

Geothermal in Albania as a Potential Energy Resource

Polo N^{1.}, Kodhelaj N^{1.}, Karamani E^{1.}, Vlashi^{1.}, Gropa O^{1.}, Bozgo Sh^{1.}, Sopaj E^{2.}, Aliko A^{3.} and Ismaili L.^{4.}

¹Energy Resources Department, Faculty of Geology and Mining, Polytechnic University of Tirana, Albania

²Statkraft, Albania

³SEA Consulting, Albania

⁴Ministry of Infrastructures and Energy of Albania

nevina.koja@fgjm.edu.al; nevton.kodhelaj@fgjm.edu.al; erison.karamani@fgjm.edu.al; kejsid.vlashi@fgjm.edu.al;
ortenca.gropa@fgjm.edu.al; shkelqim.bozgo@fgjm.edu.al; sopaj.enkeleda@gmail.com; abaz.aliko@sea-consulting.co;
ismaililusjen1@gmail.com

Keywords: Geothermal, utilization, springs, wells, scheme, water, cost, risk, analyze.

ABSTRACT

Earth, our planet, which provide to us the only living environment, represent a huge source of energy, in and above ground. Like the other Balkan countries, Albania is located next to the subduction boundary between the African plate and the Euro-Asiatic one, the basis that allows to have as part of the renewable resources also the geothermal ones, which for the time being are not used at all for their energetical features, but their use is limited only with their health values. Energetic calculations including heat loose, setting of the geothermal heating system based in their viability, vertical heat exchanger capacity evaluation and their design, economic analyses and the related calculations as the preliminary installation costs, water production and injection wells costs, the comparison with the coal heater and air conditioners as part of the viability study are part of this paper.

1. INTRODUCTION

Along the 20th century, especially its second half, the technologies signed a remarkable development. All these developments made possible an unbelievable progress regarding the living standards of the population, but is never possible to have a good quality of life without having full energy supply. Thus, the global energy demand increased very rapidly, sometimes faster than the supply. The world is witnessing a new revolution driven by various trends and technologies, and the primary goal is to identify and implement new transformative models in energy and material flows. All these transformations are actually shaped by the 2030 Agenda for Sustainable Development (2030 Agenda) and the Paris Agreement on climate actions (Kodhelaj, N., 2011). As new policies, approaches and business models emerge to reshape production, consumption, transportation and delivery systems, modernized and unified ways of managing the resulting energy and material flows are needed. 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, emerging after the WW2, especially the nuclear energy had strong negative impact, i.e., human health, environment etc. It can't be neglected also the geopolitical fact that the industrial reserves of the radioactive reserves are located in "problematic countries" whose behavior is not as friendly as it should be, therefore is highly risky to depend on their homeland policies and leaderships. Is because of all these, that the efforts of the scientific communities as well as the political decision-makers of the G7, OECD, EU etc. are more and more focused toward the diversification of the energy portfolios, emphasizing the renewable ones, including the geothermal energy (A., Geothermics of Albanides, 1993) (Frashëri A. and Çermak V. (Co-editors-in chiefs), 1995).

Albania is a small country of only 28 787 km² surface area and around 4 200 000 inhabitants, situated in the southwestern part of the Balkan Peninsula. Though it is a small country could be considered relatively rich with natural resources, including the fossil fuels and the renewable ones. Like the other Balkan countries, Albania is located next to the subduction boundary between the African plate and the Euro-Asiatic one. This is the basis that allows to have as part of the renewable resources also the geothermal ones, which for the time being are not used at all for their energetical features, but their use is limited only with their health values. 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 with a number of wells (drilled for oil & gas exploration) producing water with temperatures around 40°C at variable yields. 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 (A., Heat Flow in Albania, August 18-28, 1997) (Kodhelaj N., December 27-28, 2011) (Dakoli H., 2000).

The balneological use of the geothermal fluids in Albania dates back to early in history, since the time of the Roman Empire (i.e., the Sarandaporo's thermal baths). The aim of the study is to show that the use of the Llixha Elbasan springs, part of the 12 natural geothermal springs of the country, but among the most important geothermal resources of Albania, as an energy resources if fully feasible, beside their utilization for health purposes. The respective calculation includes the open swimming pool (Frashëri A. and Çermak V. (Co-editors-in chiefs), 1995).

Same calculations made for geothermal springs, in the Lëngarica river were located eight springs blowing 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, known and used for their curative values since the time of the Roman Empire proof that they represent a competitive energy resource. Their flows directly to the river of Lëngarica, similarly with 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 (Frashëri A. and Çermak V. (Co-editors-in chiefs), 1995).

In the country have been also drilled approximately 6 200 well for oil and gas exploration, 5 000 of them before 1990 and others after 2 000. Among them, 11 wells have blown out, and still continue to do it, hot brine, with temperatures varying from slightly less than 30°C to a maximum of 67°C. Their yields vary from less than 1 l/s to a maximum of 30 l/s. The temperature (65.5°C), steady yield for more than 35 years (10.3 l/s) and most important very good location (very close to the corridor 8), are the basic parameters on choosing these waters for the designs and calculations of a Geothermal Recreational Center of the Kozani 8 well. The design provides information’s and calculations on the cascade and integral use, but not only. The center shall allow the electricity generations, through a hybrid system. The recreational center 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 (KODHELAI Nevtan, BODE Aida, KOJA Nevina, ZEQQ Esmeralda, ZOGA Pirro, MUMAJESI Rajmonda, 2012).

Not less important is also the soil temperature regime of the country. Measurements shows that the temperatures in the depth of 100 m are within the limits for heat exchangers utilization in both ways: water-water systems or even through the heat extraction. The climate of Korça, especially the winter season, enforces uses of the heating system for more than 4 months/year. The Korça university campus had been chosen not only for its characteristic but also because this is the biggest public building of the region, with very intense energy consumption, so the economical profit can be significant (Kodhelaj, N., 2011).

Surely the geothermal energy utilization in the country can’t resolve all problems related with the energy sector, but without any doubt it can help on their mitigation. Not less important are also the relief of the social problems as the employment, immovable properties related issues, environmental and the diversification of the portfolio. It can be a good step toward the decarbonization of the Albanian economy as well. Their use shall be a good start on poverty reducing in the country, promotion of the sustainable agriculture, ensuring the healthy living and well-being of the population, ensuring the sustainable management of the water resources, ensuring affordable, reliable, sustainable and modern energy systems for all, promoting the sustainable economic development and employment and protecting the terrestrial ecosystems, in full alignment with the 2030 Agenda for the Sustainable Development (Kodhelaj, N., 2011).

2. MATERIALS AND METHODS

This study is a short and synthetic literature review on issues and scientific aspects related to the current knowledge on geothermal energy and its potential in Albania regarding the industrial use of this valuable renewable energy resource. Consequently, all previous studies on this field were used. Studies were included if they evaluated as economically feasible the industrial use of the geothermal energy in Albania (Lund J. W., 2009) (Lund J.W., Lienau., 2009) (Lund J.W., Sanner B., Rybach L., Curtis R., Helstrom G., 24-29 April 2005) (Lund, J. W.: Kah-Nee-Ta, 2004) (Çermak V., 1999).

