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DIRECT USE OF GROUND HEAT FOR SPACE HEATING AND COOLING, IN THE LOW ENTHALPY GEOTHERMAL ENERGY AREAS PRESENT A CONTRIBUTION IN COUNTRY ENERGY SYSTEM

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ABSTRACT

In the paper a detailed analyse of the shallow ground heat resources in Albania, in particularly in Tirana city, and ways for direct use of this energy concretely for heating in Tirana is presented. Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump for space heating and cooling, was programmed to develop in Albania.

1. Introduction

Large numbers of geothermal energy of high and low enthalpy resources, a lot of mineral water sources represent the base for successfully application of modern technologies in Albania, to achieve economic effectiveness. There are many thermal springs and wells. Their water has temperatures that reach values of up to 65.5°C.

The geothermal situation of low enthalpy in Albania offers following directions for the exploitation of geothermal energy (Frashëri et al. 2003):

Firstly, space heating and cooling

Secondly, integrated and cascade use of geothermal waters energy

The most important direction is space heating and cooling. The Earth Heat can be use for space heating and cooling by modern systems Borehole Heat Exchanger-Geothermal Heat Pumps.

In the paper is presented a detailed analyse of the shallow ground heat resources in Albania, in particularly in Tirana city, and ways for direct use of this energy concretely for heating in Tirana.

2. Presentation of the problem

The energy crisis prevailing in the Albania, the increased demand in premises, the gradual implementation of European standards of premises' heating, are all decisive factors raising the awareness in order to contribute in finding optimal solutions to this critical situation. Actually, the electric energy consummation for heating is 1 375 GWh/year, or 23.8 % of the total electric energy production in Albania (Fig. 1) (National Agency of Energy, Tirana, 2003). The situation becomes more problematic because the use of natural gas for heating emits large quantities of CO_2 in the atmosphere.

The Earth's heat is a great source of energy, renewable and friendly to the environment. Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump represents a modern system for space heating and cooling. Two shallow geothermal sources exist: Ground heat through use of the ground-couplet (closed loop), and underground water system (open loop).

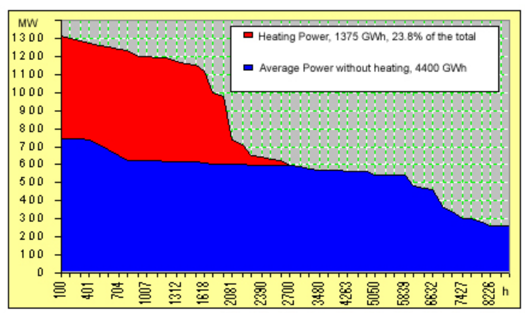

Fig. 1. Electrical power for heating and average power without heating in Albania. (National Agency of Energy)

Alike elsewhere in the world, in Albania the subsurface ground layers contain heat. This energy can be successfully exploited in heating the public premises (offices, hospitals, libraries, theatres, airports etc.) as well as private premises (houses and apartment buildings), using the modern systems of Borehole-Heat Exchanger-Geothermal Heat Pumps.

Two kind of technology is possible to applied (Lund J. W. 1996, Rybach L. et al. 2000):

Firstly, ground-source and Borehole heat Exchanger-Geothermal Heat Pump or ground-couplet (closed loop) (Fig. 2),
Secondly: underground water system – Geothermal Heat Pump (open loop).

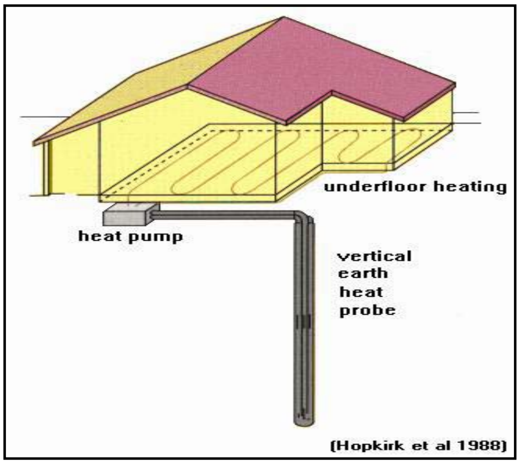

Fig. 2. Borehole- Vertical Heat Exchanger-Geothermal Heat Pump System for space heating and cooling scheme.

