UNITED NATIONS UNIVERSITY
GEOTHERMAL TRAINING PROGRAMME
Orkustofnun, Grensásvegur 9,
IS-108 Reykjavík, Iceland

30th Anniversary Workshop
August 26-27, 2008

STATUS AND OUTLOOK OF GEOTHERMAL DEVELOPMENT ON THE BALKAN PENINSULA

Klara Bojadgieva
Geological Institute, Bulgarian Academy of Sciences
Sofia
BULGARIA
klaratb@geology.bas.bg

ABSTRACT

Geothermal development in the Balkan countries is analyzed based on the presented update reports in the three World Geothermal Congresses - in Italy (1995), Japan (2000) and Turkey (2005), on printed materials and information published in the Internet sites. The share of renewables in the total primary energy supply in the Balkan countries and its change during the period of 1990-2005 is presented. Tectonic setting, heat flow distribution and hydrogeological background on the Balkan Peninsula are briefly discussed. Currently, thermal waters in the Balkan countries have only direct application. The maximum utilized flow rate is about 6329 kg/s (2005). The total installed capacity amounts to 652.7 MWt and produced energy is 9456 TJ/yr with an average capacity factor of 0.33 (2005). In regard to energy production Romania, Serbia and Bulgaria have a leading role compared to the rest of the countries. Direct application of thermal waters in the region is highly varied. The distribution of thermal energy used by category is presented. Three of the applications have the highest share - bathing and swimming (37.8%), space heating (30.7%) and greenhouse heating (20.1%). Geothermal development in the Balkan countries manifests a progress mainly in space heating, bathing and swimming, fish and animal farming and GHP during the period 1995 – 2005. The key to successful application of geothermal energy on the Balkans requires a combination of political commitment and decision making as well as support mechanisms including well defined governmental targets, technological advances and public acceptance.

1. INTRODUCTION

The Balkan Peninsula region has a combined area of about 518,000 km^2 and an approximate population of 55 million people. It takes its name from the "Balkan" mountain range (Stara Planina) in Bulgaria (from the Turkish *balkan* meaning "a chain of wooded mountains"). The Balkans are adjoined by water on three sides: the Black Sea to the east and branches of the Mediterranean Sea to the south and west (including the Adriatic, Ionian, Aegean and Marmara seas).

Historically, the area was known as a crossroads of various cultures. It has been a juncture between the Latin and Greek bodies of the Roman Empire, the destination of a massive influx of Slavs, an area where Orthodox and Catholic Christianity met, as well as the meeting point between Islam and Christianity. The Balkans today is a very diverse ethno-linguistic region, being home to multiple Slavic, Roman and Turkish languages, as well as Greek, Albanian and others.

Although there is no sharp physiographic separation between the peninsula and Central Europe, the line of the Sava and Danube rivers is commonly considered as the region's northern limit. The Balkan Peninsula therefore includes most of Slovenia, Croatia and Serbia, Bosnia and Herzegovina, Montenegro, Albania, Macedonia (FYROM), continental Greece (including the Peloponnesus), Bulgaria, European Turkey, and SE-Romania (Figure 1a). These countries, successors to the Ottoman Empire, are called the Balkan States. Historically and politically the region extends north of this line to include all of Slovenia, Croatia, Serbia, and Romania (Figure 1b). According to Encyclopedia Britannica Moldova is also a part of the Peninsula.

The current review of geothermal activity in the region is based on the available information on all mentioned above counties. Turkey is not included in the article. Its part spread on the Balkan Peninsula is much smaller compared to the Asian one, where geothermal development is more significant. No particular data are available for Kosovo, Montenegro and Moldova.

