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"OUTLOOK ON PRINCIPLES FOR PROJECTING OF INTEGRATED AND CASCADE USE OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA".

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Abstract

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. Kruja zone has a length of 180 km. Identified resources in carbonate reservoirs are $5.9x10^8$-$5.1x10^9$ GJ,

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

Peshkopia gjeotermal 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 uses of the heat flow of shallow geological section for heating and cooling of the buildings. Integrated exploitation and cascade direct use of the geothermal energy must realize by integrated scheme of geothermal energy, heat pumps and solar energy to fulfill.
- **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, achieving an economical effectiveness:

1. SPA clinics for treatment of different diseases and hotels for ecotourism.
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".

Actually in Albania the study of the possibilities of exploitation of the geothermal energy has begun. The aims of the project are to examine, demonstrate and disseminate the positive technical and financial aspects of transfer and utilization of innovative geothermal energy technologies in Albania.

Keywords: Geothermal energy, thermal water, geothermal gradient, heat flow.

1. INTRODUCTION

In Albania, rich in geothermal resources of low enthalpy and mineral waters, new technologies of direct use of geothermal energy are still untouched. Large numbers of geothermal energy of high and low enthalpy resources, a lot of mineral water sources and some CO_2 gas reservoirs represent the base for successfully application of modern technologies in Albania, to achieve economic effectively and success of complex exploitation.

Actuality, there are many geothermal, hydrogeological, hydrochemical, biological and medical investigations and studies of thermal and mineral water resources carried out in Albania. The results of the geothermal studies carried out in Albania are presented in maps and geothermal sections. Temperature maps have been drowning for different levels of up to 5000m depth. Geothermal gradient, heat flow density and geothermal resources maps have also been drawn. The natural springs with thermal waters and the geological structures with high water temperature have also been mapped. Generally, these investigations and studies are separated each from the other. Their information and data will serve for studies and evaluations in Albania regional scale. These studies and evaluations are necessary to well know in regional plane the thermal and mineral water resources potential and geothermal market of the Albania.

According to results of these new studies, the evaluation for the perspective level of the best areas in country will be necessary. After the evaluation is possible to start investments in these areas. Integrated exploitation and cascade direct use of the geothermal energy will realized by integrated scheme of geothermal energy, heat pumps and solar energy to fulfill. This scheme has an environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme). Cascade scheme should be used to fulfill the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy and the minimum energy supply from heat pumps: the promotion of energy savings will be in place.

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. These investments will be profitable in a short period of time.

2. GEOTHERMAL ENERGY RESOURCES IN ALBANIA

2.1. Methodic

The results of the geothermal studies carried out in Albania are presented in maps and geothermal sections. Temperature maps have been drowning for different levels of up to 5000m depth (Frasheri A. et al. 1995, 1996, 2004). Geothermal gradient, heat flow density and geothermal resources maps have also been drawn. The natural springs with thermal waters and the geological structures with high water temperature have also been mapped (Frasheri A. 1992, Frasheri A. et al. 1995). The water basins with higher average temperature than that of yearly average in one of the regions has been studied as well. The study of the possibility of exploitation of abandoned deep oil wells as “Vertical Earth Heat Probes” has already begun.

2.2 Geothermal Features

The Albanides form an integral part of the southern branch of the Mediterranean Alpine orogen. They are subdivided in two zones: the Internal and the External Albanides. The geology of Albanides creates the premises for the research and exploitation of natural geothermal energetic resources.

The greatest heat flow density with a value of 42 $mW \cdot m^{-2}$ is found in the center of the Preadriatic Depression (Fig. 1). In the east of the ophiolitic belt heat flow density reaches values of up to 60 $mW \cdot m^{-2}$.

The temperature at a depth of 100m ranges 6.7 to 18.8°C, in average 16.4^{o}C (Fig. 2) and at a depth of 500m from 21 to 27.7°C.The temperature ranges up to 105.8°C at a depth of 6000m. In the central part of the Preadriatic Depression, there are many deep oil wells where the temperature reaches up to 68°C at a depth of 3000m (Fig. 3).

The geothermal gradient has the highest value about 18.7 $mK \cdot m^{-1}$ in the center of the Peri Adriatic Depression. Elsewhere the gradient is mostly 15 $mK \cdot m^{-1}$ (Fig. 4, 5). In the south of the country the geothermal gradient has low values 11.5-13 $mK \cdot m^{-1}$. Towards the northeastern and southeastern regions of Albania, over the ophiolitic belt, the geothermal gradient increases, reaching the value of 23.5 $mK \cdot m^{-1}$.

2.3. Geothermal Areas and Reservoirs

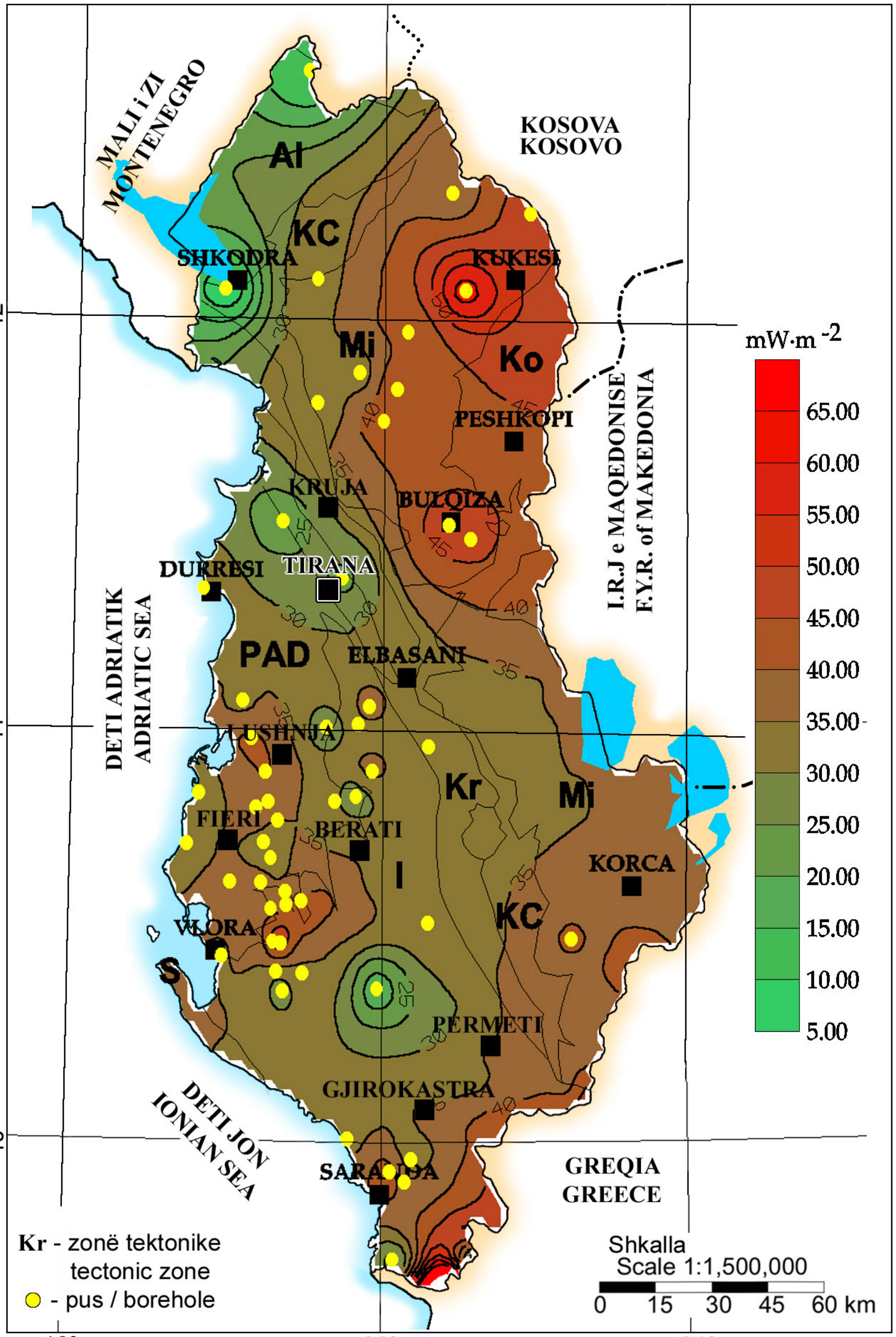
In Albania there are many thermal springs and wells of low enthalpy (Fig. 6, Tab. 1) (Frasheri A. et al. 1997, 2004) .

Tab. 1

Thermal water sources and wells in Albania

Type of the source	Location	Tempe-rature, (°C)	Salt, (mg/l)	Yeild, l/sec
Natural Spring	Llixha Elbasan, Peshkopi, Krane (Sarande), Langaric (Permet), Shupal (Tiranë), Sarandoporo (Leskovik), Postenan (Leskovik) Tërvoll (Gramsh), Mamurras (Tiranë).	21-60	0.3-26	10-40
Deep wells	Peri Adriatic Depression and in the Kruja tectonic zone	29.3-65.5	1-19.3	0.9-18

