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Geothermal Energy Resources in Albania - Country Update

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ABSTRACT

In this paper the geothermal region of Albanides and geothermal resources of Albania are presented. Shortly there are represented the methodic of geothermal studies and the evaluation of geothermal energy reserves. The fields of geothermal gradient are detailed and heat flow fields are represented. Particular attention is shown to the analysis of geothermal energy resources.

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters are sulfate, sulfide, methane, and iodinate-bromide types. Thermal sources are located in three geothermal zones:

Kruja geothermal zone represents a zone in carbonate reservoirs.

Ardenica geothermal zone with sandstone reservoirs.

Peshkopia geothermal zone, is located with disjunctive tectonics of the gypsum diapir.

The geothermal situation in Albania offers three directions for the exploitation of geothermal energy:

1. The use of the ground heat flow for space heating and cooling, by borehole heat exchanger-heat pumps systems.

2. Thermal water sources and wells of low enthalpy. They represent the basis for a successful use of modern technologies for a complex and cascading utilization of this energy:

SPA clinics and hotels for eco-tourism.

Sanitary hot water for SPA and hotels, and hot waters for greenhouses and aquaculture installations.

Extraction of chemical microelements.

3. The use of deep abandoned oil and gas wells as “Vertical Earth Heat Probe”.

Actually in Albania it is published the “Atlas of Geothermal Resources in Albania” (http://www.inima.al/~nfra/projects/geothermal/AlbanianGeothermalAtlas.pdf).

Sensitization brochure on “Use of environmental friendly geothermal energy” (supported by UNDP-GEF SGP) may be found at http://www.inima.al/~nfra/geothermal/ and also at http://www.Geothermie.de/.

1. INTRODUCTION

This paper represents a summary of the important results of the Monograph “Atlas of geothermal resources in Albania” 2004 The Monograph is prepared in the framework of the National Program for Research and Developing- Natural Resources, 2003-2005. This Atlas represents the publication of the results of studies which were performed in the framework of the Committee for Sciences and Technology of Albania Projects and agreement between the Faculty of Geology and Mining, and the Geophysical Institute, Czech Acad. Sci., Prague, European Commision- International Heat Flow Commission and UNDP-GEF/SGP Tirana Office projects [Frasheri A. 1992, Frasheri A. et al. 1994, 1995, 1996, 2001, 2003].

In Albania there are many thermal water springs and wells of low enthalpy, with a temperature of up to 65.5°C, which indicates that there are possibilities for direct use of the geothermal energy. In Albania the new technologies of direct use of geothermal energy are either partly developed or remain still untouched. Integrated and cascading use of geothermal energy of low enthalpy will represent an important direction for profitable investment. Utilization of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and at the same time ameliorating the standard of living of the people.

2. GEOLOGY BEACKGROUND

The Albanides represent the main geological structures that lie on the territory of Albania. They are located between the Dinarides in the north and the Helenides in the south, and together they form the Dinaric Branch of Mediterranean Alpine Belt. Albanides are divided in two big peleogeographical zones: the Inner Albanides and the External Albanides. Korabi, Mirdita (ophiolitic belt), presents the Inner Albanides and Gashi zones. The Alps, the Krasta-Cukali, the Kruja, the Ionian zone, the Sazani zone and the Pre-Adriatic Depression represent the External Albanides. The Depression as a part of Albanian Sedimentary Basin, continues towards the shelf of the Adriatic Sea. The geological cross-section of Albanian Sedimentary Basin is about 15 km thick and it also continues into the Adriatic Sea Shelf.

The Ionian zone developed as a large pelagic trough in the Upper Triassic. There, the evaporites of the Permian-Triassic are overlapped by a thick carbonatic formation of the Upper Triassic-Eocene. The geological section on this carbonatic formation is covered by Oligocene flysch, a flyschoid formation of the Aquitanian and by schilieres of the Burdigalian, Helvetian and particularly of Serravalian-Tortonian molasse. Burdigalian deposits are overlapped transgressively with an angular unconformity, anticline belts. The Tortonian Age deposits have filled the synclinal belts of Ionic and Kruja tectonic zones.

