Combined use of 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 ℃ up to 65.5 ℃ to Kozani -8, the most important among the Albanian geothermal wells. 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 economic analyses, based on the NPV calculations, shows that this resource is completely competitive, and is unjustified it's further "waste". Despite the fact that the investment is too high (over 5.5 million Euro), it is completely feasible. It will also help on improving the living standards for the local community.**

***Keywords:*Geothermal, Kozani-8, pool, temperature, cascade, heat exchanger, economics.**

INTRODUCTION

The Ishmi-Kruja geothermal zone 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 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 ℃, and yield 10 l/s. In the aquifer top of the well trunk the water is 80 ℃. Hot water has salinity of (4.6-19.3) g/l. actually all these waters are "wasted": they flows directly to a creek, meaning high 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.

THE GEOLOGICAL STRUCTURE OF THE REGION

The Kruja Geothermal Zone extends for 180 km from the Adriatic Sea in the North and continues down to the South - Eastern area of Albania and to the Konitza area in Greece [1]. Geothermal aquifer is represented by a carstified neritic carbonate formation with numerous fissures and micro fissures. 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 [2]. On the regional point of view, sink up to the depth of 10 km, where they are placed above the Triassic evaporites formation [3]. In this depth the temperature reach the values of 120-150 ℃. Important for this region is the presence of the tectonic, related with the evaporites formations [4]. Kozani-8 well is placed in the S-E of Tirana. The water comes from the interval 1816-1837 m of depth [1]. The formation temperature is 80 ℃, while the pressure is 191 bars. The wellhead pressure is 12 bars, while the temperature is 65.5 ℃. The mineralization is 4.6 g/l [3], 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.

ENERGETIC RESERVES EVALUATION OF THE KOZANI LIMESTONE STRUCTURE

Theenergetic calculation of the proposed center intent to give the results of the formation heat Q_0, geothermal energy reserves Q_1, recoverable energy E, specific reserves q, energetic capacity Q_e, and annual energy use S_e and the capacity factor K. Their values are showed in the table 1 [5].

TABLE 1: THE ENERGETIC VALUES OF THE KOZANI-8 GEOTHERMAL WELL

Energetic values of the Kozani-8 well, geothermal water						
Q_0	Q_1	E	q	Q_e	S_e	K
$1.0712 * 10^{10}$ GJ	$1.0712 * 10^{9}$ GJ	$2.4011 * 10^{10}$ GJ	39.63 GJ/m^2	2.05 Mwah	0.39 TJ/year	0.006

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 [6]. 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) [7], while for the cooling will be installed a geothermal heat pump [4]. 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. 1", is showed the frontal view of the center, while in the "Fig. 2", the principal sketch of the integral, cascade and the hybrid system [7].

Fig.3. The Shijoni recreational center frontal view

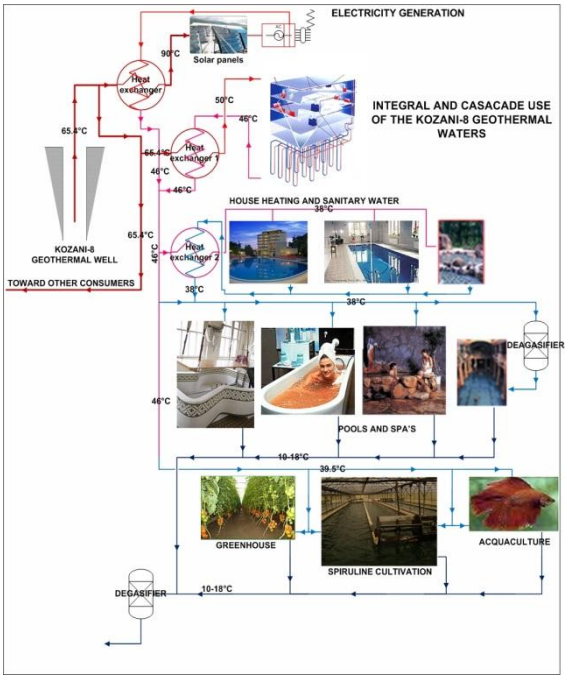

Fig.3. The principal sketch of the center

HEAT LOSSES

The proposed center will have several pools: 1 geothermal pool (designed as a natural pond, sized 10*8*0.5 m, water temperature 38 ℃-degasified); 1 open Olympic pool (sized 50*23*3 m, water temperature 30 ℃); 1 sweet water pool (sized 10*5*1.5 m-escalate, water temperature 38 ℃-degasified, lightly closed); 1 kids sweet water pool (sized 5*3*0.5 m-escalate, water temperature 30 ℃) [8]. 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. In the tables 2, 3 and 4 can be seen the results [9].

