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Macedonia – Country Update 2004

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ABSTRACT

Macedonia passed another period of five years of stagnation in geothermal development. The largest greenhouse project in Gevgelia (22,5 ha) was abandoned and the organizational structure of the Bansko geothermal project destroyed. There were no investments in explorations and new projects development. However, several reconstructions and modernizations have been realized with foreign grants and their success gives hopes that some positive changes shall come during the coming years. Reasons for such a situation are discussed in the paper and necessary measures to remove the negative influencing factors.

INTRODUCTION

Macedonia has been one of the leading European countries in direct uses development during the 80ies of last century. Even rather modest, the state investments in geothermal explorations gave opportunity to the scientists and economy sector to develop three successful big and several small geothermal projects. However, when positive influence of that began to give results, i.e. when state planned some new larger investments, political and economy transition process from the beginning of 90ies resulted with a complete collapse of the state economy and, with that, lost of interest for any further investments in the geothermal energy development. Even more, thanks to the collapse of the heat users, some of the existing projects have been abandoned.

Recently, first signs of the recovery of some users resulted with several investments in the geothermal projects reconstruction and optimization (Popovski, 2002). There is interest of the others to do the same, and new candidates are trying to get concession for development of new projects. However, the process is very much slowed due to the list of constraints, mainly in the legal and financing sector. There is no anymore any strategy of development in the country, no concrete institution responsible for that and no concrete programs for supporting renewable energies development. If something has been done, it was more a result of engagements of several scientists and grants from more developed European countries. Existing “pressure” of WB and EC to work more on the environmental protection can have a positive influence for removing the constraints but it can be predicted that the process shall last at least 4-5 years, according to the experience with the other legislative changes and improving the possibilities for financing new developments.

The country update gives information about the present state of geothermal investigations and use in Macedonia, with identification and comments about possibilities to remove the negatively influencing factors

2. GEOTHERMAL RESOURCE AND POTENTIAL (MICEVSKI, 2003)

2.1. Geological Framework and Tectonic Settings of Macedonia

In the territory of Macedonia rocks of different age occur, and starting from Precambrian to Quaternary. Almost all lithological types are represented. The oldest, Precambrian rocks, consist of gneiss, micaschists, marble and orthometamorphites. The rocks of Paleozoic age mostly belong to the type of green schists, and the Mesozoic ones are represented by marble limestones, acid, basic and ultrabasic magmatic rocks. The Tertiary sediments consist of flysch and lacustrine sediments, sandstones, limestones, clays and sands.

With respect to the structural relations the territory can be divided into six geotectonic units: The Cukali-Krasta zone, West Macedonian zone, Pelagonian horst anticlinorium, Vardar zone, Serbo-Macedonian massif and the Kraisthide zone (Fig.1). This tectonic setting is based on actual terrain and geological data without using the geotectonic hypothesis (Arsovski, 1998). First four tectonic units are parts of Dinarides, Serbo-Masedonian mass is part of Rodops and the Kraisthide zone is part of Karpato-Balkanides distinguished on the Balkan peninsula as geotectonic units of first stage.

2.2. Geothermal Background (Gorgieva, 2002)

The territory of the Republic of Macedonia belongs to the Alpine-Himalayan zone, with the Alpine subzone having no contemporary volcanic activity. This part starts from Hungary, across Serbia, Macedonia and North Greece and stretches to Turkey. Several geothermal regions have been distinguished including the Macedonian region, which is connected to the Vardar tectonic unit. This region shows positive geothermal anomalies and is hosting different geothermal systems. The hydrogeothermal systems, at the moment, are the only ones that are worth for investigation and exploitation.

There are 18 geothermal known fields in the country with more than 50 thermal springs, boreholes and wells with hot water. These discharge about 1.000 l/s water flow with temperatures of 20-79 ^{0}C. Hot waters are mostly of hydrocarbonate nature, according to their dominant anion, and mixed with equal presence of Na, Ca and Mg. The dissolved minerals range from 0.5 to 3.7 g/l.