Miocene and Pliocene molasse of Peri-Adriatic Depression overlies the structures of northern part of the Ionian zone. The structure of Neogenic molasses represents the upper tectonic stage of the structure of the Peri-Adriatic Depression.

In the over part of the section of Kruja zone, the carbonatic neritic rocks of the Cretaceous-Paleogene age are overlying the Oligocene flysch of a thickness of 5 km.

The structures of the Albanides are typically Alpine ones. The SSE-NNW directions represent their general strike. The structures are asymmetrical and have a western vengeance. Recumbent, overthrusted and overtwisted structures are also found. Generally, their western flanks are affected by disjunctive tectonic.

3. METHODS AND STUDY AREA

Geothermal studies carried out in Albania are oriented toward the study of the distribution of the geothermal field and the natural thermal water springs and wells. Geothermal studies were extended throughout the country territory.

The temperatures have been measured and the geothermal gradient and the heat flow density at different depths have also been calculated (Frasheri et al. 1995). Temperature measurements were carried out both in 145 deep wells, in boreholes and in mines, at different hypsometric levels. The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and thermistor thermometers. The average absolute measurement error was 0.3°C. The measurements were carried out in a steady-state regime of the wells filled with mud or water. The recorded data was processed using the trend analysis of first and second degrees. The chemical composition of the waters was found. The output of the springs and wells and their hydrogeology was evaluated.

4. RESULTS

4.1.Geothermal Regime

The Geothermal Regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological location (Frasheri A. 1992, Frasheri et al. 1994, 1995, 2004).

4.1.1. Temperature

The geothermal field is characterized by a relatively low value of temperature. The temperature at a depth of 100 meters, varies from less than 10 to almost 20°C, with the lowest values in the mountain regions. The temperature is 105.8°C at a depth of 6000 meters, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel to the Albanides strike (Fig. 1). Going deeper and deeper the zones of highest the temperatures move from southeast to northwest, towards the center of the Peri-Adriatic Depression and even further towards the northwestern coast. The temperatures in the ophiolitic belt is higher than in sedimentary basin, at the same depth.

4.1.2. Geothermal Gradient

In the External Albanides the geothermal gradient is relatively higher. The geothermal gradient displays the highest value of about 21.3 mK.m-1 in the Pliocene clay section in the centre of Peri-Adriatic Depression. The largest gradients are detected in the anticline molasses structures of the center of Pre-Adriatic Depression (Fig. 5). The gradient decreases about 10-29% where the core of anticlines in Ionic zone contains limestone. The lowest values of 7-11 mK.m-1 of the gradient are observed in the deep synclinal belts of Ionic and Kruja tectonic zones (Fig.2).

In the ophiolitic belt of the Mirdita tectonic zone, the geothermal gradient values increase up to 36 mK.m-1 at northeastern and southeastern part of the Albania.

4.1.3. Heat Flow Density:

Regional patterns of heat flow density in Albanian territory are presented in the Heat Flow Map. There are observed, two particularities of the scattering of the thermal field in Albanides (Fig. 3):

Firstly, maximal value of the heat flow is equal to 42 mW/m2 in the center of Peri-Adriatic Depression of External Albanides. The 30 mW-2 value isotherm is open towards the Adriatic Sea Shelf. These phenomena have taken place owing to the great thickness of sedimentary crust, mainly carbonatic one in this zone.

Secondly, in the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m2. The contours of Heat Flow Density give a clear configuration of the ophiolitic belt. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt, is linked with heat flow transmitting from the depth. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source.