2.1 Results

2.1.1 Geological background of Albania

Albania, although a small territory, has not only and simply geological events and characteristics, but is also favored for having both kind of heat sources: the internal and external ones. Consequently, in this small area is possible to find a wide specter of sedimentary rocks, magmatic and metamorphic ones, of different geological ages and with high geothermal capacity, in the form of structural chains, whose tent to create some tectonic zones, clearly different from each-other due to the very active longitudinal and transversal tectonics. The structural scale, tectonic regimes and neo-tectonic activity are strongly related with the east Orogen and Adria Plate in West and wider, in the frame of the African Plate (South) with the Euro-Asiatic one in North collision, as showed in Figure 1. Some of these tectonic faults goes some tenth kilometers deep below the Earth crust, changes their status to liquid due to the fact that the temperature and pressure go to extremely high values (Frashëri A. and Çermak V. (Co-editors-in chiefs), 1995) (Frashëri, A., Čermak, V., 2004).

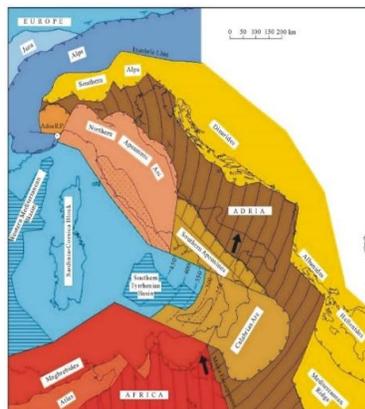


Figure 1: Adria tectonic plate sketch

2.1.2 Geothermal energy in Albania

The geothermal fluids, are found as natural springs and wells, of Albania are located in three zones: Kruja, Ardenica and Peshkopia. The three zones differ from each-other by the geological characteristics and thermo-hydrogeological features, as shown in Figure 2. They are related with the regional tectonic and the seismological activities (Çermak V., 1999) (A., Geothermics of Albanides, 1993).

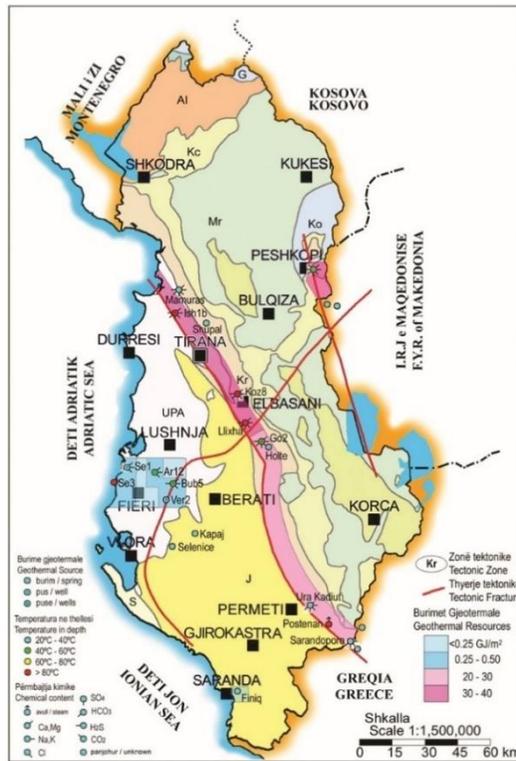


Figure 2: Geothermal map of Albania

Kruja Geothermal Zone extends over a length of 180 km from the Adriatic Sea in the North, down to the Southeastern area of Albania, and further S-E to the Konitza area in Greece. The 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. Thermal springs of the Llixha Elbasani spa are located about 12 km S of Elbasani city. The Ishmi - 1/b is the northernmost borehole of Kruja geothermal field, about 20 km NW of Tirana. The Kozani - 8 well was drilled in 1989 and is located 26 km SE of Tirana. Hot water has continuously discharged from the Ishmi-1/b and Kozani - 8 boreholes at rates of 3.5 l/s and 10.3 l/s, respectively, since the end of drilling operations in 1964 and 1988, respectively. Galigati-2 borehole is located on a hill, about 50 km SE of Tirana. Elbasani Llixha spring's location is about 12 km South of Elbasani. There are seven spring groups that extend like a belt with an azimuth of 320°. In this area, the reservoir is represented by the Llixha limestone structure. These springs have been known since before the Second World War. Surface water temperatures in the Tirana-Elbasani zone vary from 60°C to 65.5°C. Wellhead temperatures in the Tirana-Elbasani zone vary from 60 - 65.5°C. The temperature at the top of aquifer reaches 80°C in the Kozani-8 hole. According to the temperature logs in Ishmi - 1/b and Galigati - 2, temperatures at depth in the carbonate section are 42.2°C and 52.8°C, respectively. The Lëngarica river thermal springs, near of the Vjosa River Valley, Postenani steam springs and the Sarandaporo springs can be found south of the Kruja geothermal area. Water temperature is 29°C. Yield is 30-40 l/s. For the Tirana-Elbasani subzone heat in place is $5.87 \times 10^{18} - 50.8 \times 10^{18} \text{ J}$, identified resources are $0.59 \times 10^{18} - 5.08 \times 10^{18} \text{ J}$, while the specific reserves range between values of 38.5-39.6 GJ/m². The second subzone, Galigati, has lower concentration of resources 20.63 GJ/m², while geothermal resources amount to $0.65 \times 10^{18} \text{ J}$. These reserves have been extrapolated for this whole subzone up to the Albanian-Greek border (Frashëri, A., Čermak, V., 2004).

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs. Hot water discharges from the boreholes Ardenica - 3 and Ardenica - 12, both situated in the Ardenica brachy anticline, Semani - 1 and Semani - 3 boreholes in the Semani anticline structure, in the Verbas - 2 drilled in the Patosi monocline and the Bubullima - 5 borehole that intercepts the carbonate section of the Patos-Verbas structure. At the surface, the boreholes discharge waters at temperatures of 32-67°C. At the wellhead, temperatures are 32°C for Ardenica - 12 well, 35°C for Semani - 1 well, 38°C for Ardenica - 3 well and 67°C for the well Semani - 3. However, the temperature in the aquifers at depth of 1935-1955 m is 45.8°C. Ardenica reservoir has energy reserves in the range of $0.82 \times 10^{18} \text{ J}$. Resources density varies from 0.25-0.39 GJ/m². The boreholes have been abandoned from a long time and await renewed investments to be converted into geothermal exploration (Frashëri, A., Čermak, V., 2004).

Peshkopia geothermal zone is located two kilometers east of Peshkopia, and water at 43.5°C flows out of a group of thermal springs on a river slope composed of flysch deposits. Some of the springs yield flow rates up to 14 l/s. Different geothermometers indicate the reservoir temperatures are 140 - 270°C. Considering the regional geothermal gradient, temperatures of 220°C would be found at depth of 8 - 12 km. Water temperature, big yield, stability, and also aquifer temperature of Peshkopia Geothermal Area, are similar with those

of Kruja Geothermal Area. For this reason, the geothermal resources of Peshkopia Area have been estimated to be similar to those of Tirana-Elbasani Area (A., Geothermics of Albanides, 1993) (Frashëri A. and Çermak V. (Co-editors-in chiefs), 1995). Actually, in Albania are identified 12 natural geothermal springs as well as are drilled in total 10 geothermal wells, although none of them was designed and drilled for this aim, but as oil&gas exploration one. Table 1 shows the main characteristics and location of each one of them.

