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Designing of the Integral, Cascade and Hybrid Use Scheme, for the Kozani-8 Geothermal Water; Some Thermal and Economical Calculations

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Abstract

Albania is relatively rich with low up to the middle enthalpy, geothermal resources. Their temperature varies from 34°C up to 65.5°C to Kozani -8, the most important among the Albanian geothermal wells. It had been drilled in 1989. The well is located on the hills, 26km SE of Tirana. It encounters limestone strata at 1819m, penetrating 10m into the section. The yield of the well is 10.3 l/s, and is stable from more than 23 years. The geographical position of the well, placed in the middle of a village, very close to the corridor 8, are the basic parameters on choosing these waters for our designs and calculations. The design provides the cascade and integral use, but not only. It also provide the electricity generations, through a hybrid system. The centre will be also equipped with SPA, open and closed pools, fitness, massages, and greenhouse & also aquaculture pools. The economic analyses shows that this resource is completely competitive, and is unjustified it's further "waste". It will also help on improving the living standards for the local community.

Keywords: Geothermal; Kozani-8; pool; temperature; cascade; heat exchanger;

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1. Introduction

The Ishmi-Kruja geothermal zone, Fig. 1, is close to the "Mother Teresa" international airport. It is also next to the Kruja historical city, the wonderful Adriatic Sea beaches & Lake of Ohrid. The demonstrative geothermal centre, 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. Actually all these waters are "wasted": they flows directly to a creek, meaning huge economical loses. Among different processes of the cascade, will 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.

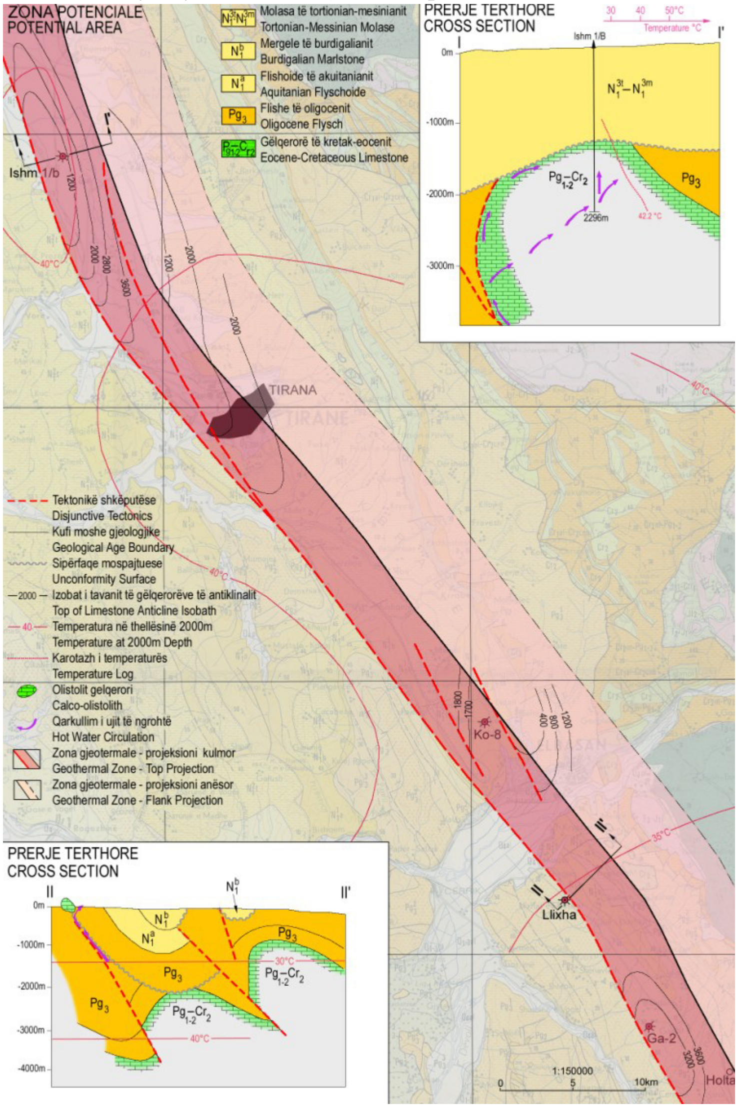

Figure 1: Map of the Ishmi-Kruja Geothermal zone

Nomenclature

Φ	the effective porosity of the limestone ($P=5.8x10^{-3}$)
ρ_m	mean density of the matrix ($\rho_m= 2640$ kg/m^3)
c_m	specific heat capacity of the formation ($c_m=1.1$ kJ/kgK)
ρ_w	water density ($\rho_w= 980.37$ kg/m^3)
c_w	water specific heat ($c_w=4.1893$ kJ/kgK)
t_1	formation temperature ($t_1=85°C$)
t_0	ground temperature ($t_0=16.5°C$)