Energy resources of the Balkan Peninsula are scarce. There are some deposits of coal especially in Romania, Bulgaria, Serbia, Bosnia and Herzegovina. Lignite deposits are widespread in Greece. Natural gas fields are also scarce. Petroleum is most notably present in Romania, although some reserves exist in Greece, Serbia, Albania and Croatia. EIA (Energy Information Administration, US) estimates that regional oil consumption on the Balkans in 2005 totaled 237,000 bbl/d, leaving the region dependent on imports for roughly 80% of its oil needs (*www.eia.doe.gov*).

Balkan countries use much more energy for the production of a unit of work than in any other European country. Very little investments and priority are given to increasing efficiency in comparison to the investments going to unsustainable fossil fuel projects and to nuclear ones. The region is becoming more important as a transit center for Russian and Caspian Sea region oil exports to Western European consumers *(www.bankwatch.org/balkan_energy).*

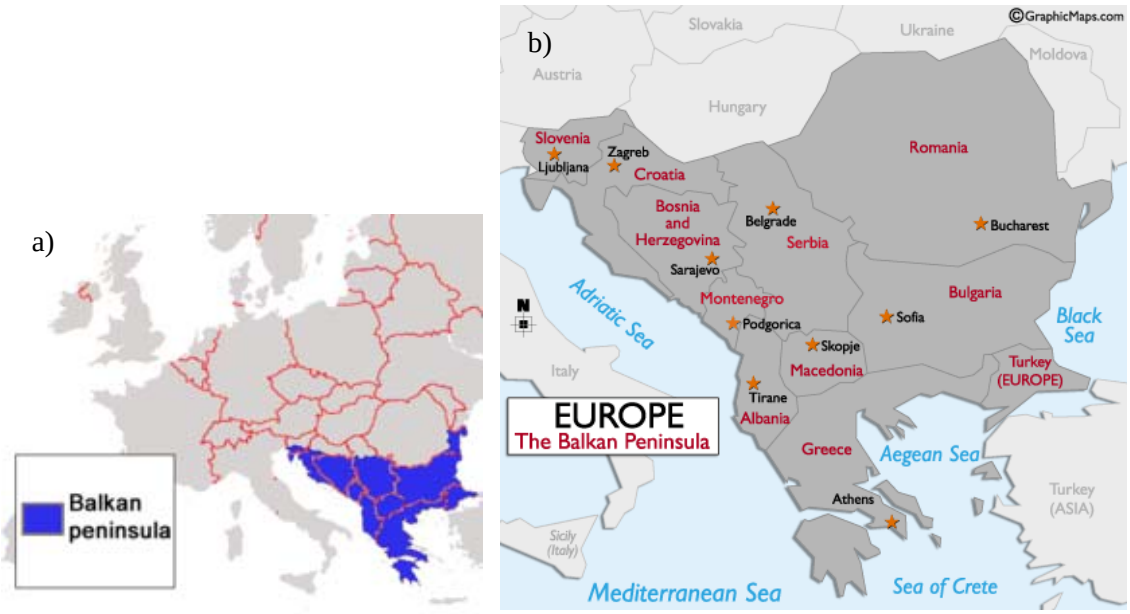

FIGURE 1: Countries in the Balkan Peninsula (a - short list, b - enlarged list)

2. RENEWABLE ENERGY

Since the Balkan countries are located in a mountainous area covered by forest and agriculture there is a huge potential for hydro and biomass energy. In most of them (Albania, Serbia, Bosnia and Herzegovina, Romania, Bulgaria and Macedonia (FYROM)) hydro energy is dominant with the

majority coming from plants with installed capacity of more than 10 MW. Only traditional wood biomass for domestic heating is being exploited everywhere. Electric power generation from wind and biomass are reported only for Slovenia and Bulgaria.

Thermal waters use has an ancient tradition in the region for recreation, washing, bathing and treatment. As early as Roman times waters were used on a large scale for under floor heating in public baths (hypocausts). Nowadays they have the widest variety of direct application compared to other renewable sources – prevention, rehabilitation and treatment, swimming pools, space heating and air-conditioning, domestic hot water supply, greenhouse heating, geothermal heat pumps, bottling of potable water, agricultural and industrial uses and others. In spite of the good hydrothermal potential in most of the countries geothermal energy has not still attained a leading role among other renewables. Total contribution of hydro, solar, wind and geothermal energy in the primary energy supply of the Balkan countries is shown on Figure 2 (Watkins, 2008).