Actually, these modern systems in use, highly effective and with low consume of electric energy, technologically advanced and environmental friendly, are gaining huge popularity (Curtis, et al. 2005, Lund, 1996, Rybach, et al. 2000, Rybach, 2005, Sanner, 2004).

In order to make use of this renewable geothermal energy and environmental friendly ground heat for space heating and cooling in Albania, we have introduced the idea of building a demonstrative installation for heating and cooling purposes in Tirana (Frashëri et al. 2003). The implementation of this project contributes in raising the awareness of the public administration, of the business and scientific communities, to make use of this economically optimal solution for heating and cooling of premises. The public administration should introduce the necessary tools and incentives for enabling the entering into the market of such modern and environmentally friendly systems. The business community should have in consideration and invest in installation of these Borehole-Heat Exchanger-Geothermal Heat Pumps, making way for new businesses. The universities should teach about these modern systems and insists on their applicability.

3. Ground Geothermal Energy Resources in Tirana City

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

Thermal field distribution and geothermal gradient values in the ground at shallow geological section are conditioned that at the depth 100m the temperatures reaches from 16oC up to 18.8o at plane areas in the Ionian tectonic zone and in Peri Adriatic Depression (Fig. 3). The areas with a temperature between 18 °C and 19 °C are located at Kolonjë-Divjakë-Kryevidh, Vlorë and Sarandë-Delvinë zones. There are some particularities in the distribution of the temperature at the depth 100m:

Temperature in subsurface ground at littoral area:
Minimal temperature is 16.60 ^{o}C
Maximal temperature is 18.80 ^{o}C
Average temperature is 17.80 ^{o}C

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

Temperature in subsurface ground at hilly-mountains regions:
Minimal temperature is 6.70 ^{o}C
Maximal temperature is 18.60 ^{o}C
Average temperature is 14.75 ^{o}C

In plane area of Albania, example in the Tirana field (Rinasi), the temperature is 15.5 ^{o}C, up to logging depth 31 m, in the Quaternary deposits (Fig. 4) (Frashëri et al. 2003). According to the well-known data, the layers at the depth from 0-8-10 m have a temperature, which is conditioned by solar radiation energy. During the winter, the temperature is lower than during the summer. Below, the ground temperature is constant during the year, because don't have the influence from solar radiation. Depth limit of the solar radiation influence zone is not unique. Lateral changes up to 0.5 ^{o}C are observed in the 500m distances, for the same time. These lateral changes are conditioned by lithology of the Quaternary loose deposits. The belt of the constant temperature continues up to the depth 50 m in the mountain regions of the Albania.

Water temperature of the Quaternary sandstone layers is 15-16^{o}C

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

Ground geothermal energy has heated the underground water reservoir. In Tirana underground water basin are following temperatures: Water temperature of the Quaternary gravel layer is 14-15 °C,

Consequently, concluded that water of the Tirana underground basin can be a heat source for the geothermal pumps (Fig. 5).

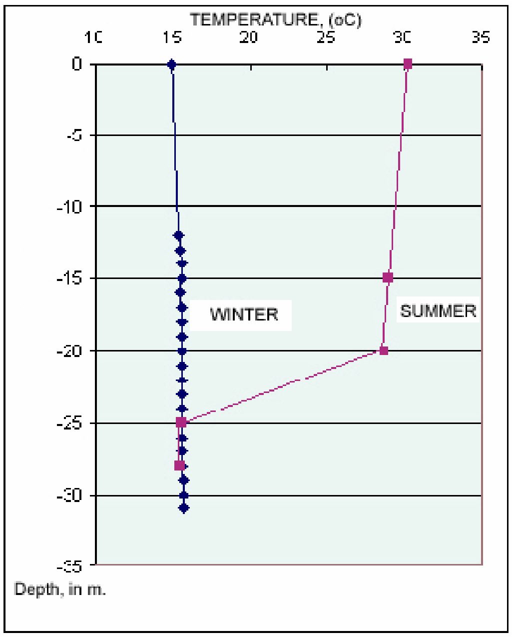

Fig. 4. Thermolog of the Rinasi borehole

4. Economic evaluation of the proposed scheme
Heating of the Hotel in Tirana:
Total heated surface, for three-floors: 610 m²
Heating system: Borehole-Heat Pump-Radiators
Heating capacity 68.5 KW
Heating period 1836 hours