1.1. The geological structure of the region

Kozani-8 geothermal well lies on the limestone structure of Kozani, which lies about 180 km, with a width of 4-5 km [6]. On the regional point of view, sink up to the depth of 10 km, where they are placed above the Triassic evaporites formation Aliaj et al., 1996. In this depth the temperature reach the values of 120-150°C. Important for this region is the presence of the tectonic, related with the evaporites formations, Hyseni et al., 2000. Kozani-8 well is placed in the S-E of Tirana. The water comes from the interval 1816-1837 m of depth Frashëri et al., 2004. 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 mineralisation is 4.6 g/l, Frashëri et al., 2004.

1.2. Energetic reserves evaluation of the Kozani limestone structure

The formation heat is calculated through the relation Frashëri et al., 2004:

$$Q_0 = \left[(1-\Phi)\cdot \rho_m \cdot c_m + P \cdot \rho_w \cdot c_w\right](t_1 - t_0)\cdot A \cdot \Delta z \quad (1)$$

$$Q_0 = \left[\left(1-5.8\cdot 10^3\right) * 2640 * 1100 + 5.8\cdot 10^{-3} * 980.37 * 4189.2\right](85-16.5) * 27\cdot 10^6 * 2\cdot 10^3 = 1.0712\cdot 10^{10}\, GJ \quad (2)$$

The geothermal energy reserves are calculated through the relation:

$$Q_1 = R_0 \cdot Q_0 = 1.0712\cdot 10^{18} = 1.0712\cdot 10^9 \;\; GJ \quad (3)$$

$R_0=0.1$ because Kozani-8 is the only well, erupting hot water. The recoverable geothermal energy is:

$$E = Q_v\left(t_t - t_r\right)\cdot \rho_w \cdot c_w \cdot \Delta t = 10{,}3\cdot 10^{-3}(85-25)\cdot 980.37 * 4189.3 * 365 * 86400 * 30 = 2{,}401\cdot 10^6 \;\; GJ \quad (4)$$

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

It was thought by the group of authors, that the best and more efficient way to use the geothermal waters of Kozani-8 well is the constructions of a multicenter. 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) Ingersoll et al., 1950, while for the cooling will be installed a geothermal heat pump, Harlow & Klapper, 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). In the Fig. 2, is showed the frontal and lateral view of the center, while in the Fig. 3, the principal sketch of the cascade and the hybrid system.

