Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

Cascade and Integral Scheme – the Optimal Way for the Albanian Geothermal Utilization

Nevton Kodhelaj

Faculty of Geology and Mining, Elbasanit street, Tirana, Albania

nevtonkodheli@yahoo.com

Keywords: Geothermal, modelling, risk assessment, temperature, heat exchanger, cascade, integral, combined

ABSTRACT

Albania is relatively rich with low enthalpy geothermal resources. Due to totally different characteristics, Albanian territory is divided in three main geothermal areas, each one of them has it most important resources. This paper represents calculations on their possible direct utilization through combined and cascade systems. Due the expected high investments also the economic analysis including their risk assessment are part of this study. Geothermal water of Llixha hot springs, of Kozani-8 geothermal well, of Bënja Përmet springs fulfils all requirements needed for a district heating system in Albania.

1 INTRODUCTION

Along the 20th century, especially its second half, the technologies signed a remarkable development. In paralel with these developments increased the demand and living standards all around the planet. Beside the positive impacts this development brought the increasing demand regarding the energy consumption and its resources. The increase in consumption has driven to the reduction of the natural reserves, especially if referring to the fossil fuels. Actually, the consumption of the fossil fuels is unbalanced with the exploration of new ones, at least in yearly basis. The alternative resources of energy utilized in the second half of the last century, especially the atomic energy had strong negative impact, i.e. human health, environment etc. Because of this, the efforts of the scientific communities as well as the political decision-making are more and more focused toward the renewable energies, including the geothermal energy. Earth, our planet, which provide to us the living environment, represent beside this a huge source of energy, in and above ground. Unfortunately, this energy is nearly not used at all allowing in the way to do a tremendous waste of it. Albania, although a small country could be considered as rich with natural resources, including the fossil fuels and the renewable ones. Part of the renewable resources are also the geothermal ones, which are not used at all for their energetical features, but their use is limited only with their health values. Albania is a small country of only 28 787 km^2 surface area and around 4 500 000 inhabitants, situated in the southwestern part of the Balkan Peninsula. This paper provides some details on the electricity generation, the geothermal energy, resources, geological features & geothermal reserves. Like the other Balkan countries, Albania is located next to the subduction boundary between the African plate and the Euro-Asiatic one. This makes the presence of geothermal resources possible. Surface manifestations of geothermal resources are found throughout Albania, ranging from the region of Peshkopia in the northeast, where hot springs with water temperature of about 43°C and inflow above 14 l/s are found, through the central part of the country with different sources (including the springs of Llixha-Elbasan) with temperatures above 66°C, to the Peri-Adriatic depression (see Fig. 1) with a number of wells (drilled for oil & gas exploration) producing water with temperatures around 40°C at variable yields. The thermal water in Albania is only used for balneology. This form of use dates back to early in history, or to the time of the Roman Empire (i.e. the Sarandaporo's thermal baths). So far, the geothermal resources have not been utilized for other purposes, such as space heating. Estimated temperature measurements based on different geothermometers indicates that the temperature of the waters in the formation of the Llixha reservoir may be above 220°C. The conclusions are given based to the results of the study and provide the most efficient ways regarding the geothermal energy use in Albania.

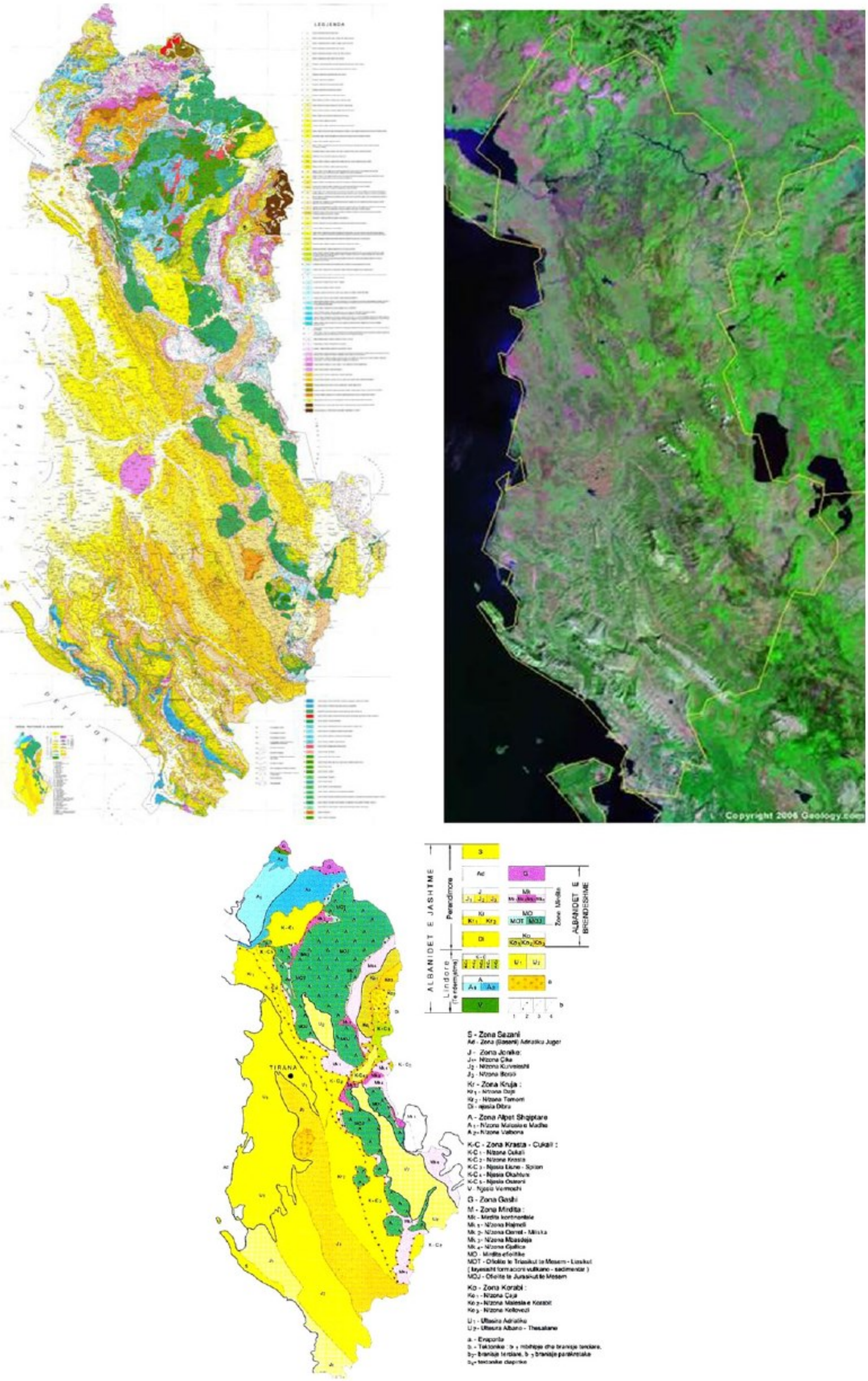

Figure 1: The map of Albania.

2 GEOTHERMAL IN ALBANIA

The geothermal fluids (springs and wells) of Albanian are located in three zones: Kruja, Ardenica and Peshkopia (Frashëri et al. 2004). The three zones differ from each-other by the geological characteristics and thermos-hydrogeological features, as showed in Figure 2. They are related with the regional tectonic and the seismological activities.