4.2. Geothermal energy resources in Albania

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters with a temperatures that reach values of up to 65.5°C are sulfate, sulfide, methane, and iodinate-bromide types (Frasheri A. et al. 1996, 2004) (Tab. 1, Fig.4). In many deep oil and gas wells there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (table 2, Fig. 3)

Albanian geothermal areas have different geologic and thermo-hydrogeological features. Thermal sources are located in three geothermal zones (fig. 4):

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Kruja geothermal zone is extended from the Adriatic Sea in the North and continues to the South-Eastern area of Albania and into the Konitza area in Greece. Photo 1 shows Langarica - Permet thermal springs in southern Albania. Identified resources in carbonate reservoirs in the Albanian side are 5.9x108-5.1x109 GJ. The most important resources, explored until now, are located in the Northern half of the Kruja Geothermal Area, from Llixha-Elbasan in the South to Ishmi, in the North of Tirana. The values of specific reserves vary between 38.5-39.63 GJ/m2.

The Kruja geothermal area represents an anticline structure chain with carbonatic core of Cretaceous-Eocene age. They are covered with Eocenic- Oligocenic flysch. Anticlinals are linear with lengths between 20-30 km. They are assymmetric and their western flanks are separated from disjunctive tectonics. Geothermal aquifers are represented by a karstified neritic carbonatic formation with numerous fissures and microfissures.

In the Ishmi area, the Ishmi 1-b well had been drilled in 1994. It is situated at the top part of the limestone structure. It is located 20 km North- West of Tirana, in the plain area, near “Mother Theresa” Tirana airport. It meets limestone at 1300m of depth and goes through a carbonatic coupe of 1016 m thickness.

Kozani 8 well had been drilled in 1989 (Photo 2). It is situated 35 km South- East of Tirana and 8 km North- West of Elbasani. It is situated on hills close to Tirana- Elbasani national road. It meets limestone at 1810m of depth and goes 10m deep in them.

Since the end of the drilling to this day hot water continues to fountain from Ishmi 1-b and Kozani 8 wells.

Elbasani Llixha watering place is about 12 km South of Elbasani. There are seven spring groups that extend like a belt with 320o azimuth. All of them are connected with the main regional disjunctive tectonics of Kruja zone. Thermal waters flow out through the contact of a conglomerate layer with calcolistolith. In this area too, the reservoir is represented by the Llixha limestone structure. The springs had been discovered before the Second World War.

Surface water temperatures in the Tirana-Elbasani zone varies from 60° to 65.5°. In the aquifer top in the well trunk of Kozani 8 the temperature is 80°C. Hot water is mineralized, with a general mineralization of 4.6-19.3 g/l. Elbasani Nosi Llixha water has the following formula:

$$H_2S_{0.403}M_{7.1}\frac{Cl_{59}SO^4_{38}}{Na_{46}Ca_{35}}$$

Peshkopia geothermal zone is situated in the Northeast of Albania. Two kilometers East of Peshkopia some thermal springs are situated very close to each other. These thermal springs flow out on the Banja river slope. These springs are linked with the disjunctive tectonic seismic-active zone Ohrid Lake-Debar, at periphery of gypsum diapir of Triassic age, that has penetrated Eocenic flysch, which surround it like a ring. The occurrence of thermal waters is connected with the low circulation zone always under water pressure. They are of sulfate-calcium type, with a mineralization of up to 4.4 g/l, containing 50 mg/l H2S. Their chemical formula is:

$$H_2S_{0.0495}M_{4.4}\frac{SO^4_{56}}{Ca_{65}}$$

The yield of some of the springs goes up to 14 l/sec. Water temperature is 43.5 °C.

The water temperature, high yield, stability, and aquifer temperature of Peshkopia Geothermal Area are similar with those of Kruja Geothermal Area. For this reason geothermal resources of Peshkopia Area have been estimated to be similar to those of Tirana- Elbasani area.

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

5. DIRECTIONS FOR THE DIRECT USE OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers three possibilities for the direct use of geothermal waters energy. Geothermal energy utilization must be realized by an integrated scheme of geothermal energy, heat pumps and solar energy, and the cascading use of this energy (Frasheri A. 2001, Frasheri A. et al. 2003, 2004).