Table 1: Albanian Geothermal Springs/Wells location, temperature and yield

| Geothermal springs of Albania | | | | | | | | | | | |
|-------------------------------|----------------------------------|------------------|--------------|---------------|-----------|-----------|------------|-------------|-------------|-------------|-------|
| No | Spring/well and location | Temperature (°C) | Coordinates | | | Yield | | | | | |
| | | | Latitude (N) | Longitude (E) | | | | | | | |
| 1 | Mamurras 1 & 2 | 21±22 | 41°42'24" | 19°42'48" | 46.951081 | 7.438637 | 381189.160 | 5200911.095 | 2609561.177 | 5202377.524 | 11.7 |
| 2 | Shupal | 29.5 | 41°26'9" | 19°55'24" | 41.435833 | 19.923333 | 410049.076 | 4587699.836 | N/A | N/A | <10 |
| 3 | Llixha, Elbasan | 60 | 41°0'2" | 20°04'20" | 41.033333 | 20.072222 | 422011.295 | 4542871.902 | N/A | N/A | 15 |
| 4 | Hydraj, Elbasan | 55 | 41°1'20" | 20°5'15" | 41.022222 | 20.0875 | 423282.678 | 4541624.906 | N/A | N/A | 18 |
| 5 | Peshkopia | 43.5 | 41°42'10" | 20°27'15" | 41.702778 | 20.454167 | 454585.581 | 4616920.778 | N/A | N/A | 14 |
| 6 | Katint Bridge, Lëngarica, Përmet | 30 | 40°14'36" | 20°2'6" | 40.243333 | 20.433333 | 451801.477 | 4454919.354 | N/A | N/A | >160 |
| 7 | Vronomer, Sarandaporo, Leskovik | 26.7 | 40°5'54" | 20°40'18" | 40.098333 | 20.671667 | 472013.810 | 4438722.962 | N/A | N/A | >10 |
| 8 | Finiq, Sarandë | 34 | 39°52'54" | 20°0'3" | 39.881667 | 20.05 | 418767.812 | 4415055.382 | N/A | N/A | <10 |
| 9 | Holta Creek, Gramsh | 24 | 40°55'30" | 20°33'36" | 40.925 | 20.56 | 462953.359 | 4530524.589 | N/A | N/A | >10 |
| 10 | Postenan, Leskovik | Steam source | 40°10'24" | 19°48'42" | 40.173333 | 19.811667 | 398819.963 | 4447672.704 | N/A | N/A | N/A |
| 11 | Kapaj, Mallakastër | 16.9±17.9 | 40°32'30" | 19°39'30" | 40.541667 | 19.658333 | 386384.116 | 4488744.524 | N/A | N/A | 12 |
| 12 | Selenicë, Vlorë | 35.3 | 40°32'18" | 19°39'30" | 40.538333 | 19.658333 | 386378.482 | 4488374.432 | N/A | N/A | <10 |
| Geothermal wells of Albania | | | | | | | | | | | |
| 1 | Kozani 8 | 65.5 | 41°06" | 20°01'6" | 41.1 | 20.018333 | 417564.653 | 4550322.367 | N/A | N/A | 10.3 |
| 2 | Ishmi 1/b | 60 | 41°29'2" | 19°40'4" | 41.483889 | 19.667778 | 388780.261 | 4593332.187 | N/A | N/A | 3.5 |
| 3 | Letan | 50 | 41°0'79" | 20°22'49" | 41.119167 | 20.380278 | 447974.276 | 4552170.900 | N/A | N/A | 5.5 |
| 4 | Galigati 2 | 45±50 | 40°57'6" | 20°09'24" | 40.951667 | 20.156667 | 429022.251 | 4533734.042 | N/A | N/A | 0.9 |
| 5 | Bubullima 5 | 48±50 | 41°19'18" | 19°40'36" | 41.321667 | 19.676667 | 389247.220 | 4575310.738 | N/A | N/A | N/A |
| 6 | Ardenica 3 | 38 | 40°48'48" | 19°35'36" | 40.813333 | 19.593333 | 381362.258 | 4518987.550 | N/A | N/A | 15±18 |
| 7 | Semani 1 | 35 | 40°50' | 19°26' | 40.833333 | 19.433333 | 367907.147 | 4521436.705 | N/A | N/A | 5 |
| 8 | Semani 3 | 67 | 40°46'12" | 19°22'24" | 40.77 | 19.373333 | 362717.610 | 4514498.170 | N/A | N/A | 30 |
| 9 | Ardenica 12 | 32 | 40°48'12" | 19°35'42" | 40.803333 | 19.595 | 381485.063 | 4517875.188 | N/A | N/A | N/A |
| 10 | Verbasi 2 | 29.3 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 1±3 |

2.2 Discussion

2.2.1 Llixha Elbasan hot springs in Albania, study of temperature conditions and utilization calculations

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. The mineralization of the water is 7.2 g/l, the H₂S content 410 mg/l and free CO₂ 180 mg/l. 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⁻, SO₄⁻ and HCO₃⁻. The Ph is in the range 6.8-7 and the density 1000-1060 kg/m³. 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 center. The use of the water flowing from these springs can help to improve the economical effectiveness district heating in the village. A finite volume model was set up for a crustal volume with an area of 10 x 10 km and 5 km thickness to model the temperature, density and fluid velocity distribution in the Llixha region. The grid is shown in Figure 3. Here it is assumed that the medium is homogeneous and isotropic and that k_x = k_y = k_z = 2 W/m²K. 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), cp =4180 J/kg°C. 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 the temperature are showed at the Figure 4 (Kodhelaj N., 2009) (Kodhelaj N., December 27-28, 2011).

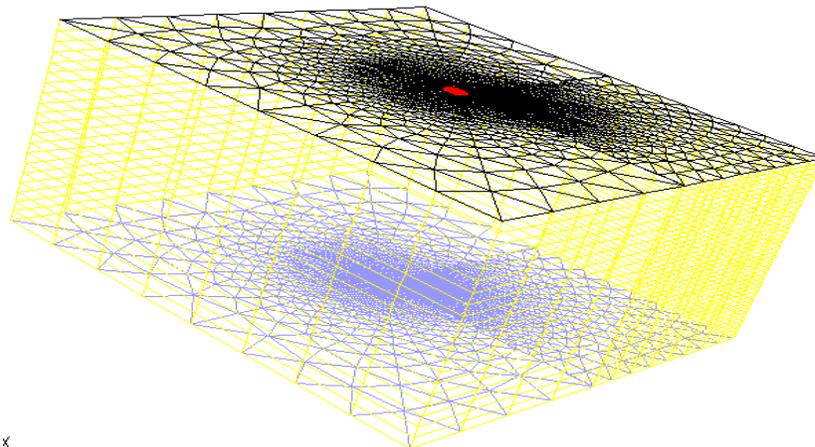


Figure 3: The finite volume grid used to model temperature and flow conditions in the Llixha region