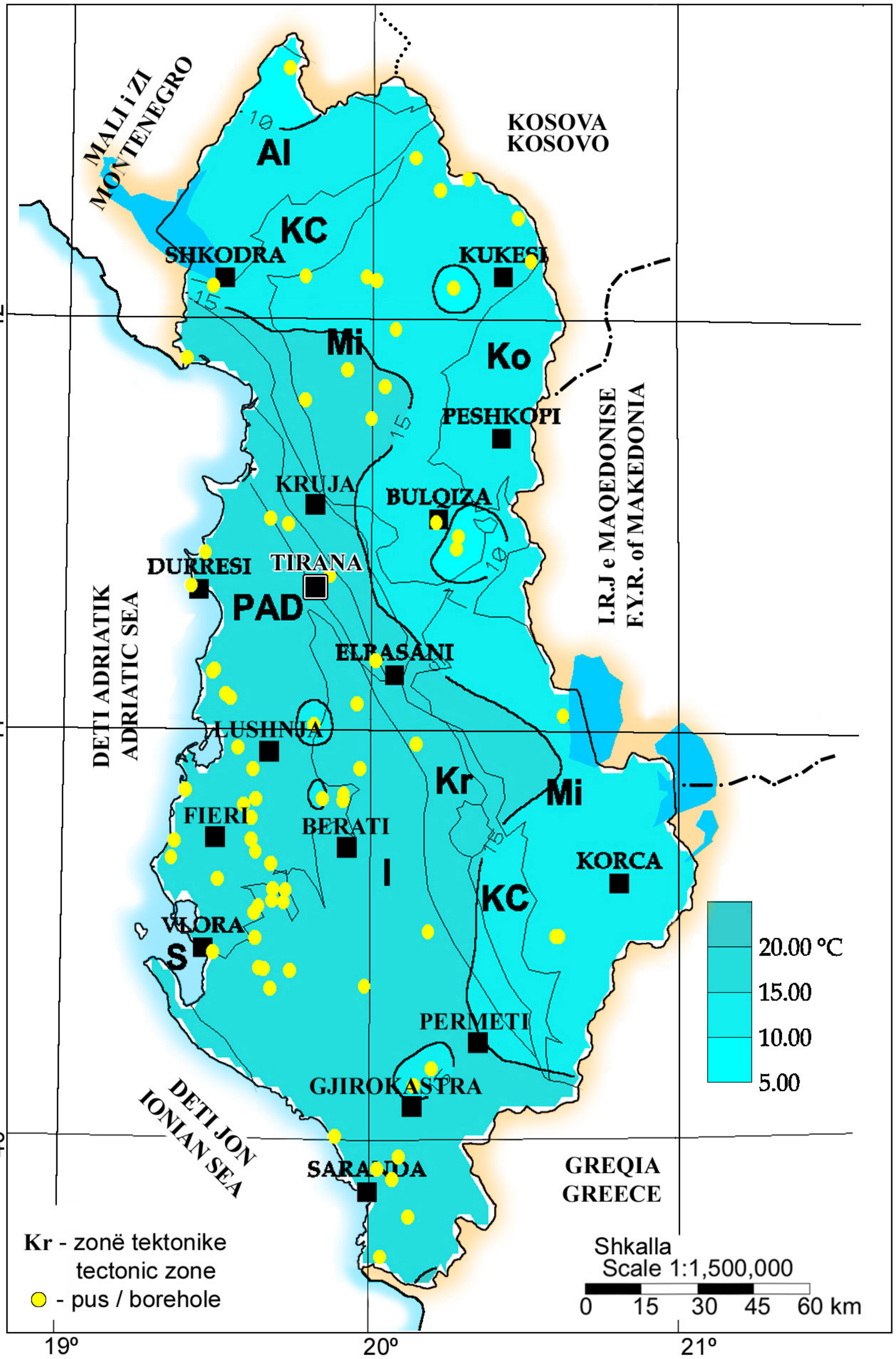
These thermal water springs and wells are mainly near zones of regional tectonic fractures. Generally the water circulates through carbonatic rocks of the structures and evaporitic beds at some kilometers of depth. The water of these springs contains salt, absorbed gas and organic matter. They are sulfide: methane, iodine-bromium and sulfate types. The waters come from different depth levels (800-3000 m) of limestone reservoirs and sandstone reservoirs. Thermal sources are located in three geothermal zones (Fig. 6):