Firstly, the Ground Heat can be use for space heating and cooling by the Borehole Heat Exchanger-Geothermal Heat Pumps modern systems.

Secondly, thermal sources of low enthalpy and of maximal temperature are up to 65.5°C.

Thermal waters of springs and wells may be used in several ways:

1. Modern SPA clinics for treatment of different diseases and hotels, with thermal pools, for the development of eco-tourism. Such centers may attract a lot of clients not only from Albania, because of the curative properties of waters and springs are situated near the seaside, the Gjinari mountains or Ohrid Lake pearl.

The oldest and most important thermal springs are at the Elbasani Llixha SPA, located in Central Albania. By national road communication, the Llixha area is connected with Elbasani. These thermal springs from about 2000 years ago are known, near the old road “Via Egnatia" that has passed from Durresi-Ohrid- to Constantinople. All seven groups of the springs in Llixha Elbasani and Kozani-8 well, near of Saint Vladimir Monastery at Elbasani, have the possibilities for modern complex utilization. Ishmi 1/b geothermal well is located in beautiful the Tirana field, near the Mother Theresa- Tirana Airport, close to the Adriatic coastline and the Kruja - Skenderbeg Mountain.

Peshkopia SPA was constructed by modern concepts as balneological geothermal center. There are thermal pools, for medical treatment and recreation. Construction of the Peshkopia SPA must be en good example for new SPA construction in Albania.

2. The hot water can be used also for heating of hotels, SPA and tourist centers, as well as for the preparation of sanitary hot water used there. Near these medical and tourist centers it is possible to build greenhouses for flowers and vegetables, and aquaculture installations.

3. From thermal mineral waters it is possible to extract very useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for preparation of pomades for the treatment of many skin diseases as well as for beauty treatments. From these waters it is possible to extract sulphidric and carbonic gas.

Thirdly, the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a “Vertical Earth Heat Probe”. The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 mK·m-1. At 2 000 m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. Greenhouses can be built near these wells.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, represent the basis for a successful use of modern technologies for a complex and cascading utilization of this environmentally friendly renewable energy, thus achieving economic effectiveness. Such developments are useful for the creation of new working places and improvements to the standard of living for local communities near thermal sources.

6. CONCLUSIONS

Albania has geothermal energy resources, which can be directly used as alternative, environmental friendly energy.

2. Resources of the geothermal energy in Albania are;

Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.

Heat of subsurface ground, with an average temperature of 16.4oC and depth Earth Heat Flow.

3. Construction of a space-heating system, based on direct use of ground heat, by using the shallow borehole heat exchanger (BHE)-Heat Pumps systems, are actually the most important usage of geothermal energy.

7. ACKNOWLEDGMENTS

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Photo 1. Langarica-Permeti thermal water springs

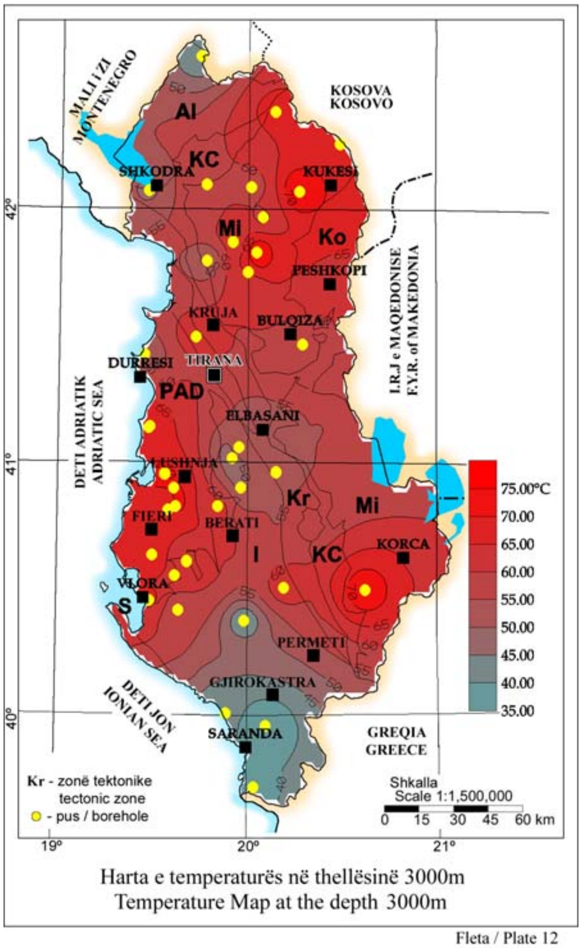
Photo 2. Geothermak deep well Kozani – 8