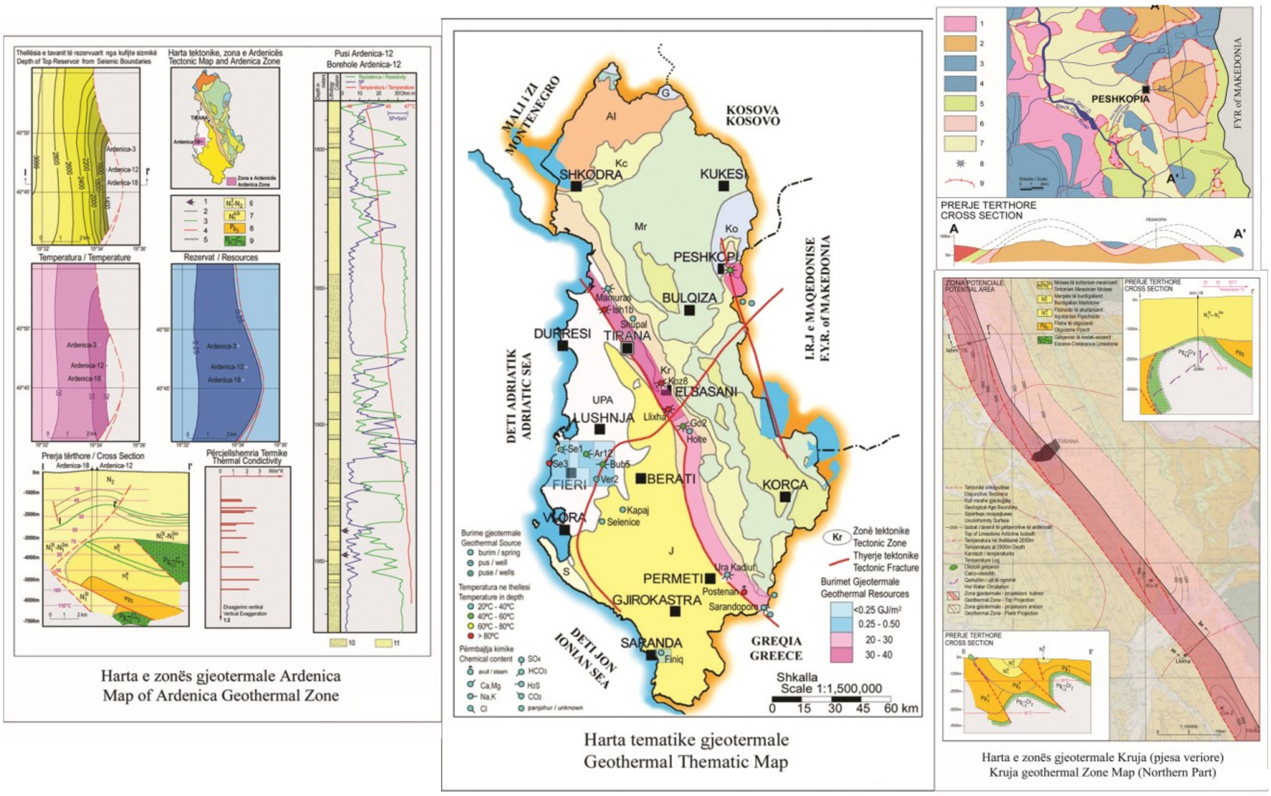

Figure 2: Geothermal map of Albania.

The main geothermal springs of Albania and some technical data on them are presented in Table 1 (Frashëri et al. 2004).

Table 1: Geothermal springs of Albania.

No	Spring and location	Temperature (°C)	Coordinates		Yield (l/s)
			Latitude (N)	Longitude (E)	
1	Mamurras 1 & 2	21÷22	41°42'24"	19°42'48"	11.7
2	Shupal	29.5	41°26'9"	19°55'24"	<10
3	Llixha, Elbasan	60	41°02'	20°04'20"	15
4	Hydraj, Elbasan	55	41°1'20"	20°5'15"	18
5	Peshkopia	43.5	41°42'10"	20°27'15"	14
6	Katiut Bridge, Lëngarica, Përmet	30	40°14'36"	20°26'	>160
7	Vronomer, Sarandaporo, Leskovik	26.7	40°5'54"	20°40'18"	>10
8	Finiq, Sarandë	34	39°52'54"	20°03'	<10
9	Holta Creek, Gramsh	24	40°55'30"	20°33'36"	>10
10	Postenan, Leskovik	Steam source	40°10'24"	19°48'42"	N/A
11	Kapaj, Mallakastër	16.9÷17.9	40°32'30"	19°39'30"	12
12	Selenicë, Vlorë	35.3	40°32'18"	19°39'30"	<10

Along the second half of the 20th century in Albania have been done very intensive drilling on oil and gas explorations. During these drilling, some of the wells "accidentally" blow out "hot water". Table 2 present all "geothermal wells" of Albania as well some of the most important technical data of them (Frashëri et al. 2004).

Table 2: Geothermal wells of Albania.

No	Well	Temperature (°C)	Coordinates		Yield (l/s)
			Latitude (N)	Longitude (E)	
1	Kozani 8	65.5	41°06'"	20°01'6"	10.3
2	Ishmi 1/b	60	41°29'2"	19°40'4"	3.5
3	Letan	50	41°07'9"	20°22'49"	5.5
4	Galigati 2	45÷50	40°57'6"	20°09'24"	0.9
5	Bubullima 5	48÷50	41°19'18"	19°40'36"	
6	Ardenica 3	38	40°48'48"	19°35'36"	15÷18
7	Semani 1	35	40°50'	19°26'	5
8	Semani 3	67	40°46'12"	19°22'24"	30
9	Ardenica 12	32	40°48'12"	19°35'42"	
10	Verbasi 2	29.3			1÷3

The aquatic potential of Albania has the following main characteristics (Frashëri et al. 2004):

-The volume of the underground water is estimated to be in the range of 12.8 km^3;

-The underground water flow width is estimated to be in the range of 295 mm;

-The average modulus of the underground water yield is estimated to be in the range of 9.5 l/(s*km^2).

The underground water of Albania contains 31% of the total aquatic reserves of the country. So far, the geothermal resources have been used only for their balneological values and unfortunately not at all for their energetic ones. Albanian geothermal fluids have temperatures up to the lower limits of the middle enthalpy, except the Postenani steam spring, which gives good hopes to find resources with temperatures in the range of 80^{0}C.

3 ENGINEERIC CALCULATIONS – DIRECT USE OF GEOTHERMAL ENERGY IN ALBANIA

3.1 Llixha Elbasan springs use

The six hot water springs at Llixha in the Elbasan region, have water temperature up to 65°C and flow rate up to 23 l/s. Estimated reservoir temperature at depth associated with the hot springs, based on the chemical composition using different geo-thermometers, is given in Table 3.

Table 3: Estimated water temperature at depth based on different geo-thermometers

Geothermometer	Spring "Nosi" Llixha, Elbasan (°C)
Fournier	254
Truesdell	235
Na+Ka+Ca	143

These values show that the water is coming from great depth where the average temperature is over 200°C. The mineralization of the water is 7.2 g/l, the H_2S content 410 mg/l and free CO_2 180 mg/l. The high content of CO_2 makes the Na+Ka+Ca geo-thermometer unreliable so the reservoir temperature is likely to be in the range of 220-235°C (Arnórsson, 2000; 2007; Arnórsson and D'Amore, 2005). This is in agreement with calculations based on the geothermal gradient and a depth of 4500-5000 m. The water contains <1.2% tritium. The absence of tritium shows that this water originated as precipitation centuries ago. The water is chloro-magnesia and contain the cations Ca^+, Mg^+ and Na^+ and the anions Cl^-, SO^{4-} and HCO^{3-}. The Ph is in the range 6.8-7 and the density 1000-1060 kg/m^3. The hot water has been used only for balneology for several centuries possibly since the time of the Roman Empire. The first modern use dates back to 1937 with the building of the "Hotel Park" medical Centre. The use of the water flowing from these springs can help to improve the economical effectiveness district heating in the village.

3.1.1 3D modelling of the temperature field of Llixha, Elbasan region

A finite volume model was set up for a crustal volume with an area of 10 x 10 km and 5 km thickness/depth (Figure 3) to model the temperature, density and fluid velocity distribution in the Llixha region. Here it is assumed that the medium is homogeneous and isotropic and that $k_x = k_y = k_z = 2$ W/m°K (Osmani, 1987). We also know that $Q = 20$ l/s (corresponding to $m_i = Q/6 = 3.3$ l/s or 3.224 kg/s for each of the hot springs), c_p =4180 J/kg°C (Frashëri et al., 2004). The temperature at depth in the formation is set at 221°C while the temperature of the water at the surface is in the range 60-65°C. The temperature gradient of the surroundings is assumed 12°C/km. The modelling software FLUENT is use to solve the problem, it provides calculation results for temperature, density and velocity for the volume modelled. In the model water flows with a velocity of 1.25*10^{-7} m/s. The results for temperature, density and velocity, as well as velocity vectors, are shown in Figure 4.