All thermal waters in Macedonia are of meteoric origin. Heat source is the regional heat flow, in the Vardar zone is about 100 mW/m^2 and crust thickness 32 km.

Fig.1. Geological settings and geothermal regions in Macedonia (Arsovski, 1997)

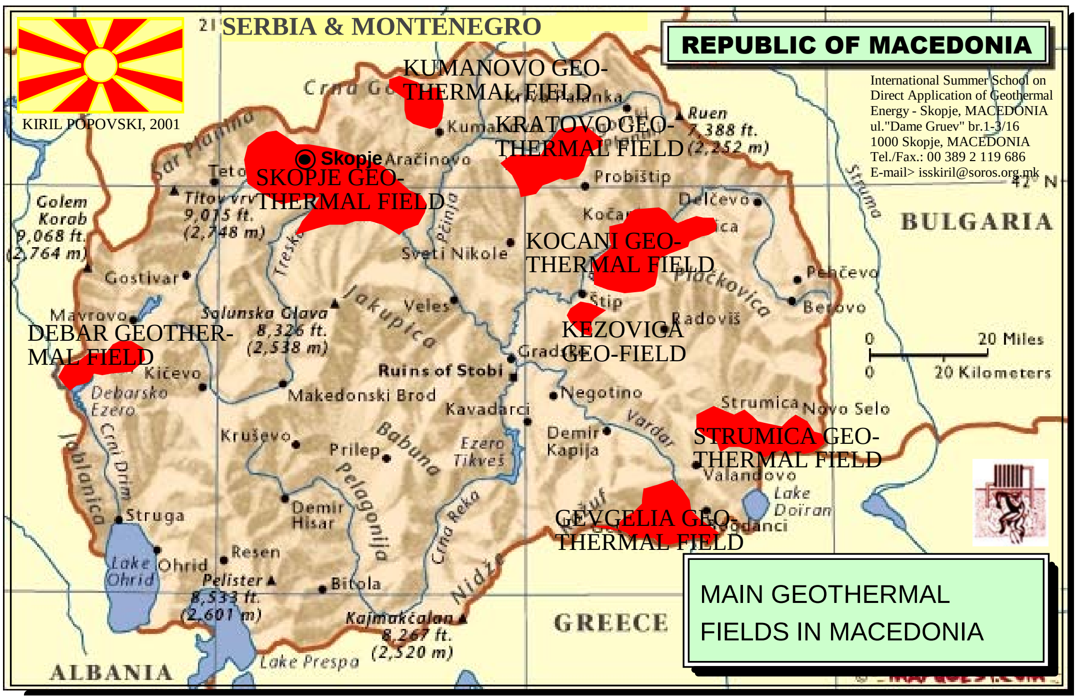

Fig.2. Main geothermal fields in Macedonia (Popovski, 2001)