Table 1: Thermal Water Springs In Albania

N° of Springs	Location	Temperature in °C	Salt in mg/l	Artesian Spring yield in l.s-1
1	Llixha Elbasan	60	0.3	0
2	Peshkopi	5-43	9	10
3	Krane-Sarande	34		<10
4	Langarica-Permet	6-31		>10
5	Shupal-Tirana	29.5		10
6	Sarandoporo-Leskovik	26.7		>10
7	Tervoll-Gramsh	24		>10
8	Mamurras-Tirane	21	26	>10
9	Steam Postenani springs			

Table 2: The Oil And Gas Wells That Have Self-Discharge Of The Thermal Water,

N°	Well Name	Temperature in °C	Salt in $mg.l^{-1}$	Self-discharge in $l.sec^{-1}$
1	Kozani	65.5	4.6	10.4
2	Ishmi	64	19.3	4.4
3	Galigati	45-50	5.7	0.9
4	Bubullima	48-50	35	
5	Ardenica	38		15-18
6	Ardenica	32		
7	Semani	35		5
8	Verbasi	29.3		1-3



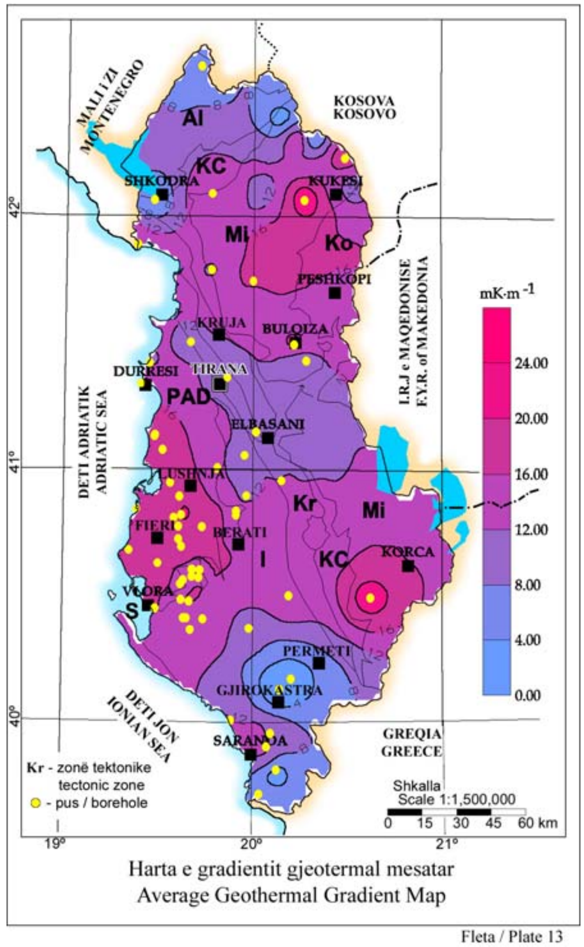
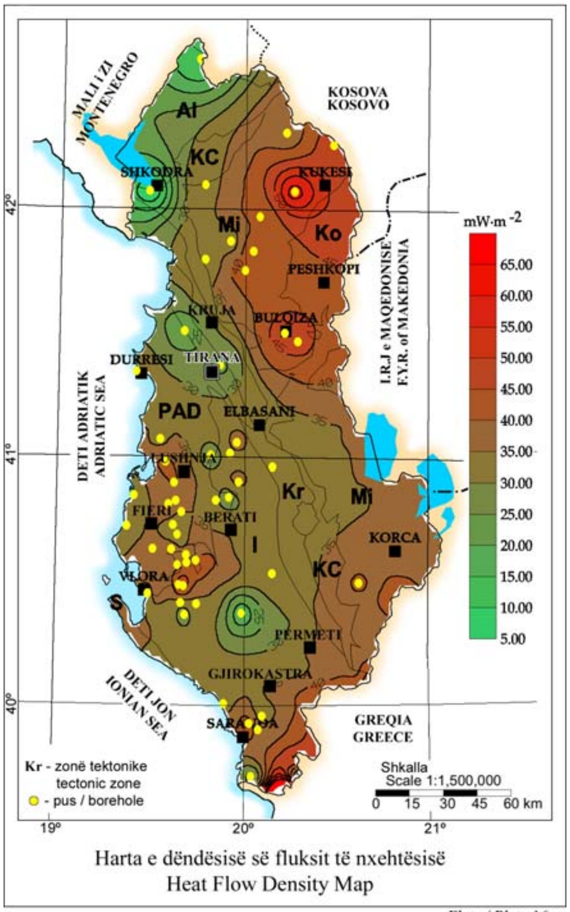