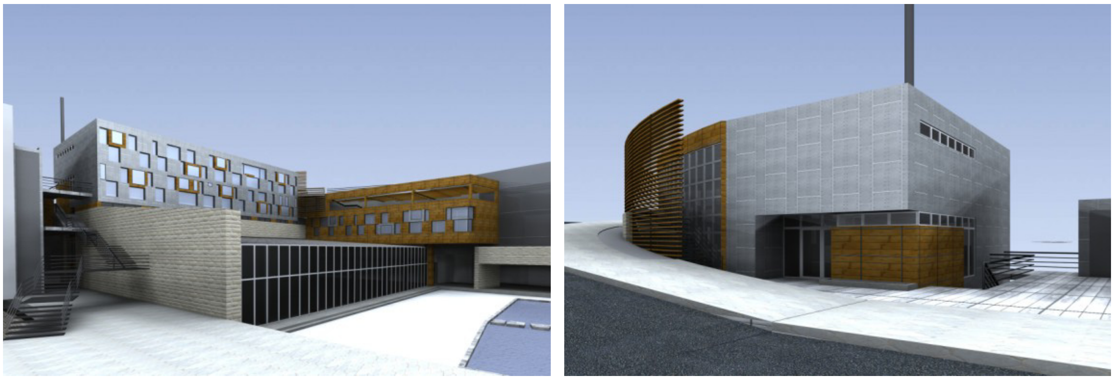

Figure 2: Frontal and lateral view of the Hotel-Clinic and SPA center

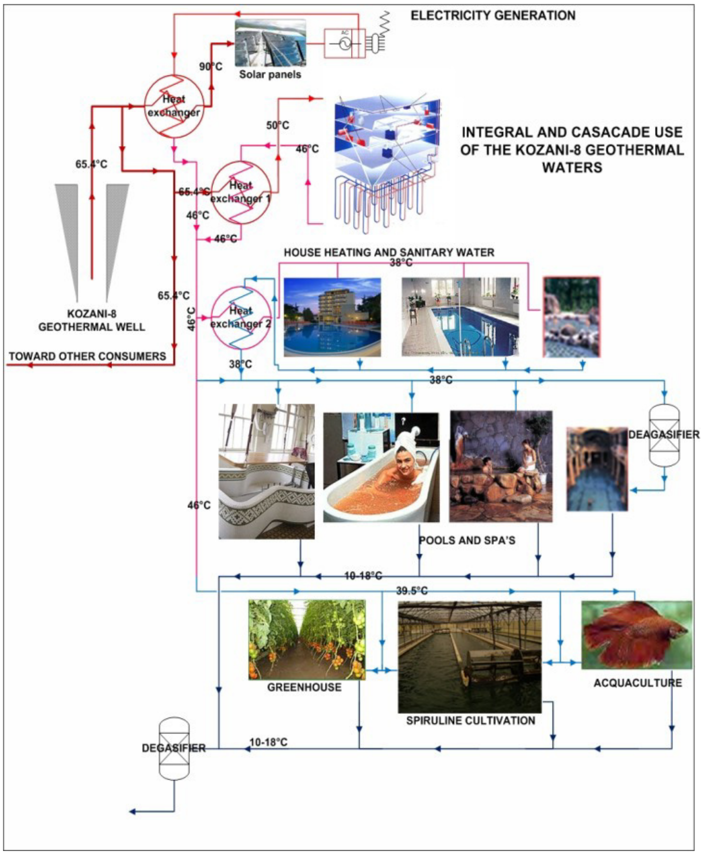

Figure 3: The principal sketch of the centre

1.4. Heat looses

The proposed centre 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 super dimensioning. In the Fig. 4 is showed 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, Kodhelaj 2012. 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, Kodhelaj 2012.

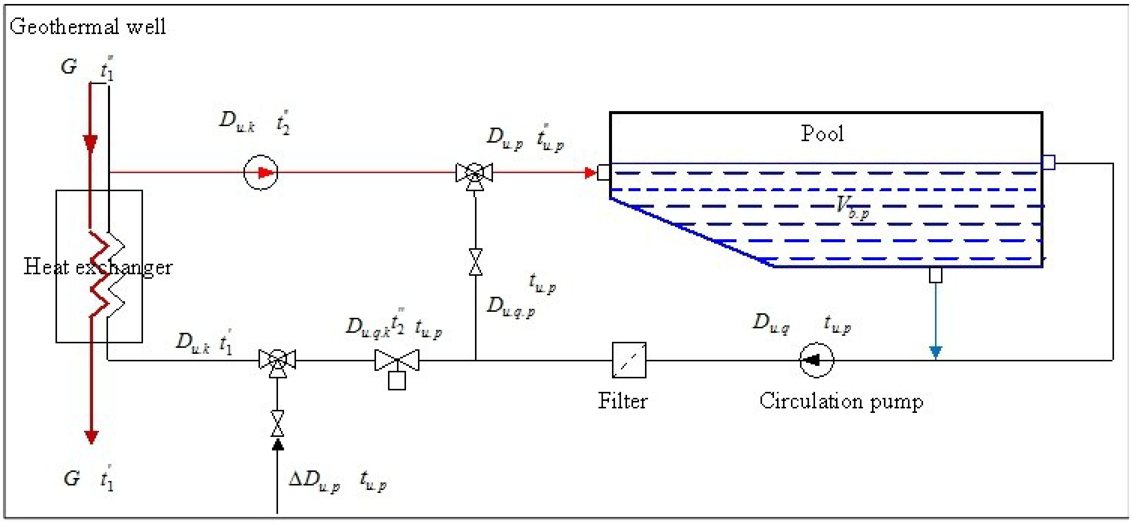

Figure 4: The pools circulation scheme

In the Table 1 are presented the thermal loads for the centre for both seasons: winter and summer, while in the Table 2 the parameters of the closed pools environment, Kodhelaj 2007:

