

Geothermal Energy Resources in Albania-Country Update Paper

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ABSTRACT

Resources of geothermal energy of low enthalpy in Albania, and the platform for their direct use are presented in the paper.

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 with bigness geothermal resources, in carbonate reservoirs.

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

Peshkopia geothermal zone at northeastern area of Albania. Several springs are located with disjunctive tectonics of the gypsum diapir.

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

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

Secondly, thermal sources of low enthalpy are natural sources or wells in a wide territory of Albania. They represent the basis for a successful use of modern technologies for a complex and cascade exploitation of this energy:

1. SPA clinics for treatment of different diseases and hotels for eco-tourism.
2. The hot water for heating and sanitary waters of the SPA and hotels, greenhouses and aquaculture installations.
3. From thermal waters it is possible to extract chemical microelements.

Thirdly, the use of deep abandoned oil and gas wells as “Vertical Earth Heat Probe”.

1. INTRODUCTION

Geothermal resources of Albania evaluation and platform for their use are based on the results of more than two decades of geothermal studies.

Geothermal Atlas of Albania and Atlas of Geothermal Resources in Albania (2004), have been performed in the framework of the of the Committee for Sciences and Technology of Albania projects, by agreement between the Faculty of Geology and Mining, and the Geophysical Institute, Czech Acad. Sci., Prague, European Commission- International Heat Flow Commission (Frashëri A. 1992, Frashëri A. et al. 1994, 1995, 1996). The geothermal team of the Faculty of Geology and Mining, have worked for the UNDP-GEF/SGP Tirana Office project (2003), and “Geothermal Resources of Albania and platform for their use”, in the framework of the National Program for Research and Developing, Natural Resources, 2003-2005 (Frashëri A. et al. 2003, 2004, 2005). It has been published in electronic format the “Atlas of Geothermal Resources in Albania (Frashëri A. et. al. 2004) and in hard format “Geothermal Atlas of Albania and platform for use of Earth’s Heat” (2013).

The geothermal team from Faculty of Geology and Mining and Department of Energy of Faculty of Mechanical Engineering, during 2008 has worked for the Project: “Platform for integrated and cascade use of geothermal energy of low enthalpy in the framework of energetic balance of Albania”, in the framework of the National Program for Research and Development, “Water and Energy” 2007-2009. They have been published a monograph: “Space Heating/Cooling Borehole-Vertical Heat Exchanger-Heat Pump System” (Frashëri A. et. al. 2008). In same time, we had prepared three project ideas: “Geothermal Center for integrated and cascade direct use of geothermal energy of Kozani-8 well, near Elbasani City” (spa-hotel with hot pools, greenhouse and aquaculture installations (spirulina and fish), project idea for space heating of Korça University using borehole-vertical heat exchanger heat pump system, and project idea for the set up of the “Geo-Energy Ressources Laboratory” in the Department of Energy Reasources, Faculty of Geology and Mining (Frashëri A. et al. 2008, 2009). “Geothermal Resources of Albania and platform for their use”, monograph, was published during 2010 by Faculty of Geology and Mining, Faculty of Mechanical Engineering, Polytechnic University of Tirana (Frashëri A. & Kodhelaj N., 2010).

The Promemory “Earth Heat is an alternative, environ friendly renewable energy, which is necessary to use in Albania” has been addressed to the Albanian Government.

Periodically, results of the geothermal energy studies in Albania have been published and presented in International Symposiums, Conferences and Workshops.

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 cascade use of geothermal energy of low enthalpy will represent an important direction for profitable investment. Exploitation 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 BACKGROUND

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 Hellenides in the south, and together they form the Dinaric Branch of Mediterranean Alpine Belt. Albanides are divided in two big paleogeographical zones: the Inner Albanides and the External Albanides. Korabi and 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 present the External Albanides. Depression as a part of Albanian Sedimentary Basin continued towards the shelf of the Adriatic Sea. The geological cross-section of Albanian Sedimentary Basin is about 15 km thick and it continues also in the Adriatic Sea Shelf.

Ionian zone is developed as a large pelagic trough in the Upper Triassic. There, the evaporites of the Permian-Triassic are overlapped by a thick carbonate formation of the Upper Triassic-Eocene. The geological section on this carbonate formation is covered by Oligocene flysch, a flyschoid formation of the Aquitanian and by schlieres of the Burdigalian, Helvetian and particularly of Serravalian- Tortonian molasses. 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 molasses of Peri-Adriatic Depression overlies the structures of the northern part of the Ionian zone. The structure of Neogene molasses represents the upper tectonic stage of the structure of the Peri-Adriatic Depression.