Figure 1 **Figure 2**



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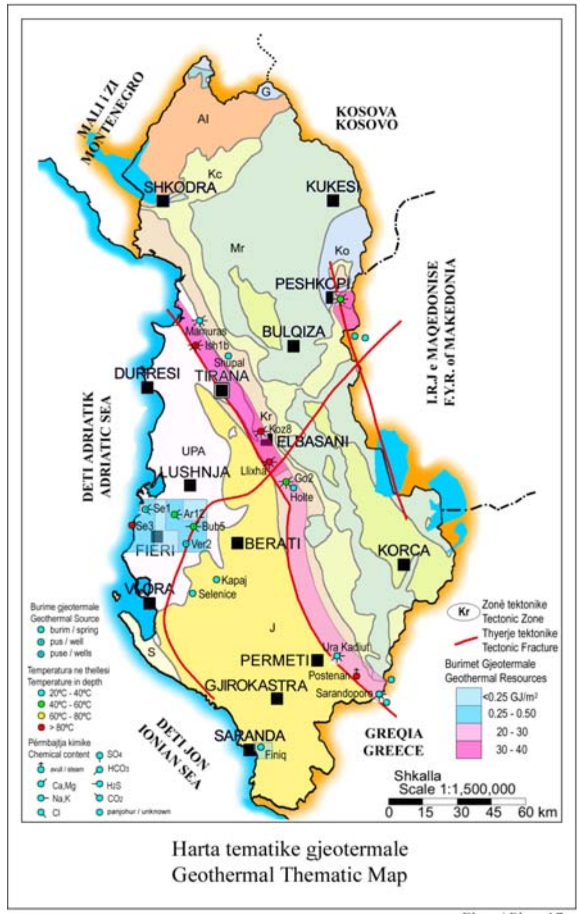