***Heating system*, there are analyzed three variants:**
a) Borehole-Geothermal Heat Pump
b) Oil Fired Boiler
c) Air-Air Conditioners

Installed cost for Borehole-Geothermal Heat Pump System:
Geothermal Heat Pump, with a heating capacity 68.5 kW, 19.840 USD/unit
Installation of the Geothermal Heat Pump System 1.800 USD
Heating and cooling equipment (radiators, pipes etc) and its installation in the room 16.7 USD/m³, for 1830 m³ for all building 25.860 USD
Providing water to the geothermal heating pump and re-injection of water in the collector after the use (Shallow boreholes, circulating pump, pipeline), according to the price index in Tirana: 7.500 USD.
Total 55.000 USD
90,16 USD/m²

Preliminary installed cost for three systems:
a) Borehole-Geothermal heat pump 55.000 USD
b) Borehole-Vert. Heat Exchanger-heat pump 87.630 USD
c) Oil Fired Boiler 26.880 USD
d) Air-air conditioners, type “General” 19.970 USD

Preliminary installed cost for square meters of heated surface:
a) Borehole-Geothermal Heat Pump 90,16 USD/m²
b) Borehole-Vertical Heat Exchanger-Heat Pump 144,17 USD/m²
c) Oil Fired Boiler 57,04 USD/m²
d) Air-Air Conditioners, type “General” 33,28 USD/m²

Preliminary electric energy or fuel yearly consumption (operating) cost:
a) Borehole-Geothermal Heat Pump 33.304 KW/y 4.332 USD/y
b) Oil Fired Boiler 12.282 Lit. oil/y 15.337 USD/y
c) Air-air conditioners 93.636 KW/y 12.179 USD/y

Preliminary total yearly heating energy cost (installed and operating cost):

- USD/kW	*First year*	*Second year*
a) Borehole-Geothermal Heat Pump	866,74	63,23
b) Borehole-Vert. Heat Excanger-Heat Pump	1.342.50	63,23
c) Oil Fired Boiler	728,42	177,80
d) Air-air conditioners	469,49	261,48

- USD/m²		
a) Borehole-Geothermal Heat Pump	97,33	7,10
b) Borehole-Vert. Heat Exchanger-Heat Pump	150,76	7,10
c) Oil Fired Boiler	81,79	19,64
d) Air-Air Conditioners	52,72	15,60
e) Electrical Radiators	29,36	29,36

Electric energy or fuel yearly consumption (operating) cost total yearly heating energy cost (installed and operating cost) during 10 years of the different heating system using in the fig. 6 and 7 are presented.