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fig. 1

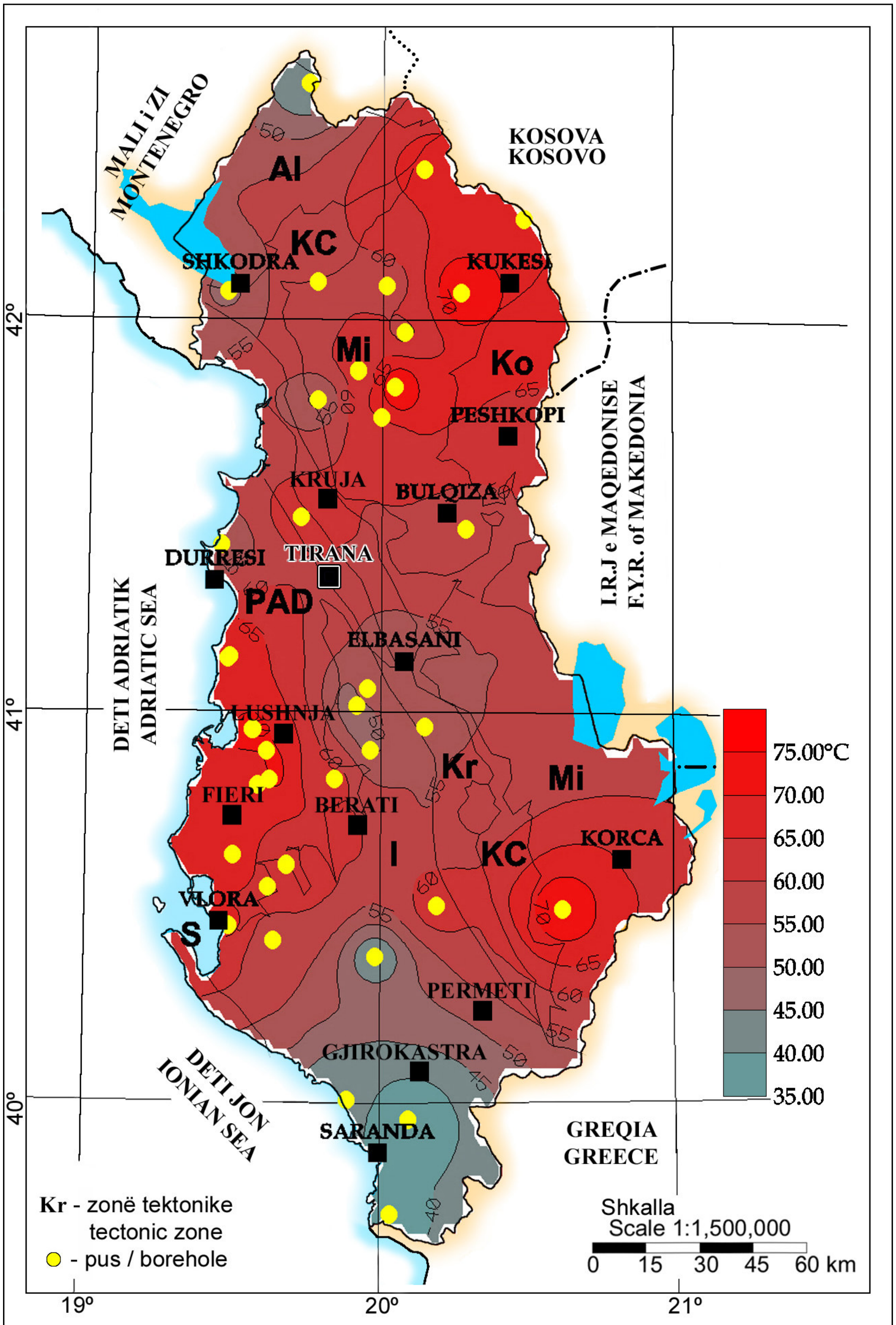
Fleta / Plate 16



Harta e temperaturës në thellësinë 100m
Temperature Map at the depth 100m

Fig. 2

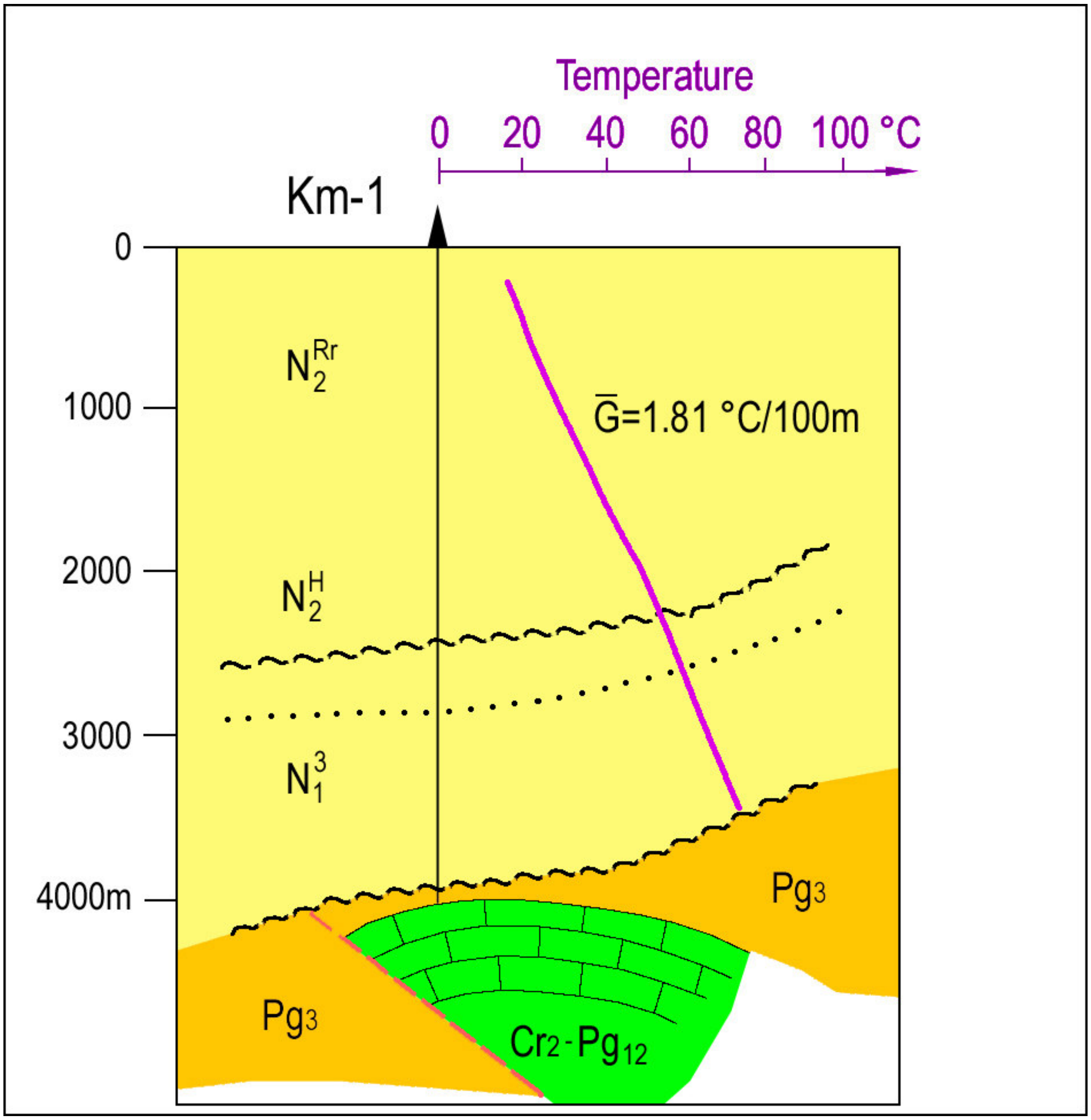
Fleta / Plate 7



Harta e temperaturës në thellësinë 3000m
Temperature Map at the depth 3000m

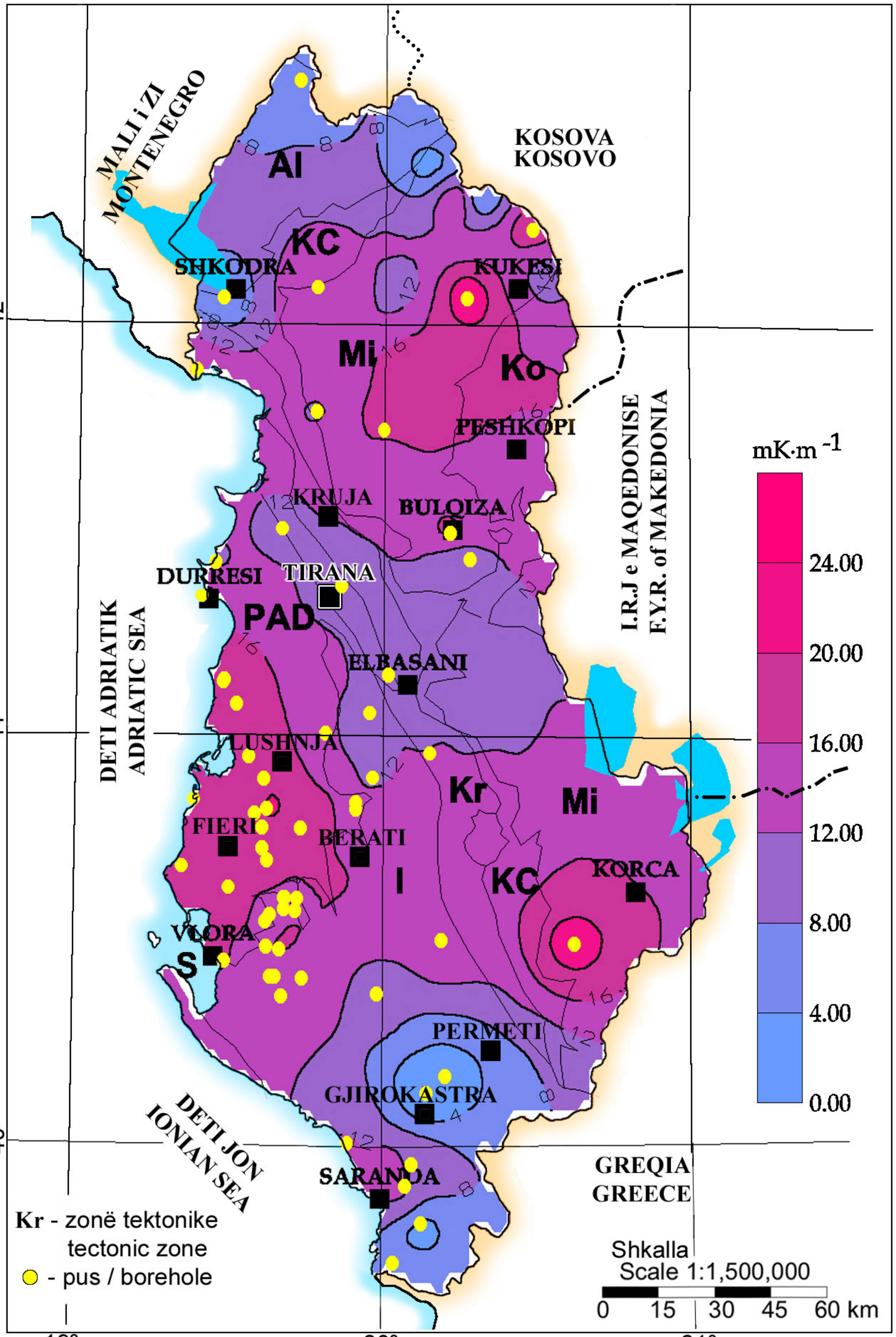
Fig. 3

Fleta / Plate 12



Temperature
0
20
40
60
80
100 °C
Km-1
0
1000
2000
3000
4000m
N_2^{Rr}
$\bar{G}$=1.81 °C/100m
N_2^H
N_1^3
Pg_3
Pg_3
Cr_2-Pg_{12}

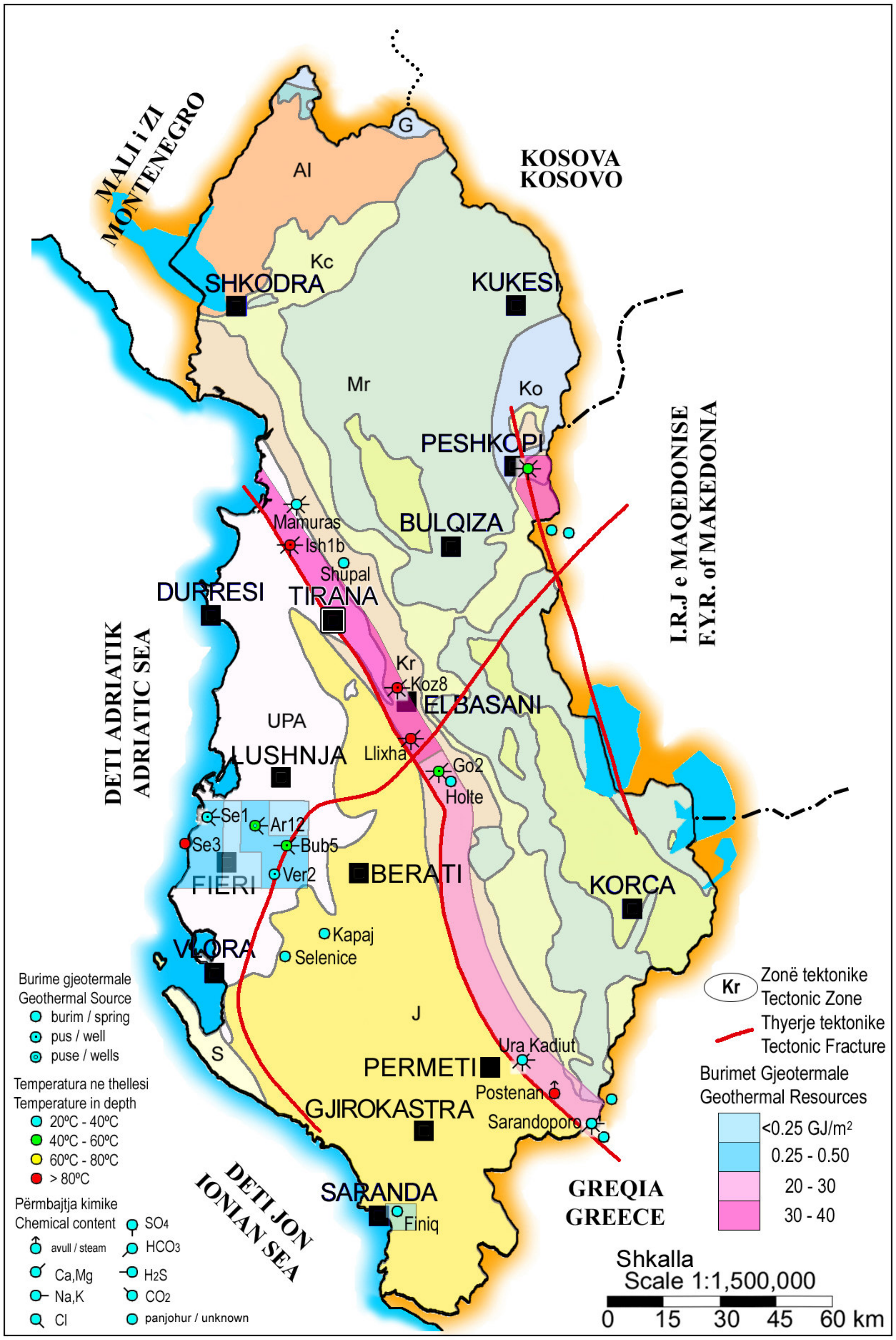
Fig. 4



Harta e gradientit gjeotermal mesatar
Average Geothermal Gradient Map

Fig. 5

Fleta / Plate 13



Harta tematike gjeotermale
Geothermal Thematic Map

Fleta / Plate 17

Fig. 6

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Identified resources in carbonate reservoirs are $5.9x10^8$-$5.1x10^9$ GJ,
Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.
Peshkopia gjeotermal zone at northeastern area of Albania. Several springs are located with disjunctive tectonics of the gypsum diapir.

3. DIRECTIONS FOR THE EXPLOITATION OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers following directions for the exploitation of geothermal energy, which is unused until now. This exploitation will realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of this energy (Frasheri A. 2000, Frasheri A. et al. 1997).

- **Firstly,** space heating and cooling using ground heat by the Borehole Heat Exchanger (BHE), in the shallow (about 100 m depth) boreholes.

- **Secondly**, thermal sources of low enthalpy and of maximal temperature up to 80°C. These are natural sources or wells in a wide territory of Albania, from the South near Albanian-Greek boundary to Northeast districts in Diber Region.

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

1. Modern SPA clinics for treatment of different diseases and hotels, with thermal pools, for development of eco-tourism.

Such centers may attract a lot of clients not only from Albania, because not only the good curative properties of these waters but also because they are situated in nice places near sea side, mountains or Ohrid lake. In the present some SPA, with a primitive technology, worked in some geothermal springs and wells in Albania.

2. The hot water can be used also for heating of hotels, clinics 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 built the 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 creams for the treatment of many skin diseases as well as for beauty care products. From these waters it is possible to extract sulphidric and carbonic gas. It is possible to built installations for processing of mineral waters.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this energy, achieving a 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.

- **Secondly,** 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 $mK \cdot m^{-1}$. 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 of these wells, can be build greenhouses.

Actually in Albania the study of the possibilities of exploitation of the geothermal energy has begun. Based on the above analysis, for the best area selected, a Feasibility Study will be 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.

4. ALBANIAN GEOTHERMAL ENERGY MARKET

Objectives of market study:

- Evaluation of present status of geothermal development in Europe, particularly in Balkan countries, regarding promotion activities, results, application, barriers for market penetration, legal and financial framework, etc.
- Comparison of present status between the different Albanian regions.
- Identification of the attitude and feelings (awareness, knowledge, preference, etc.) for the target groups towards geothermal energy.
- Identification of the attitude and feelings of the target groups towards environmental aspects of geothermal energy.
- Evaluation of the outcome of promotion methods adopted by EU and national institutions.
- Formulation of proposals for effective promotion strategies for geothermal energy in Albania.