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Figure 3 **Figure 4**

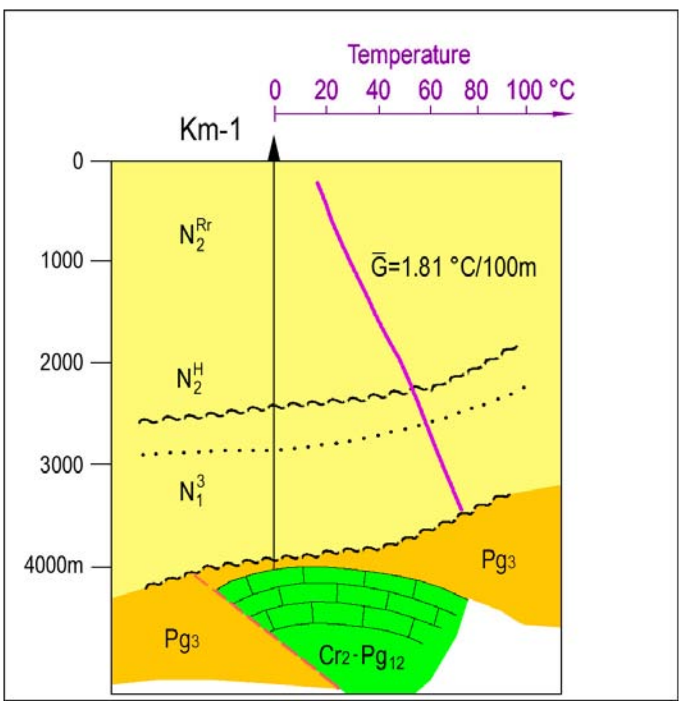

Figure 5

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY (Installed capacity

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr
In operation in December 2004			224	81	1446	4876					1670	4957
Under construction in December 2004												
Funds committed, but not yet under construction in December 2004											220	390
Total projected use by 2010			839	3781	1646	6870					2475	10651

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2004 (other than heat pumps)

[1)] I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish farming
K = Animal farming
S = Snow melting
H = Individual space heating (other than heat pumps)
D = 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. (^{o}C) - outlet temp. (^{o}C)] x 0.004184 (MW=106 W)
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. (^{o}C) - outlet temp. (^{o}C)] x 0.1319 (TJ=1012 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)/Capacity (MWt)] x 0.03171
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.

Note: please report all numbers to three significant figures.

Locality	Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature (^{o}C)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
Llixha Elbasan	B	15	60	18			2.64	9	3.56	0.042
Peshkopi	B	16	43	18			1.49	6	2.4	0.051
Hydrat	B	18	55	18			2.78	3	1.19	0.013
Ishmi	B	3.5	64	18			0.61	2.5	0.99	0.019
Kozani	B	10.3	65.5	18			2.05	1	0.39	0.006
TOTAL		62.8					9.57	21.5	8.53	0.131

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2004

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}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. (^{o}C) - outlet temp. (^{o}C)] x 0.1319 (TJ = 1012 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)/Capacity (MWt)] x 0.03171 (MW = 106 W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less,
since projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]	---	---	---
District Heating [4]	---	---	---
Air Conditioning (Cooling)	---	---	---
Greenhouse Heating	---	---	---
Fish Farming	---	---	---
Animal Farming	---	---	---
Agricultural Drying[5]	---	---	---
Industrial Process Heat[6]	---	---	---
Snow Melting	---	---	---
Bathing and Swimming[7]	9.57	8.53	0.131
Other Uses (specify)	---	---	---
Subtotal			
Geothermal Heat Pumps	---	---	---
TOTAL	9.57	8.53	0.131

4) Other than heat pumps
5) Includes drying or dehydration of grains, fruits and vegetables
6) Excludes agricultural drying and dehydration
7) Includes balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2000 TO DECEMBER 31, 2004 (excluding heat pump wells)

[1)] Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)	
		Electric Power	Direct Use	Combined	Other (specify)		
Exploration[1)]	(all)						
Production	>150^{o} C						
	150-100^{o} C						
	<100^{o} C		2			3.5	
Injection	(all)						
Total			2			3.5	

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES
(Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2000			2			95
2001			2			110
2002			2			110
2003		5	13			115
2004		5	9			135
Total		10	28			566

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2004) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1990-1994	0.009		1.525		0.164	1.37
1995-1999	0.046		1.722		0.755	1.013
2000-2004	0.06		2.071		1.151	0.98