Table 1. THERMAL WATERS IN MACEDONIA AND THEIR PHYSICAL CHARACTERISTICS

No	Place Spring (i)	Occurrence Borehole (d)	Coordinate x	y	z	Temp. (¼C)	Flow (l/s)
1	Volkovo	GTD-1 (d)	4 654 971	7 527 841	374	25	63
2		IBSKG-3 (d)	4 654 330	7 528 150	317	22	22
3	Katlanovska b	D-1 (d)	4 639 800	7 557 650	287	54,2	10
4		B-1,B-2 (d)	4 638 990	7 558 125	255	32	4
5		Nervna v (i)	4 639 225	7 558 100	250	28	2
6		Potkop	4 639 500	7 557 850	265	38	2
7		Fontana (i)	4 639 750	7 557 000	270	28	0,2
8		izvor (I)	4 639 260	7 557 910	230	38	1
9	Proevci	(d)	4 664 460	7 562 100	310	31	2
10	Strnovec	(d)	4 670 300	7 570 050	280	40	17
11	Podlog	EBMP-1 (d)	4 638 625	7 613 175	310	78	150
12		R-3 (d)	4 638 775	7 613 095	310	77,8	80
13	Krupiste	K-1/83 (d)	4 634 000	7 605 000	300	32	0,5
14		K-2/83 (d)	4 634 000	7 605 100	295	40,6	6,9
15	Kocansko pole	R-11 (d)	4 640 700	7 618 252	335	50,6	2,6
16	Kocani	Ka-1 (d)	4 641 750	7 617 200	340	22,4	6
17	Podlog	EB-4 (d)	4 639 000	7 613 000	310	79	120
18	Podlog	EB-3 (d)	4 639 025	7 613 070	310	78	350
19	Istibanja	I -5 (d)	4 643 000	7 624 350	350	66,4	12
20		I -3 (d)	4 643 100	7 624 350	350	67	5
21		I -4 (d)	4 643 025	7 624 475	350	56,6	4,2
22	Trkanje	EB-2 (d)	4 649 560	7 612 660	311	71,3	50
23		R-9 (d)	4 639 375	7 612 675	310	71,3	85
34	Banja	B-1 (d)	4 641 550	7 611 225	350	63	8,3
25		B-2 (d)	4 641 525	7 611 205	348	63,2	55,3
26		R-1 (d)	4 640 300	7 615 840	347	63	30
27		R-6 (d)	4 639 925	7 611 600	350	40	1
28	Bansko	B-1 (d)	4 583 900	7 647 225	258	68	55
29		izvor (I)	4 583 500	7 647 160	270	73	6
30	Negorci	NB-3 (d)	4 559 875	7 625 530	65,1	47,2	40
31		NB-4 (d)	4 559 750	7 625 600	64,3	53,2	40
32		B-1 (d)	4 559 100	7 625 410	65	32	3
33	Smokvica	Sied6 (d)	4 570 375	7 624 812	56,9	45,1	7,2
34		Sied1 (d)	4 570 340	7 624 800	57,5	56,7	60
35		Sied2 (d)	4 569 650	7 624 775	57,1	48,1	5,2
36		Sied4 (d)	4 570 250	7 624 815	57	56,1	35
37		Sied5 (d)	4 570 400	7 624 780	57,1	64	40
38		Sied7 (d)	4 520 369	7 624 725	57,1	68,5	60
39	Stip	Ldzi (i)	4 621 825	7 598 552	300	59	1
40		Kezovica (d)	4 621 700	7 598 360	280	57	7
41		B-4 (d)	4 621 850	7 598 630	260	32	30
42	Kozuf	Topli dol(i)	4 560 225	7 583 760	740	28	0,5
43		Toplik (i)	4 558 275	7 579 743	880	22	8
44		Mrezicko (i)	4 561 875	7 583 450	720	21	0,2
45		Gornicet (i)	4 558 425	7 619 650	220	23	0,1
46	Kratovo	Povisica (d)	4 659 035	7 590 143	443	31	4
47		Dobrevo (d)	4 654 510	7 600 300	330	28	5,5
48	Veles	Sabota voda	4 620 025	7 567 810	280	21	5
49	Rakles	dupn (d)	4 609 287	7 624 308	349	26	2
50	Dojran	Toplec (i)	4 566 550	7 642 530	161	25	2
51		Deribas (d)	4 561 580	7 643 900	240	20,5	10
52	Debar	Kosovrasti (d)	4 561 580	7 643 900	400	48,5	10
53		Baniste (d)	4 561 580	7 643 900	750	40,5	5-100

(Gorgieva, 2003)

.3. Geothermal Fields in Macedonia (Fig.2 and Table 1)

There are 18 localities where geothermal fields occur and geothermal energy is in use for different proposes. The most known areas are listed below:

2.3.1. Kochani valley *(Popovski, 2002)*

The main characteristics of the Kochani valley geothermal system are: presence of two geothermal fields, Podlog and Istibanja, without hydraulic connection between them. The primary reservoir is build by Precambrian gneiss and Paleozoic carbonated schists and the highest measured temperature in Macedonia of 79^0C is obtained by drilling to it. Predicted maximum reservoir temperature is about 100^0C (Gorgieva, 1989). Kocani geothermal system is the best investigated system in Macedonia. There are more than 25 boreholes and wells with depths of 100-1.170 m.(Gorgieva, 2002)