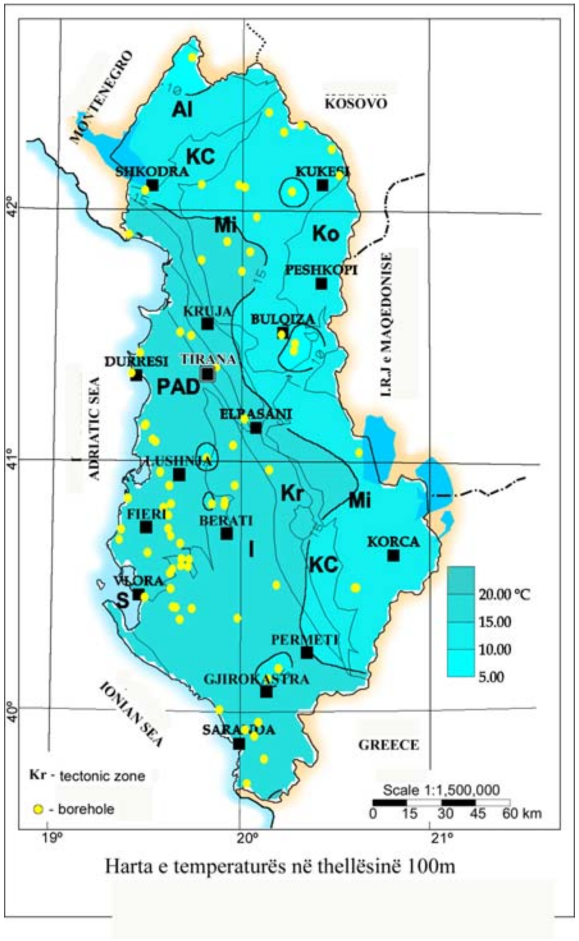
MONTENEGRO
KOSOVO
Al
KC
SHKODRA
KUKESI
Mi
Ko
PESHKOPI
KRUJA
BULQIZA
DURRESI
TIRANA
PAD
ELBASANI
ADRIATIC SEA
LUSHNJA
Kr
Mi
FIERI
BERATI
I
KORCA
KC
VLORA
S
PERMETI
GJIROKASTRA
IONIAN SEA
SARANDA
GREECE
I.R.J e MAQEDONISE
20.00 °C
15.00
10.00
5.00
Kr - tectonic zone
- borehole
Scale 1:1,500,000
0 15 30 45 60 km
19°
20°
21°
42°
41°
40°
Harta e temperaturës në thellësinë 100m

Fig. 3

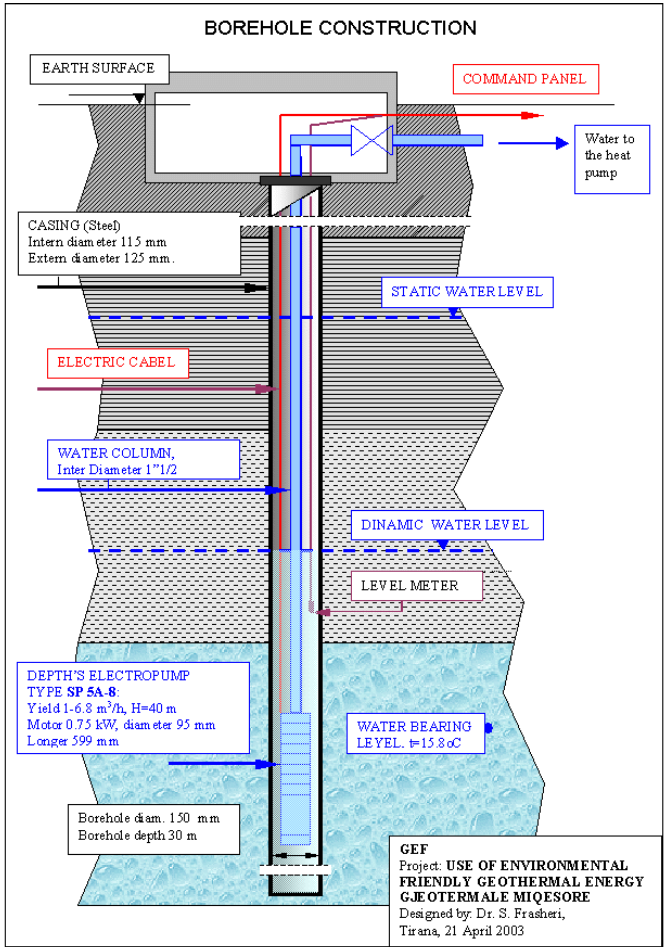
BOREHOLE CONSTRUCTION
EARTH SURFACE
COMMAND PANEL
Water to
the heat
pump
CASING (Steel)
Intern diameter 115 mm
Extern diameter 125 mm.
STATIC WATER LEVEL
ELECTRIC CABEL
WATER COLUMN,
Inter Diameter 1"1/2
DINAMIC WATER LEVEL
LEVEL METER
DEPTH'S ELECTROPUMP
TYPE SP 5A-8:
Yield 1-6.8 m³/h, H=40 m
Motor 0.75 kW, diameter 95 mm
Longer 599 mm
WATER BEARING
LEVEL. t=15.8 oC
Borehole diam. 150 mm
Borehole depth 30 m
GEF
Project: USE OF ENVIRONMENTAL
FRIENDLY GEOTHERMAL ENERGY
GJEOTERMALE MIQESORE
Designed by: Dr. S. Frasheri,
Tirana, 21 April 2003