TABLE 2: THE WINTER THERMAL LOAD OF THE CENTER

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

TABLE 3: THE SUMMER THERMAL LOAD OF THE CENTER

Room/environment	SUMMER			
	Thermal load [kW]	**Air [kW]**	**Sanitary water [kW]**	**Total [kW]**
Main building	100	130	53	*283*
Closed pools				*130.5*
Geothermal pool (10x 8)m				*72*
Sweet water pool (10x5m)				*45*
Kids pool (5x3m)				*13.5*
Subtotal				***413.5***
Closed pool (water)				
Geothermal pool (water)				
Sweet water pool (water)				
Olympic pool (water)				
Total				**413.5**

TABLE 4: 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]

ECONOMICAL ANALYSIS

In Table 5 is showed some costs data's 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 [6].

TABLE 5: COSTS CALCULATIONS FOR THE SHIJONI RECREATIONAL GEOTHERMAL CENTER & SPA

Constituent	Investment [€]
Property (land)	440 880
Hotel-Clinic - Building - Acclimatize system - Furniture	 3 808 280 654 560 229 670
Greenhouse	186 710
Spirouline cultivation center	252 085
Acquaculture installations	136 100
Total [€]	5 708 285

The economic analyses are done based on the Net Present Value (NPV) Calculations. The center will be constructed through a banking 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%). In the Table 6 are showed 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. In the "Fig. 4", is showed the chart of PV/time, while in the "Fig. 5", the chart of NPV/CF. Analytical analyses (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 predict a CF of about 445 000 €/y, based in the Albanian touristic market and its prices [10].

TABLE 6: 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**

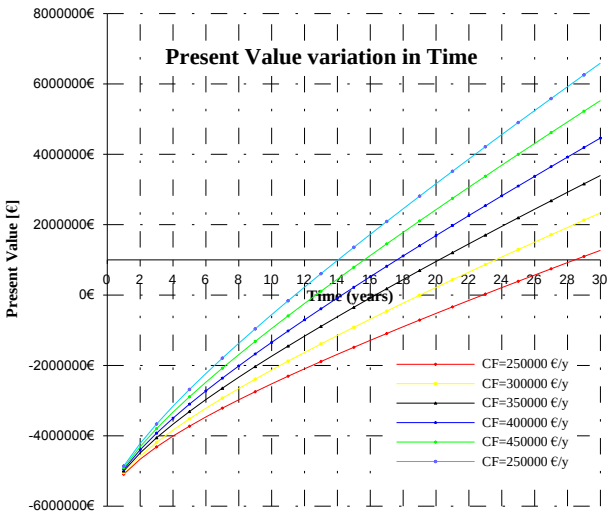

Fig.4. Present Value variation versus Time

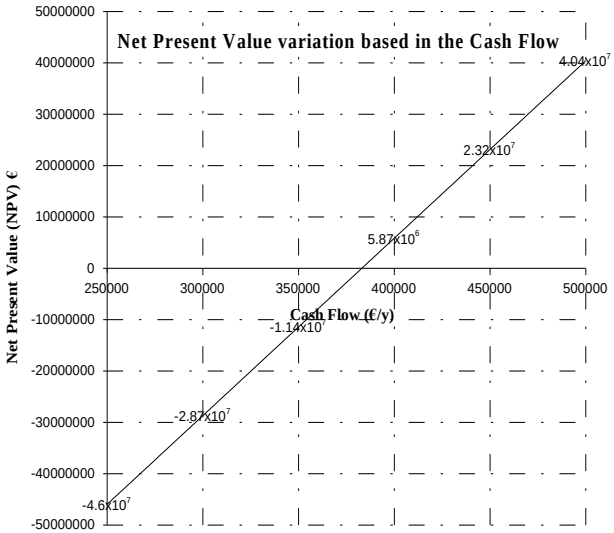

FIG.5. NET PRESENT VALUES FLUCTUATION BASED ON THE CASH FLOW

Due to the investment value and also to the fact that this project-proposal is the first of its kind in Albania it was performed the risk analyses, using Palisade Decision Tool suite Industrial (Monte Carlo simulation). The results are showed in the "Fig. 6"& "Fig. 7" [11].