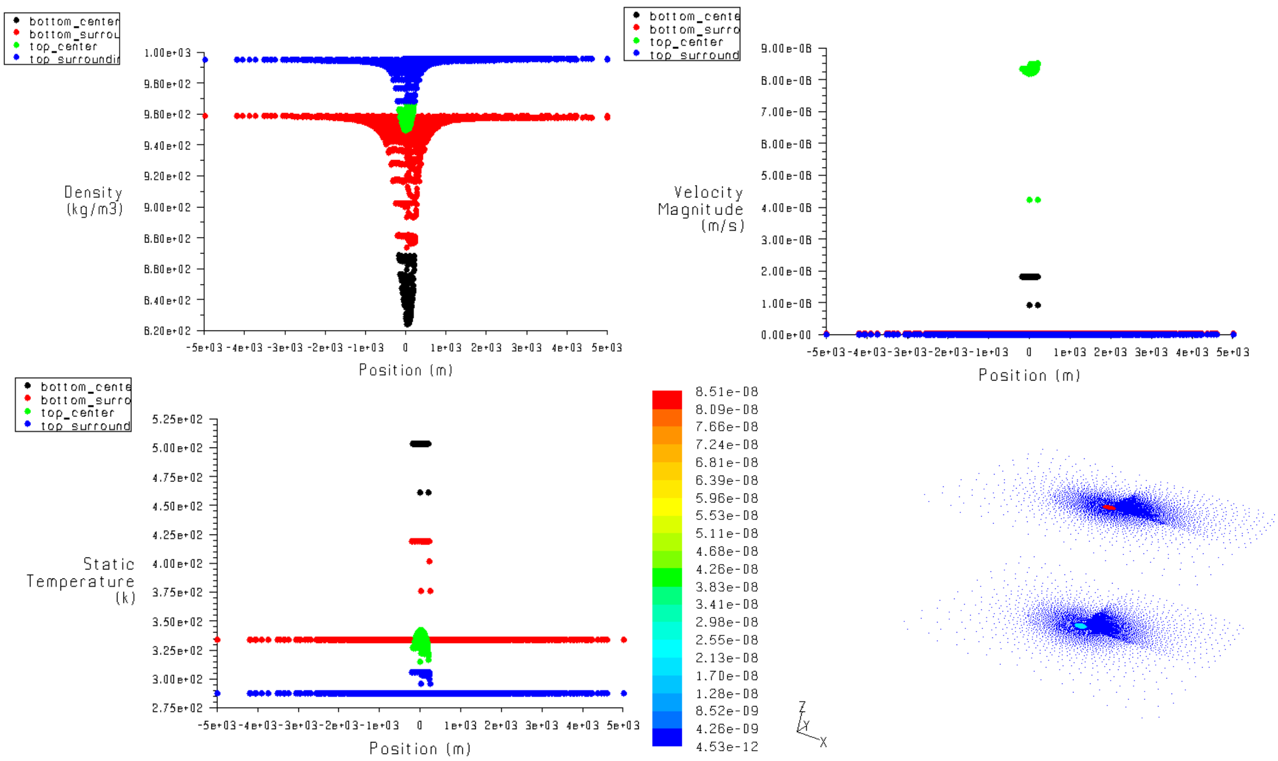

Figure 3: The finite volume grid used to model temperature and flow conditions in the Llixha region.

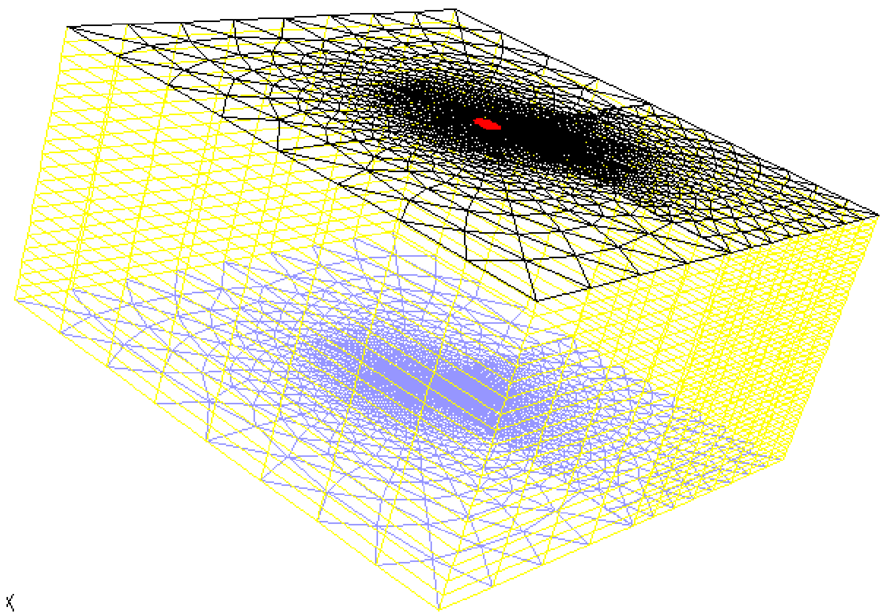

Figure 4: Llixha Elbasan 3-D modelling results.

It can be clearly seen that the water density varies in the range of 820-1000 kg/m^3, the velocity change from 10^{-8}-$9*10^{-8}$ m/s and the temperature takes value in the range of 275-500°C at the depth of 5000 m.

3.2 Bënja geothermal springs a competitive energy resource

In the Bënja of Përmeti village, in the Lëngarica creek are found eight springs, known and used for their curative values since the time of the Roman Empire. These springs blow out mineral water with temperatures in the range of 23÷30°C and yields in the range of 8 up to more than 40 l/s. These waters, even though of the low enthalpy represent a competitive energy resource. Their flow direct to the river, as in the case of the other geothermal resources of Albania can be “translated” as throwing in the creek of considerable monetary values, delay in the economic development, infrastructure and also social of the area. Below will be showed that these waters are not only a competitive energy resource, but they can by efficiently used for greenhouses, aquaculture and mineral salts extraction (Frashëri et al., 2004; 2010; 2010).

3.2.1 Ura e Katiut (Katiu bridge), Lëngarica-Përmet geothermal springs

In the village of Bënja, there are 8 springs with temperatures 23÷30°C and yields in between 8÷40 l/s each. They are linked with the regional dissociative tectonic of the Bodar-Postenan anticlines chain. The limestone's sink toward west with an angle of 20°C and azimuth of 210÷215°C. The limestones are carstified, especially in the right bank of the river where some caves or cavities can be found. In a 500m long belt, in both sides of the river are found the geothermal springs: 4 in the left side and 4 in the right side. The water generally blows out in the water level, below or even 1÷2.5 m above it. Their placement is (Frashëri et al., 2004; 2010):

Spring 1 is 25÷30 m further down the bridge, 20 m far from the riverbed. Its temperature is 26°C;

Spring 2 is 8 m beyond the bridge and blow out below the water level. It can be seen by its blue with some white tint color on the limestone's surface, by whose fractures the waters blow out;

Spring 3 is 25 m beyond the bridge, in the water table but 15 m far from the river shore. They blow out as three very potent griffons. The water temperature is 26°C and the yield about 8 l/s;

Spring 4 is 150÷200 m beyond the bridge, where the canyon width is over 20 m. they blow out as two griffons. The most important about 15÷20 cm height, blow 0.5 m above the water level, have a yield 8÷9 l/s and temperature 23°C. Approx. 30 m beyond is the second griffon with yield of 4 l/s and the same temperature.

The other four springs are placed in the left bank of the river. Their main characteristics are given below:

Spring 5 is 300÷400 m beyond the bridge, before the canyon whose is 10-12 m wide and 40÷50 m height. Some powerful water blows out by the limestone fractures have yields of 30÷40 l/s and temperature 30°C;

Spring 6 is at the bridge pier, 0.81 m above the water level and 4 m away from the river. Its yield is 30 l/s and the temperature 30°C;

Spring 7 is 7 m further down the bridge, in the water level and 2÷3 m away. The yield is 30÷40 l/s and the temperature 30°C;

Spring 8 is the biggest one. This spring is 20÷25m further down the bridge, 1÷1.5 m above the water level and 8÷10 m away from the river. The yield is over 40 l/s and the temperature 30°C.

The demonstrative geothermal complex for the integral and cascade uses of Katiut Bridge, Lëngarica, Përmet assume that the construction will be completed step by step in order to decrease the value of the initial investments (Frashëri et al., 2004; 2010; 2010). In the design phase of the center should be considered several factors and parameters as: orientation, approach with different environment, thermal insulation of the walls, floor, windows, sealing etc. Based in the yield of the geothermal spring is possible to be installed a capacity of 10,040 kW. Due to the fact that their temperature is low for optimizing their utilization should be used the complex and cascade scheme that includes the hybrid system through combining of geothermal with solar panels and water-water geothermal heat pumps as it is shown in Figure 5 (Frashëri et al., 2010).

