Geothermal Energy Use, Country Update for Serbia

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ABSTRACT

The territory of Serbia has favourable geothermal characteristics. There are more than eighty hydrogeothermal systems within four geothermal provinces. According to the recent data in Serbia in 2018 **514.91 GW$_{th}$** was produced from geothermal sources with total capacity **128.45 MW$_{th}$**, where **480.55 GW$_{th}$** was in geothermal direct use with thermal capacity **112.86 MW$_{th}$**, and **34.37 GW$_{th}$** from shallow geothermal systems using heat pumps of total capacity **15.59 MW$_{th}$**. The commonest use of geothermal energy in Serbia is the traditional ones: balneology and recreation. However, 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. Until 1990 numerous deep geothermal drill holes had been constructed and put into operation. Today's situation is quite different. Geothermal energy use in Serbia was greater in 1990 than it is in the present when a great number of the existing sources are closed and not in use or is in use only partially.

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.

Currently, 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.

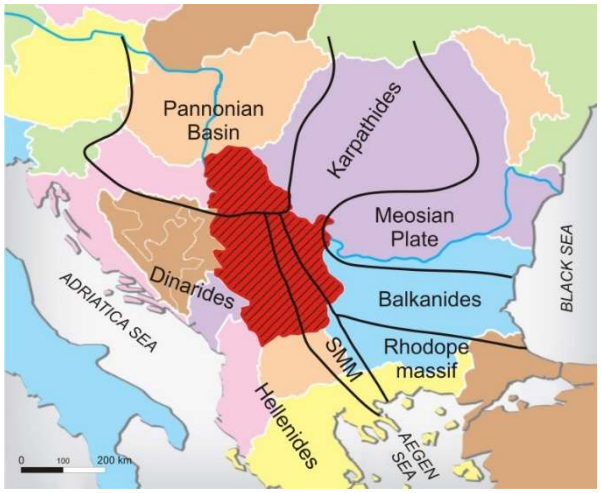


Figure 2: Tectonic map of Balkan Peninsula (Martinovic and Milivojevic, 2010)

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 geotectonic units.

Excluding Pannonian basin, there are 159 natural springs of thermal water with temperature above 15 ºC. The thermal springs with the highest temperature are in Vranjska spa (96ºC), then Josanicka Spa (78 ºC), Sijarinska Spa (76 ºC), Kursumlijska Spa (68 ºC) and Novopazarska Spa (54 ºC). 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 83 hydrogeothermal drill holes with total average flow of about 700 l/s, and water temperature that ranges from 21ºC 1 to 82ºC.

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. GEOTHERMAL UTILIZATION

In Serbia nowadays at over 50 locations 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. Geothermal energy utilization for heating is usually connected with systems used for spas and balneology, while district heating systems based on geothermal energy are rather rare. Those are old systems, working only partially. However, there is a growing interest in using the geothermal energy from shallow systems using heat pumps for individual commercial and residential buildings heating.

There are 130 hydrogeothermal drill holes, of which 83 are in Pannonian basin and 47 in other provinces. The total heat capacity of all hydrogeothermal drill holes in Serbia is about 200 MW_{th}, where 82.5 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 is in use for spa premises heating and in agriculture.

Geothermal energy use decreases after 1990 due to the economic and political situation in country and surroundings. 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 the great number of existing objects to be put out of operation.

