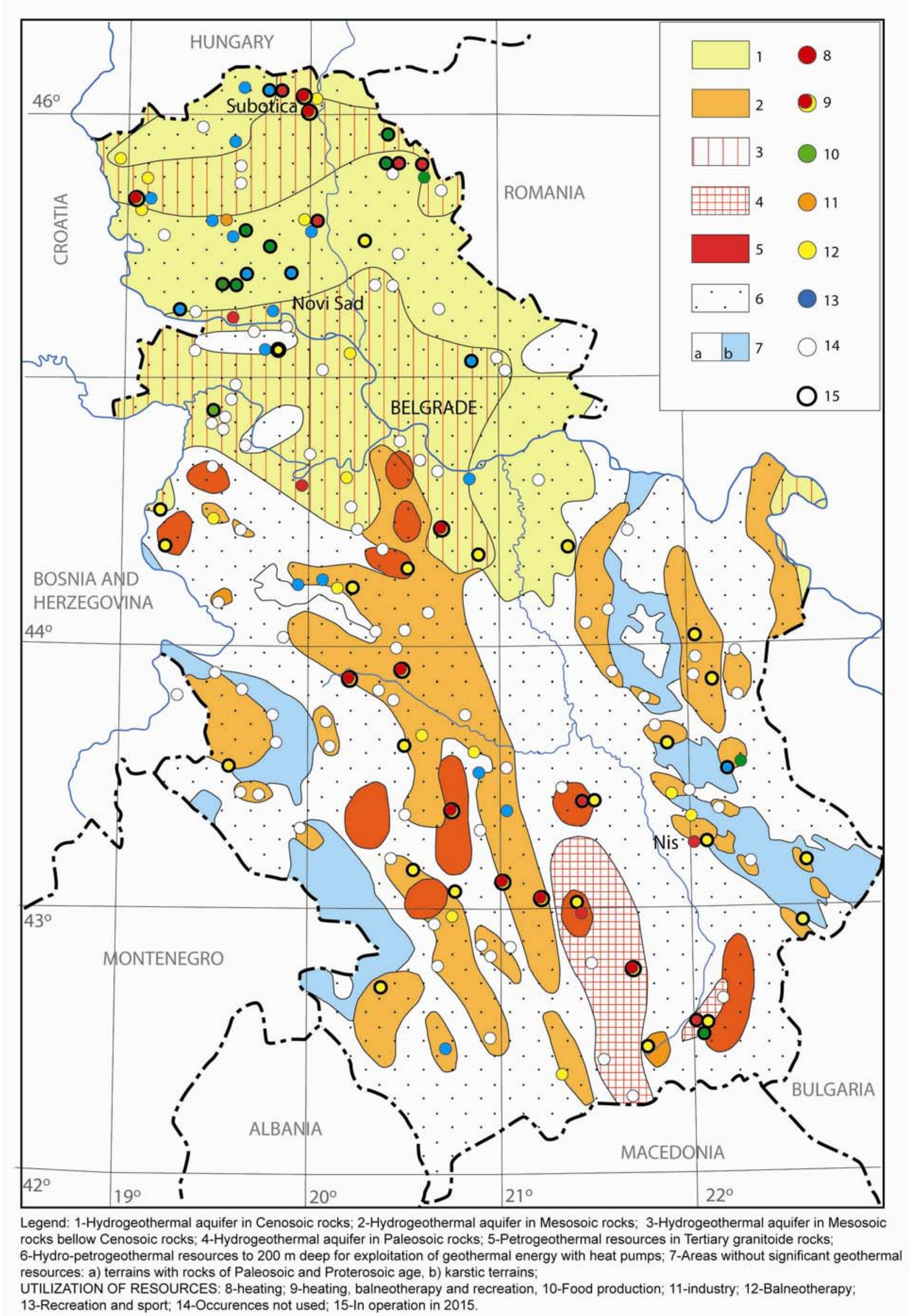

Figure 3: Map of geothermal resources of Serbia (background: Geothermal resources map, Milivojevic, 2001).

Close to BB-1 there is another drill hole BB-2, which free outflow is 50 l/s and water temperature reaches 80 ^{o}C. This drill hole was revitalised in 2004 and planned for heating in agriculture, unfortunately this project still waits for its realization.

Heat pumps use in Serbia became popular in last several years along with use of solar panels. There are about **827** heat pumps installed throughout Serbia with total capacity **12.82 MW** that produced **28.19 GW$_{th}$/yr** in 2015. The most is used for heating commercial and residential buildings in cities in Serbia like Belgrade, Novi Sad and Nis.

We must emphasize that the use of geothermal energy, especially those from shallow geothermal installations, for small greenhouses and individual buildings are difficult to follow in the exact number, which is growing very quickly where users are not always following the complicated procedure proscribed by Serbian regulations.