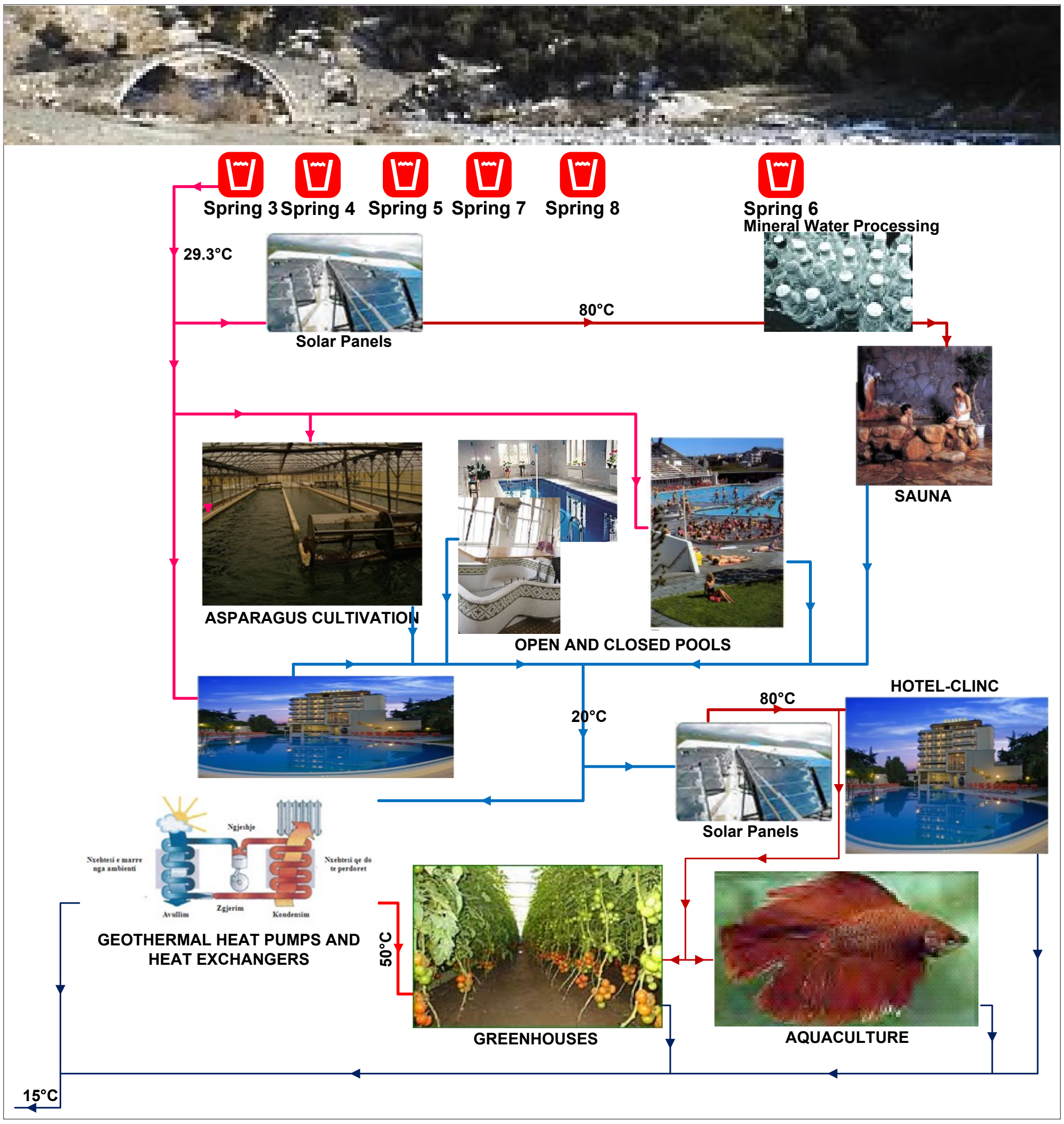

Figure 5: Bënja, Përmet geothermal springs utilization sketch.

3.2.2 Cost calculation and economic analysis of the proposed center

In Table 4 is presented the detailed cost for the construction of the proposed center. There is clearly seen that main investment goes for the main building (40.27%) while the total investment goes about 3,024,645 Euro (Frashëri et al., 2004; 2010).

Table 4: Cost analysis of the proposed center based in the constituent.

Constituent	Investment [€]
Property (land)	370,980
Hotel Clinic – Building – Acclimatization system – Furniture's	 1,812,280 354,560 129,670
Greenhouse	86,710
Spirouline cultivation center	154,085
Aquaculture installations	116,900
Total Investment [€]	3,024,645

Due to the fact that for the proposed area there are some WB programmer, the construction will be released through a bank loan with interest of only 2%/year. Based in this information the ROR results:

$$ROR = \ln\left(\frac{Final\ value}{Investment}\right) = \ln\left(\frac{4051504.93}{3024645}\right) = 0.2923 = 29.23\%$$

Further economical calculations about the Present Value and Net Present Values are presented in Table 5. There can be clearly seen that NPV become positive for income not lower than 250,000 €/y (Frashëri et al., 2004; 2010; 2010).

Table 0: NPV calculation for different Cash Flow.

Time (years)	NPV calculation for different CF (€/year)						
	50000	**100000**	**150000**	**200000**	**250000**	**300000**	**350000**
1	-2429000	-2388000	-2347000	-2307000	-2266000	-2225000	-2184000
2	-2121000	-2049000	-1976000	-1904000	-1831000	-1759000	-1686000
3	-1917000	-1817000	-1717000	-1617000	-1517000	-1417000	-1317000
4	-1765000	-1640000	-1515000	-1390000	-1265000	-1140000	-1015000
5	-1643000	-1495000	-1347000	-1199000	-1051000	-903057	-754980
6	-1543000	-1373000	-1203000	-1033000	-863270	-693407	-523544
7	-1456000	-1266000	-1075000	-884678	-694090	-503503	-312915
8	-1381000	-1170000	-959960	-749517	-539074	-328631	-118188
9	-1313000	-1084000	-854324	-624756	-395187	-165618	63950
10	-1253000	-1004000	-756432	-508363	-260295	-12227	235841
11	-1197000	-930906	-664884	-398862	-132839	133183	399205
12	-1146000	-862130	-578635	-295140	-11645	271851	555346
13	-1098000	-797419	-496880	-196342	104197	404735	705274
14	-1053000	-736185	-418990	-101795	215400	532596	849791
15	-1011000	-677961	-344460	-10959	322542	656043	989544
16	-971853	-622367	-272881	76605	426091	775577	1125000
17	-934270	-569093	-203917	161260	526436	891613	1257000
18	-898476	-517882	-137287	243308	623903	1004000	1385000
19	-864277	-468516	-72755	323005	718766	1115000	1510000
20	-831504	-420813	-10121	400570	811261	1222000	1633000
21	-800016	-374615	50787	476189	901590	1327000	1752000
22	-769693	-329787	110118	550024	989930	1430000	1870000
23	-740429	-286213	168003	622218	1076000	1531000	1985000
24	-712132	-243790	224553	692895	1161000	1630000	2098000
25	-684723	-202427	279868	762164	1244000	1727000	2209000
26	-658131	-162046	334039	830123	1326000	1822000	2318000
27	-632293	-122576	387142	896859	1407000	1916000	2426000
28	-607155	-83953	439248	962450	1486000	2009000	2532000
29	-582667	-46122	490422	1027000	1564000	2100000	2637000
30	-558784	-9032	540719	1090000	1640000	2190000	2740000
NPV	**-33572403**	**-23749833**	**-13926627**	**-4105742**	**5717716**	**15541155**	**25364324**

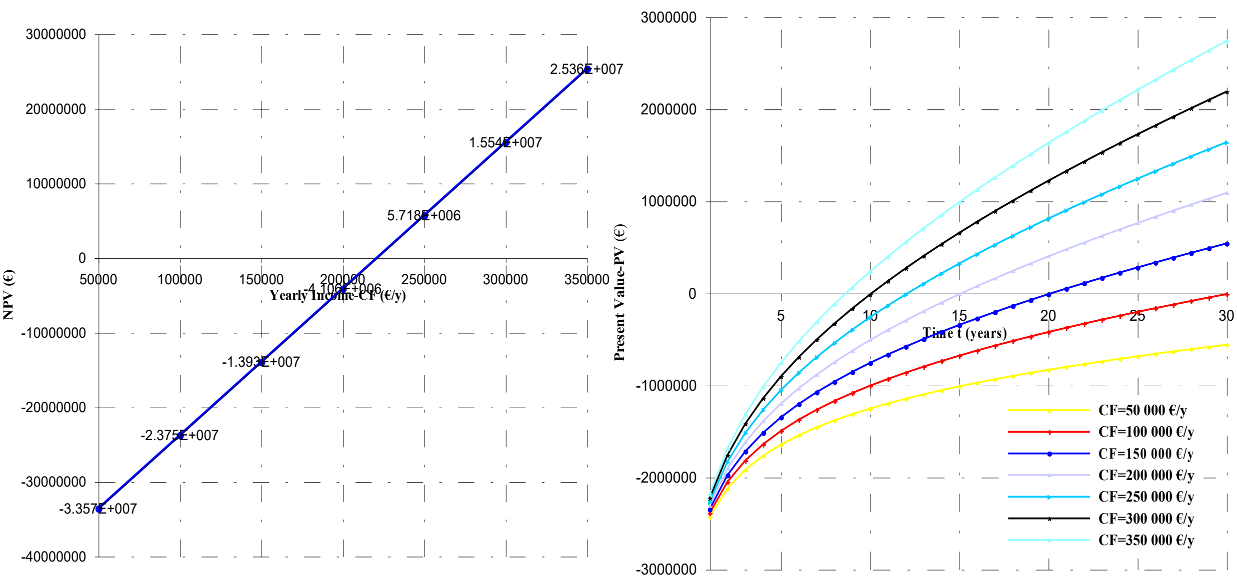

Figure 6: Economic analysis of the Bënja-Përmet recreational geothermal center.

Figure 6 presents the charts of the PV & NPV fluctuations in time. Their analytic processing proves that the NPV is equalized to zero for yearly income of 220,893 €/y. The business plan based in the Albanian touristic market and its prices evaluate that the yearly CF will be around 237,000 €/y, so 7.29% higher than the minimal calculated value (Frashëri et al., 2004; 2010).