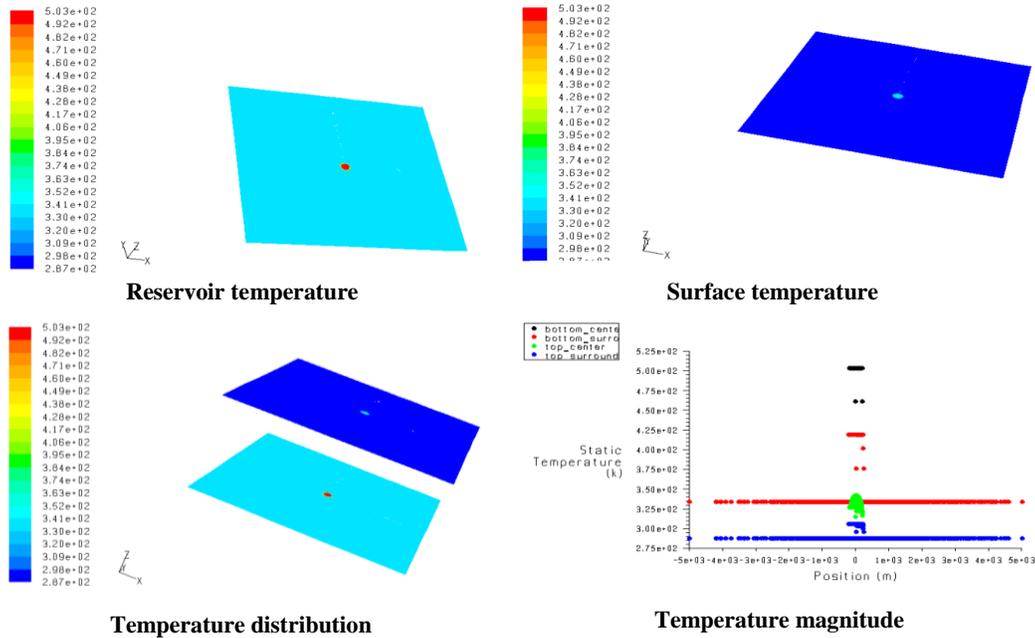


Figure 4: Llixha Elbasan modelling results

2.2.2 Kozani-8 Low Enthalpy Geothermal Water Use Through a Cascade and Hybrid System

The temperature of the water blowing out of the wells (see Table 1) 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. Finding of the hot brine was considered “accident” at that time, as the well had been designed and drilled to search oil & gas. The well is located on the hills, 26 km SE of Tirana. It encounters limestone strata at 1819 m, penetrating over 10 m into this section. The yield of the well is 10.3 l/s, and is presented 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 some of the most important parameters on choosing these waters for our designs and the related calculations (KODHELAIJ Nevton, BODE Aida, KOJA Nevina, ZEJO Esmeralda, ZOGA Pirro, MUMAJESI Rajmonda, 2012).

The recreational center provides the cascade and integral use of the Kozani-8 geothermal water, but not only [18]. It also provides the electricity generations, through a hybrid system. The center will be also equipped with SPA, open and closed pools, fitness, massages, greenhouse & also aquaculture. The center will be heated through the geothermal direct use (through the installation of the heat exchangers) while for the cooling will be installed a geothermal heat pump. The roof, covered with solar panels, whose combination can provide the sanitary water and also a part of them, will circulate the geothermal water and 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 Figure 5, is showed the frontal and lateral view of the center, in the Figure 6 is showed the aquaculture cultivation principal sketch while in the principal sketch of the integral, cascade and the hybrid system (Kodhelaj. N., Bode. A., et al., 2012).



Figure 5: Recreational Center Shijon - Elbasan

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, and this is proven also by the risk analyses. It will also help on improving the living standards for the local community. 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. In the aquifer top of the well trunk the water is 80°C.

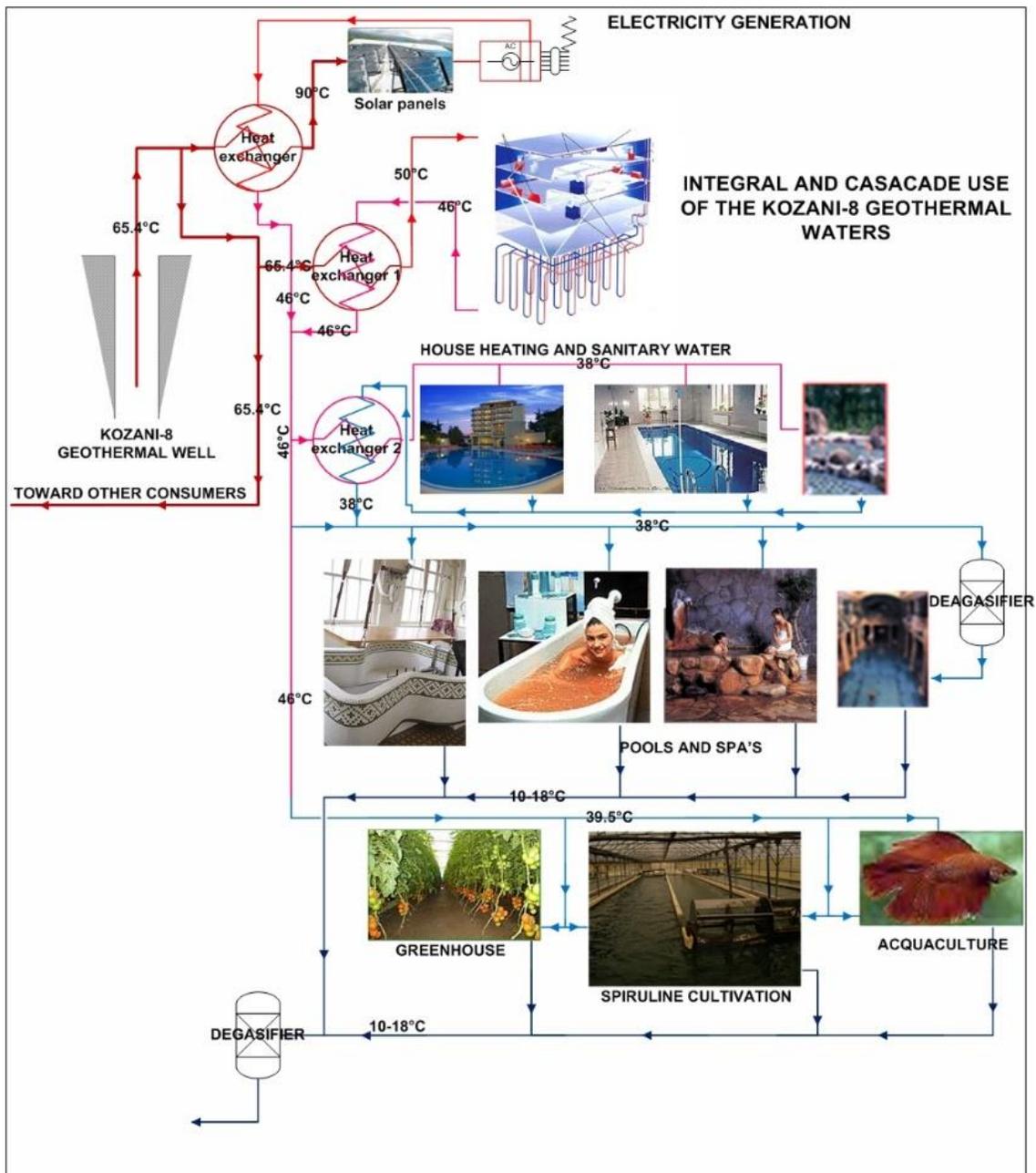


Figure 6: Principal sketch of the integral, cascade and hybrid use of the Kozani 8 geothermal water use

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, will be released CO₂ and H₂S, which will be used for food products (conservation) and medical purposes (see Figure 7). The hybrid system, combing of the middle enthalpy geothermal waters, with the solar panels, based on the fact that the Albanian climate allows such a thing (there are more than 280 sunny days on the area), will improve the economic efficiency of the project (Kodhelaj. N., Çela. B., Aleti. R., December, 2012).

Table 2 shows some costs data related with the constructions cost for the Recreational Geothermal Centre & 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 (Kodhelaj. N., Bode. A., et al., 2012).

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%). Figure 8 shows the chart of NPV/CF, while Figure 9 the chart of PV/time. The 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 will be positive. The business plan predicts a CF of about 445 000 €/y, based in the Albanian touristic market and its prices (KODHELAIJ Newton, BODE Aida, KOJA Nevina, ZEJO Esmeralda, ZOGA Pirro, MUMAJESI Rajmonda, 2012) (Kodhelaj. N., Bode. A., et al., 2012) (Kodhelaj. N., Çela. B., Aleti. R., December, 2012).