2.3.2. Strumica valley *(Popovski, 2002)*

The main characteristics of this field are: the recharge and discharge zone occur in the same lithological formation-granites; there are springs and boreholes with different temperature at small distances; maximum measured temperature is 73^0C; the predicted maximum temperature is 120^0C (Gorgieva, 1989); the reservoir in the granites lies under thick Tertiary sediments. Bansko geothermal system has not been examined in detail apart the drilling of several boreholes with depths of 100-600m. (Gorgieva, 2002)

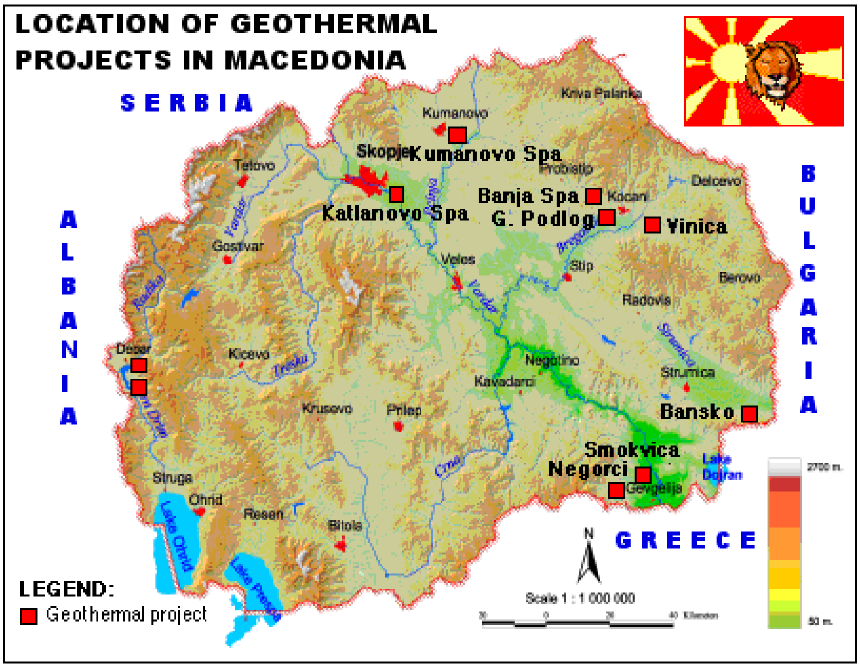

Fig.3. Location of geothermal projects in Macedonia

Fig.4. Large block of geothermally heated greenhouses in Macedonia

2.3.3. Gevgelia valley *(Popovski, 2002)*

There are two geothermal fields in the Gevgelia valley: Negorci spa and Smokvica. The discharge zone in both geothermal fields are fault zones in Jurassic diabases and spilites. These two fields are separated by several km and there is no hydraulic connection between them, despite intensive pumping of thermal waters. The maximum temperature is 54^{0}C, and the predicted reservoir temperature is 75-100^{0}C (Gorgieva, 1989). Geothermal system in the Gevgelia valley has been well studied by 15 boreholes with depths between 100-800 m. (Gorgieva, 2002)

2.3.4. Skopje valley *(Popovski, 2002)*

There are two geothermal fields in the Skopje valley: Volkovo and Katlanovo spa. There is no hydraulic connection between them. The main characteristics of the Skopje hydrogeothermal system are: maximum measured temperature of 54.4 ^{0}C and predicted reservoir temperature (by chemical geothermometers) of 80-115^{0}C (Gorgieva, 1989); the primary reservoir is composed of Precambrian and Paleozoic marbles; big masses of travertine deposited during Pliocene and Quaternary period along the valley margins. There are only five boreholes with depths of 86 m in Katlanovo spa, 186 and 350 m in Volkovo and 1.654 and 2.000 m in the middle part of the valley. The last two boreholes are without geothermal anomaly and thermal waters because of their locations in Tertiary sediments with thickness up to 3.800 m. (Gorgieva, 2002).