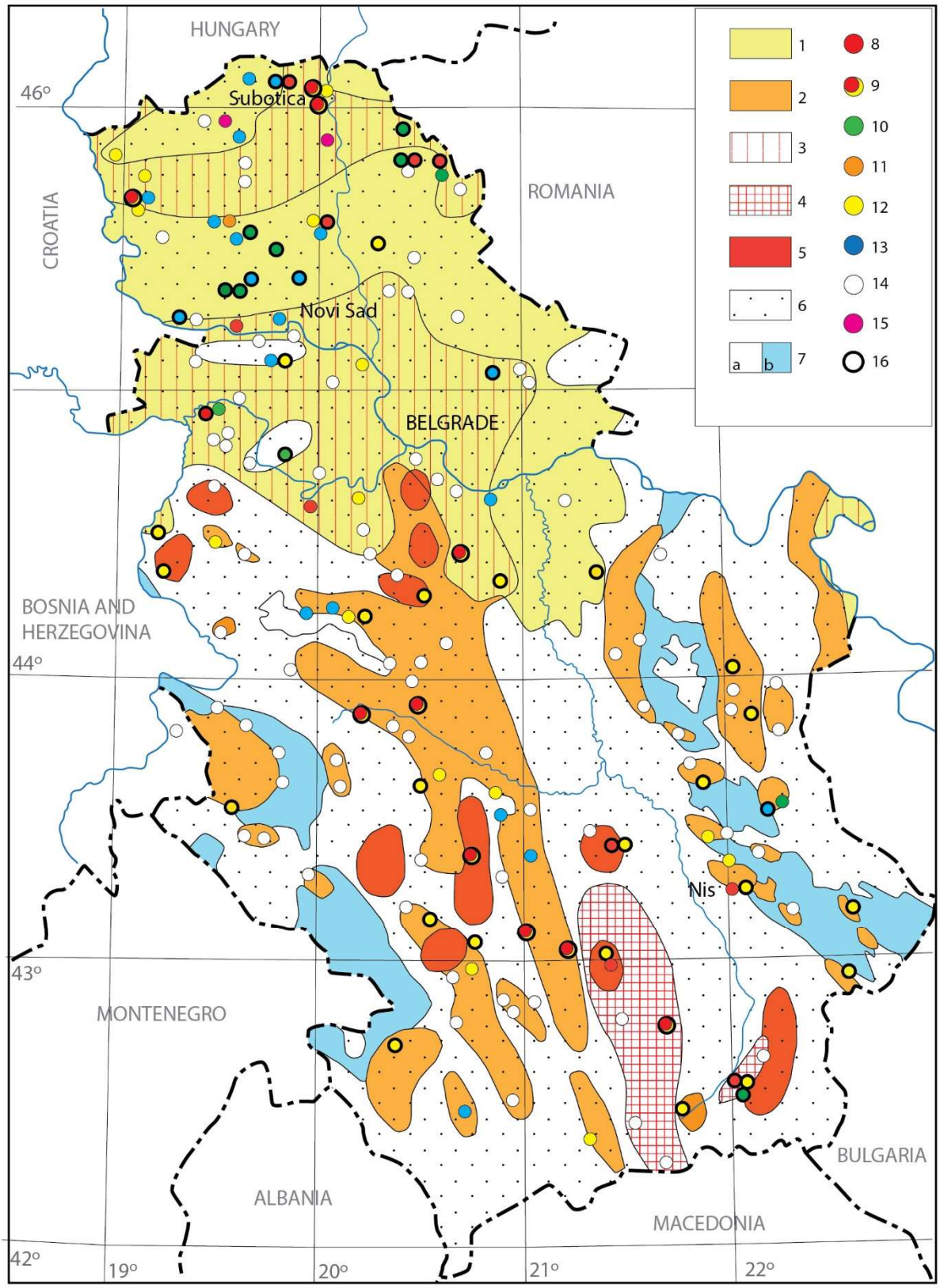
However, in the last decade the interest in geothermal energy usage have been revoked due to petrol energy products imbalance and permanent growth of demand on one side and deficit of fossil organic and nuclear fuels on another. Growth of transport costs, regional separation, environmental degradation and increased costs of environmental protection made a strong reason to look towards the renewable energy sources.

The highest interest in Serbia 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 heating the premises and sanitary hot water as well.

In the last decade six hydrogeothermal drill holes were constructed in Vojvodina (Pannonian basin) and all were planned to be used for heating and recreational and wellness centres. A short preview of temperatures and yields of these drill holes is given in the table 1.