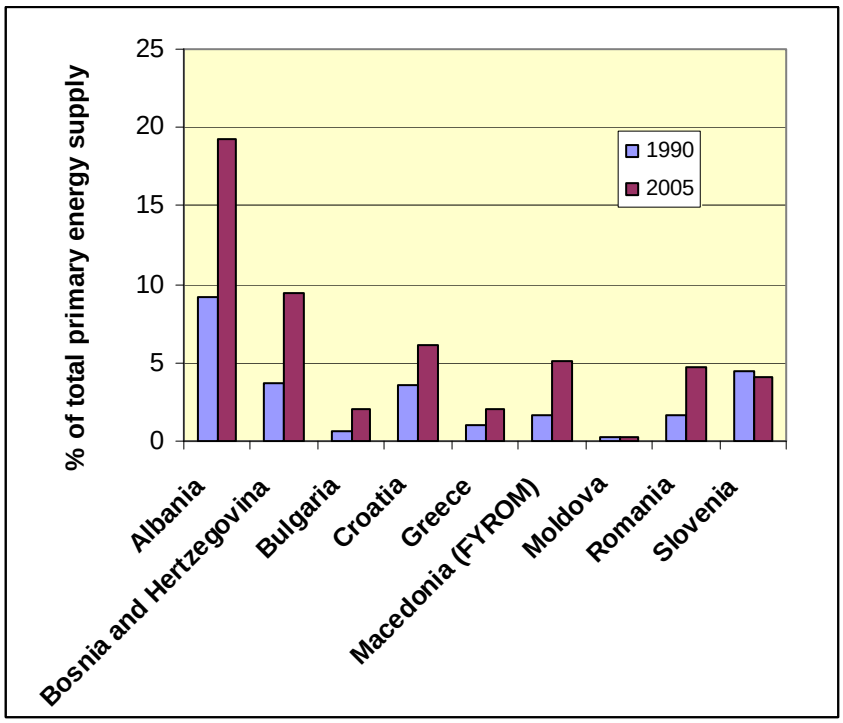

FIGURE 2: Change of renewable energy contribution of the Balkan countries for the period of 15 years

Data show an increase in renewables contribution for all countries (except Slovenia) with the shares of Albania (hydro) and Bosnia and Herzegovina (hydro and biomass) being the highest. In general, renewables play a modest role in the Balkan Peninsula energy balance (6.6% in 2005). According to the International Energy Agency, 12.6% of the world's energy needs were provided by renewable sources in 2005 (Watkins, 2008).

2. HEAT FLOW AND TECTONIC SETTINGS

The Central Balkan neotectonic region has a complicated block structure (horst and graben pattern) dominated by Struma and Vardar lineaments (NNW–SSE), Sava and Maritsa lineaments (WNW-ESE) and Middle Mesta and North Anatolian fault zones (Zagorcev,1992) (Figure 3). The configuration of heat flow isolines follows the major neotectonic structures (Figure 4). The highest heat flow values are associated with the main active zones - lineaments. Heat flow values for the Balkan countries vary from 10 (Albania) to 388 mW/m^2 (Lesvos island, Greece). Maximum values,