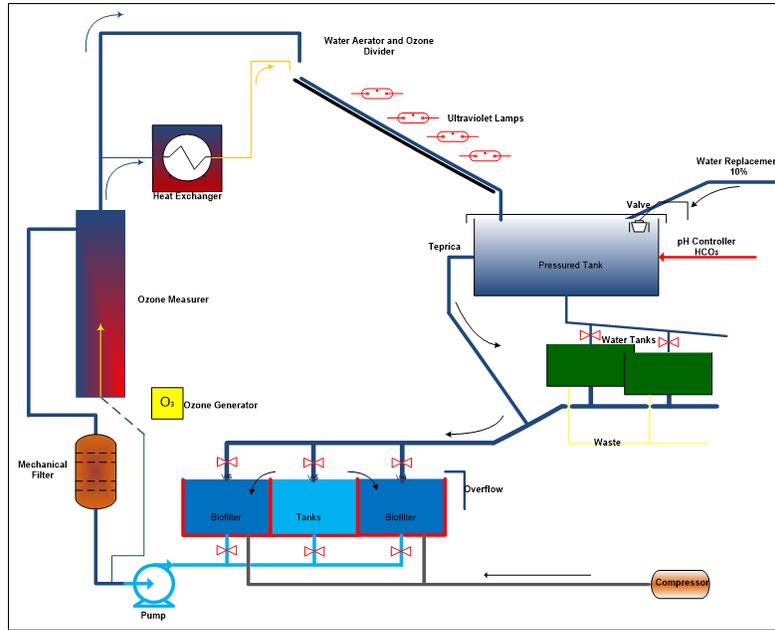


Figure 7: Aquaculture cultivation, desalination and degasifying principal sketch

Table 2: Costs calculations for the Shijoni Recreative Geothermal Centre & SPA

| Constituent | Investment [€] |
|------------------------------|------------------|
| Property (land) | 440 880 |
| Hotel-Clinic Building | 3 808 280 |
| Acclimatize System | 654 560 |
| Furniture | 229 670 |
| Greenhouse | 186 710 |
| Spirulina Cultivation Centre | 252 085 |
| Aquaculture Installations | 136 100 |
| Total [€] | 5 708 285 |

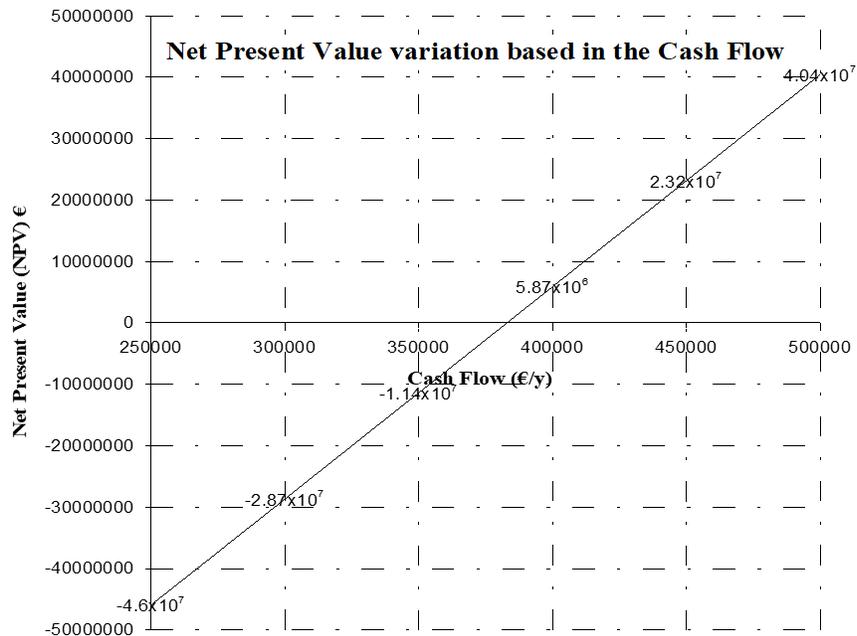


Figure 8: Net present value calculation chart

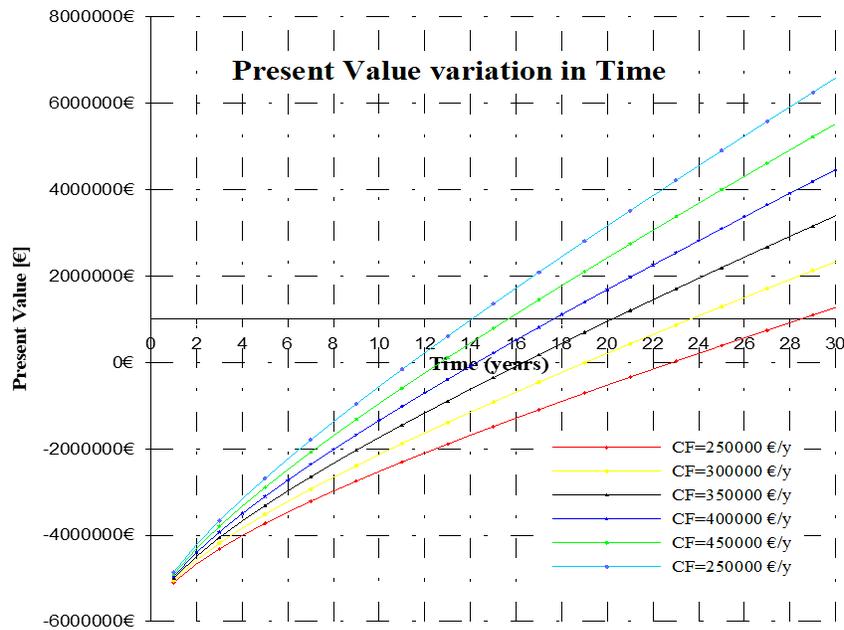


Figure 9: Present value calculation chart

2.2.3 “FAN S. NOLI” university campus geothermal heating design and viability

The following gives the basic calculation for the heating system of the “Fan. S. Noli” University campus building. The chosen of this building is made based in its importance and the climatic regime of Korça that makes necessary the heating for more than 5 months for year. In Korça there is no evidence of hot waters or steam sources, but the geothermal regime of the region allows the use of both systems: Water-Water and Earth-Water. Despite the fact that the initial investment is larger for the geothermal systems the NPV calculations and the risk analysis shows very clearly that they are much more viable, without mentioning another fact, they are environmentally friendly (Kodhelaj N., December 27-28, 2011).

Due to the Albanian geothermal regime, the cooling/heating systems of the buildings seems to be the best way to start its direct utilization. Albania is relatively rich with low up to the middle enthalpy geothermal resources whose had not been used until now for their energetic values. The temperatures in the depth of 100 m are within the limits for heat exchangers utilization in both ways: water-water systems or even through the heat extraction. The climate of Korça, especially the winter season, enforces uses of the heating system for more than 4 months/year. The university campus had been chosen not only for its characteristic but also because this is the biggest public building of the region, so the economical profit can be significant. Some important problems as: energetic calculations including heat loose, setting of the geothermal heating system based in their viability, Vertical heat exchanger capacity evaluation and their design, economic analyses and the related calculations as the preliminary installation costs, water production and injection wells costs, the comparison with the coal heater and air conditioners are part of the viability study (Dakoli H., 2000) (Frashëri, A., Čermak, V., 2004).

The city of Korça is in the S-E of Albania and its climatic regime is Mediterranean highlands and peri-highlands. The “Fan S. Noli” University campus is in third climatic region of Albania. The low temperatures during the winter make necessary the heating for the period October-May (see Figure 10) (Kodhelaj, N., 2011) (A., Boreholes temperature and climate changes in Albania. , 1995).