Amend above proposals in order to transform them to effective promotion strategies for geothermal technologies in Albania.

4.1. Space heating and cooling

The energy crisis prevailing in the Albania, the increased demand in energy for heating and cooling of premises. Actually, the electric energy consummation for heating is 1 375 GWh/year, or 23.8 % of the total electric energy production in Albania (Fig. 7) (National Agency of Energy, Tirana, 2003). The situation becomes more problematic because the use of natural gas for heating emits large quantities of CO_2 in the atmosphere.

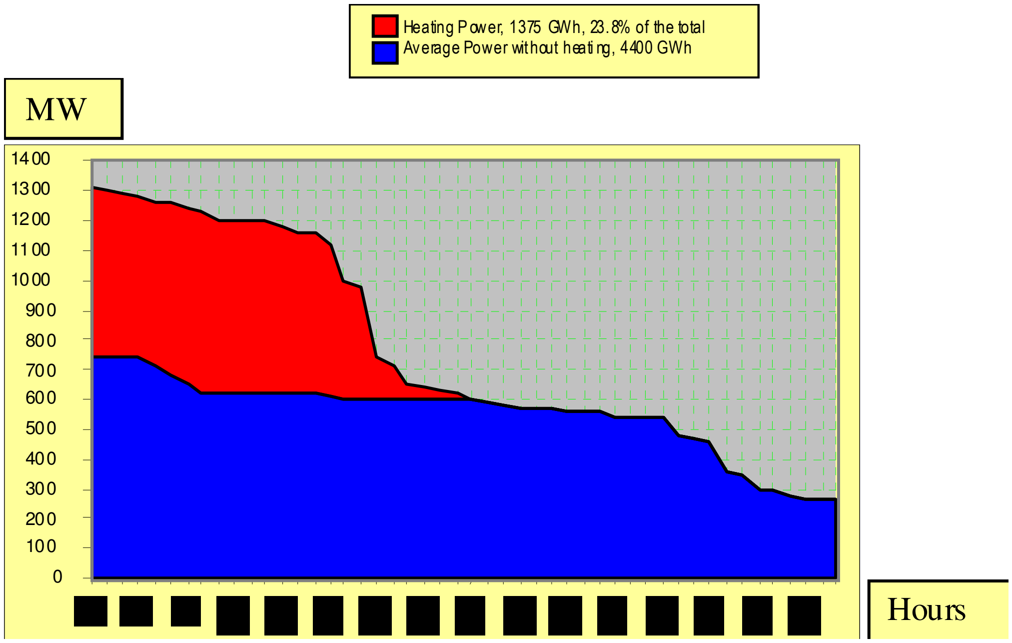


Fig. 7. Consummation for heating is 1 375 GWh/year, or 23.8 % of the total electric energy production in Albania

Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump represents a modern system for space heating and cooling. Two types of shallow heat sources exist: ground heat and underground waters heat. Consequently two kind of technology is possible to applied:

Firstly, ground-source and Borehole heat Exchanger-Geothermal Heat Pump or ground-couplet (closed loop) (Fig. 8),

Secondly: underground water system – Geothermal Heat Pump (open loop). Ground coupling is used where insufficient well water is available or where quality of the well water is a problem.

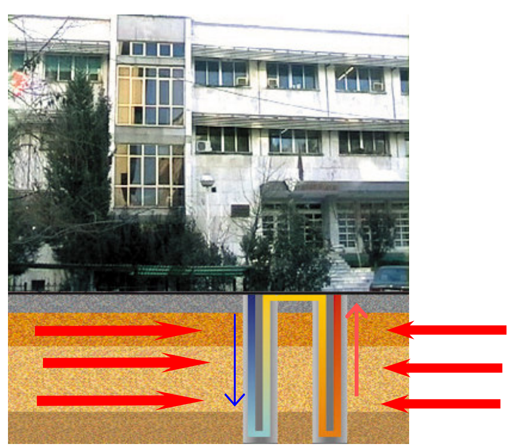


Fig. 8. Borehole Heat Exchanger-Geothermal Heat Pump System

In order to make use of this renewable geothermal energy and environmental friendly ground heat for space heating and cooling in Albania, we have introduced the idea of building a demonstrative installation for heating and cooling purposes in Tirana (Frasheri et al. 2003). It will contribute in solving the problematic issue of heating and cooling of premises in Albania.

Heat quantity, temperature at Earth surface, and geothermal gradient in shallow geological section, are conditioned by geographical location, geomorphological conditions, ground and bedrocks lithology, specific heat and humidity, seson and weather. According to the multy annual meteorological surveys result that in average is 140,000 calory.cm^{-2} heat from solar radiation of the ground during the summer at the plane areas of the Albania. Heat quantity reaches 120,000 calory.cm^{-2} at noertheaster mountains regions [Gjoka L., 1990].

There are some particularities in the distribution of the temperature at the depth 100m (Fig. 2):

Temperature in subsurface ground at littoral area:
Minimal temperature is 16.60 ^oC
Maximal temperature is 18.80 ^oC
Average temperature is 17.80 ^oC

Temperature in subsurface ground at western plane-hilly area:
Minimal temperature is 17.15 ^oC
Maximal Temperature is 18.41 ^oC
Average Temperature is 18.0 ^oC

Temperature in subsurface ground at hilly-mountains regions:
Minimal temperature is 6.70 ^oC
Maximal temperature is 18.60 ^oC
Average temperature is 14.75 ^oC

In plane area of Albania, example in the Tirana field (Rinasi), the temperature is 15.5 ^oC, up to logging depth 31 m, in the Quaternary deposits (Fig. 9) (Frasheri et al. 2003).

According to the analyse of the geothermal regime of the shallow geological section is concluded that is possible to use the ground heat for the space heating and cooling, applied modern Borehole Heat exchanger – geothermal Heat Pump.

Ground geothermal energy has heated the underground water reservoir (Fig. 10). In Tirana underground water basin are following temperatures:

Water temperature of the Quaternary gravel layer is 14-15 ^oC,
Water temperature of the Quaternary sandstone layers is 15-16^oC

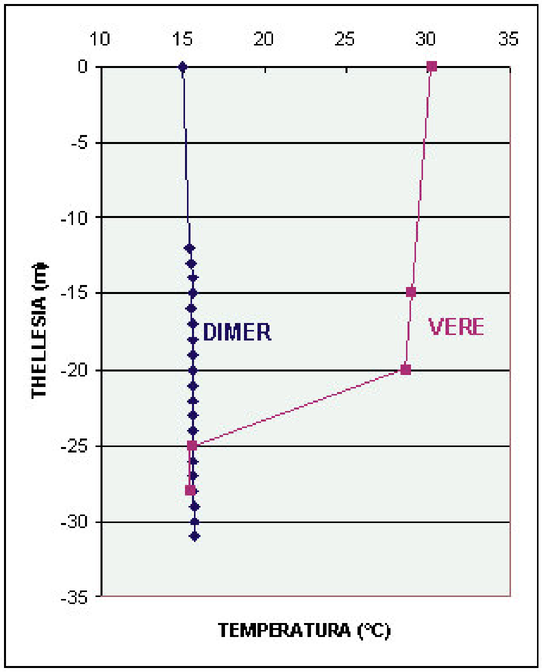


Fig. 9. Ground temperature at Tirana Area

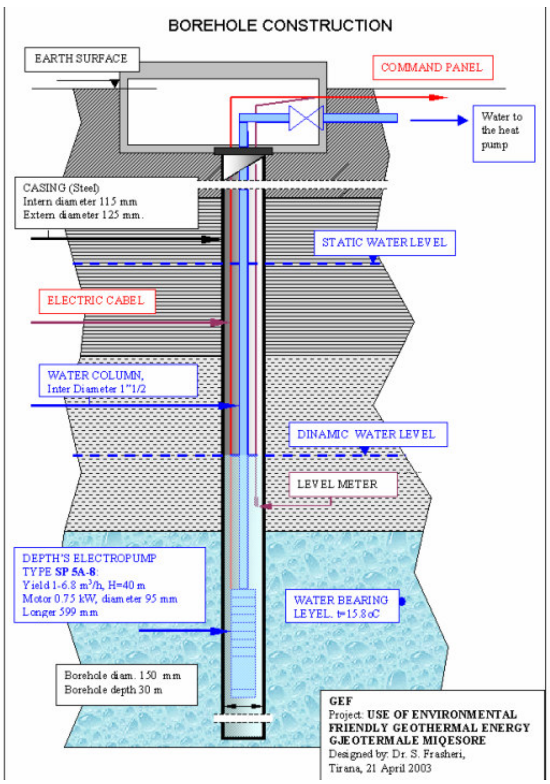


Fig. 10 . Borehole in underground water basin in Tirana region

Consequently, concluded that water of the Tirana underground basin can be a heat source for the geothermal pumps.

COST FOR HEATING SYSTEMS

Total surfaces of 3 floors 610 m^2, 20 rooms, 3 halls.