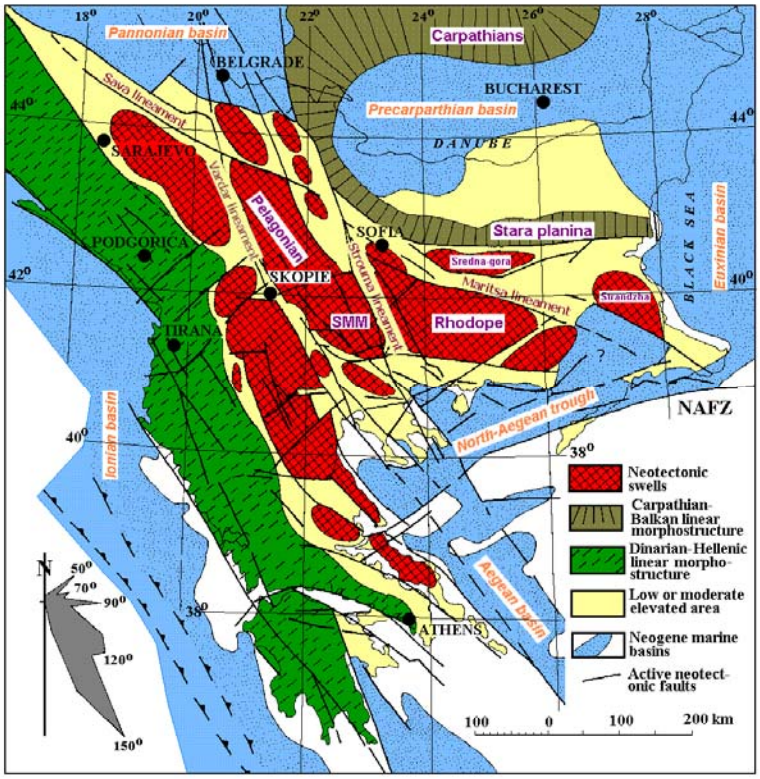

FIGURE 3: Neotectonics layout of the Balkan Peninsula (Zagorcev, 1992)

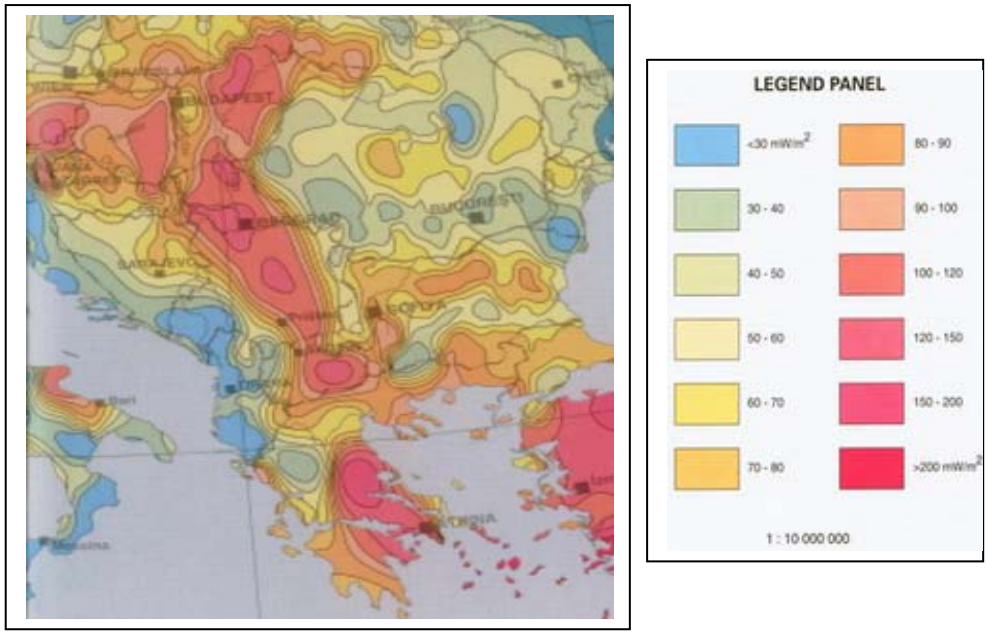

FIGURE 4: Heat flow map of the Balkan Peninsula (Hurter and Haenel,1992)

associated with geothermal reservoirs are measured in Bulgaria (160 mW/m^2), Romania (132 mW/m^2), and on the territory of former Yugoslavia (196 mW/m^2), (Cermak et al.,1991).