Fig. 5

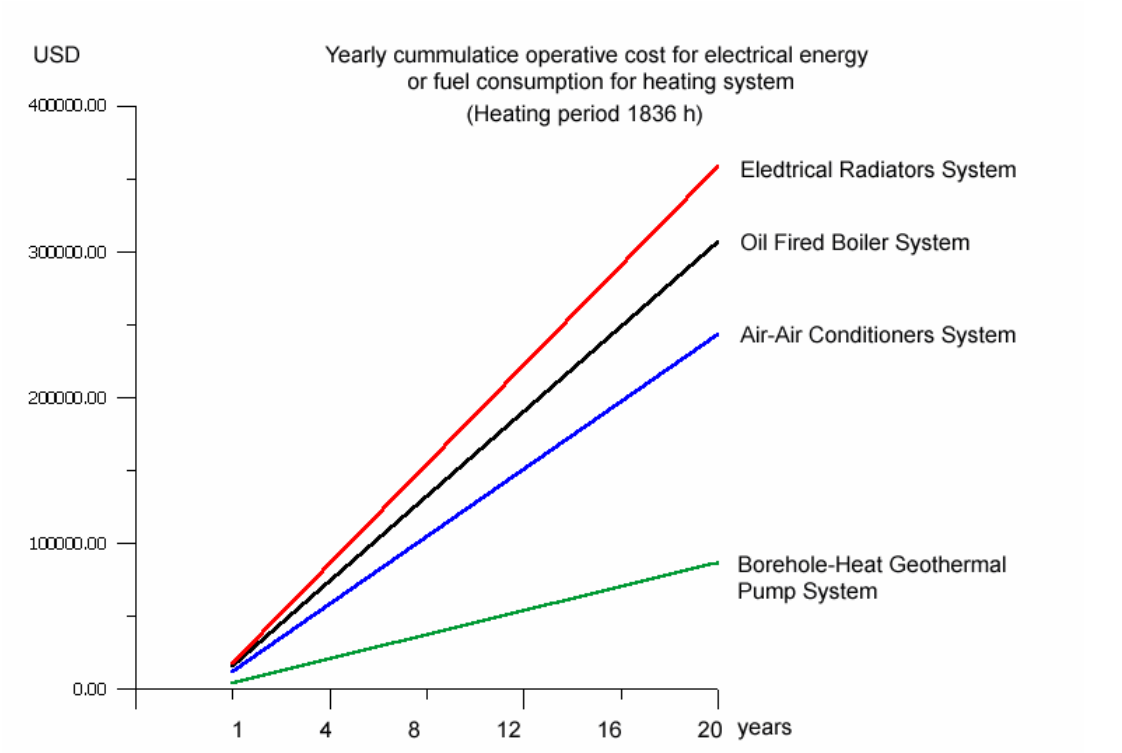
USD
Yearly cummulatice operative cost for electrical energy
or fuel consumption for heating system
(Heating period 1836 h)
400000.00
300000.00
200000.00
100000.00
0.00
Eledtrical Radiators System
Oil Fired Boiler System
Air-Air Conditioners System
Borehole-Heat Geothermal
Pump System
1
4
8
12
16
20
years