Heating: by heat conveying-radiators

Heating Capacity 68.5 KW

Installation cost	**Total,** (in Euro)	**Specific,** (in Euro/m2)
- Borehole-Geothermal Heat Pump	43.000	71,66
- Gas boiler	21.000	35,00
- Air-Air conditioners, type "General"	15.600	26,00

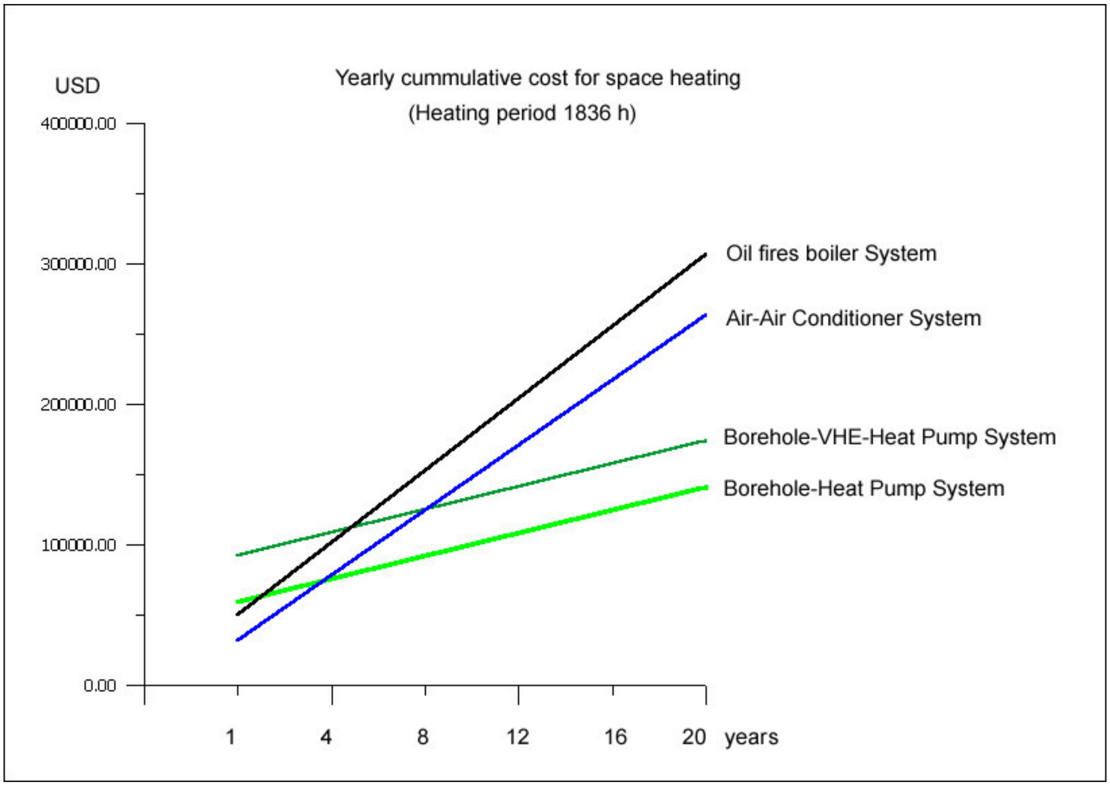
Yearly of the electrical energy or gas consumption and cost:

a) Borehole-Geothermal Heat Pump	42.447 KW	4.295 Euro
b) Gas boiler	15.654 Liter gas	14.089
c) Air-Air conditioners	119.340 KW	11.982
d) Electrical heat conveying-radiators	175.500 KW	17.480

Yearly cost of heating energy:	**First year**		**Second year**	
	In Euro/KW	in - Euro/m^2	in - Euro/KW	in - Euro/m^2
Borehole-Geothermal Heat Pump	691,4	77,5	62,7	4,07
Gas boiler	513,2	57,5	205,9	23.09
Air-Air conditioners	403,2	45,2	175,2	19,64

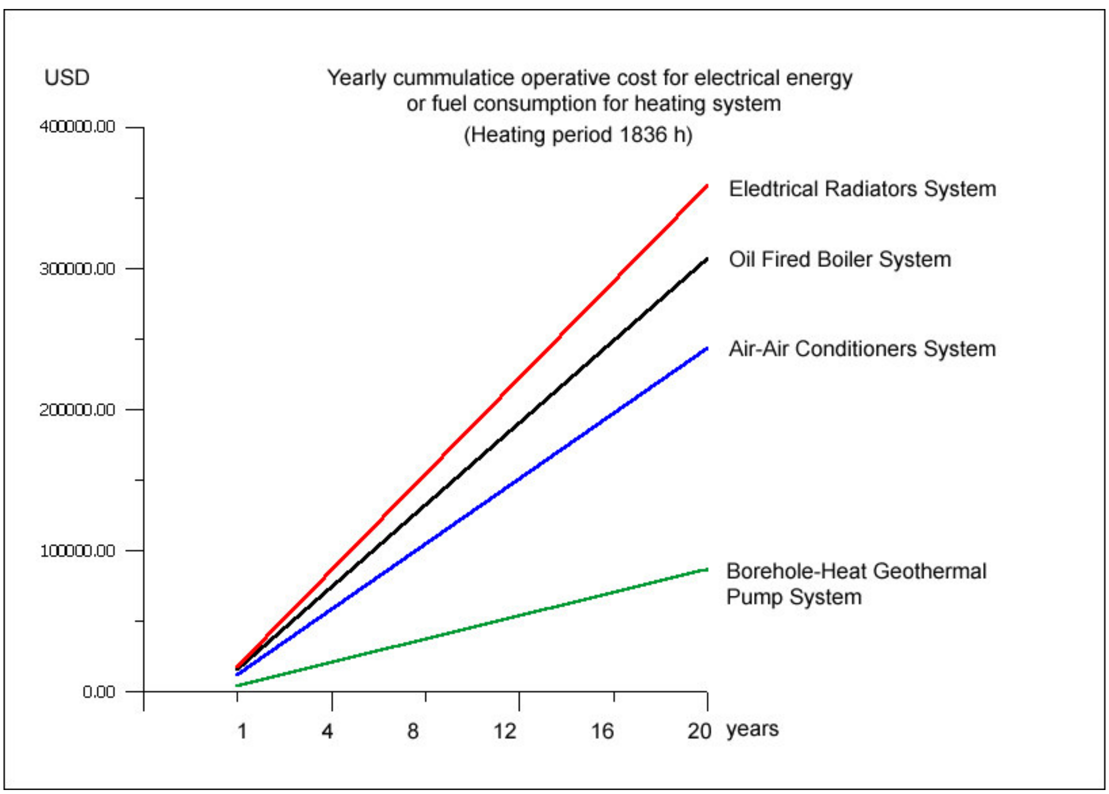
Payback period for installation of the "Borehole-Geothermal Heat Pump" System investment:

Payback period for installation of the "Borehole-Geothermal Heat Pump" open loop system is 3 years. Payback period will be 6 years for "Borehole-Vertical Heat Exchanger-Heat Pump" closed loop system.



USD
Yearly cummulative cost for space heating
(Heating period 1836 h)
400000.00
300000.00
200000.00
100000.00
0.00
1
4
8
12
16
20
years
Oil fires boiler System
Air-Air Conditioner System
Borehole-VHE-Heat Pump System
Borehole-Heat Pump System

Fig. 11.



USD
Yearly cummulatice operative cost for electrical energy
or fuel consumption for heating system
(Heating period 1836 h)
400000.00
300000.00
200000.00
100000.00
0.00
1
4
8
12
16
20
years
Eledtrical Radiators System
Oil Fired Boiler System
Air-Air Conditioners System
Borehole-Heat Geothermal
Pump System

Fig.12.

In fig 13 is presented the graphic of the cost of space heating for different heating systems (in USD/kW). According to this graphic results that geothermal heating and cooling system is more economic system.

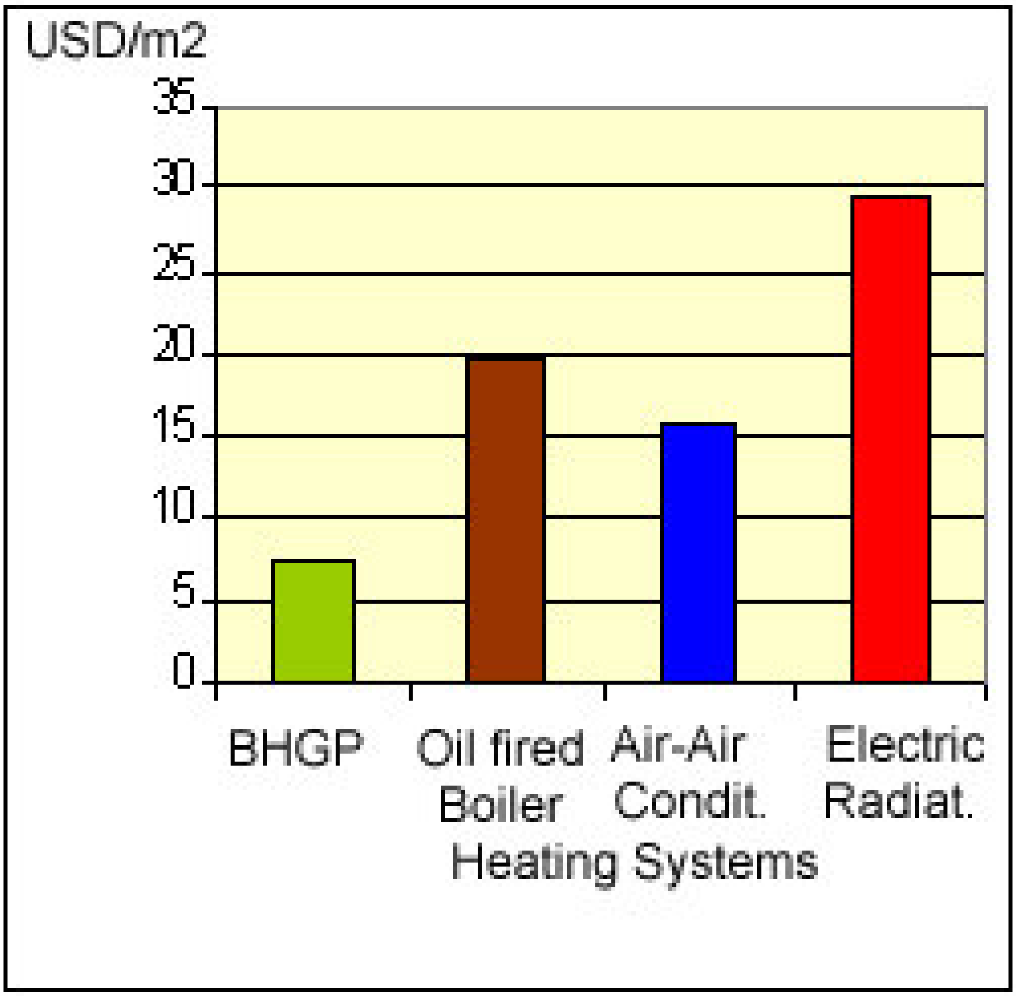


Fig. 13. Cost of space heating for different heating systems (in USD/m^2).

1- Geothermal System; 2- Oil Fired Boiler System; 3- Air-Air Conditioner System; 4- Electric Radiator System.

4.2. Consumers for geothermal energy & thermal water (heat, spa, cooling, power production, drinking water, aquaculture, agriculture)

At the present, some spa, with a primitive technology, worked in geothermal springs and wells in Albania: Lixha Elbasani (Photo 7), Bilaj Balneological Center (Ishmi 1/b well) (Photo 8), Peshkopia (Diber district) SPA (Photo 9), Sarandaporo (Leskovik Disrict) SPA, Langarica-Ura Kadiut (Permeti District) SPA.