3. HYDROGEOLOGICAL BACKGROUND

Thermal waters on the Balkan Peninsula are classified in four provinces by K. Shterev (1999) according to their origin, chemical composition and physical and chemical characteristics - low mineralized thermal waters with nitrogen gas composition, thermal waters containing endogene CO_2, saline mineral waters and brines of marine origin and mineral waters that leach evaporates. The province of low mineralized thermal waters occupies the largest area compared to the other three. These are formed at a depth from 400-500 m to 3000-3500 m below the local erosion base. Temperatures of the discovered thermal waters on the Peninsula are mostly between 20 and 100°C. The highest values are reported for Romania (115°C, Bors), (Rosca et al., 2005) and Croatia (170°C, Velica Ciglena), (Jelic et al., 2005). There are two high-enthalpy geothermal fields in Greece islands, namely Milos and Nisyros, where seven deep wells identified temperatures of 318 and 325°C, respectively (Fytikas et al., 1995).

A hydrothermal potential of about 3390 MWt for the Western Balkan countries was estimated by Battocletti (2001). By adding the data for Bulgaria (Bojadgieva et al., 2005), Romania (Rosca et al., 2005) and Greece (Fytikas et al., 2000) the hydrothermal potential for the Balkans reaches 4710 MWt.

4. GEOTHERMAL ENERGY USE

Currently, thermal waters in the Balkan countries have only direct application. A double flash 2 MWe power plant was installed in Milos island in Greece and operated until 1989. The plant was shut down due to H_2S emissions to the atmosphere (Fytikas et al., 2005). Feasibility study on combined electricity and heat production were performed for two high temperature reservoirs (Velika Ciglena and Lunjkovec-Kutnjak) in Croatia. The initial power of 4.4 MWe obtained from the existing well should be increased up to 13.1 MWe after drilling of two additional production wells by year 2015 (Jelic et al., 2005). Plans for thermal water use for electric power generation are discussed in Bosnia and Herzegovina. The economical potential for electricity generation on the Balkans is estimated to about 16.7 TWh/yr. Data are taken from an Internet site focused on daily and scientific iformation on renewable energy *(renewenergy.wordpress.com).*

The total installed capacity for direct use on the Balkans amounts to 652.7 MWt and the produced energy is 9456 TJ/yr with an average capacity factor of 0.33 (2005). For comparison, the worldwide capacity factor is 0.3 (Lund et al., 2005). According to the currently existing data the maximum utilized flow rate is about 6329 kg/s (2005).

The total installed capacity and produced energy are lowest in Albania, respectively 9.6 MWt and 8.5 TJ/y. The installed capacity in the rest Balkan countries varies from 48.6 MWt (Slovenia), (Rajver and Lapanje, 2005) to 145.1 MWt (Romania), (Rosca et al., 2005), Figure 5a. In regard to energy production, Romania, Serbia and Bulgaria have a leading role compared to the rest of the countries, Figure 5b. The produced energy corresponds to a calculated capacity factor between 0.46 and 0.62 for Slovenia, Bulgaria and Romania (Figure 6).

The distribution of thermal energy used by category is shown on Figure 7 (no data is available for Serbia). Three of the applications have the highest share - bathing and swimming (37.8%), space heating (30.7%) and greenhouse heating (20.1%). These are also the most developed applications on a worldwide scale (Lund et al., 2005). Space heating in the region refers to individual buildings in all countries, only for Slovenia a small energy use for district heating (17 TJ/yr) is reported (Rajver and Lapanje, 2005). Utilization for air-conditioning exists in Bulgaria and Slovenia and amounts totally to 118 TJ/yr. The leading countries in geothermal energy use in bathing and swimming and in space heating are Romania, Bulgaria and Serbia - totally 575 TJ/yr (Figure 8), while in greenhouse heating the highest contribution comes from Macedonia (FYROM), Romania and Bulgaria. Fish and animal farming are reported for Serbia, Greece and Romania.