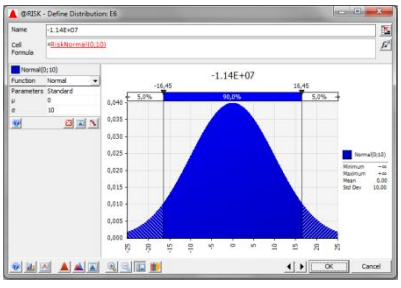

FIG.6. RISK ANALYSIS CHART FOR PV 350 000 US$/YEAR

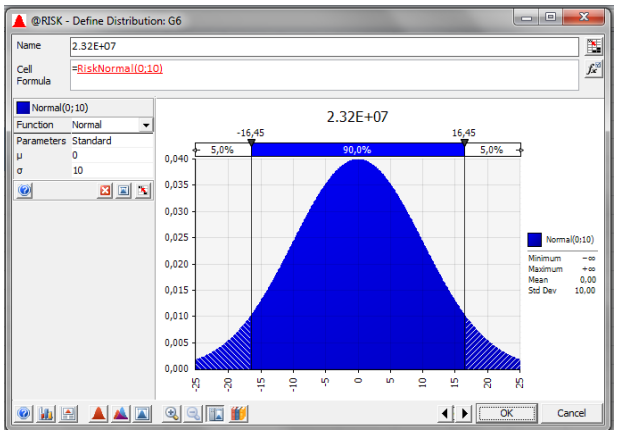

FIG.7. RISK ANALYSIS CHART FOR PV 450 000 US$/YEAR

The precision tree is showed in the "Fig. 8", this analysis prove that there is not any risk for the investment.

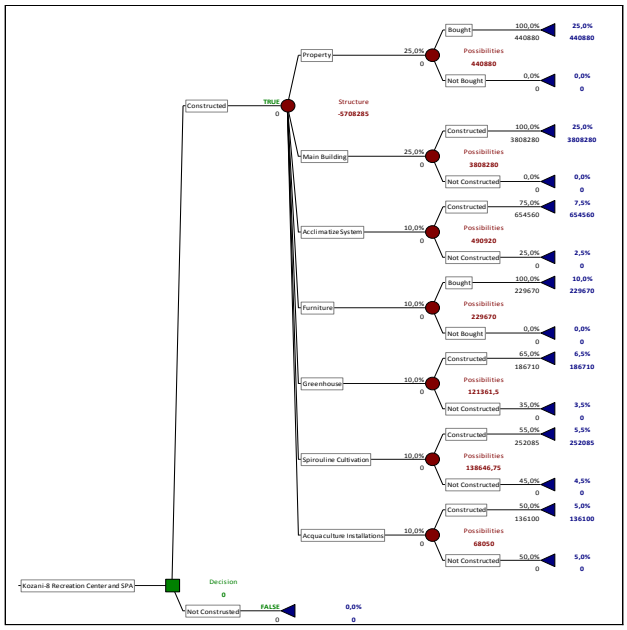

FIG.8. THE PRECISION TREE (USING MONTE CARLO SIMULATION)

CONCLUSIONS

1. The Kozani-8 water temperature is suitable for the supply of a recreational centre, including geothermal indoor and outdoor pools;
2. The water temperature is suitable for feeding of two cascades;
3. The hybrid system will improve the economic efficiency of the project;
4. The construction of the centre will improve the energetic balance of the region;
5. The construction of the centre will help on diversifying the energy resources in Albania;
6. The degasified and desalination line will improve the environmental status of the area, as actually is highly polluted;
7. It will improve the living standards of the community;
8. The economic analyses show that it is viable;
9. The risk analysis shows very optimistic data's for the future of the investment.

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