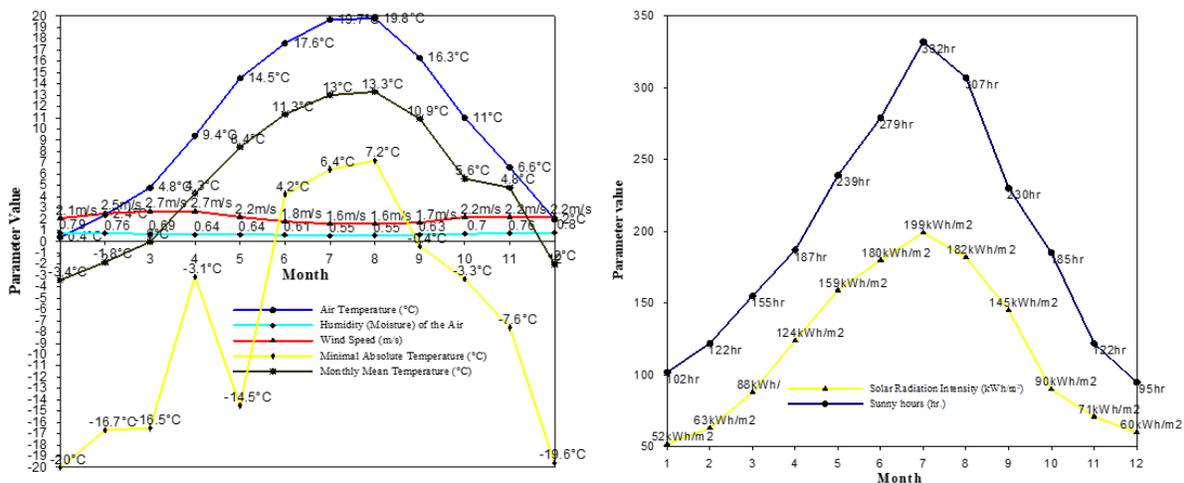


Figure 10: Annual fluctuation of different climatic parameters in Korça

The general area to heat is 1260 m² and has three floors. The elements of this system will be: The heater, the oil deposit, the burner, the chimney, the circulation pump and control panel. The energy of this system is calculated 178 kW, with an increase of 15% to cover losses. The calculation for the VHE shows that their length should be 1257 m for the water-water pump and 1500 m for the soil heat extraction. To achieve this length will be drilled 13 wells 100m deep/each for the water-water pump and 15 wells 100 m deep/each for the soil extraction system. Based in the energetic calculations and the market options the system will be composed by two geothermal heating pumps by 87.7 kW each. Two options were considered: Water-Water pumps and the soil heating extraction through the vertical heat exchanger (VHE) use. The soil temperatures in the Korça region make more viable the soil heat extraction through the VHE use (Frashëri, A., Čermak, V., 2004). Figure 11 shows the temperature annual variation at different depth in Korça and Figure 12 is a simplified sketch of a VHW installation using well drilled for this purpose (Kodhelaj N., 2009).

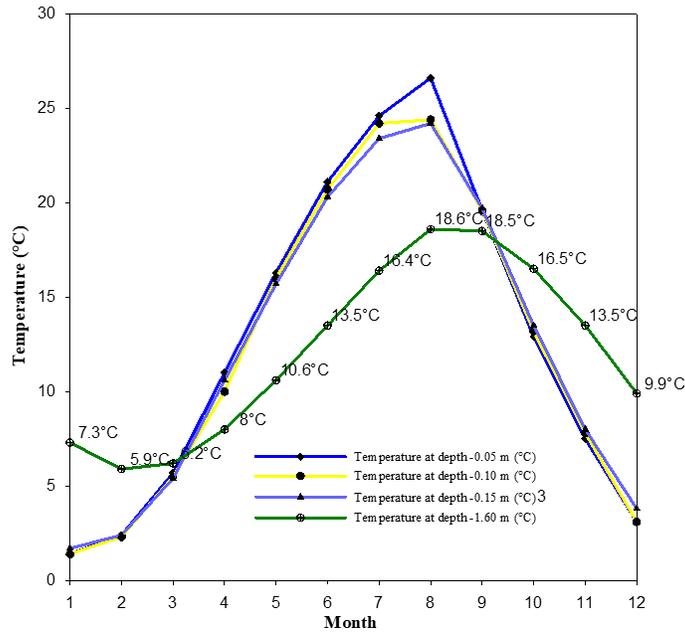


Figure 11: Underground temperature variation

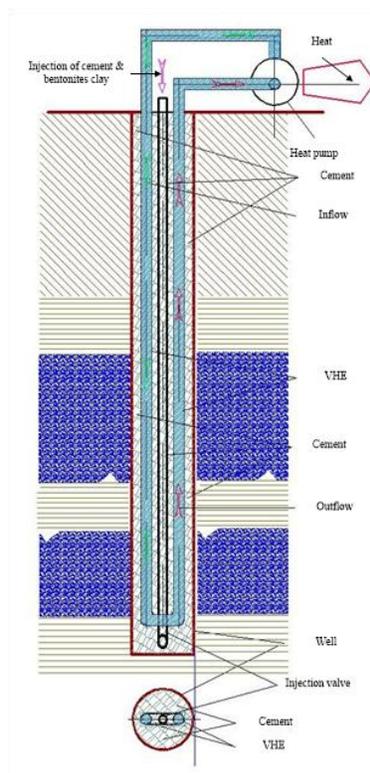


Figure 12: VHE installation

Due to fact that the authors considered three different scenarios the cost is calculated for all of them. The results based in the international market (Table 3) shows that the oil heater system is the cheapest one (Kodhelaj, N., 2011).

Table 3: Cost calculations for all the heating systems implants

| The elements | Costs for each elements according to the system [€] | | |
|------------------|---|-----------------------------|----------------------|
| | Oil heater system | Geothermal heating systems | |
| | | Water-water geothermal pump | Soil heat extraction |
| Radiators | 7.667 | 15.334 | 15.334 |
| Pipes | 2.144 | 5.424 | 5.424 |
| Switching relays | 727 | 1.157 | 1.157 |
| Valves | 2.566 | 2.893 | 2.893 |
| Pumps | 475 | 950 | 950 |
| Boilers | 3.000 | 22.100 | 33.500 |

The total cost including the other elements is showed in the Table 4 (Kodhelaj, N., 2011).

Table 4: Total cost for the heating systems

| Heating system | Element | Cost/Element [€] | Total [€] |
|-------------------------------|----------------------|------------------|-----------|
| Oil Heating system | Implant installation | 16579 | 16579 |
| | Implant | 47888 | |
| Geothermal water-water system | Geothermal node | 19959 | 74680 |
| | Implant | 59288 | |
| VHE (soil-water system) | Geothermal node | 78424 | 137712 |
| | Implant | 59288 | |

The cost analysis for the different scenarios is done by NPV calculations. This calculation is made based in the yearly expenditures of 25780 € (oil price 75€/l) 39960 € (oil price 1.16 €/l) for the oil heating system, 13290 € for the water-water pump and 15146 € for the VHE soil heat extraction system. The ROR was taken as 10% as the Albanian banking system work only under these conditions. The results are really impressive (see Figure 13) (Kodhelaj, N., 2011).