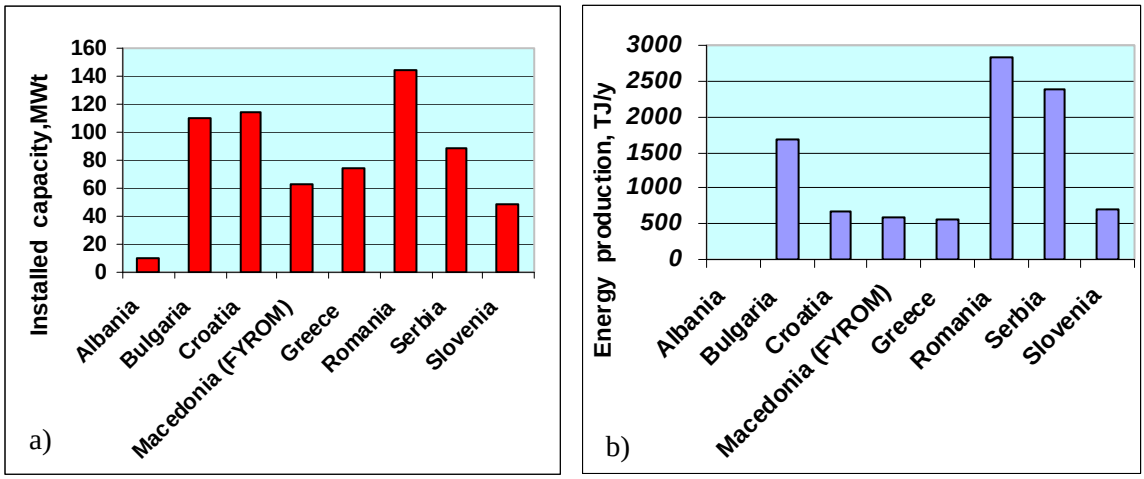

FIGURE 5: Installed capacity a) and energy production b) for the Balkan countries in 2005

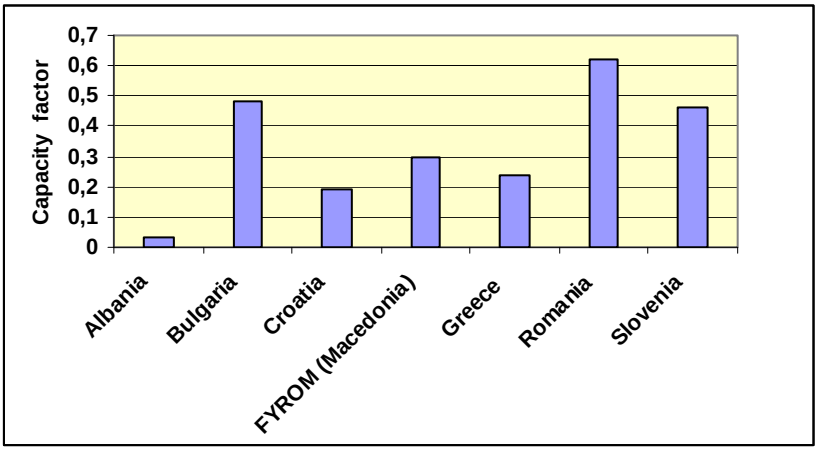

FIGURE 6: Capacity factor for annual utilization of geothermal energy for direct use in Balkan countries in 2005