In the over part of the section of the Kruja zone, the carbonate 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, over thrust and over twisted structures are found, too. 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 all over the country.

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 were 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, 2010).

4.1.1. Temperature

The geothermal field is characterized by a relatively low value of temperature. The temperature at 100 meters depth varies from less than 10 to almost 20°C, with the lowest values in the mountain regions. The temperature is 105.8°C at 6,000 meters depth, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel the Albanides strike (Fig. 1). Going deeper and deeper the zones of the highest temperature move from southeast to northwest, towards the center of the Peri-Adriatic Depression and even further towards the northwestern coast. The temperatures in ophiolitic belt are higher than in sedimentary basin, at the same depth.

4.1.2. Geothermal Gradient

In the External Albanides the geothermal gradient is relatively higher (Fig.2). 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 the Ionic zone contains limestone. The lowest values of 7-11 mK.m⁻¹ of the gradient are observed in the deep synclinal belts of the Ionic and Kruja tectonic zones.

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

The regional pattern of heat flow density in Albanian territory is presented in the Heat Flow Map. There are observed two particularities of the scattering of the thermal field in Albanides (Fig. 3):

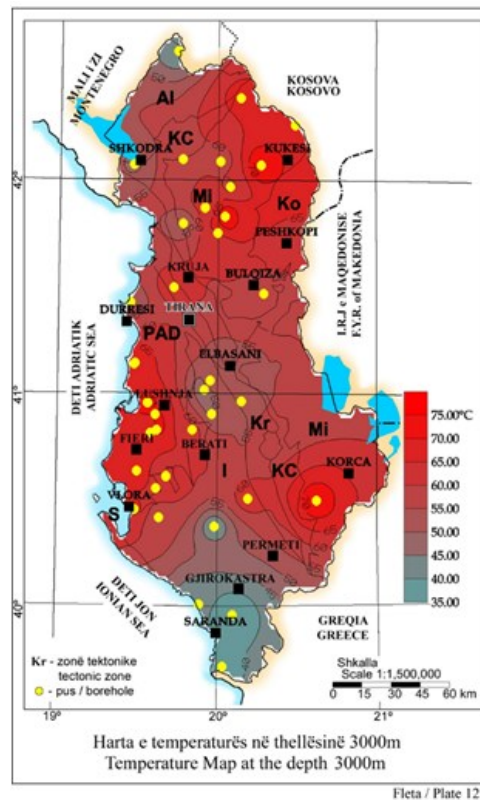


Fig. 1

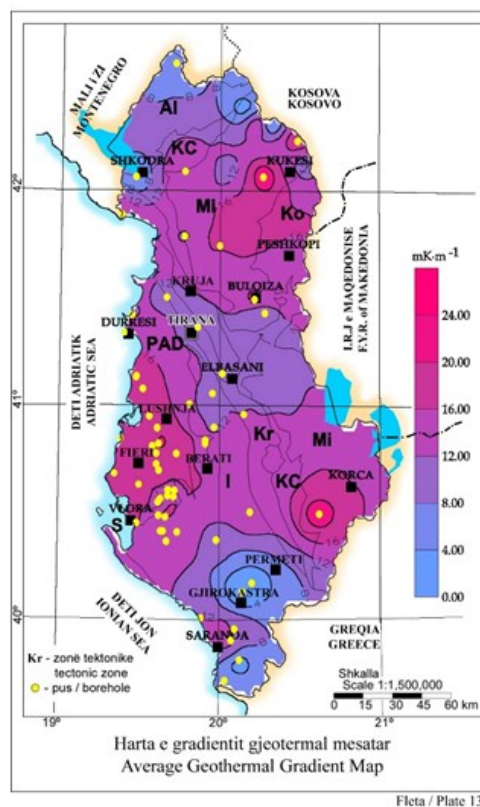


Fig. 2

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

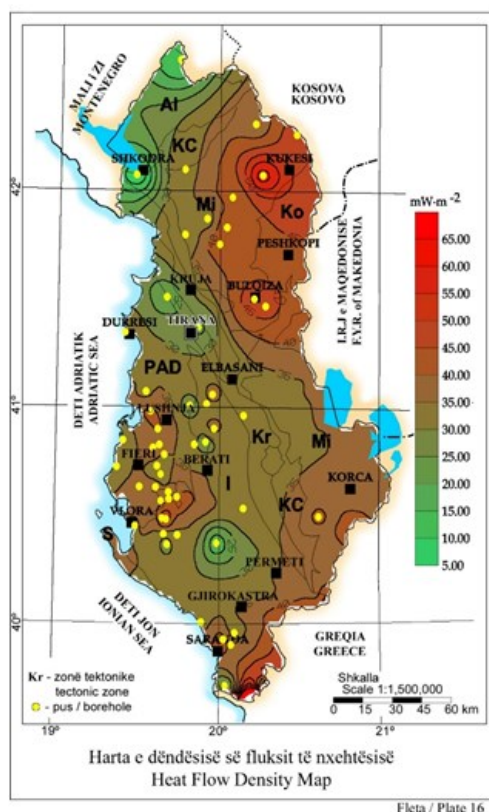


Fig. 3

Secondly, in the ophiolitic belt at the eastern part of Albania, the heat flow density values are up to 60 mW/m^2 . The contours of heat flow density give a clear configuration of the ophiolitic belt. Radiogenic 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 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 temperatures that reach values of up to 65.5°C are sulfate, sulfide, methane, and iodinate-bromide types (Frasheri A. et al. 1996, 2004, 2010) (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):

Table 1. THERMAL WATER SPRINGS IN ALBANIA

N° of Springs	Location	Temperature in $^\circ\text{C}$	Salt in mg/l	Artesian Spring yield in l.s-1
1	Llixha Elbasan	60	6.3	15-18
2	Peshkopi	5-43	4.2	23
3	Lëngarica-Permet	6-31	1.65	>10
4	Sarandoporo-Leskovik	26.7	1.2	>10
5	Tervoll-Gramsh	24	2.5	>10
6	Mamurras-Tirane	21	5.4	>10
7	Steam Postenani springs			

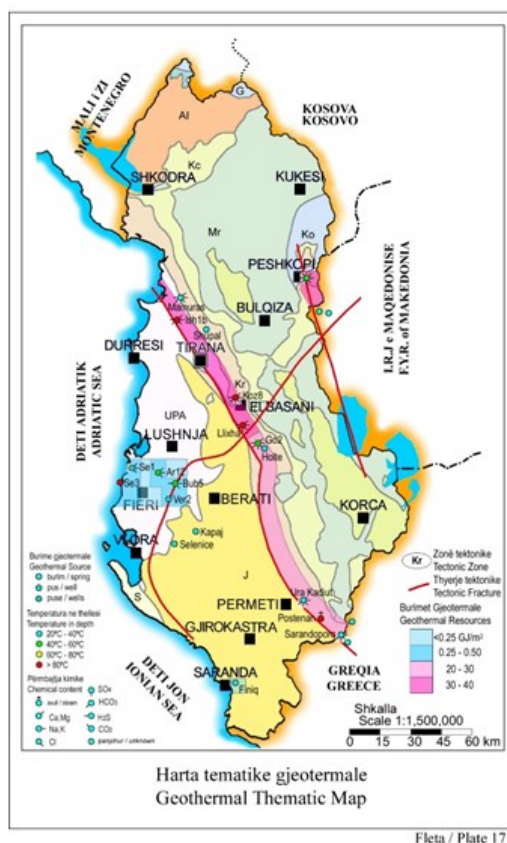


Fig. 4

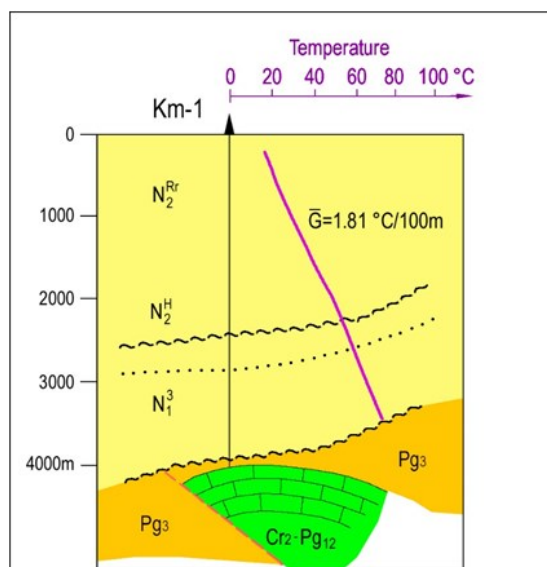


Fig. 5 - Geothermal Section Peri-Adriatic Depression

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	15	4.4

N°	Well Name	Temperature in °C	Salt in mg.l ⁻¹	Self-discharge in l.sec ⁻¹
3	Shupal-Tirana	29.5	1,6	1.6
4	Galigati	45-50	5,7	0.9
5	Bubullima	48-50	35	
6	Ardenica 3	38	38.2	15-18
7	Ardenica 12	32	53.6	5-18
8	Semani 1	35		5
	Semani 3	67	20.7	30
9	Verbasi	29.3	8.2	1-3