The oldest and important is **Elbasani Llixha SPA,** which located about 10 km south of Elbasani city and 61 km in southeast of Tirana, in the Central part of Albania. By national road communication, Llixha area is connected with Elbasani and Tirana. Only 10 km will be from the highway Durresi- Skopje- Sofia- Istanbul, which is projected for construction in the future and nominated as No. 8 European Corridor. The proximity with highways create great possibilities for Elbasani Lixha SPA to be a nice place. This area may be frequented by a large number of people from different Balkan countries, Italy, UK, Germany, Ostrich, France, Low Countries, and by Albanians from Albania, Macedonia and Kosovo as well. These thermal springs from about 2000 are know years ago. According to historic data, in Elbasani Llixha thermal springs there has been an inn, near of the old road “Via Egnatia" that has passed from Durresi to Constantinople.

Llixha Elbasani Geothermal Springs Area

There are seven spring groups that extend like a belt with 320^{o} azimuth. Surface water temperature is about 60^{o}C and yield in total 15 l/sec. Springs have constant hot water yield and temperature for a long period of time. These data are evidence of a stable thermo-hydrodinamic reservoir regime.

Before the Second World War, in one from the springs (“Nosi spring”) has been constructed “ PARK-NOSI” SPA (***), with 166 beds, for medical treatment of various diseases, generally rheumatic. The "NOSI" SPA functioned during a period of time more than 60 years and for the present is private property. Land with surface of 20 000 m^2, hotel and restaurant are owned by PARK NOSI Sh.p.k.. Particularly reconstructed hotel after the privatization actually is in work. Near this property there is located a public hotel, with 180 beds, almost in destruction state, but which may be reconstruct.

Park Hotel SPA at Llixha Elbasani Geothermal Springs

Albanian patients treated for rheumatism and various illnesses in Elbasani Lixha SPA are:

in 1990	7899 persons (Public two hotels)
1994	3603 persons (after the privatization, only in Park NOSI Hotel)
2002	1800 persons, generally retained seek people (only in Park NOSI Hotel. In Elbasani spa actually are three hotels).

The price in PARK-Nosi SPA, for day's treatment (hotel, meal and treatment) in SPA, for Albanian patient, in actual economical situation, is 10 USD/day, (VAT Is included in the price). This is a more chipper price compared with hotels in Elbasani city, regarding accommodation and breakfast only. From 40 to 240 USD per dayare actually the price in Tirana hotels. About this price, it is necessary to expose the following: In the future, the increase of price for daily treatment of the patient in spa, will be increase also the profit, according to:

Firstly, improvement of the medical treatment, of the accommodation and food conditions in the spa. SPA will be visited by Albanian or foreign tourists, not only olld and retired perople, like at the present.

Secondly, from foreign and Albanian patients, the spa frequenting demand will be increase, according to new situation of the supply and demand.

Thirdly, the life level of Albanian people will be higher. Spa will be frequenting by Albanians from Macedonia and Kosovo, which have more high economic level.

Land price in Elbasani region, in 1996, has been 5-7 USD/m^2.

Actually, is not a law for thermal waters in Albania, last year has been prepared the draft of the law. The PARK NOSI Sh.p.k. Llixha Elbasani, is using thermal spring as ex-owner of spa before the Second World War. SPA in Ishmi well area and Sarandaporo spa have been private in 1993 and 1998 respectively.

All seven groups of the springs in Llixha Elbasani and Kozani-8 well geothermal area will have the possibilities for modern complex exploitation. The beautiful landscape of Elbasani Lixha area will be not only for medical treatment but also as tourist place. This area located near of the very know Ohrid Lake pearl or mountains Gjinari, with their fantastic forests and nice climate. Ishmi 1/b geothermal well is located in beautiful Tirana field, near of "Mother Theresa" Rinasi (Tirana) Airport, near of the Adriatic coastline and Kruja - Skendergeg Mountain. There are all the possibilities for the echo-tourism development: thermal water, Ishmi beach at the Adreatic Sea , and mountain's area.

Benja and Sarandaporo thermal water areas and Postenani steam springs are located near of the beautiful Vjosa River valley. Peshkopia geothermal springs area is located near of the Korrabi Mountain, higher mountain in Albania (2753m). The beautiful landscape of Vjosa valley, near Albanian-Greek border, and Peshkopia area near of the Debar region in Macedonia, will be not a thermal water bearing place for medical treatment but also as tourist place.

Benja Geothermal Springs Area

Postenani Steam Springs Area

7

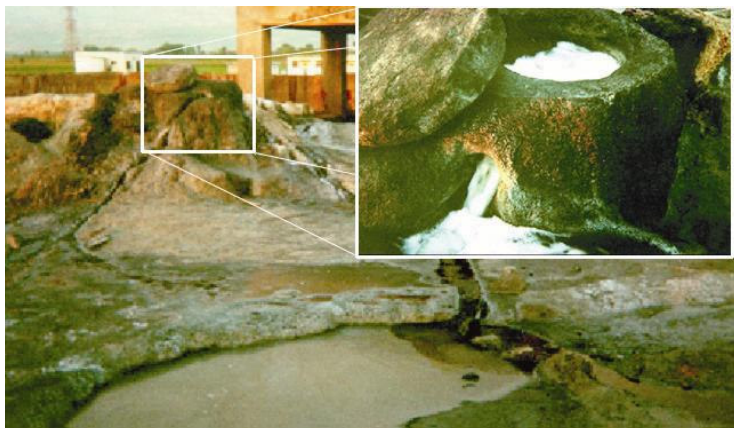
Sarandaporo Geothermal Springs Area

Geological risk, financial possibilities to cover geological risk

No geological and financial risk for the exploitation of thermal water of geothermal springs and wells in Albania.

Traffic connections: roads, railways, navigation, and possibilities for transport of heavy goods

The **Ishmi-1/b well** is located in Ishmi area and represents the northernmost geothermal well of the Kruja geothermal area. It is located in 20 kilometers NW of Tirana (near of "Mother Theresa" Tirana Airport). By national road communication, Ishmi 1/b well is connected with Tirana, Tirana Airport, Durresi and Shkodra cities.



Kozani-8 well is located 35 kilometers southeast of Tirana, on hill's area. Well connected by 1.7 km road with Tirana-Elbasani national road, and hightway "Corridor 8" Durresi-Elbasan-Skopje. One km from Kozani 8 well located Saint George Vladimir Monastery.

Elbasani Llixha SPA is located about 12 km south of Elbasani city and 61 km in south-east of Tirana, in the Central part of Albania. By national road communication, Llixha area is connected with Elbasani and Tirana. Only 10 km will be from the highway Durresi- Skopje- Sofia- Istanbul, which is projected for construction in the future and nominated as No. 8 European Corridor. These thermal springs from about 2000 are known years ago. According to historic data, in Elbasani Llixha thermal springs there has been an inn, near of the old road "Via Egnatia" that has passed from Durresi to Constantinople.

Peshkopia geothermal springs are connected with Tirana by national road (182 km).

Peshkopia Geothermal Srings Area

Peshkopia SPA

Benja-Langarica, Postenani and Sarandaporo geothermal springs areas are located near of the national road Tirana-Permeti (about 217 km)-Konistza (Greece).

5. THE AIMS AND OBJECTIVES OF THE PROJECT FOR DIRECT USE OF THERMAL WATERS OF LOW ENTHALPY

5.1. The aims of the project

To examine, demonstrate and disseminate the positive technical and financial aspects of transfer and utilization of innovative geothermal energy technologies in Albania, which 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.

This development will be achieved in parallel with the reduction of any negative environmental effect, which would have followed this type of development if older geothermal energy technology or even conventional sources of energy were to be utilized. Significant financial, social and technical benefits will arise from the promotion and final application of the results of this project.

5.2. Objectives:

Integrated exploitation and cascade direct use of the geothermal energy has projected.

The objectives of the project:

5.1. **Geothermal energy and mineral water resources evaluation** of country

5.2. **In-situ detailed investigation** of the pre-selected zones with high energy potential & consumers geothermal source, where will installed demonstrative unit.

Among others this task will be concerned with:

-Intentions of users-thermal load inspections
-Initial energy balance analyses
-Thermal characteristics of individual users
-Technical geothermal data collection
-Examination of existing technology

It is necessary to select the thermal applications, which correspond to the local needs. The following will be defined:

a) In situ consideration of geothermal physical-chemical parameters and potential
b) Thermal load demands for space heating for each end-user of geothermal sources:

- Dwellings,
- Geothermal SPA,
- Greenhouses,
- Geothermal pools, etc.,

-. Aquaculture,
- Mineral waters production
- Extraction of the micro-elements and natural salts

b) Energy balance between different end-users,
c) Technologies to be applied
d) Preliminary design of the geothermal energy exploitation system
e) Definition of thermal demands
i) Energy conservation, and
k) Economic evaluation of thermal energy (space heating and hot water production installation cost, life cycle, energy product cost, pay back period). This evaluation will be based on actual market prices for equipment, construction etc.

Based on the above analysis, for the best area selected, a feasibility study will be 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.

5.3. **Environmental protection and preserving** level will be improved, to well assist the echo-system protection of thermal and mineral water source areas.

Among other subjects this phase will focus mainly on:

-Examination of the nature of the geothermal fluid
-Environmental impact of the geothermal fluids during their utilization and disposition
- Selection of the most acceptable environmentally methods for the disposal of the geothermal fluids

5.4. **The concrete detailed design** for the implementation phase of the Project will be prepared.

Task 1. Demonstrative units (pilot plants) will be constructed, monitored and finally demonstrated. These demonstrative units will assist in the promotion of the new innovative technology application facilitating in parallel the transfer of this innovative technology to end users as well as industrial production.

The proposed schemes represent an integrated scheme and cascade scheme for exploitation of geothermal energy. This exploitation will realize by integrated scheme of geothermal energy, heat pumps and solar energy to fulfil. This scheme has an environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme).

Cascade scheme should be used to fulfil the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy and the minimum energy supply from heat pumps: the promotion of energy savings will be in place.

These demonstrative units will make researcher and scientists aware, on-site, of specific plant operational problems, new technology implementation problems and finally assist to their in situ solution.

These pilot demonstrative units will help potential users overcome psychological barriers towards the utilization of new innovative technologies for direct application.

Task 2: A promotion and tourist agency will be organized. This agency will prepare the reclaims and booking of the rooms for Albanian and foreign patients.