3.3 Combined use of the Kozani-8 geothermal water through an integral, cascade and hybrid scheme

The Ishmi-Kruja geothermal zone, is close to the "Mother Teresa" international airport, next to the Kruja historical city, the wonderful Adriatic Sea beaches & Lake of Ohrid. Kruja geothermal zone represents a zone with large geothermal resources. Three boreholes produce hot and mineralized water: Ishmi-1/b, Kozani-8 and Galigati-2. Kozani-8 geothermal well lies on the limestone structure of Kozani, which lies about 180 km, with a width of 4÷5 km (Aliaj and Hyseni, 1996). The demonstrative geothermal center, with the cascade and integral use, but also combined with the solar panels (hybrid system), is designed for the Kozani-8 well waters. The choice had been made because of its temperature, on the value of 65.5°C, and yield 10 l/s. Hot water has salinity of 4.6÷19.3 g/l. actually all these waters are "wasted": they flow directly to a creek, meaning high economical loses. Among different processes of the cascade, shall be released CO_2 and H_2S, which will be used for food products (conservation) and medical purposes. The hybrid system, combing of the middle enthalpy geothermal waters, with the solar panels, based on the fact that the Albanian climate allow such a thing (there are more than 280 sunny days on the area), will improve the economic efficiency of the project. On the regional point of view, sink up to the depth of 10 km, where they are placed above the Triassic evaporates formation (Frashëri et al., 2008). In this depth, the temperature reaches the values of 120-150°C. Important for this region is the presence of the tectonic, related with the evaporates formations (Hyseni and Melo, 2000). Kozani-8 well is placed in the S-E of Tirana. The water comes from the interval 1816-1837 m of depth. The formation temperature is 80°C, while the pressure is 191 bars. The wellhead pressure is 12 bars, while the temperature is 65.5°C. The mineralization is 4.6 g/l, pH= 7.5; the cations Ca^{2+}=27.62 mg/l, Mg^{2+}=20.4 mg/l, Na^{+}= 268.5 mg/l, NH_4^{+}=47.5 mg/l; the anions Cl^{-}=270.2 mg/l, SO_4^{2-}=46.2 mg/l and HCO_3^{2-}=10 mg/l; the microelements B=0.00067 µg/l (Frashëri and Kodhelaj, 2010).

3.3.1 The scheme for the integral, cascade and hybrid use of the Kozani-8 geothermal waters

It was thought by the designer, that the best and more efficient way to use the geothermal waters of Kozani-8 well is the constructions of a multicenter (Aliaj et al., 2003; Aliaj and Hyseni, 1996; Arnórsson, 2000). The center will include the SPA, massage and fitness center, open and closed pools (with different sizes and temperatures), greenhouse, aquaculture cultivation pools, conference rooms etc. The center will be heated through the geothermal direct use (through the installation of the heat exchangers) (Aliaj et al., 2003; Aliaj and Hyseni, 1996; Arnórsson, 2000), while for the cooling will be installed a geothermal heat pump (Harlow, J. H. & Klapper, G. E., 1952). The roof will be covered will solar panels, whose will provide the sanitary water and also a part of them, will circulate the geothermal water, increase its temperature, allowing so the electricity production (the hybrid system). This electricity will serve for the lighting system of the center (green energy). Figure 7 represents the frontal and lateral view of the center, while Figure 8, the principal sketch of the integral, cascade and the hybrid system (Aliaj et al., 2003; Aliaj and Hyseni, 1996; Arnórsson, 2000).

Figure 7: Frontal and lateral view of the Hotel-Clinic and SPA center.

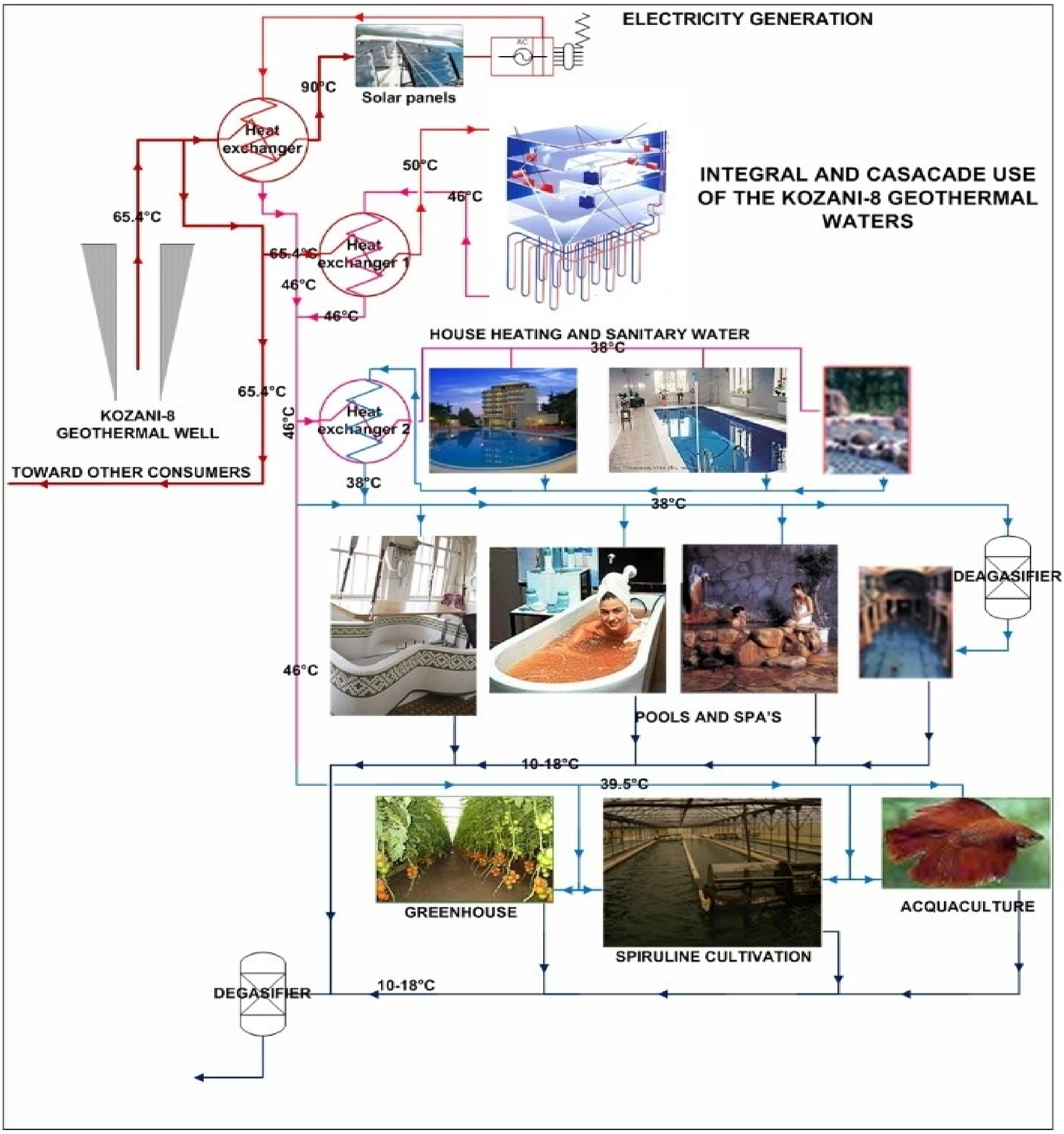

Figure 8: The principal sketch of the center.

3.3.2 Heat looses

The proposed center will have several pools: 1 geothermal pool (designed as a natural pond, sized 10*8*0.5 m, water temperature 38°C-degasified); 1 open Olympic pool (sized 50*23*3 m, water temperature 30°C); 1 sweet water pool (sized 10*5*1.5 m-escalate, water temperature 38°C-degasified, lightly closed); 1 kids sweet water pool (sized 5*3*0.5 m-escalate, water temperature 30°C). The criteria for pool designing are: psychological and physiological comfort, roads width 1-3 m, height of the closed pools 4 m, temperature & humidity level, easy maintenance and the noise level below 60 dB The thermal loads, based on their nature and effect on the thermal balance, can be calculated as loses or thermal increment. The heat loses of the system are influenced by a number of factors including the number of the guests, their physical activity, the electrical equipment's, solar radiation, natural ventilation, thermo insulation etc. Calculation for the electrical equipment's are made based on the assumption that the maximum load, varies during the day, to avoid their supersizing. Figure 9 shows the water circulation scheme for the pools. On the first cascade the water will be used for house-heating and also for pools. The water discharged by the geothermal and hot water pool (38°C) will be used for the spirulina cultivation. On the first heat exchanger the water supply should be 22.69 t/h of water, for an installed capacity of 512 kW (Aliaj et al., 2003; Aliaj and Hyseni, 1996; Arnórsson, 2000). This amount of energy will be transmitted through the sweet water, heated at the level of 45-50°C. On the second heat exchanger are needed 15 [t/h of water] for an installed capacity of 480 kW. The water temperature in this heat exchanger should be in the range of 40-50°C (Arnórsson, 2000). Table 6 present the thermal loads for the center for both seasons: winter and summer, while Table 7 the parameters of the closed pools environment (Arnórsson, 2004). This center as the first demonstrative one for Albania will have also the facilities for aquaculture cultivation. In Figure 10.a is presented the principal sketch for this purpose, while Figure 10.b the heat exchanger and geothermal heat pump sketch of the center (Frashëri et al., 2004; 2010; 2010).