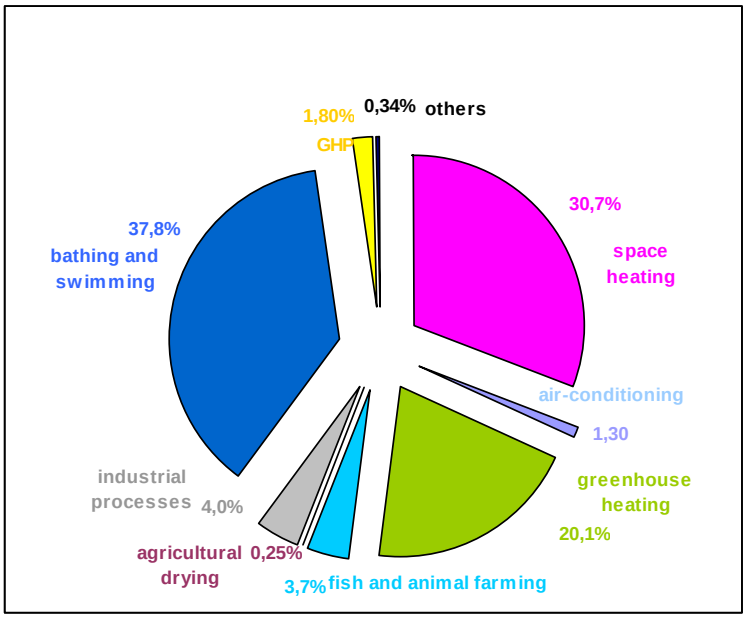

FIGURE 7: Categories of energy use in % in 2005

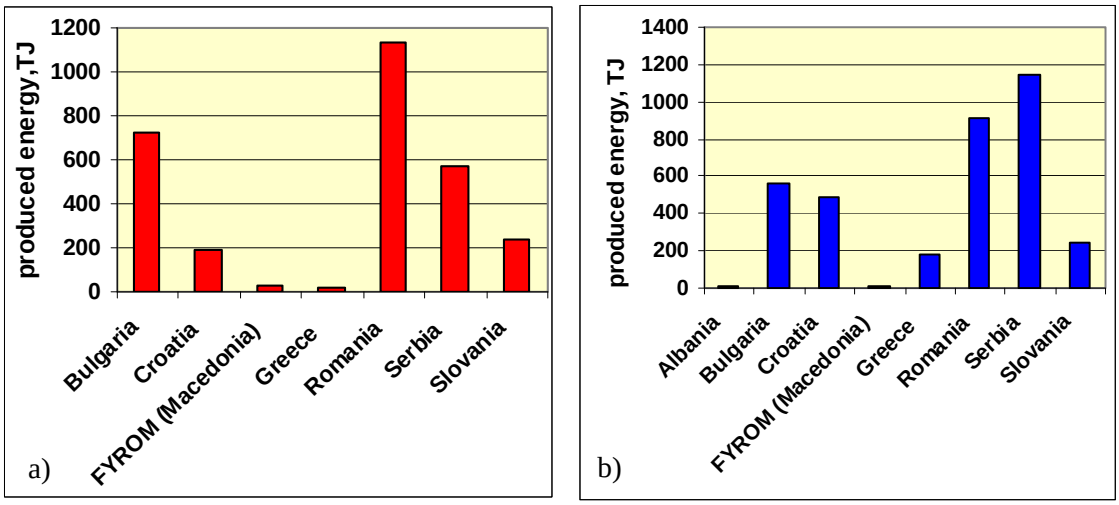

FIGURE 8: Distribution of geothermal energy use in the Balkan countries for a) space heating, and b) for bathing and swimming

Direct application of geothermal energy in the Balkan countries is highly varied. Apart from traditional application some more uncommon ones exist such as Spirulina cultivation, soil heating for early season asparagus, tomato dehydration and water desalination in Greece (Fytikas et al., 2005), heating pig and poultry farms in Serbia, use in leather and textile factories (Slovenia, Serbia) (Milivojevic and Martinovic,2005), snow melting around some private houses in Bulgaria. Bottling of mineral water is reported for Bulgaria (41 companies) (Bojadgieva et al., 2005) and Serbia (9 companies) (Milivojevic and Martinovic, 2005). GHP have received rapid development in Bulgaria, Greece, Serbia and Slovenia. Their total installed capacity amounts to about 14.3 MW and produced energy – to 172.6 TJ/yr (2005).