3. GEOTHERMAL UTILIZATION

Thermal waters utilization consists of 7 geothermal projects and 6 spas. All are completed before and during the 80es of last century. Present state of the projects is as follows:

3.1 Istibanja (Vinica) Geothermal Project

Project consists of 6 ha greenhouse complex heating in combination with a heavy oil boiler for covering the peak loadings. It has been one of the worst completed projects before the crisis, however after the privatization in 2000 it has been reconstructed and optimized with Austrian and Dutch grants and now properly covers the heat requirements of the roses production for export. Owners are interested to follow investigations in order to enable geothermal heating of additional 6 ha of greenhouses.

3.2 Kocani (Podlog) Geothermal Project ("Geoterma")

That is the presently largest geothermal project in Macedonia, consisting of 18 ha greenhouse complex heating, and space heating in the center of the town. Due to the economic crisis in the country, paper industry, vehicle parts industry and rice drying have been lost as consumers of heat during the last 10 years. However, thanks to one Austrian grant, an additional borehole has been drilled, partial reinjection of used water completed and monitoring system introduced in the system. Presently, activities to finalize the completion of reinjection of the effluent water and connection of public buildings in the center of the town is in flow. Project works as a public utility and its organizational structure is good covered by the existing team. Onliest problem in work is the price of supplied heat, which is kept very low by the State Regulatory Committee and doesn't consist funding for all necessary maintenance works and system development.

3.3 Bansko Geothermal Project

The bankrupt of ZIK "Strumica" and slow process of its privatization resulted with the collaps of organizational structure and proper use of the system, particularly during the period of last three years when heating of the greenhouse complex was out of work. That was used by the other uses (existing and new ones) with the increase of "agreed" geothermal water flows. This year, when again the greenhouse heating started with work, a trial for introduction of new organizational structure has been made but without success because not consisting centralized governing of the system exploitation. Introduction of centralized governing of the geothermal system and new exploitation boreholes are an absolute need for its proper work, due to the increased number of users and escorting not covered peak loadings. Also, a list of reconstructions and optimizations are necessary is necessary in order to put it in proper technical order.

3.4 Smokvica (Gevgelia) Geothermal System

Once the largest geothermal system in Macedonia covering the heat requirements of 22,5 ha glasshouses and about 10 ha plastichouses is now out of exploitation. Unproper privatization resulted with division of the property to 10 entities and they cannot find a common language for covering the costs of the system exploitation. Meanwhile, also the biggest exploitation borehole has been lost. Renewal of the system exploitation is nearly impossible because conditioning large investments with doubtful economy due to the present production capacity of the users.

3.5 Negorci (Gevgelia) Spa

Reconstruction of the heating installations has been finalized and now all the hotel and therapeutical projects are heated with geothermal energy. However, undefined property doesn't allow realization of necessary reconstructions and improvements of heating and sani tary installations.

3.6 Other Spas in Macedonia

Even planned, reconstruction of heating systems and their orientation towards geothermal energy use in Macedonian spas has not been realized due to the undefined property of them and absence of funds. Activities to find possible investors are in flow in Katlanovo Spa, Kezovica Spa and Bansko Spa. However, it is not possible to expect any positive result before the definition of property of them (presently public utilities but with declared privatization during the coming period).

4. FUTURE DEVELOPMENT AND INSTALLATIONS

According to the information and data on disposal, in can be expected that the following activities and projects realization shall be realized during the period of the next five years:

- Preparation of the "Geothermal Atlas of Macedonia"
- Preparation of the feasibility study "Strategy of Geothermal Development of Macedonia"
- Preparation of the feasibility study "Geothermal District Heating of Kocani" and partial realization of the town district heating system
- Preparation of the feasibility study "Geothermal Potential of the South/West Macedonia"
- Completion of the second phase of the reinjection system of the Kocani geothermal system
- Recompletion of the Bansko geothermal system
- Reconstruction of the existing heating installations in Hotel "Car Samuil" in Bansko and their orientation towards geothermal energy use in Katlanovo Spa, Kezovica Spa, Debar Spa and Kosovrasti Spa, and probably
- Beginning of development of the Kratovo geothermal field.