Fig. 6

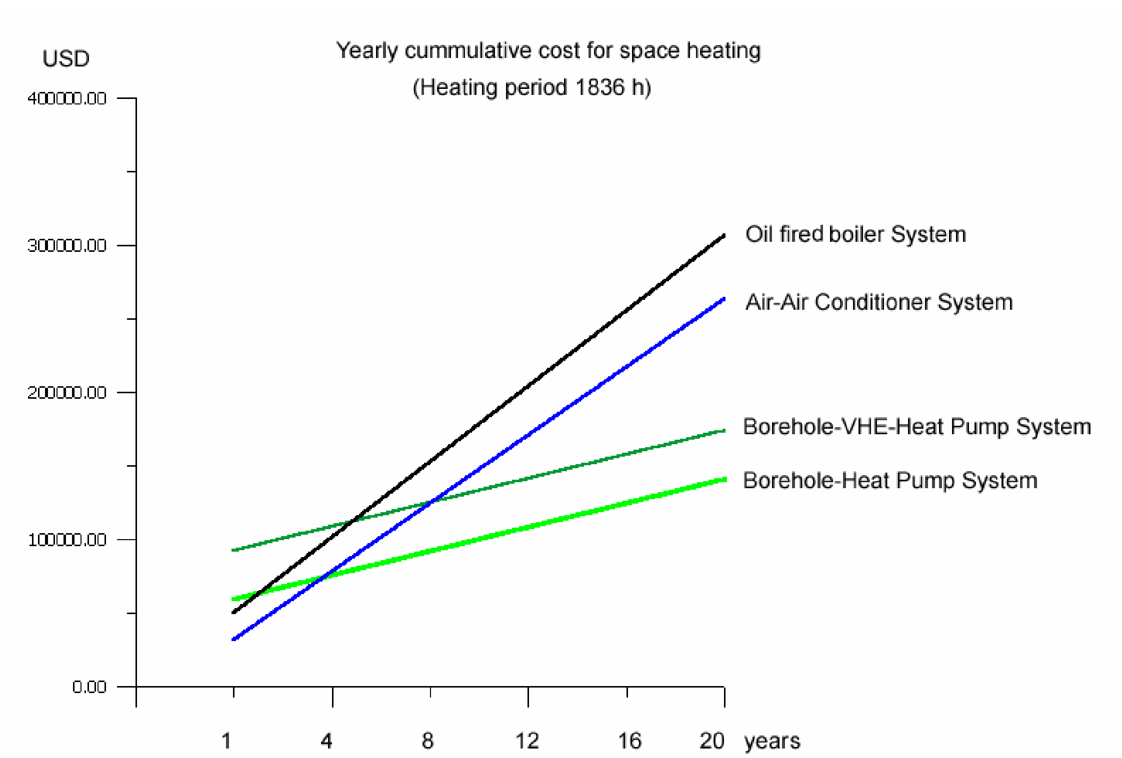
USD
Yearly cummulative cost for space heating
(Heating period 1836 h)
400000.00
300000.00
200000.00
100000.00
0.00
Oil fired boiler System
Air-Air Conditioner System
Borehole-VHE-Heat Pump System
Borehole-Heat Pump System
1
4
8
12
16
20
years

Fig. 7

Installed cost for geothermal system unit result 83-133 USD/m^2, and 744-1180 USD/kW, depended from the heat source. Borehole-Vertical Heat Exchanger-Geothermal Heat Pump System has the higher cost.

Lower costs have Borehole-Geothermal Heat Pumps systems, with shallow underground water heat source.

After the data presented in the fig. 5 and 6, results that installed cost for the geothermal systems is 2.0-2.8 much higher than for the boiler or air-air conditioner systems.

Payback period for the intalled cost for the "Borehole-Geothermal Heat Pump" System will be 2 years, covered only by expenses savings for boiler fuel, and 4 years, covered only by expenses savings for air-air conditioners.

Payback period for the intalled cost for the "Borehole-Vertical Heat Exchanger-Geothermal Heat Pump" System will be 4 years, covered only by expenses savings for boiler fuel, and 8 years, covered only by expenses savings for air-air conditioners.

In fig 8 is presented the graphic of the cost of space heating for different heating systems (in USD/kW). According to this graphic results that geothermal heating and cooling system is more economic system.