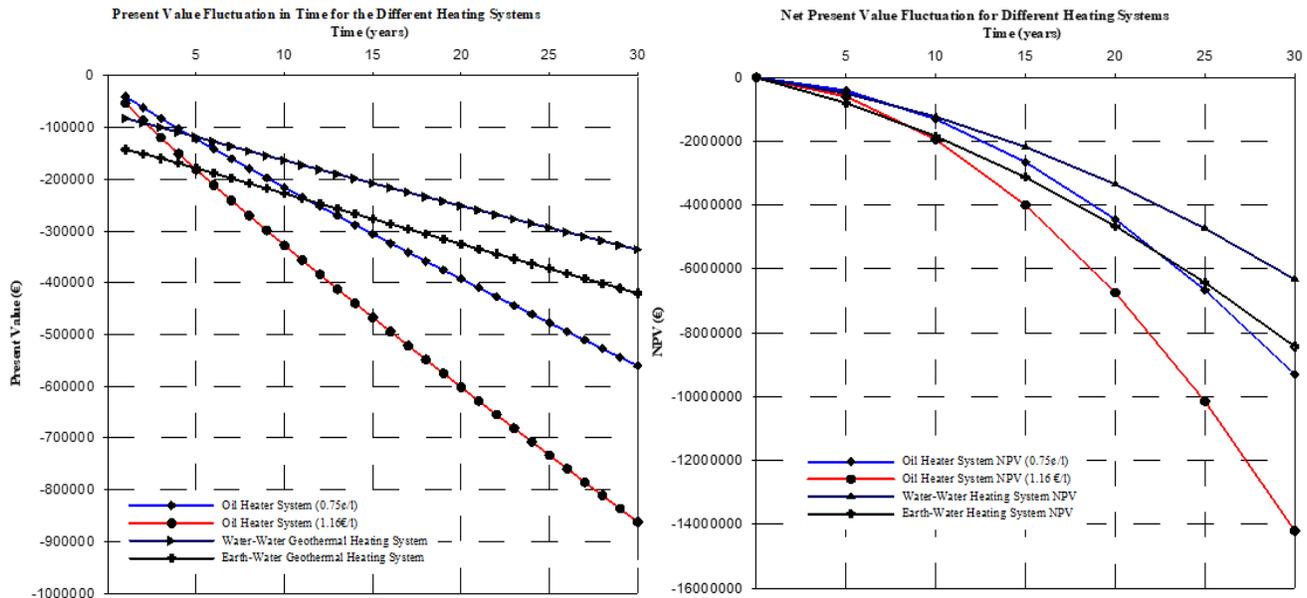


Figure 13: Present Value and Net Present Value calculations for all the heating systems

By analyzing the calculations result that by comparing the Oil Heating System (oil price 75€/l) with the Water-Water Geothermal Heating System the NPV are equalized after 4.367 years. After this time the geothermal system is more viable, while that with the second scenario (oil price 1.16 €/l) it becomes more viable only after 2.172 years. In the second geothermal scenario (Soil-Water System) the times are respectively 11.37 & 4.874 years. If we add to this even the positive impact in the environment protection is out of any reasonable doubt that the geothermal systems are much more viable, as they are considered to be environmentally friendly.

The risk is evaluated through the Palisade Decision Tool (Monte Carlo Simulation). The results are presented in the Figure 14. There can be clearly seen that the risk is minimal for the water-water geothermal system, it goes up while goes to the earth-water geothermal system and rich the maximal value at the oil heating system (oil price 1.16 €/l). So combined with the NPV analyses the decision is even easier to install the geothermal heating system Figure 14 (Kodhelaj N., 2009) (Kodhelaj, N., 2011).

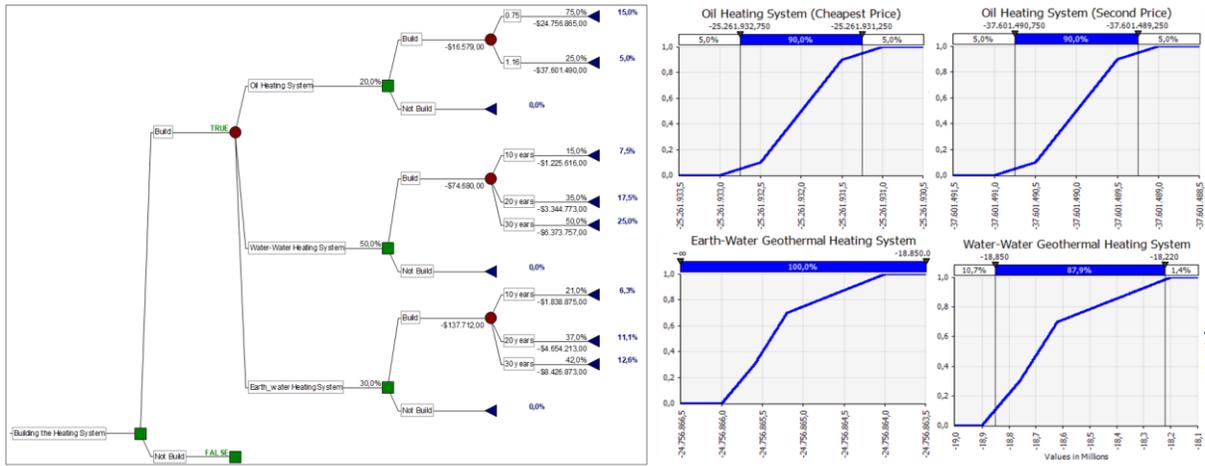


Figure 14: Precision tree and risk analysis charts

2.3 Conclusions and recommendations

2.3.1 Conclusions

The study's conclusions suggest that the utilization of geothermal resources in Albania is economically viable and can help diversify the country's energy resources, improve living standards, and mitigate environmental problems. The study recommends to develop adequate geological models of the geothermal aquifers and conducting extensive studies to evaluate their possible further development. Additionally, conducting ESIA studies and extensive public consultations with stakeholders are crucial for the socio-economic viability of the project. To further advance geothermal utilization in Albania, continued efforts towards capacity building, technology transfer, and knowledge dissemination could be implemented.

Based on the calculations presented in this report the following can be concluded regarding utilization of the hot springs of the Llixha-Elbasan hot-spring area in Albania:

- The water temperature is expected to be stable in the future;
- 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 fulfils all requirements for district heating's in the region;
- Considerably higher temperature expected through further well drilling.

Kozani 8

- The Kozani-8 water temperature is suitable for the supply of a recreational center, including geothermal indoor and outdoor pools;
- The water temperature is suitable for feeding of two cascades;
- The hybrid system will improve the economic efficiency of the project;
- 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;
- It will improve the living standards of the community;
- The economic analyses show that it is feasible.
- The risk analysis shows very optimistic data for the future of the investment.

Korça district heating

- Albanian geothermal regime allows different scale borehole heat exchangers applications;
- The heating system of the “Fan S. Noli” University campus was discussed between the oil and geothermal systems;
- The geothermal regime of Korça allows use of both geothermal systems: Water-Water and Earth-Water;
- The Water-Water system is the most viable;
- The Oil Heating systems are the less viable, despite the oil price;
- The geothermal system has also very good environmental impact;
- This project application will help the diversification of the Albanian energetic system.

2.3.2 Recommendations

Obviously, the development of geothermal projects is a complex and time-consuming process that requires several experts' (developers, suppliers and regulatory bodies) involvement in setting objectives to achieve project bankability and begin implementation. It is of an extreme importance to emphasize the creation of resource inventories based on separate categorizations for environmental–socio-economic viability, technical project feasibility and confidence levels, based on geological knowledge and future resource availability.

This provides useful classifications for assessing recent, current or potential resource development projects. It also helps with analyzing all phases of project development, with the aim determining viability or the need for further analysis and improvement. The following activities should be considered:

- Conducting more detailed geological studies to understand the geothermal aquifers, including the reservoir conditions, temperature, permeability, porosity, and flow rate.
- Developing adequate geological models of the geothermal resources to enable realistic evaluations of their potential further development.
- Conducting extensive environmental and social impact assessments (ESIA) studies, including public hearings and consultations with residents, local and central governments, and other stakeholders as per international and national laws and regulations.
- Improving the capacity building of local experts and stakeholders in geothermal resource management and development.
- Establishing a regulatory framework for geothermal resource management and development to ensure sustainable development and protection of the environment.
- Encouraging investment in geothermal projects by providing incentives, including tax breaks, subsidies, and favorable policies.
- Strengthening the partnership between the public and private sectors to facilitate geothermal development in the country.