6. APPLICATION AND TRANSFER TECHNOLOGY FOR A COMPLEX AND CASCADE EXPLOITATION OF GEOTHERMAL WATERS ENERGY

6.1. **Construction of thermal supply installations**:

1. Installation of pipe – distribution system
2. Heat exchanger
2. Distributors
3. Control Room-Monitoring.

6.2. **Construction of the experimental units** for exploitation of the geothermal energy:

1. Building of spa, with 30-40 beds, for the medical treatment (gynecological and rheumatic diseases),
2. Construction of heating installation in the buildings
3. Construction of the greenhouse for the flower.
4. Construction of the greenhouse for the legumes.
5. Construction of thermal pool for tourists, wardrobe and bar.
6. Installation of equipment for extraction microelements and natural salts.

<u>Feasibility Study</u>

Technical and financial feasibility study for innovative geothermal energy utilization technology applications. Market penetration of geothermal energy.

Economic evaluation should include:

• First investments for the proposed schemes (integrated scheme, cascade scheme);

• Evaluation of thermal energy (space heating and hot water production) unit cost produced by integrated scheme: geothermal energy, heat pumps and solar energy;

• Evaluation of benefits (in financial terms) through comparison with the classical scheme of the proposed integrated and cascades scheme;

• Other benefits will be assessed for example the environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme).

Among others and for one of the two application cases this phase will be examine:

- Preliminary consideration for each case
- Definition of the main parameters affecting each system
- Analysis of the effect of the different parameters
- Selection of the "basic" application cases/techniques

- Design of the system
- Selection of alternative cases
- Final technical conclusions

Based on the above analysis, for the best area selected, a Feasibility Study will be 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.

7. PRELIMINARY COST FOR THE INVESTMENT

Cost estimation is carried out only for the first phases, to realize investment step by step:

No	**Object**	**Cost, in USD**
1	Reconstruction of heating and thermal baths	50 000
2	Construction of two thermal water unit equipment's	80 000
	Construction of green houses, 2 * surface 3 000 m^2	240 000
4	Construction of new SPA Clinic and for new hotel building), (****)	2 200 000
5	Feasibility study and project idea	53 000
9	Other Expenditures	20 000
10	Overhead rate TOTAL exc. VAT	15 000 2 418 000

8. ECONOMICAL-FINANCIAL EVALUATIONS

HOTEL-SPA, First Phase: 25 bed rooms, 40 beds.
Currency: USD Inflation rate: 3.5%

Table 1

Economic bases	Years				
	1st	2nd	3rd	4th	5th
1. Number of rooms (1)	25	25	25	25	25
2. Number of beds	40	40	40	40	40
3. Days of operation	280	280	280	290	290
4. Food&beverages-facilities	280	280	280	290	290
5. Guest structure and room price	100%	100%	100%	100%	100%
6. Average room occupancy	72	74	75	75	75
7. Average room price	50	50	55	55	60

1) Hotel has 15 doubles rooms and 10 single rooms
Rata: Single room 50 USD; Double room 70 USD (Include VAT) (Present room's rate in *** Hotels in Tirana)

Supplementary facilities:

1. Outdoor-indoor thermal & swimming pool
2. Ball sports (tennis, volleyball, basketball)
3. Recreation (sauna, Turkish bath, solarium)
4. Fitness Center with aerobic
5. Restaurant, bar

6. Meeting room
7. Others (rent a car, coiffeur, boutiques)

9. APPLICATION AND TRANSFER TECHNOLOGY FOR A COMPLEX AND CASCADE EXPLOITATION OF GEOTHERMAL WATER ENERGY

9.1. Construction of thermal supply installations:

- Installation of pipe – distribution system
- Heat exchanger
- Distributors
- Control Room-Monitoring.

9.2. Construction of the experimental units for exploitation of the geothermal energy:

- Building of SPA, with 30-40 beds, for the medical treatment (gynecological and rheumatic diseases),
- Construction of heating installation in the buildings
- Construction of the greenhouse for the flower.
- Construction of the greenhouse for the legumes.
- Construction of thermal pool for tourists, wardrobe and bar.
- Installation of equipment for extraction microelements and natural salts.

9.3. Feasibility Study

Technical and financial feasibility study for innovative geothermal energy utilization technology applications. Market penetration of geothermal energy.

Economic evaluation should include:

- First investments for the proposed schemes (integrated scheme, cascade scheme);

• Evaluation of thermal energy (space heating and hot water production) unit cost produced by integrated scheme: geothermal energy, heat pumps and solar energy;

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Among others and for one of the two application cases this phase will be examine:

- Preliminary consideration for each case
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Based on the above analysis, for the best area selected, a Feasibility Study will be 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.

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11. ECONOMICAL-FINANCIAL EVALUATIONS

HOTEL-SPA, First Phase: 25 bed rooms, 40 beds.
Currency: USD Inflation rate: 3.5%

Table 1

Economic bases	Years				
	1st	2nd	3rd	4th	5th
8. Number of rooms (1)	25	25	25	25	25
9. Number of beds	40	40	40	40	40
10. Days of operation	280	280	280	290	290
11. Food&beverages-facilities	280	280	280	290	290
12. Guest structure and room price					
13. Average room occupancy	100%	100%	100%	100%	100%
14. Average room price					
	72	74	75	75	75
	50	50	55	55	60

2) Hotel has 15 doubles rooms and 10 single rooms
Rata: Single room 50 USD; Double room 70 USD (Include VAT) (Present room's rate in *** Hotels in Tirana)

Supplementary facilities:

- Outdoor-indoor thermal & swimming pool
- Ball sports (tennis, volleyball, basketball)
- Recreation (sauna, Turkish bath, solarium)

- Fitness Center with aerobic
- Restaurant, bar
- Meeting room
- Others (rent a car, coiffeur, boutiques)

FINANCIAL BASES

Table 2

Proceeds	%	Years				
		1st	2nd	3rd	4th	5th
1. **Room Rental**	71					
(without breakfast)						
number of rooms		25	25	25	25	25
*day of operation		280	280	280	290	290
=max. room overnight		7 000	7 000	7 000	7 250	7 250
*average room occupancy				75%	75%	75%
=number of room overnight		72%	74%	5 250	5 438	5438
*average room price		5 040	5 180	55	55	60
=**arrangement** (without		50	50	288 750	299 090	326 280
f&b)		252 000	259 000			
2.**Food&beverage**	26					
a) Full Pension		100%	100%	100%	100%	100%
Number of consumptions		7 056	7 252	7 350	7 612	7 612
*Proceeds/guest		10	10	11	11	12
=full pension		70 560	72 520	80 850	80 850	80 850
b)Beverages		21 168	21 756	22 050	22 836	22 836
-full pension (full pens. * 3)						
Total revenues F&B		91 728	94 276	102 900	106 568	114 180
2.**Food&beverage**	26					
b) Full Pension		100%	100%	100%	100%	100%
Number of consumptions		7 056	7 252	7 350	7 612	7 612
*Proceeds/guest		10	10	11	11	12
=full pension		70 560	72 520	80 850	80 850	80 850
b)Beverages		21 168	21 756	22 050	22 836	22 836
-full pension (full pens. * 3)						
Total revenues F&B		91 728	94 276	102 900	106 568	114 180
3. Telephone revenues	3	10 311	10 560	11 750	12 170	13 214
4. Shopping revenues						
5. Other revenues for rental						
TOTAL REVENUES		**354 040**	**363 874**	**403 399**	**417 828**	**458 674**

OPERATING EXPENSES 1.Personnel Expenses number of employed Year's salary per employed Personnel Salary Insurance Personnel Expenses	28. 1	37 1 440 36 000 13 500 67 500	37 1 4040 36 000 13 500 67 500	37 1 560 39 000 14 625 72 345	37 1 560 39 000 14 625 72 345	37 1 620 40 500 15 187 75 127
2. **Cost of goods sold**	19. 1	45 864	47 138	51 450	53 284	57 090
3. F&B for the personnel (3 USD/day)	13	31 500	31 500	32 625	32 625	32 625
4. Direct expenses Phone+fax; laundry+cleaning	3	7 080	7 277	8 068	8 356	9 073
5. Indirect Expenses - energy, water - Maintenance - Small wares - Travel expenses - Insurance - Advertising - Marketing+Management - Office material - Bensol - Transport ***TOTAL***	11. 9	28 677	29 474	32 675	33 844	37 152
VAT, 20%		59 511	61 164	67 969	70 402	77 565
TOTAL OPERATING EXPENSES		**240 132**	**244 053**	**265 132**	**270 856**	**288 632**
GROSS OPERATING PROFIT		**113 908**	**119 821**	**138 267**	**146 972**	**170 042**

REPAYMENT OF THE CREDIT

Table 3

Moderate credit 1 300 000 USD
Interest: 3%
Repayment period 15 years

Financial bases	Years				
	1st	2nd	3rd	4th	5th
GROSS OPERATING PROFIT	113 908	119 821	138 267	146 972	170 042
Interest			39 000	39 000	39 000
Credit repayment	101 908	104 821	83 095	89 972	112 042
Cumulating credit repayment	101 908	206 729	289 824	379 796	491 838
Cash flow	12 000	15 000	17 300	18 000	19 000

Financial bases	Years				
	6th	7th	8th	9th	10th
GROSS OPERATING PROFIT	170 042	170 042	170 042	170 042	170 042
Interest	39 000	39 000	39 000	39 000	39 000
Credit repayment	112 042	112 042	112 042	112 042	112 042
Cumulating credit repayment	603 880	715 922	827 964	940 006	1 052 048
Cash flow	19 000	19 000	19 000	19 000	19 000

Financial bases	Years				
	11th	12th	13th	14th	15th
GROSS OPERATING PROFIT	170 042	170 042	170 042	170 042	170 042
Interest	39 000	39 000	39 000		
Credit repayment	112 042	112 042	23 868		
Cumulating credit repayment	1 164 090	1 276 132	1 300 000		
Cash flow	19 000	19 000	19 000	170 042	170 042

payback is 13 years for one hotel-SPA for first their phase, 40 beds (25 rooms), for one moderate credit of 1 300 000 USD.

12. WORK PROGRAMME

Methodology

This project must be implemented during the 3 years period, by the integration of the following phases:

FIRST PHASE.

The project must be realized using a complex of modern methods according to the objectives:

1. Complex and integrated study of all geothermal data on resources of geothermal energy in Albania:

- Integrated geothermal, hydrogeological, hydrochemical surveys in the sources and wells of geothermal energy.
- Mathematical modeling for calculation of potential of geothermal energy in Albania, as well as for the study of reservoirs.
- Geothermal and mineral water resources detailed feasibility study will be carried out in geothermal area. Project idea will be compiled, too.
- Technical projects will be compiled for investments in more perspective areas.