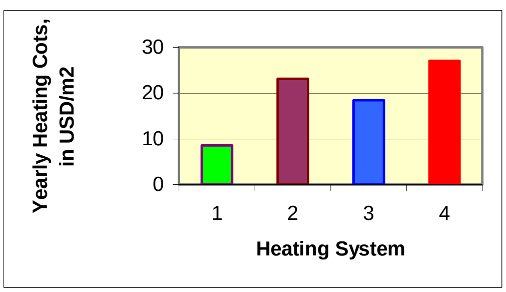

Fig. 8. Cost of space heating for different heating systems (in USD/m^2).
1- Geothermal System; 2- Oil Fired Boiler System; 3- Air-Air Conditioner System; 4- Electric Radiator System.

4. Call for investment

The heating problem and its economic solution is an important task, taking into consideration the current severe energetic crises. One of the ways out is the use of geothermal energy. In Albania there are many high-rise building, which are still projected to include oil or gas fired boiler systems, as well as with air conditioning units. Air conditioning units heat all public institutions. The hospitals, dorms, hotels are heated by oil and gas fired boilers. It is the ripe time to move out of such practices, which do not provide for long term sustainable solutions to the heating and cooling problems in Albania. It is the right time to introduce systems using renewable energy sources such as the geothermal energy.

In order to introduce the system of geothermal energy, a renewable and environmental friendly energy source, we propose to build a demonstrative installation, heating and cooling any given building in Tirana.

Implementing this project will provide for an optimal and economically efficient solution, which will be of benefit to the public administration, business community, as well as to the technical and scientific community. It will pave the way for a more economically efficient solution to heat and cool buildings. Optimally the government will promote and stimulate the introduction of such systems in Albania. In addition there are economic incentives for the business community to invest in this new venture, which we believe is the most sound solution for our country.

4.1. Project goal and objectives

4.1.1. Project goal:

a) Design and construction of the demonstrative space heating system, with underground waters or shallow ground heating sources.

b) Albanian investors and communities sensitizing for high economic effectiveness of integrated and cascade use of environmental friendly geothermal energy in Albania.

4.1.2. Objectives:

1. Design and construction of the demonstrative space heating system, in one of a new constructed or existing building, with oil fired boiler heating system..

2. Construction of the demonstrative space heating system.

3. Knowledge dissemination: Workshops, seminars, TV emissions, lectures in the Universities: "Space heating and cooling direct using of the environmental friendly geothermal energy, in the framework of the renewable energies use, to improve the country energy balance and an important profitable investment present"

4.1.3. Necessary Investment

It is necessary to match the installation of the demonstrative geothermal system to the size of the building. It is also necessary to have a building, which is heated by a boiler. Initially it would be most suitable to build an installation, which will use underground water as the heat source. This will provide for a lower cost.

Based on feasibility study, the installed cost of geothermal heating system, with underground waters heat source will be 83-133 USD/m^2.

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

Economical considerations (Curtis, et al. 2005, Lund, 1996, Rybach, et al. 2000, Rybach, 2005, Sanner, 2004). Actually, the cost of installing the Borehole-Heat Exchanger-Geothermal Heat Pump is higher than the conventional fuel installations. Nonetheless, the annual cost of "fuel" of the Borehole-Heat Exchanger-Geothermal Heat Pump (Electric energy for the heat pump and circulating pump) are considerably lower than the fuel of the conventional heating by gas. ***For the coefficient of performance 3, is saved up to 66% of the electrical energy.*** Consequently, the payback of the Borehole-Heat Exchanger-Geothermal Heat Pump system is shorter than the durability of using the other heating system.

Environmental considerations. Borehole-Heat Exchanger-Geothermal Heat Pump is an environmental system that does not emits CO2 ("greenhouse effect"), therefore the proprietor avoid paying the tax on emittance of CO_2 gas, which is under discussion in the countries of the European Community.

Governmental support. Japan using the geothermal energy of subsurface ground layers saves up to 40% of the total energy (Japan Times, Jan. 21, 2003). The expenses necessary to carry out this project will be paid within 10 years. Two thirds of the building costs, valued up to 10 million yen for the government and local authorities support each installation. The Japanese government has invested 200 USD for every kW of the Heat Geothermal Pump, with an upper limit of 5 200 USD.

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