Table 1: Hydrogeothermal drill holes constructed in the last decade in Pannonian basin.

Location	year	depth (m)	yield (l/s)	T (ºC)
B. Petrovac	2011	810	15	45
Becej	2011	1100	20	65
Senta	2013	920	25	55
Indjija	2015	1300	30	60
Ada	2017	1056	8.6	61
B. Topola	2018	500	12	37



Legend: 1-Hydrogeothermal aquifer in Cenosoic rocks; 2-Hydrogeothermal aquifer in Mesosoic rocks; 3-Hydrogeothermal aquifer in Mesosoic rocks bellow Cenosoic rocks; 4-Hydrogeothermal aquifer in Paleosoic rocks; 5-Petrogeothermal resources in Tertiary granitoide rocks; 6-Hydro-petrogeothermal resources to 200 m deep for exploitation of geothermal energy with heat pumps; 7-Areas without significant geothermal resources: a) terrains with rocks of Paleosoic and Proterosoic age, b) karstic terrains;
UTILIZATION OF RESOURCES: 8-heating; 9-heating, balneotherapy and recreation, 10-Food production; 11-industry; 12-Balneotherapy; 13-Recreation and sport; 14-Occurences not used; 15-Under construction in 2018; 16-In operation in 2018.

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

Of these six drillholes only the one in Bački Petrovac is in use for large aqua park, while projects in Senta, Becej and Indjija, for mainly financial reasons, had already been delayed several times and at the moment it is uncertain when those will start with operation. Recently constructed drill holes in Ada and Backa Topola are currently not in use but it is expected that entire projects will be completed by the end of 2020.

In other geothermal provinces in Serbia, Macva region is considered as one of the highest prospects for multipurpose use of geothermal energy and so far has been the subject of many detailed geothermal investigations. Within the Europe Aid Project "Promotion of Renewable Energy Sources and Energy Efficiency", Municipality Bogatic was chosen as one of the three prospective locations for geothermal energy utilization (along with Vrbas in Vojvodina and Mataruska Spa in central Serbia). Local government recognized this opportunity and set up the project of the existing drill hole BB-1 reconstruction 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 ºC. Projected capacity of the system was **2.62 MW_{th}**. System was put into operation in July 2018.

In the same area, close to BB-1 there is another drill hole BB-2, which free outflow is 50 l/s and water temperature reaches 80 ºC. 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 **1000** heat pumps installed throughout Serbia with total capacity **15.59 MW** that produced **34.37 GW_{th}/yr** in 2018. 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 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 procedures proscribed by Serbian regulations.

4. DISCUSSION

According to abovementioned Serbia has a great geothermal potential, where only small amount is being used. The great number of the existing systems that were constructed in the “golden era of geothermal energy”, before 1990, is now closed or operates only partially.

The situation started slightly improving in the last decade 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 was rapidly increasing and geothermal energy utilization among other renewable energy sources came 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 a 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 prepared 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).

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

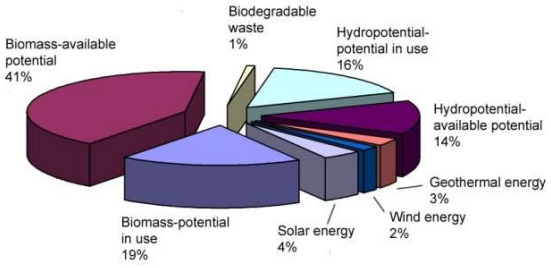


Figure 4: Structure of RES in Serbia (National Action Plan about use of renewable energy sources, 2013)

So far Serbia managed to considerably increase the use of wind energy. On the other side high costs of the geothermal systems, uncertain outcome, then 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 caused investors to lose interest in investing in geothermal energy utilization despite to the abet measurements prepared by the government. Often we face the situation that after drilling a deep hydrogeothermal drill hole, the beneficiary is unable to collect and provide enough funds to finalize the project. In this pace it is highly uncertain if Serbia will manage to fulfil the goal of total share of all renewable energy

sources in gross final energy consumption by the end of 2020.