More angles that may be considered based on environmental-social-economic viability and technical feasibility include:

- The potential to use geothermal energy for other purposes beyond district heating and recreational centers, such as agriculture, aquaculture, or industrial processes.
- Investigate the possibility of using geothermal energy to power electric vehicles or public transportation in the region, which could reduce air pollution and promote sustainable mobility.
- Explore the potential of using geothermal energy for carbon capture and storage, which could help mitigate greenhouse gas emissions from industries and power plants. (Through a process called geothermal energy with carbon capture and storage (GECO), carbon dioxide (CO₂) is captured from industrial processes or directly from geothermal fluid and then injected into geothermal reservoirs. The CO₂ is stored in the reservoirs, and the geothermal heat helps accelerate the mineralization rate, which converts the CO₂ into stable mineral carbonates over time. This process allows for the permanent storage of CO₂ and helps mitigate climate change's impacts. Additionally, the injection of CO₂ into geothermal reservoirs can enhance geothermal energy production by increasing the pressure and temperature of the reservoir.)
- Partnering with neighboring countries with advanced geothermal industries, such as Iceland or Italy, to exchange knowledge and expertise and to facilitate technology transfer and investment in the Albanian geothermal sector.
- Using blockchain technology to create a transparent and secure platform for geothermal resource management, trading, and financing could attract more private investment and promote sustainable development.

REFERENCES

- A., F. (1993). *Geothermics of Albanides*. Geophysical Institute of Academy of Sciences of Czech Republic, *Studia Geophysica et Geodaetica*. Praha: Geophysical Institute of Academy of Sciences of Czech Republic.
- A., F. (1995). Boreholes temperature and climate changes in Albania. *IASPEI Meeting, International Union of Geology and Geophysics, XXI General Assembly*. Colorado, USA: International Union of Geology and Geophysics.
- A., F. (25-27 March 1998). Tectonics of the Albanides in relation to the geothermal conditions. *Micro temperature Signals of the Earth's Crust, 192 WE-Heraeus-Seminar*. Bad Honnef, Germany: Physikzentrum .
- A., F. (August 18-28, 1997). Heat Flow in Albania. *29th General Assembly of the IASPEI*. Thessaloniki, Greece: IASPEI.
- Çermak V., S. J. (1999). Heat Flow in Albania in a broader context of Geothermal mapping in Pancardi region. . *Dobrogea-the interface between the Carpathians and the Trans-European Suture Zone, Joint Meeting Europrobe*. Bucharest.
- Dakoli H., D. K. (2000). Sulphidric thermomineral waters in Albania. . *Bulletin of Geological Sciences, XXXVI(XVII)*, 81-89.
- Frashëri A. and Çermak V. (Co-editors-in chiefs), L. R. (1995). *Geothermal Atlas of Albania*. (F. o.-P.-G. Czech, Ed.) Tirana, Tirana, Albania: Project of the Committee for Science and Technology and Acad.Sci, Prague.
- Frashëri A., A. R. (8-11 Settembre 2009). Direct use of ground heat for space heating and cooling, in the low enthalpy geothermal energy areas present a contribution in country energy system. *64° Congresso Nazionale ATI L'Aquila*. Aquila, Italy.
- Frashëri, A. (November 15-17, 1998). Geothermal Energy Resources in Albania. In E. U. Action (Ed.), *European Union Thermal Action - Seminar on transfer of Geothermal Technology and Knowledge*. Reykjavik, Iceland.
- Frashëri, A., Čermak, V. (2004). *The geothermal atlas of Albania*. Tirana: SHBLU.
- Kodhelaj N. (2009). *Geothermal energy and its use in Albania*. Faculty of Geology and Mining, Energy Resources Department. Tirana: Polytechnic University of Tirana. Retrieved January 2009

- Kodhelaj N. (December 27-28, 2011). Albanian possibilities for the low enthalpy geothermal resources direct utilization. In E. P. (Elsevier) (Ed.), *2nd International Conference on Advances in Energy Engineering (ICAEE2011)* (pp. 81-87). Bangkok, Thailand: Energy Procedia (Elsevier). Retrieved from www.elsevier.com/locate/procedia
- Kodhelaj N., Bode A., Çela B., Aleti R., Thodhorjani S. (April 21-22, 2013). Direct use of the Kozani-8 Well, Geothermal through an Integral, Cascade and hybrid Scheme and its Economic Analysis . In A. M. Research (Ed.), *International Conference "ICMMA 2013, International Conference on Mechatronic, Materials and Automatization"*. 740, pp. 765-771. Singapore: Trans Tech Publications, Switzerland. doi:10.4028/www.scientific.net/AMR.740.765
- KODHELAIJ Nevton, BODE Aida, KOJA Nevina, ZEZO Esmeralda, ZOGA Pirro, MUMAJESI Rajmonda. (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. In CMSE (Ed.), *CMSE* (pp. 44-59). CMSE.
- Kodhelaj, N. (2011). Albanian Possibilities on Geothermal Direct Utilization. (Elsevier, Ed.) *Renewable and Sustainable Energy*, 15(5), 2534-2544.
- 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. In CMSE (Ed.), *CMSE*, (pp. 44-59).
- Kodhelaj. N., Çela. B., Aleti. R. (December, 2012). Kozani-8 Low Enthalpy Geothermal Water Use through a Cascade and Hybrid System. (U. David Publishing House, Ed.) *Study for Civil Engineering and Architecture*, 1(1), 1-10. Retrieved from www.seipub.org/scea
- Lund J. W. (2009). Balneological use of thermal waters. International Geothermal Days, . Conference and Summer School. *International Geothermal Days, Slovakia, 2009. Conference and Summer School*. Slovakia: International Geothermal Days, Slovakia, 2009. Conference and Summer School.
- Lund J.W., Freeston D.H., Boyd T.L. (24-29 April 2005). World-wide direct use of Geothermal Energy, 2005. *World Geothermal Congress 2005*. Antalya, Turkey: World Geothermal Congress 2005, Antalya, Turkey.
- Lund J.W., Lienau., (2009). Geothermal district heating. In S. 2. International Geothermal Days (Ed.), *International Geothermal Days, Slovakia 2009. Conference and Summer School*. Slovakia: International Geothermal Days, Slovakia 2009. Conference and Summer School.
- Lund J.W., Sanner B., Rybach L., Curtis R., Helstrom G. (24-29 April 2005). Geothermal (Ground Surce) heat pumps, a world overview. In A. T. World Geothermal Congress 2005 (Ed.), *World Geothermal Congress 2005, Antalya, Turkey*. Antalya, Turkey: World Geothermal Congress 2005, Antalya, Turkey.
- Lund, J. W. (24-29 April 2005). Basic Principles of Geothermal Balneology and Examples in the United States. In T. World Geothermal Congress 2005 Antalya (Ed.), *World Geothermal Congress 2005 Antalya, Turkey*. Antalya, Turkey: World Geothermal Congress 2005 Antalya, Turkey.
- Lund, J. W.: Kah-Nee-Ta. (2004). Swimming Pool, Warm Springs . (K. F. Geo-Heat Centre, Ed.) *Quarterly Bulletin*, 1, pp. 1-2.