5. DISCUSSION

According to abovementioned Serbia has a great geothermal potential, where only small amount is being used. Since 1974 till 1990 numerous deep geothermal drill holes have been constructed and put into operation. Todays situation is quite different. Geothermal energy use in Serbia was greater in 1992 than it is in present. The great number of the existing sources are closed and not in use or being in use only partially. On the other side, in last 8 years 5 new deep hydrogeothermal drill holes were drilled and all in period 2009-2012.

The situation started slightly improving in the last several years caused by the global trends on one side and forced by EU on the other, when the official attitude of the Serbian Government is in question. At the same time the interest in using renewable energy in a variety of industry sectors is rapidly increasing and geothermal energy utilization among other renewable energy sources comes to focus.

In 2006 by Contract ratification about establishment of energetic community, Republic of Serbia has taken international obligation to apply EU Directives about renewable energy sources. In accordance to Directive 2009/28/EC a scope for Republic of Serbia was set to increase total share of all renewable energy sources in gross final energy consumption to 27%, by the end of 2020.

To fulfil this task Republic of Serbia has defined the development strategy of energetic sector and prepared National Action plan. Adequate Laws and Acts have been made following this problematic. Appropriate Guides for prospect investors in this field have been made along with the abet measurement from the Republic of Serbia (Feed in Tariff).

Technically usable potential of renewable energy sources in Republic of Serbia is significant and estimated to 5.6 Mtoe per year (Fig 4.), of which about 3.4 Mtoe is in biomass (1.1 Mtoe already in use), 1.7 Mtoe of hydro potential (0.9 Mtoe already in use), 0.2 Mtoe in existing geothermal sources, 0.1 Mtoe in wind energy and 0.2 Mtoe in use of solar potential. (National Action Plan, 2013).

Use of these sources contributes to more efficient use of owned potential in energy production, and then contributes to reduction of fossil fuels import, local industry development and new vacancies opening.

It is expected that the share of annual production of electric energy from renewable sources will improve by the end of 2020 to 36.6 %. Serbia will by the end of 2020 install additional 1092 MW where 1 MW of geothermal energy is planned.

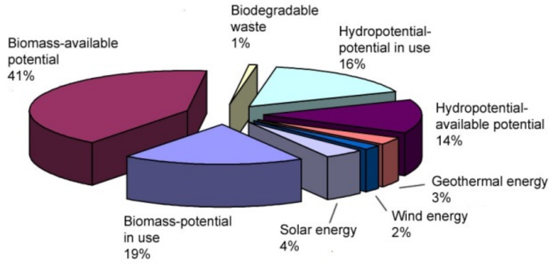

Figure 4: Structure of RES in Serbia (National Action Plan about use of renewable energy sources, 2013).

In the Tables C and E updated data from the field where available were used. Bearing in mind that in some spas thermal water is used for heating and balneology and sometimes the record about the amount used for heating and balneology did not exist, in these cases we used some free estimates regarding temperatures to calculate the total heat used for balneology and heating.

As the Government of Serbia started with campaign about recording all the resources in database and compulsory monitoring of quantity and quality of the resource, it is expected that in future all existing data will be systematized and that we will have relevant up to date data that is necessary if the future use of this resource is planned. Government of Serbia is also intensively working on education in the field of energy efficiency and use of renewable energy.

On the other hand to get to the final result, investors are facing a complicated, long and slow procedure provided by Serbian regulations, where once the process started it still can be the subject of the changes in regulatory acts. Despite to the abet measurements prepared by the government, the long procedure and uncertain outcome are along with the high costs the main reasons why there is reluctance in investing in geothermal energy utilization.

6. FUTURE DEVELOPMENT AND INSTALLATIONS

For now geothermal energy in Serbia is used only in amount of **111.07 MW$_{th}$** and additional **12.82 MW$_{th}$** out of shallow systems. This can be considered as pretty low since Serbia regarding the geothermal potential is among "rich" countries. Its exploitation and use has to become intensive due to many factors. The most significant use of geothermal energy for Serbia could be for distric heating of settlements and agriculture development, more precisely food production with accordance to the ecological standards and in near future for electric power production.

Even though Serbia has a great energetic potential related to direct use geothermal energy, very few investors chose to get into this procedure. The reason is firstly very high costs of these systems as well as insecure fate of the Project due to possible unpredicted costs and rather complicated, slow and long procedure of obtaining all opinions, approvals and permits proscribed by regulations. This is the reason why many investors are interested in using the geothermal energy from the shallow systems as a more secure investment. In this way in last 3 years over 10 Projects of geothermal energy use for heating have been started in the mountain resorts and commercial and residential buildings in the cities.

The great interest in Belgrade is in using heat pumps for heating the large state-of-the-art residential buldings, hotels and shopping centres where interesting reservoirs are in alluvial sediments of Sava and Danube and Neogene sediments beneath. In addition, the prospects for use of heat pumps on pumped ground water from alluvial deposits along all major rivers are very good.