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Kruja Geothermal Zone is extended from Adriatic Sea at North and continues in South-Easter area of Albania and in Konitza area in Greece. Photo 1 shows Lëngarica - Përmet thermal springs at southern Albania. Identified resources in carbonate reservoirs in Albanian side are 5.9×10^8 - 5.1×10^9 GJ. The most important resources, explored until now, are located in the northern half of 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.



Photo 1. Langerica-Permeti thermal water springs

Kruja geothermal area represents an anticline structure chain with a carbonate core of Cretaceous-Eocene age. They are covered with Eocene- Oligocene flysch. Anticlines are linear with a length of 20-30 km. They are asymmetric and their western flanks are separated from disjunctive tectonics. Geothermal aquifer is represented by a karstified neritic carbonate formation with numerous fissures and micro fissures.

In the Ishmi area, Ishmi 1-b well was drilled in 1994. It is situated in the top part of the limestone structure. It is located 20 km northwest of Tirana, in the plain area, near “Mother Theresa” Tirana airport. It meets limestone at 1,300 m of depth and goes through a carbonate coupe of 1,016 m thickness.

Kozani 8 well was drilled in 1989 (Photo 2). It is situated 35 km southeast of Tirana and 8 km northwest of Elbasani. It is situated on hills close to Tirana- Elbasani national road. It meets limestone at 1,810 m of depth and goes 10 m 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.

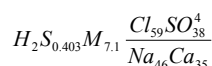
Elbasani Llixha watering place is about 12 km South of Elbasani. There are seven spring groups that extend like a belt with 320° azimuth. All of them are connected with the main regional disjunctive tectonics of the Kruja zone. Thermal waters flow out through

the contact of conglomerate layer with calcolistolith. In this area too, the reservoir is represented by the Llixha limestone structure. These springs have been known before Second World War.

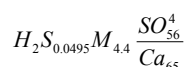


Photo 2. Geothermal deep well Kozani - 8

Surface water temperatures in the Tirana-Elbasani zone vary from 60° to 65.5°C. 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:



Peshkopia geothermal zone is situated in the northeast of Albania. Two km 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 Eocene 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:



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

The water temperature and large yield, stability, and also aquifer temperature of the 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 the Tirana- Elbasani area.

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

5. PLATFORM 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 exploitation must be realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of this energy (Frashëri A. 2001, Frasheri A. et al. 2003, 2004, 2008, 2009 and 2010).

Firstly, the ground heat can be used for space heating and cooling by Borehole Heat Exchanger Geothermal Heat Pumps modern systems. At the present they have installed geothermal heating systems in six buildings in different cities: Tirana, Korça, Shkodra, Erseka in Albania.

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

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

1. Modern Wellness SPA for treatment and healing of different diseases, recreation, thermal physical and mental relaxation, with thermal bath and pools, sauna, massages, fitness and activities for development of eco-tourism. Such centers may attract a lot of

clients not only from Albania, because the good curative properties of waters and springs are situated at nice places, near seaside, Gjinari Mountain or Ohrid Lake.

The oldest and important is Elbasani Llixha SPA is located in Central Albania. By national road communication, Llixha area is connected with Elbasani. These thermal springs from about 2,000 years ago are known, near the old road "Via Egnatia" that has passed from Durres-Ohrd- to Constantinople. All seven groups of the springs in Llixha Elbasani and Kozani-8 well, near Saint Vladimir Monastery at Elbasani, have the possibilities for modern complex exploitation. Ishmi 1/b geothermal well is located in beautiful Tirana field, near Mother Theresa Tirana Airport, near the Adriatic coastline and Kruja - Skanderbeg Mountain.

Peshkopia SPA was constructed by modern concepts as a balneological geothermal center. There are thermal pools, for medical treatment and recreation. Construction of the Peshkopia SPA must be a 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.

3. Near the thermal water springs and wells it is possible to build the greenhouses for flowers and vegetables, asparagus cultivation, etc.

4. Aquaculture installations for cultivation of the micro-alga as spirulina etc. for alimentary industry, preparation of pomades, and fish cultivation will be other profitable activities.

5. 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.