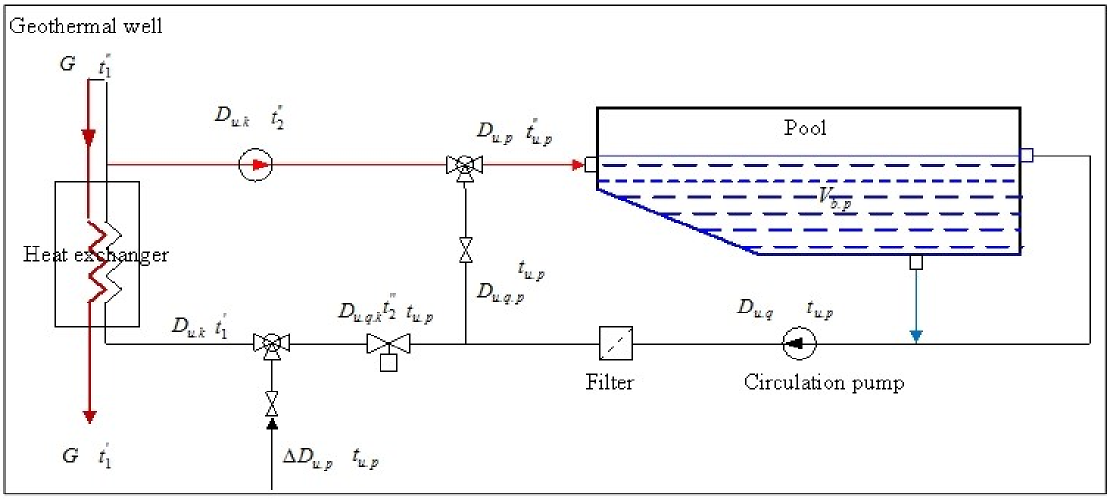

Figure 9: The pools (geothermal/fresh water) circulation scheme.

Table 6: Seasonal thermal loads of the center.

Room/environment	WINTER				SUMMER			
	Thermal load [kW]	Air [kW]	Sanitary water [kW]	Total [kW]	Thermal load [kW]	Air [kW]	Sanitary water [kW]	Total [kW]
Main building	512	420	80	1012	100	130	53	283
Closed pools	32.3	63.6	130.5	226.4				130.5
Geothermal pool (10x 8) m	18	35	72	125				72
Sweet water pool (10x5m)	11	22	45	78				45
Kids pool (5x3m)	3.3	6.6	13.5	23.4				13.5
Subtotal				**1236.4**				**413.5**
Closed pool (water)				68				
Geothermal pool (water)				48				
Sweet water pool (water)				20				
Olympic pool (water)				1300				
Total				**2674.4**				**413.5**

Table 7: Closed pools environment parameters .

Environment	Parameter
Closed pools	V_{air}=45 [m^3/hm^2]
	Q_{floor}=220 [W/m^2]
	$Q_{sanitary\ water}$=0.90 [kW/m^2]

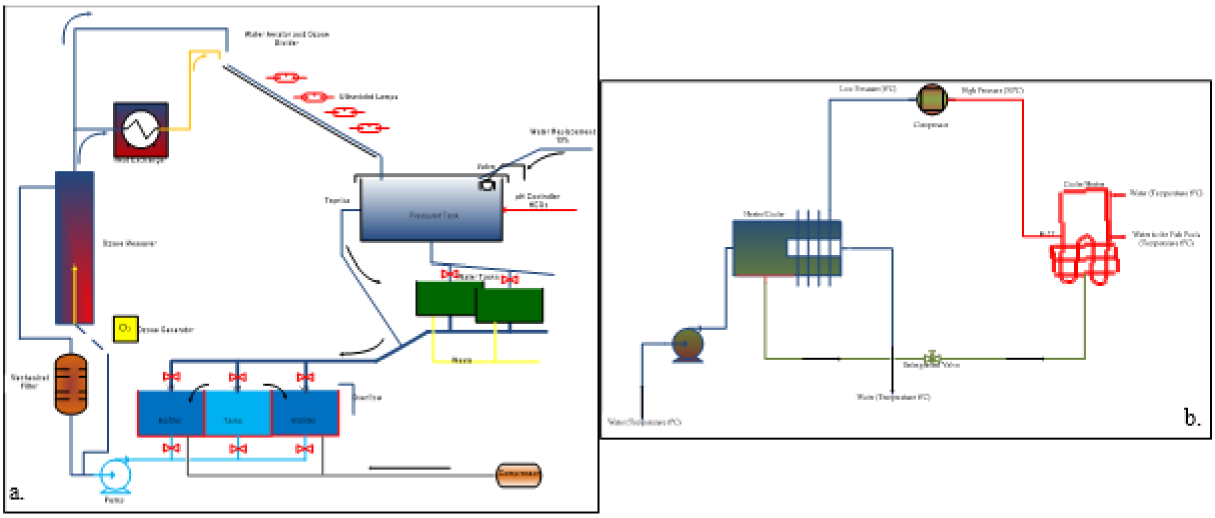

Figure 10: Aquaculture cultivation, heat exchanger and geothermal heat pumps sketch

3.3.3 Environmental analyses and positive impact of the scheme

The results of chemical analyses of the water shows that the H_2S content is 410.07 mg/l, H_2SO_4 43.1 mg/l, HBO_2 25.4 mg/l and free CO_2 184.7 mg/l. Other free elements of the water in 60°C are Cl, F, Br, J and NO_2 (Arnórsson and D'Amore, 2005). These entire chemicals are not dissolved in the geothermal water, so it's enough a small perturbation and they can be released to the atmosphere. Most of them are poisoning to the people, except that they are extremely harmful for the equipment. Their actual effect on the environment is high and also the health problem to the community, caused by them is relevant. So, it is necessary to remove all these gases through a degassing process. The results of quantitative evaluations show that the total amount of the gases that should be removed is 5.12 kg/h, for a total mass of geothermal water 12.04 t/h with average temperature 40.68°C. The mineral saline content of the Kozani-8 water is 4.6 g/l. In big amount are the cations Na^+ 1.19 g/l, Ca^{2+} 0.79 g/l, Mg^{2+} 0.2 g/l, K^+ 0.17 g/l, NH_4^+ 0.02 g/l, traces of Fe, Cu, Al and the anions Cl^- 2.36 g/l, SO_4^{2-} 1.78 g/l, HCO_3^- 0.43 g/l etc. Their effect extends on pollution of the surface and underground waters, soil pollution, and corrosion and depositions problem while the most important are the human and animal health issues. That's why the proposed scheme predicts to treat this water in order to remove all the pollutant. The purification process will involve the total desalination and as the second step, the selective desalination in order to get the valuable compounds. This scheme will be economically efficient, as part of them have market values, so they will be sold to the national market (Frashëri et al., 2004; 2010; 2010).

3.3.4 Economic analyses

Table 8 presents some costs data related with the constructions cost for the Recreational Geothermal Center & SPA, Shijon, and Elbasan. There can be clearly seen that the biggest investment should be done for the building (66.7%), while that the total investment is calculated to be 5,708,285 Euro (Frashëri et al., 2004; 2010; 2010).

Table 8: Costs calculations for the Shijoni Recreative Geothermal Center & SPA.

Constituent	Investment [€]
Property (land)	440,080
Hotel Clinic – Building – Acclimatization system – Furniture's	 3,808,280 654,560 239,670
Greenhouse	186,710
Spirouline cultivation center	252,085
Aquaculture installations	136,900
Total Investment [€]	5,708,285

The economic analyses are done based on the Net Present Value (NPV) Calculations. The center will be constructed through a bank loan. Is underlined this fact, because the Albanian banking system do not give loan in such case if the Rate of Return (ROR) is lower than 0.1 (10%). Table 9 shows the NPV values for different scenarios, based in different Cash Flow (CF). From this table can be seen that the NPV become positive for CF greater than 350,000 €/y. Figure 11 shows the chart of PV/time and the chart of NPV/CF. Both analyses, analytical and also graphical shows that the NPV is equalized to zero, only if the CF is 382,949 €/y. For lower CF, the NPV result negative and of course for greater CF it will be positive. The business plan predicts a CF of about 445,000 €/y, based in the Albanian touristic market and its prices. The precision tree, Figure 12, gives a better picture about the fact that this investment is totally viable and also about the potential risks for each one of its components (Frashëri et al., 2004; 2010; 2010).

Table 9: The NPV calculations for different scenarios (based in the CF).