5. FUTURE DEVELOPMENT AND INSTALLATIONS

For now geothermal energy in Serbia is used only in amount of **112.86 MW_{th}** and additional **15.59 MW_{th}** out of shallow systems. This can be considered as pretty low having in mind its potential.

The most significant use of geothermal energy for Serbia could be for district 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 buildings, hotels and shopping centres where reservoirs of interest 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 significant.

According to the geothermal exploration results intensive use of thermal waters in agro- and aqua-culture and district heating has the best prospect in the area western of Belgrade, in Macva. As already mentioned, in settlement of Bogatic, one system for district heating has started with operation in 2018 with capacity of **2.62 MW_{th}**, while another with capacity of **8.49 MW_{th}** is planned for agricultural purposes. Both are using geothermal energy from reservoirs in karstified limestone beneath the Neogene sediments.

There are 3 geothermal systems located in Panonnian basin currently on hold awaiting further investments. Expected total capacity of these three systems is **12.45 MW_{th}**. Another two constructed in 2017 and 2018 are in the development phase where total expected capacity is **2.23 MW_{th}.**

In the optimistic scenario we could have additional **23.17 MW_{th}** utilized for heating, recreational purposes and agriculture by the end of 2020.

Through the above mentioned Europe Aid project "Promotion of Renewable Energy Sources and Energy Efficiency", 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.

6. 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 and unfortunately lost after facing many obstacles, we hope that government would simplify and shorten the procedure of obtaining licences, as well as provide higher funds to make geothermal utilization projects more available in order to achieve the goal set for 2020

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Tables A-G

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 2018			7355*	34004*	0	0
Under construction end of 2018			-	-	-	-
Total projected by 2020	-	-	8206**	35611**	-	-
Total expected by 2025	1	7	8206	35611	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 2018 (indicate exploration/exploitation if applicable):					Under development: 3 (exploration)	
					Under investigation:	

* Numbers for 2017 used

** Value taken from the National Action Plan, scenario with energy efficiency measurements included

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	47.673	153.806	11.626	62.493	16.840	77.989	36.722	186.257
Under construction end 2018	-	-	-	-	1.657	14.509	0.569	4.983
Total projected by 2020	7.427	65.034	8.494	74.377	5.422	47.484	1.824	15.975
Total expected by 2025	55.100	218.840	20.120	136.870	22.262	125.473	38.546	202.232

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})	2018 produc-tion (GW_{th}/y)	Geoth. share in total prod. (%)
Junaković spa	Pb-1/H, Pb-3/H	1984	N	N	5.145	5.145	11.263	100
Kanjiža spa	Kž-1/H, Kž-2/H, Kž-3/H	1981	N	N	5,412	5.412	8.595	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
Bogatić	BB-1	2018	N	N	2.615	2.615	6.870	100
total					47.673	47.673	153.806	100

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	*est. 1000*	15.590	34.366	*est. 55*	0.880	
Projected total by 2020	not available	not available	not available			

Table F: Investment and Employment in geothermal energy

	in 2018 *		Expected in 2020	
	Expenditures (million €)	Personnel (number)	Expenditures (million €)	Personnel (number)
Geothermal electric power	-	-	-	-
Geothermal direct uses	*est.* 1.0	*est.* 125	*est.* 1.5	*est.* 135
Shallow geothermal	*est.* 0.8	*est.* 220	*est.* 0.8	*est.* 230
total	*est.* **1.8**	*est.* **345**	*est.* **2.3**	*est.* **365**

Table G: Incentives, Information, Education

	Geothermal electricity	Deep Geothermal for heating and cooling	Shallow geothermal
Financial Incentives – R&D	-	-	-
Financial Incentives – Investment	-	*est* 0.3 million € - DIS *est* 0.7 million € - LIL	*est* 0.8 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)