6. Scientific research for the study of the possibility of generating electricity from geothermal sources of low enthalpy, about 80°C, as good local energy sources and provides a secure domestic energy supply with stable output.

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 $18.7 \text{ mK} \cdot \text{m}^{-1}$. 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. Near these wells, can be build greenhouses.

Actually, in Albania, is prepared a platform with scenarios for integrated and cascade use of the geothermal energy, in the framework of the National Program for Research and Development, Water and Energy (2007-2009). Based on complex analysis, for the best area selected according to the scenarios, a Feasibility Study is performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

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 cascade exploitation of this environmental friendly renewable energy, achieving an economical effectiveness. Such developments are useful also for the creation of new working places and improvement of the level of life for local communities near thermal sources.

6. CONCLUSIONS

1. 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 16.4°C and depth Earth Heat Flow.

3. Construction of the space-heating system, based on direct use of ground heat, by using of the shallow borehole heat exchanger (BHE) heat pumps systems, is actually most important direction of the use of geothermal energy.

7. ACKNOWLEDGMENTS

The authors express their thanks also to their colleagues of the Geothermal Team at the Faculty of Geology and Mining of the Polytechnic University of Tirana and of Geophysical Institute at Academy of Sciences of the Czech Republic in Prague, for their scientific collaboration and help in our studies of geothermal energy.

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STANDARD TABLES

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables Wind & Biomass		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2009					1464	4362					1464	4362
Under construction in December 2009			348	116	150	447					498	563
Funds committed, but not yet under construction in Dec-09			150	54	475	1415					625	1469
Total projected use by 2015			498	170	1964	6224			880		2462	6394

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2014 (other than heat pumps)

Locality	Type ¹⁾	Maximum Utilization					Capacity ³⁾	Annual Utilization		
		Flow Rate Kg/s	Temperature, (°C)		Enthalpy ²⁾ , (kJ/kg)			Ave Flow Kg/s	Energy ⁴⁾ (TJ/yr)	Capacity Factor ⁵⁾
			Inlet	Outlet	Inlet	Outlet				
Llixh Elbasan	B	15	60	18			2.64	9	19.01	0.228
Peshkopi	B	16	43	18			1.49	6	10.72	0.228
Hydrat	B	18	55	18			2.78	3	20.02	0.228
Ishëm-Bilaj	B	3.5	64	18			0.61	2.5	4.39	0.228
Kozani-8	B	10.3	65.5	18			2.05	1	14.76	0.228
Bënjë	B	30-40	30	18			1.75		12.6	0.228
Sarandaporo	B	>10	26.7	18			0.36		2.59	0.228
Shupal	B	>10	29.5	18			0.048		0.34	0.228
TOTAL		>112.8	373.7	144			11.728	21.5	84.43	0.228

B = Bathing and swimming (including balneology)

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2014

Locality	Ground or water temperature (°C ¹)	Typical Heat Pump Rating Or Capacity (kW)	Number of	Type ²	COP ³	Heating Equivalent Full Load (Hr/yr ⁴)	Thermal Energy Used TJ/Yr	Cooling Energy Used TJ/Yr
Tirana (Twins Towers)	12	1200	100	W	2.5	2400	6.22	0.008
Tirana (Culture Palace)	12	500	1	W	4.06	880		0.009
Tirana	12	2480	31	W	4	2400		0.01656
Korçë	11	22.7	1	W	5.7	1300		
Shkodër	12	80	2	W	5	2400		0.00053
Shkodër (School)	12	180	2	W	4.1	2400		0.001077
Ersekë (School)	10	34	1	W	4.7	1300		
TOTAL		4497000				2400	23.26	

W = water source (well or lake water)

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2014

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			
Individual Process Heat ⁶			
Snow Melting			
Bathing and Swimming ⁷	11.728	84.43	0.228
Other uses (specify)			
Subtotal	11.728	84.430	0.228
Geothermal Heat Pumps	4.497	23.260	0.164
TOTAL	16.225	107.690	0.210

⁷ Include balneology

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

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2005		5	9			7
2006		5	12		3	7
2007		2	11			8
2008		2	14			8
2009		2	18			8
2014		2	2			10
Total		18	64			48

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2014) US\$

Period	Research & Development	Fiedel Development Including Production	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million USD	Million USD	Million USD	Million USD	%	%
1995-1999	0.099		1.525		94	6
2000-2004	0.046		1.732		97.5	2.5
2005-2009	0.06		2.071		97.2	2.8
2010-2014	0.14		5.375		97.4	2.6