6 months

SECOND PHASE. 1. Construction of thermal water unit equipment in geothermal springs and wells.

2. Heating system, the thermal water unit equipment and

baths must be reconstructed in existing Hotels SPA. After second phase, all year SPA frequenting will realize. During the winter there are more demands for the medical treatment.

Good conditions in the SPA will help to have patient numbers increasing.

2. Green house, up to 3000 m^2 surface, must be constructed in the territory of thermal springs and wells

6 months

THIRTY PHASE: New Hotels-Clinic SPA hotel construction of (****) in geothermal areas. For the first time, the SPA Clinic and the hotel will have two or three floors, with the possibilities to build and 2 or three other floors in the future. In the ground floor will be located the restaurant, bar, medical clinic and thermal baths. Bedrooms will be located in the first and second floors. Thermal swimming pool will construct in the ground floor or in the yard.

24 months

FOUR PHASE: 1. Unit equipment for the extraction of chemical microelements and salts, CO2 and H2S gas will be designed and installed.

2. Unit equipment and collector for treatment and clearing the thermal water before their outflow will be designed and installed, to protect echo-system of the area.

3. Promotion and tourist agency will be organized. Put in full efficiency of all complex of the SPA will be completed.

10 months

13. ECONOMIC EVALUATION OF THE PROPOSED SCHEME FOR SPACE HEATING AND COOLING

A preliminary budget of the scheme Open loop: Borehole - Geothermal Heat Pump System for the one private residence. Two floor building has a total surface 460 m^2.

- Geothermal Heat Pump, with a heating capacity 42 kW, and cooling capacity 38 kW, after DELTA TECHNIKI Ltd Athens Greece, Athens, Greece price: 5 500 USD/unit
- Installation of the Geothermal Heat Pump System 1 800 USD
- Heating and cooling equipment (Fan-Coils, pipes etc) and its installation in the room 16.7 USD/m^3, for 1380 m^3 for all building 23 046 USD
- Providing water to the geothermal heating pump and re-injection of water in the collector after the use (Circulating pump, pipeline), according to the price index in Tirana: 7 500 USD.

Total 37 846

- Expenses for electrical energy, for 24 hours non-stop use of the heating and cooling system:
    - Water circulating pump 6 570 kWh/year.

- For Coefficient of Performance of the system C= 4, 87 600 kWh/year,

Total 94 170 kWh/hour or 23.3 Wh/m^2

After the literature data, in Switzerland for heating of a private residence, with geothermal pumps, the installation costs is 28 500 Swiss Francs, whereas the heating of a residence by gas boiler costs 21 000 Fr. (Rybach L. et al., 1995, 2000).

Direct use of the Geothermal Energy in Albania must start as soon as possible, first of all for the solving of the space heating and cooling. Will be high economic effectiveness investment.

14. ECONOMIC EVALUATION OF THE PROPOSED SCHEME FOR GREENHOUSE CONSTRUCTION

Economical evaluation has been performed for the construction of the industrial glass greenhouse, with sections 3.20 x 3.00 = 9.60 m^2, and surface 500 m^2 (0.05 ha). Water source-heat pumps system will be used for greenhouse heating. Ten l/sec of water, by the temperature 15-16 ^{o}C, from the underground basin at the depth of 30 m, will be used for the heat pump supply.

14.1. Greenhouse construction costs:

- Construction works, greenhouse heating system equipment, ventilation equipment, irrigation equipment, electric equipment, in total

7 655leke x 500 m^2 = 3 827 500 leke or 32 000 USD

- Borehole, circulating line, heat pump and re-injection borehole**: 2 207 385 leke**

in total : 6 034 885 leke 50 300 USD or 100.6 USD/m^2.

For 15 year payback period, can be estimate that in Albania, annual construction costs will be:

402 325 lekë/year or **3 353** USD/year.

After Rafferty K., Boyd T. economical analysis (1997) result that:

- Greenhouse costs (include greenhouse and equipment) 122 – 153 USD/m^2
- Construction costs 78 - 87 USD/m^2

14.2. Operative expenses in the greenhouse:

Operative expenses in the greenhouse, in the relation to the total expenses, have this annual structure(Rafferty K., Boyd T):

•	Work	40 – 50%	27.8 USD/m^2
•	Plants and materials	16 – 25%	13.4
•	Heating, electric energy, lighting, water	6 – 16%	7.2
•	Credite and siguracioni payments	17 – 19%	11.8
•	Miscellaneous	8 – 10%	5.2
		Total	**65.4** USD/m^2

After Albanian farm experience total operative expenses for the projected greenhouse with a surface 0.05 ha, these expenses can be **45000** lekë/year**.**

Feasibility study:

1. ***Greenhouse expenses:***

- Construction 402 325 lekë/year
- Total operative expenses 45 000 lekë/year
- Electric energy expenses:
  - Heat pump system:
    83.5 kWh x 376.8 orë x 9 lekë = 282 564 lekë/year
  - Water circulating pump:
    4.2 kWh x 376.8 x 9 lekë = 14 243 lekë/year

Total annual expenses for the projected greenhouse are 744 132 lekë or **6 200** USD

2. Greenhouse production:

Kind of production: Tomato. Greenhouses produce in Albania is 2000 kv/ha.year. Average price is 111.1 leke/kg. Consequently for the 0.05 ha greenhouse production income will be:

1 111 000 lekë/year or **9 258** USD/year.

Consequently for projected greenhouse, with a 15-year payback, result that:

- Income 9 258 USD/year
- Expenses 6 200 USD/year

Consequently, geothermal heating greenhouses represent an economic effective investment. Normally, the incomes will be bigger for the flower or olive plant cultivation in the greenhouse.

In the existing greenhouses, the heating system construction will have only a cost 488 966 leke/year or 4 100 USD/year, for a 15 years payback period. For a 10myears payback period the expenses will be 562 545 lekë/year or 4 700 USD/year, and investment will be profitable.

15. GATHERING INFORMATION MATERIAL AND KNOWLEDGE DISSEMINATION IT IS VERY IMPORTANT ELEMENT OF UTILIZATION OF GEOTHERMAL ENERGY

Task 1

Information material concerning the general principles of geothermal application and new technologies will be gathered and created. An information booklet and posters will be published and distributed to possible users.

Task 2. Establishment of communication channels with local users

Communication with local authorities will take place in order to find the end users, especially those capable of installing geothermal applications. Direct personal contacts with end users will also take place.

The investigators will implement this study by answering and focusing on the solution of the following questions:

The selection of the most suitable utilization plan according to the actual applications of the new technologies in question, the energy conservation, the desired transfer of the innovative technology to country, the probable users intentions and the existing heating consumption needs of the planned innovative applications.

The investigation of any probable environmental impact and the selection of the most suitable method for the disposal of the geothermal fluids to avoid possible environmental problems.

The selection of the best possible network for the geothermal fluid transport to ensure the violability of the utilization carrier, a single disposition price and the disposition of considerable quantities of energy (converted in TOE-s).

Task 3.

- To creates ready for use permanent educational and informative structures.
- To provide a useful tool for the education and information of geothermal energy end users
- For further dissemination of the results of this projects will organize days of open conferences. Workshops, seminars, TV and radio-emissions, pamphlets, posters, and summer school will organize. .In parallel, the strategies presented for the geothermal energy exploitation will be announced and criticized during these activities. The participant will originate from the public sector, user's, associations, Technical Chambers, higher educational institutes etc. Finally, material from Phase C will be also forwarded to the public authorities that are responsible for the awareness of users and therefore in close contact with them.
- To introduce, via an attractive method, the concepts of geothermal energy utilization and new technology transfer in the third level education

16. SIGNIFICANCE OF THE PROJECT PROPOSAL AND ITS EXPECTED ACHIEVEMENTS

The project proposal has great importance for Albania:

Firstly, it creates the scientific knowledge base for evaluation of natural wealth of geothermal energy and mineral waters in Albania. These data will be used to evaluate and select the rich areas in country. In these areas it is possible to start the investment for complex exploitation of geothermal energy and mineral water resources

Secondly, transfer of new methods for R&D and evaluation of geothermal water resources, modern technologies and unit equipment for thermal waters exploitation in Albania.

Thirdly, a technical and organizing base for modern hotel SPA construction will be created.

Thermal and mineral water springs, usually, are located in coastal or very beautiful mountainous regions of the Albania. The tourism will be developed. Thermal waters of low enthalpy will be used for the heating of green houses and SPA hotels and tourist villages near the springs. Extraction of chemical micro- elements as Iodine, Bromine, Borax, various natural salts from thermal and mineral waters, CO_2 and H_2S gas, will be achieved by installing the necessary equipment. Drinking-mineral water installations will be constructed. This development will create new working posts and will ameliorate the life conditions and level for habitants in thermal and mineral water spring areas.

Fourthly, new modern studying technologies will be disseminated in scientific and business community of country.

Fifthly, Environmental protection and preserving level will be improved, to well assist the echo-system protection of thermal and mineral water source areas.

17. CONCLUSIONS

1.Albania has the resources of geothermal energy of low enthalpy, which is possible for integrated and cascade direct use as an alternative energy.
2. Resources of the geothermal energy in Albania are;
   a) Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.
   b) Heat of subsurface ground, with an average temperature of 16.4^{o}C and depth Earth Heat Flow.
3. Construction of the space-heating system, using shallow borehole heat exchanger (BHE)-Heat Pumps systems present the most important direction of the use of geothermal energy in Albania.

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19. LIST OF CAPTIONS

Fig. 1. Heat Flow Density Map of Albania.
Fig. 2. Temperature Map of Albania, at the depth 100 m.
Fig. 3. Temperature Map of Albania, at the depth 3000 m.
Fig. 4. Geothermal profile in the Peri Adriatic Depression.
Fig. 5 Geothermal Gradient Map of Albania
Fig. 6. Geothermal Zones in Albania.
Fig. 7. Annual Electric Power with and without heating, 1999. [National Agency of Energy].
Fig. 8. Heat Exchanger- Geothermal heat Pump System for space heating scheme.
Fig. 9. Thermolog of the Rinasi borehole.
Fig. 10. Hydrogeological column of Tirana underground water basin.
Fig. 11. Yearly cumulative cost for space heating.
Fig. 12. Yearly cumulative operative cost for electrical energy or fuel consumption for space heating.
Fig. 13. Cost of space heating for different heating systems (in USD/m^2).
1- Geothermal System; 2- Oil Fired Boiler System; 3- Air-Air Conditioner System; 4- Electric Radiator System.