Table 1: Seasonal thermal loads of the centre

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 2: Closed loops 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]

In the Table 3 are showed some costs data's related with the constructions cost for the Recreative Geothermal Center & SPA, Shijon, Elbasan. There can be clearly seen that the biggest investemnt should be done for the building (66.7%), while that the total investment is calculated to be 5 708 285 Euro, Kodhelaj 2007.

Table 3: Costs calculations for the Shijoni Recreational Geothermal Centre & SPA

Constituent	**Investment (€)**
Property (land acquisition)	440 880
Hotel Clinic center	
• Building	3 808 280
• Acclimatize system	654 560
• Furniture	229 670
Greenhouse	186 710
Spirulina cultivation center	252 085
Aquaculture installations	136 100
Total (€)	**5 708 285**

Calculations for the NPV, with different yearly income and ROR=10%, shows that the NPV is equalized to zero, only if the yearly income is 333326.258 €. For lower income the NPV result negative while for greater income it is positive, while is expected to be a yearly income of about 500 000 €. It can be seen clearly in the Fig. 5, Kodhelaj 2007.

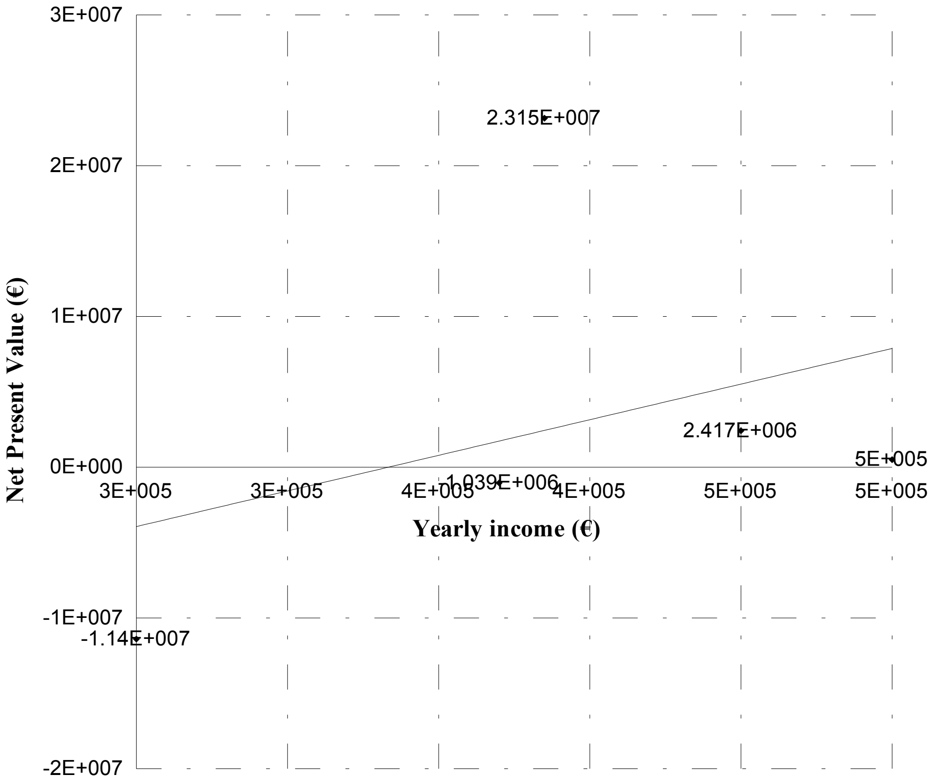

Figure 5: The NPV analyses

2. Conclusions

- The Kozani-8 water temperature is suitable for the supply of an recreational center, including geothermal, indoor and outdoor pools;
- The water temperature is suitable for feeding of two cascades;
- The hybrid systemm will improve the economical efficience of the project;
- The construction of the center will improve the energetic balnace of the region;
- The construction of the center will help on diversifying the energy resources in Albania;
- It will improve the living standards of the community;
- The economical analyses shows that it is feasible.

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