5. OUTLOOK

Favorable climate factors in the Balkans, well geologically studied region of good geothermal potential, location of thermal water sources in mountainous tourist regions or close to the sea coasts, spa resorts developed in places of old Thracian and Roman residential areas, presence of low salinity potable thermal water, available know-how in space heating and air-conditioning create excellent conditions for development of thermal waters direct application. Geothermal heat pumps also mark a significant implementation in private family houses and office buildings.

During the last 18 years most of the Balkan countries had to pass a difficult political and economical transition period. The split of Yugoslavia also resulted in a collapse of state economy and investments in geothermal energy in the newly created countries. In spite of these difficulties the geothermal development during the period (1995 – 2005), (Tabl.1), manifests a progress mainly in space heating, bathing and swimming, fish and animal farming and GHP. More reliable trend expression are data for the period 2000-2005 as several countries are not presented in the data set for 1995. The analysis shows that the increase of installed capacity is 17% for space heating and 35% - for bathing and swimming. Although the data for GHP are incomplete they confirm the high rate of development. These equipments are installed by private companies and the information about their number and capacity is not always at disposal.

Recently, two Balkan countries, Slovenia and Bulgaria, have been involved in a project (Rimining-Lowex, FP6), which aims to demonstrate the use of water in abandoned coal mines as a source of renewable energy and to prove its economic viability.

TABLE 1: Geothermal direct use in the Balkans countries from 1995 to 2005 (data are taken from update reports, presented on the three WGC, 1995 (Italy), 2000 (Japan) and 2005 (Turkey))

Application	Installed capacity, MWt			Utilization, TJ/yr			Load factor	
	2005	2000	1995	2005	2000	1995	2005	2000
Space heating	184.08	156.70	125.67	2896.35	2097.51	1584.4	0.385	0.38
Air-conditioning	11.23	6.80	8.17	118.80	56.50	81.49	0.41	0.26
Greenhouse heating	149.53	160.49	91.91	1891.69	1911.04	1015.3	0.41	0.43
Fish and animal farming	18.37	3.00	3.00	348.00	60.00	44	0.46	0.63
Agricultural drying	0.94	-	-	23.50	-	-	0.20	-
Industrial process heat	19.45	26.29	26.59	381.20	287.69	289.48	0.58	0.37
Bathing and swimming	245.22	181.79	71.40	3564.88	2021.70	1349.3	0.44	0.45
GHP	14.27	3.04	2.51	172.58	49.90	63.9	0.48	0.44

The key to successful development of geothermal energy in the Balkans requires a combination of political commitment and decision making as well as support mechanisms including well defined governmental targets, technological advances and public acceptance.
The newly introduced laws on energy in most of the counties define privileged status for producers of alternative energy resources which have priority for subsidies, tax, customs and other incentives according to the law, tax and customs regulations. Support mechanisms and feed-in conditions for electricity from renewable energy are created in several countries – Bosnia and Herzegovina, Bulgaria, Croatia and Slovenia (*www.eva.ac.at*). These sources are treated both towards the purchase electricity prices and towards the obligatory purchase of RES electricity by transmission and distribution companies. The tariff is composed of a market price and a premium. These measures will promote a wider application of geothermal energy in the region. Pre-feasibility studies for estimation of geothermal potential for electricity generation have been carried out in several countries - Bosnia and Herzegovina, Croatia, Greece and Serbia. The reported data for the current cost of geothermal energy for heating show that it is competitive with conventional energy sources. The currently dominant direct applications (bathing and swimming, space heating and GHP) will probably remain the same. The implementation of small scale energy efficiency and renewable energy projects can bring greater benefit to local communities and small businesses. Geothermal energy development will depend on the policy of renewable energy sources promotion in the Balkan countries.

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