Real realization shall mainly depend on the finalization of the privatization process of the users and success of collection of foreign financial funds for financing the necessary investments.

4. DISCUSSION

Present state-of-the-art of geothermal energy use in Macedonia is mainly a consequence of the process of the political and economic changes in flow. The economy collaps of the country, unsolved problems with the privatization of production capacities of the geothermal energy users, a list of legal constraints, absence of a strategy for development, absence of the state support for the necessary explorations and investigations and very hard conditions for financing necessary reconstructions and new investments in the sector resulted with a complete stagnation for the period of more than 10 years. Real change of the situation cannot be expected before resolving the problem of listed constraints. Therefore, even the process of elimination of them is already in flow (new laws for energy, for mineral and water resources, and for concessions, etc.), it is not possible to expect serious changes during the period of next 5 years.

REFERENCES

Arsovski M. (1997). Tektonika na Makedonija,Stip

Konstantin Dimitrov, Mirjana Gorgieva and Kiril Popovski GEOTHERMAL ENERGY RESOURCES AND THEIR USE IN THE REPUBLIC OF MACEDONIA, Proceedings World Geothermal Congress 2000 Kyushu - Tohoku, Japan, May 28 - June 10, 2000

Mira Georgieva. SUMMARY OF FUNDAMENTALS FOR EVALUATION OF THE GEOTHERMAL POTENTIAL OF THE VARDARIAN ZONE AND SERBIAN-MACEDONIAN MASS AT THE TERITORRY OF THE REPUBLIC OF MACEDONIA, Annual Workshop of MAGA, Ohrid 2003

Mirjana Gorgieva1; Dusko Gorgiev; Kiril Popovski; Kostadin Dimitrov; Saso Manasov INFERRED SECTION OF THE MAIN (LOW-TEMPERATURE) GEOTHERMAL SYSTEMS IN THE REPUBLIC OF MACEDONIA, Proceedings World Geothermal Congress 2000 Kyushu - Tohoku, Japan, May 28 - June 10, 2000

Mirjana Gorgieva; Kiril Popovski; Dusko Gorgiev GEOTHERMAL ENERGY IN MACEDONIA, STATE-OF-THE-ART AND PERSPECTIVES, International Geothermal Days of ISS “GREECE 2002”, Proceedings, Skopje 2002

Eftim Micevski. GEOTERMALEN POTENCIJAL NA JUGO-ZAPADNIOT DEL NA MAKEDONIJA, Annual Workshop of MAGA, Ohrid 2003

Kiril Popovski. Feasibility Study on POSSIBLE INVESTMENTS IN GEOTHERMAL PROJECTS IN MACEDONIA, WB study, Skopje 2002

Kiril Popovski. Geothermal Energy Use in Macedonia, International Conference GEAIA, Athens 2004