Time [years]	Present Value for Different Cash Flow					
	250000 [€/y]	300000 [€/y]	350000 [€/y]	400000 [€/y]	450000 [€/y]	500000 [€/y]
1	-5.09E+06	-5.05E+06	-5.00E+06	-4.95E+06	-4.91E+06	-4.86E+06
2	-4.67E+06	-4.58E+06	-4.49E+06	-4.40E+06	-4.31E+06	-4.22E+06
3	-4.32E+06	-4.19E+06	-4.06E+06	-3.93E+06	-3.79E+06	-3.66E+06
4	-4.01E+06	-3.84E+06	-3.67E+06	-3.50E+06	-3.33E+06	-3.16E+06
5	-3.73E+06	-3.52E+06	-3.31E+06	-3.10E+06	-2.89E+06	-2.68E+06
6	-3.46E+06	-3.22E+06	-2.97E+06	-2.72E+06	-2.48E+06	-2.23E+06
7	-3.22E+06	-2.93E+06	-2.65E+06	-2.36E+06	-2.08E+06	-1.79E+06
8	-2.98E+06	-2.66E+06	-2.34E+06	-2.01E+06	-1.69E+06	-1.37E+06
9	-2.75E+06	-2.39E+06	-2.03E+06	-1.68E+06	-1.32E+06	-959775
10	-2.52E+06	-2.13E+06	-1.74E+06	-1.34E+06	-950671	-557274
11	-2.31E+06	-1.88E+06	-1.45E+06	-1.02E+06	-591445	-162458
12	-2.10E+06	-1.63E+06	-1.17E+06	-702794	-238538	225717
13	-1.89E+06	-1.39E+06	-889616	-390386	108844	608073
14	-1.68E+06	-1.15E+06	-616532	-82596	451340	985275
15	-1.48E+06	-915709	-347315	221079	789472	1.36E+06
16	-1.29E+06	-684191	-81569	521053	1.12E+06	1.73E+06
17	-1.09E+06	-455596	181041	817677	1.45E+06	2.09E+06
18	-900107	-229656	440796	1.11E+06	1.78E+06	2.45E+06
19	-710218	-6140	697937	1.40E+06	2.11E+06	2.81E+06
20	-522379	215148	952675	1.69E+06	2.43E+06	3.17E+06
21	-336429	434380	1.21E+06	1.98E+06	2.75E+06	3.52E+06
22	-152225	651708	1.46E+06	2.26E+06	3.06E+06	3.87E+06
23	30358	867264	1.70E+06	2.54E+06	3.38E+06	4.22E+06
24	211429	1.08E+06	1.95E+06	2.82E+06	3.69E+06	4.56E+06
25	391087	1.29E+06	2.20E+06	3.10E+06	4.00E+06	4.90E+06
26	569420	1.50E+06	2.44E+06	3.37E+06	4.31E+06	5.24E+06
27	746506	1.71E+06	2.68E+06	3.65E+06	4.62E+06	5.58E+06
28	922416	1.92E+06	2.92E+06	3.92E+06	4.92E+06	5.92E+06
29	1.10E+06	2.13E+06	3.16E+06	4.19E+06	5.23E+06	6.26E+06
30	1.27E+06	2.34E+06	3.40E+06	4.46E+06	5.53E+06	6.59E+06
N.P. V	**-4.60E+07**	**-2.87E+07**	**-1.14E+07**	**5.87E+06**	**2.32E+07**	**4.04E+07**

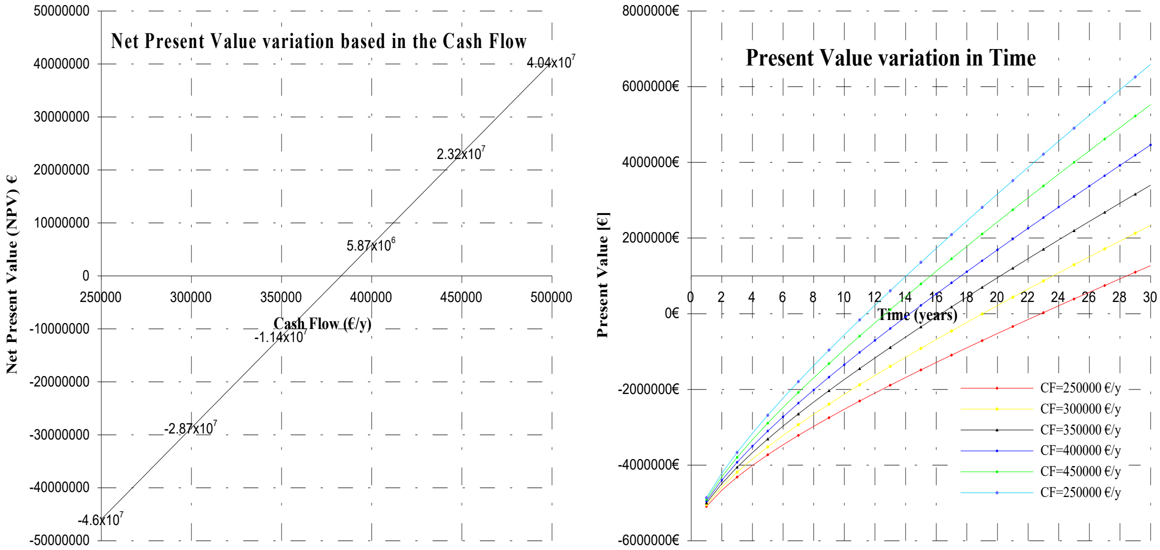

Figure 11: PV and NPV fluctuations in time.

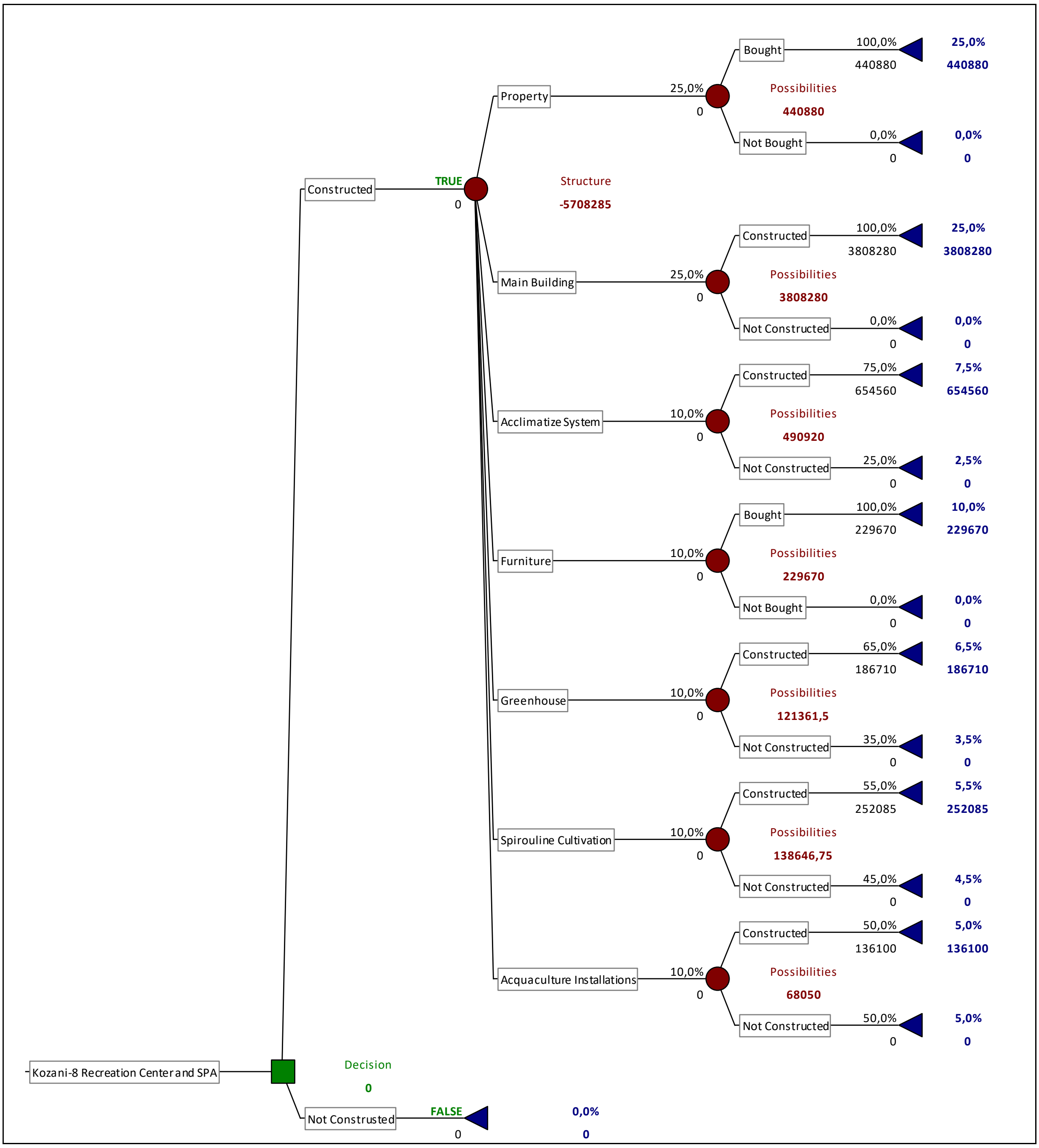

Figure 12: Precision tree.

4 CONCLUSIONS

Albanian geothermal regime allows different scale borehole heat exchangers applications. Low enthalpy geothermal waters fulfill all the technical requirements for combined and cascade use. The water temperature is expected to be stable in the future. Considerably higher temperature expected through further deep well drilling. The geothermal reservoir temperature at 4500-5000 m depth is thought to be about 220°C. The water starts to cool down when it reaches 160 m depth. The geothermal water from the Llixha hot springs fulfills all requirements for district heating's in the region. Demographic and geological features of the student's city allow, and furthermore are feasible the borehole heat exchanger's utilization. Direct utilization of the low enthalpy geothermal resources of Albania will help in diversifying of the energetic resources mitigating so the supply problems faced in the near past. It will improve the living standards of the community of the Bënja village.