According to the geothermal exploration results intensive use of thermal waters in agro- and aqua- culture and distric heating has the best prospect in the area western of Belgrade. The area with the highest prospects of multipurpose use of geothermal energy is west of Belgrade, in Macva area. As already mentioned, in settlement of Bogatic, two systems have been planned from reservoirs in karstified limestone beneath the Neogene sediments, one for district heating and another for agricultural purposes with total capacity of **14.25 MW_{th}**. Another two district heating systems located in Panonnian basin (Senta and Becej) started the paperwork for obtaining the exploitation licence. Expected total capacity of these two systems is **7.43 MW_{th}**, which together with systems in Macva makes additional **21.67 MWth** expected to be in operation by the end of 2018**.**

Through the above mentioned "Promotion of Renewable Energy Sources and Energy Efficiency", Europe Aid/129768/C/SER/RS" prefeasibility studies were made for 3 locations, Bogatic, Mataruska spa and Vrbas as the most interesting locations from the aspect of geothermal resource utilization and development. These are considered as potential locations from the economic and social aspects. They were chosen among 12 locations where other 9 locations (chosen from 33, provided by Ministry of Energetics in previous task of the Project), represent interesting locations for further development regarding geothermal energy utilization as well.

7. CONCLUSIONS

It is certain that Serbia has a great potential in hydrogeothermal energy for direct use and that this kind of energy is used in a very small amount. Recent explorations displayed that many sources were closed and out of operation and that many data were out dated. With its potential and having in mind the entire global situation with fossil fuels it would be prodigal not to use it. Since the great interest in geothermal energy utilization has been revoked, we hope for fast development which requires database organization, then simplifying and shortening the procedure of obtaining licences, as well as higher funds provided by government programmes to make geothermal utilization projects more available in order to achieve the goal set for 2020.

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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 *	0	0	7124	35563	0	0
Under construction end of 2015	0	0	-	-	-	-
Total projected by 2018	0	0	-	-	-	-
Total expected by 2020	1	7	8206 Value taken from the National Action Plan, scenario with energy efficiency measurements included	35611 Value taken from the National Action Plan, scenario with energy efficiency measurements included	0.5	0.5

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):	5, exploration

* If 2014 numbers need to be used, please identify such numbers using an asterisk

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 *	45.886	161.012	11.626	62.493	16.840	77.989	36.722	186.257
Under constru-ction end 2015	13.180	115.413	-	-	-	-	0.922	8.075
Total projected by 2018	13.180	115.413	8.494	74.377	-	-	-	-
Total expected by 2020	59.066	276.425	20.120	136.870	16.840	77.989	37.644	194.332

* If 2014 numbers need to be used, please identify such numbers using an asterisk

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 * (GW_{th}/y)	Geoth. share in total prod. (%)
Junaković spa	Pb-1/H, Pb-3/H	1984	N	N	5.145	5.155	12.538	100
Kanjiža spa	Kž-1/H, Kž-2/H, Kž-3/H	1981	N	N	6,236	6.236	21.397	100
Ribarska Spa	Rb-4	1988	N	N	0.795	0.795	4.177	100
Lukovska Spa			N	N	1.607	1.607	14.069	100
Sijarinska Spa	B-4	1990	N	N	4.268	4.268	4.485	100
Niška Spa			N	N	3.012	3.012	15.388	100
Debrc-1	IEDc-1	1990	N	N	2.310	2.310	10.112	100
Debrc-2	Debrc-2	1990	N	N	7.113	7.113	24.914	100
Vranjska Spa	WG-2, WG-3	1989	N	N	15.400	15.400	53.932	100
total					45.886	45.886	161.012	100

* If 2014 numbers need to be used, please identify such numbers using an asterisk

** 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 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 *	827	12.822	28.192	*est.* 52*	*est.* 0.832*	
Projected total by 2018	not available	not available	not available			

* If 2014 numbers need to be used, please identify such numbers using an asterisk

Table F: Investment and Employment in geothermal energy

	in 2015 *		Expected in 2018	
	Expenditures ** (million €)	Personnel *** (number)	Expenditures ** (million €)	Personnel *** (number)
Geothermal electric power	-	-	-	-
Geothermal direct uses	*est.* 1.0	*est.* 120	*est.* 1.5	*est.* 130
Shallow geothermal	*est.* 0.5	*est.* 200	*est.* 0.8	*est.* 220
total	*est.* **1.5**	*est.* **320**	*est.* **2.3**	*est.* **350**

* If 2014 numbers need to be used, please identify such numbers using an asterisk

** Expenditures in installation, operation and maintenance, decommissioning

*** 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.

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	-	-	-
Financial Incentives – Investment	-	*est* 0.3 million € - DIS *est* 0.7 million € - LIL	*est* 0.7 million € - LIL
Financial Incentives – Operation/Production	FIT	FIT	FIT
Information activities – promotion for the public	yes, through media	yes, through media	yes, through media
Information activities – geological information	yes, through articles and media	yes through public media	yes, through public media
Education/Training – Academic	yes, through Msc studies	yes, through Msc studies	yes, through Msc studies
Education/Training – Vocational	yes, through workshops and conferences	yes, through workshops and conferences	yes, through workshops and conferences

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)