Table 2. GEOTHERMAL PROJECTS IN MACEDONIA

GEOTHERMAL LOCATION	GEOTHERMAL FIELD	APPLICATION	HEAT POWER TOTAL kW	GEOTHERMAL kW	HEATING INSTALLATION
Istibanja	Kotchany heating (6,0 ha)	Greenhouse	17.500	7.480	Aerial steel pipes (reconstruction of existing installation with heavy oil boiler)
Bansko (Itegrated geothermal project)	Strumica	Greenhouse heating (2,9 ha) Greenhouse heating (600 sq.m Plastichouses heating (3,0 ha) Space heating Sanitary warm water preparation Swiming pool heating. Balneology	10,35 ~~150~~ 3.000 1.560 700 350	10,35 ~~150~~ 3.000 1.560 700 350	Aerial steel pipes and on th soil surface PP pipes Corrugated PP pipes on soi surface + fan jet air heating Soil heating. Aluminium radiators. Plate heat exchangers + warm water accumulator. Plate heat exchanger.
Podlog	Kotchany	Greenhouse heating (6,0 ha)	17.500	17.500	Aerial steel pipes.
Kotchany (District heating scheme)	Kotchany	Greenhouse heating (12,0 ha) Rice drying Paper industry Space heating	40.700 ~~1.600~~ ~~3.200~~ 650	20.500 ~~1.600~~ ~~3.200~~ 650	Aerial steel pipes. Square finned pipes heat exchanger (water/air). Plate heat exchanger. Aluminium and iron radiators
Smokvica	Gevgelija	Greenhouse heating (22,5 ha) Plastichouse heating (10 ha)	~~65.500~~ ~~10.000~~	~~11.750~~ ~~10.000~~	Aerial steel pipes + corrugated PP pipes on soil surf. Corrugated PP pipes on the soil surface)
Negorci	Gevgelija	Space heating Balneology	250	250	Steel radiators.
Katlanovo	Skopje	Balneology			
Kumanovo	Kumanovo	Balneology			
Banja	Kotchany	Balneology			
Kezovica	Shtip	Balneology			
Kosovrasti	Debar	Balneology			
Banjishte	Debar	Balneology			
T O T A L	27,2 ha	~~62,46~~ ha greenhouses Space heating (5 units) ~~Paper industry (1 complete~~) Sanitary warm water preparation (2 units) ~~Rice drying (1 unit)~~ Swimming pool heating (1 unit) Balneology (8 spas)	~~82.560~~ 62.340 kW		

LEGEND: ——— Not in working conditions
——— Reconstructed

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2003

1) I = Industrial process heat; C= Air Conditioning (cooling); A= Agricultural drying (grain, fruit, vegetables); F= Fish and other animal farming; S= Snow melting; H= Space heating & district heating (other than heat pumps); B= Bathing and swimming (including balneology); G= Greenhouse and soil heating; O= Other (please specify by footnote)

2) Enthalpy information is given only if there is steam or two-phase flow

3) Capacity (MWt) = Max. flow rate (kg/s) [inlet temp. (°C) - outlet temp.(°C)] x 0.004184 (MW =10^6W)
or = Max. flow rate (kg/s) [inlet enthalpy (kJ/kg) – outlet enthalpy (kJ/kg)] x 0.001

4) Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp.(°C) - outlet temp.(°C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) – outlet enthalpy (kJ/kg)] x 0.03154

5) Capacity factor = [Annual energy use (TJ/yr) x 0.03171]/Capacity (MWt)
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% of capacity all year.

Locality	Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature (°C)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity Factor[5)]
		kg/s	Inlet	Outlet	Inlet	Outlet	(MWt)	kg/s	TJ/yr	
Bansko	G,H,B	55	70	25			10,35	31,60	187,82	0,575
Istibanja	G	56	67	35			7,49	18.40	77,66	0.328
Negorci	H,B	80	51	46			1.67	13.15	8.67	0.165
Podlog	I,H,G,A,B	300-450	79	38			51-77.20	60,00	324,47	0,201
Smokvica	G		Out of work							
Total		**641**					**70,51-96,71**	**123,15**	**598,62**	

TABLE 4. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2003

1) InstalledCapacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (°C) - outlet temp.(°C)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) – outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp.(°C)- outlet temp. (°C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) – outlet enthalpy (kJ/kg)] x 0.03154

3) Capacity factor = [Annual energy use (TJ/yr) x 0.03171]/Capacity (MWt) (MW =10^6W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% of capacity all year.

Use	Installed Capacity[1)] MW_t	Annual Energy Use[2)] TJ/yr=10^{12} J/yr	Capacity Factor[3)]
Space heating	2,48	25,78	0,330
Air conditioning			
Greenhouses	58.83	557,54	0,300
Fish and Animal Farming			
Agricultural Drying	Out of use		
Industrial process heat			
Snow melting			
Bathing and Swimming			
Other uses (specify)[*)]	1,05	15.3	0,462
Subtotal	62,36		
Geothermal Heat Pumps			
Total	62,36	598,62	

*) Balneology, Sanitary water preparation