Risk analysis shows that there is not any added risk for the proposed investment. The Bënja springs, water temperature is suitable for the supply of a recreational center, including geothermal indoor and outdoor pools. The construction of the center will improve the energetic balance of the region. The construction of the center will help on diversifying the energy resources in Albania. The degasified and desalination line will improve the environmental status of the area, as actually is highly polluted.

The economic analyses show that it is viable. Direct utilization of the low enthalpy geothermal resources of Albania will help in diversifying of the energetic resources mitigating so the supply problems faced in the near past. It will improve the living standards of the community of the Kozani village. The Kozani-8 water temperature is suitable for the supply of a recreational center, including geothermal indoor and outdoor pools. The hybrid system will improve the economic efficiency of the project. The economic analyses show that it is feasible. The electricity generated by the combined scheme will improve its efficiency. The water temperature is suitable for feeding of two cascades. Use of the low and middle enthalpy geothermal waters is economically viable in Albania and they can be successfully used. Use of the low enthalpy geothermal waters in Albania can mitigate the economic problems, improve the living standards of the communities and diversify the energy resources.

5 REFERENCES

Frashëri, B. Çela, S. Thodhorjani, N. Kodhelaj, Monograph series, Geothermal Heating and Cooling Systems, Klean, pp. 85-115, 2008.

Frashëri, N. Kodhelaj, Monograph series, Albanian Geothermal Resources and Platform on Their use, Klean, pp 185-198, 2010.

Frashëri, V. Čermak, the geothermal atlas of Albania. Sh. B. L. U. Tirana, 65-89, 2004.

Hyseni, V. Melo, The geodynamics of new movements in Albania and their influence in resources and environment, 2000.

Aliaj Sh., Eftimi R., Tafilaj I., 2003. A comparative study of the land subsidence of Tirana and Korça areas caused by intensive ground water extraction. Albanian Journal of Natural and Technical Sciences, 2003 (2), VIII (14), pp.121-133, Published by Academy of Sciences of Albania.

Aliaj. S. and Hyseni. A. 1996: The neotectonic map of Albania. Scale 1:200000. Sh. B. L. U. Tirana. 87 pp.

Arnórsson, S., 2000: Mineral saturation. In: Arnórsson, S.(ed.), Isotopic and chemical techniques in geothermal exploration, development and use. Sampling methods, data handling, interpretation. International Atomic Energy Agency, Vienna, 241- 266.

Arnórsson, S., 2004: Reactive and conservative components. UNU-GTP, Iceland, unpublished lectures.

Arnórsson, S., and D'Amore, F., 2005: Geo-thermometry. Geothermic, 34.

Axelsson, G., 2007: Geothermal resource management and reservoir modelling. UNU-GTP, Iceland, unpublished lectures.

Axelsson, G., 2007: Geothermal reservoir engineering, physics and resource management. UNU-GTP, Iceland, unpublished lectures.

Birch, F., and Clarck, 1940: The thermal conductivity of rocks and its dependence upon temperature and composition, Part I. American Journal of Science, 238, 529-58.

Buffon, G. L. (1778): Histoire naturelle, générale et particulière. -651 S., De l'imprimerie royale, Paris. Commented edition: Roger, J. (1962): Mémoires du Muséum National d'Histoire Naturelle, Série C, Tome X, Éditions du Muséum, Paris.

Carslaw, H.W., and Jaeger, J.C., 1959: Conduction of heat in solids. 2nd Edition, Claredon Press, Oxford, 510 pp.

Čermak, V., and Haenel, R., 1988: International Association for Seismology and Physics of the Earth's Interior, 30-33.

Cutasof, I., 1999: Applied geothermic for petroleum engineers. Elsevier Amsterdam, NY, 510 pp.

Frashëri, A., and Nishani P., 1996: Relationship between tectonically zones of Albanides based, on results of geophysical studies. In: Structure and Prospects of Alpine Basins and Forelands. Memo. Mus. Nat. Hist. Nat., 485-511.

Frashëri. A. and Čermak. V. 2004: The geothermal atlas of Albania. Sh. B. L. U. Tirana. 65-89.

Frashëri. A., Çela. B., Aleti. R., Kodhelaj. N., Project-Idea for the Geothermal Heating of the Fan Noli University Campus, Korçë, Albania, PKKZh, 2009.

Frashëri. A., Kodhelaj. N., Albanian Geothermal Resources, platform in their utilization (Monograph). Klean, 2010, 184-193 pp.

Frashëri. A., Kodhelaj. N., Albanian Geothermal Resources, platform in their utilization (Monograph). Klean, 2010, 184-193 pp.

Harlow, J. H. & Klapper, G. E. (1952): Residential Heat Pump Experiments in Philadelphia-Installation and Operating Experience. – AIEE Trans 71/II, pp. 366-375, New York.

Hyseni, A., and Kapllani, L., 1995: Geo-tectonics of Durrësi region in the outlook of complex geology-geophysical study. Proceedings in the E.E.G.S. Meet., Torino.

Hyseni. A. and Melo. V. 2000: The geodynamics of new movements in Albania and their influence in resources and environment. National programmer for research development. Toena. Tirana.

Ingersoll. L. R. Adler. F. T. Plass. H. J. &Ingersoll. A. C. (1950): Theory of Earth Heat Exchangers for the Heat Pump. – ASHVE Trans. 56. 167-188.

J. H. Harlow, G. E. Klapper, Residential Heat Pump Experiments in Philadelphia-Installation and Operating Experience. – AIEE Trans 71/II, pp. 366-375, New York, (1952).

Jonsson, M. Th., 2007: Mechanical design of geothermal power plants. UNU-GTP, Iceland, unpublished lectures.

Koçiaj, S., 1989: On the construction of the Earth Crust in Albania according to the first on set of "P" waves in the seismologic station. Bull. of Geol. Sciences, 1, 400-410.

Kodhelaj N., Frashëri. A., Çela. B., Kamberi. Z., Aleti. R., Thodhorjani. S., Bozgo. Sh., and Zeqiraj. D., Bënja low temperature geothermal springs, a competitive energy resource. Proceedings of the XXth Congress of the Carpathian Balkan Geological Association, October 24-26, 2014, Tirana, Albania.

Kodhelaj, N. Albanian Possibilities on Geothermal Direct Utilization. Renewable and Sustainable Energy-Elsevier, vol. 15, issue 5, pages 2534-2544, 2011.

Kodhelaj, N., 2007: The Llixha Elbasan hot springs in Albania, study of temperature conditions and utilization calculations, Reports of the United Nations University, Geothermal Training Programmer in 2007, 157-199 pp.

Kodhelaj, N., 2011: Albanian possibilities on geothermal direct utilization. Renewable and sustainable energy review, Elsevier, 15/5, 2011. 2534-2544 pp.

Kodhelaj, N., 2011: Albanian possibilities on geothermal direct utilization. Renewable and sustainable energy review, Elsevier, 15/5, 2011. 2534-2544 pp.

Kodhelaj, N., Bode, A., et al. (2012). Combined use of the Kozani-8 geothermal water through an integral, cascade and hybrid scheme and its positive effects on the environment, some thermal and economical calculations. CMSE proceedings 44-59.

Kodhelaj. N. 2007: The Llixha Elbasan hot springs in Albania. Study of temperature conditions and utilization calculations. Reports of the United Nations University. Geothermal Training Programmer in 2007. 157-199 pp.

Kodhelaj. N. 2011: Albanian possibilities on geothermal direct utilization. Renewable and sustainable energy review. Elsevier. 15/5. 2011. 2534-2544 pp.

Kodhelaj. N., Çela, B., Aleti. R., 2012, Kozani-8 Low Enthalpy Geothermal Water Use through a Cascade and Hybrid System, Study for Civil Engineering and Architecture, David Publishing House, USA.

Nappa, M., 2000: District heating modelling. University of Iceland, report, 47 pp.

Osmani, S., 1987: Finite elements, applications I. Sh.B.L.U., Tirana, 210 pp.

Osmani, S., 1997: Numerical methods. Sh.B.L.U., Tirana, 125 pp.

Osmani, S., and Korini, Th., 2001: Geostatistics. Sh.B.L.U., Tirana, 310 pp.

Plummer, C., 1988: Physical geology. Elsevier, N.Y, 580 pp.

Shallo, M., and Daja, S., 2000: Geodynamics. Sh.B.L.U., Tiranë, 215 pp.

Sulstarova, E., 1987: The seismic fractures of Albania and the today's tectonic stress field. Seismic studies, Vol. I, 143pp.

Turcotte, D., and Schubert, G., 2003: Geodynamics. Cambridge, 279-287, 580 pp.

V. Čermak, R. Haenel, International Association for Seismology and Physics of the Earth's interior, 30-33, 1988.

VDI (2001): Thermal use of the underground – Ground Source Heat Pumps. – Guideline VDI 4640, part 2, Beuth Verlag, Berlin.

Wu, Y., and Pruess, K., 1988: An analytical solution for wellbore heat transmission in layered formations. SPE 17947. 350-500.