INTERNATIONAL SUMMER SCHOOL on Direct Application of Geothermal Energy

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Chapter 1.9

ENERGY BENEFITS OF INTEGRATED GEOTHERMAL PROJECTS FOR BAL-NEOLOGY AND "WATER" TOURIST CENTERS

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Fig.1. Location of Bansko Spa

Introduction

A natural hot spring of 30-35 l/s at 72°C plus numerous small temporal thermal flows had long been known to exist near Bansko, and had been used since Roman times for balneological purposes. In addition, near by, a new borehole of about 55 l/s at 70°C has been completed for exploitation purposes.

Chemistry of the water is not so convenient and it is slightly aggressive to carbon steel and particularly to cement. Anyhow, in 1963, a 3,2 ha glasshouse complex has been built at a distance of about 200 m from the spring (that is the first greenhouse in the world, heated completely by geothermal energy and, in the same time, the base for future development of the "Bansko" geothermal project), using it to provide the entire heat demand. From the energy point of view it was a really a "good hit". Not any penny has been spent for heating greenhouses afterwards. That was and it is the onliest greenhouse in Macedonia which has continually realised only profits, even during the most difficult economic periods.

The positive results, achieved through more than 25 years experience with geothermal energy, have aided in the design of a technical solution for connecting all the balneological and heat-consuming installations of the "Tsar Samuil" hotel (located between the main thermal spring and the borehole B1) to the new borehole in the same geothermal field, as well the balneological installations of the three neighbouring hotels. Connection of the first one has been realised 16 years ago and the others are connected during the next three years.

Geothermal heat potential on disposal

There is still not enough data to assess finally heat potential of the geothermal field "Bansko". According to the available flows, the following design parameters can be taken as relevant:

- Natural "feeding" of the reservoir: 30 l/s
- Maximal continual flow of the natural hot spring (if additional bore-holes are closed) 35 l/s 72°C
- Maximal allowed flow from the borehole B1 (up to 12h) 55 l/s 69,5°C
- Maximal allowed flow from the borehole B1 52 l/s 69,5°C
- Maximal allowed flow from the borehole B1 for continual exploitation 50 l/s 69,5°C
- Available flow from the small thermal sources: Changeable flows and temperatures

It is necessary to underline the confirmed existing interactions between the borehole B1, main natural thermal spring and small springs. When the flow from B1 is over 40 l/s main one stops and the small ones disappear gradually. When B1 is closed, the main spring has rather continual flow (seasonal changes) and the changes of small springs are in known limits.

The estimation of dynamic heat potential (onliest possible in the moment) depends on the nature of possible heat users. If taking in account that the temperature of effluent water (after the use in heating and other installations of the users) is 25°C, than dynamic potential is in the measures of about 8,5 MW. If taking in account the average temperature of surrounding air, it is about 11 MW.

Possible geothermal heat users

The location of borehole B1 and natural thermal water flows dictates the nature of possible heat users. Practically these are all the hotels and resthouses around, the glasshouse complex, the surrounding complex of small plastic-houses for protected crop cultivation and the village Bansko itself. All of them show active interest for connection to the geothermal system.

Technical data about heat consumers (on disposal at the moment) together with the agreed division of the maximal continual geothermal water flow on disposal are given at the Table 1. There is no data about the dwellings , shops and other public houses in the Village Bansko because there is no data on disposal and because there is still no active interest of the owners to connect to the system and to invest necessary capital to enable initial conditions for that.

Technical data about the heat consumers and thermal water flow of geothermal energy of the system "Bansko"

	Heat consumer	Design heat power	Geothermal heat power	Temperature regime	Geothermal water flow	Comment
		MW	MW	°C/°C	l/s	
01	Glasshouse complex ZIK "Strumica"	9,00	4,00	70/40	30	10 c.m. h. accumulate.
02	Hotel "Tsar Samuil" - Central heating - San.warm water - Swimming pool - Balneology	1,56 0,64 0,35 0,25*	1,07 0,64 0,35 0,25*	65/45 12/40 40/25	10	2,25 MW peak boiler plant
03	Exper. greenhouse	0,17	0,17	40/25		2 install.
04	Small plastic-houses	3,00**	1,40***	65/25*****	7,50	Diff.install.
05	Rest-house "S.Zakov" - Central heating - San.warm water - Balneology	3,77 2,23 0,25*	- - 0,25*	65/45 12/40	1,25	Balneology and partially san. water preparation
06	Rest.house"Jugoiutun"				1,25	No docum.
07	Rest-house"Strumica"				1,00	No docum.

* No exact data
** Changeable
*** Proposal
***** Extremme values

Table 1: Composition of the heat users

Case history

It was in 1962 when AK "Strumica" (local agricultural combine) decided to built the first commercial glasshouse for vegetable production in Macedonia. The reason was found in the very good market for winter and early spring production, covered that time by import from Italy and Holland, and geothermal hot water on disposal, offering to cover the heat demands of such a production, free of charge.

In 1963 the plant was put in operation. It consists of 6 greenhouses of a little bit more than 0,5 ha, heated by groups of 6 steel pipes, positioned along the cultivation rows of vegetables. Heat of the water is used in cascades of two greenhouses (1 and 3, 2 and 4 and 5 and 6). To avoid construction of the peak boiler plant, investor added a heat accumulator of 10 cubic meters at the connection point of installations to the natural thermal spring.

It was a full hit. For already 25 years the greenhouse produces only profits. Even old-fashioned, with rather bad heating installations, without any technological equipment, etc. it has been always more profitable than anyone of new constructions, applied meanwhile in Macedonia. Good growers in combination with free of charge energy have been continually uncompensable advantage for all the others.

Anyhow, the success didn't stimulated other possible neighboring heat users to follow the example of AK "Strumica". First of all, the energy has been so cheap that "it was not worthy" to pay attention to such an improvement. Second, the combine has been continually jelos to allow any trial of someone else to "join the cake".

First, and particularly the second energy crisis of 1973 and 1979 changed the situation. Neighbouring small growers in plastic-houses saw the chance to profit something of the very expensive protected crop products (that time), using available thermal water. Combine didn't allowed connection to the main source but there was a number of small ones around. From that time until now, there is continually 0,8 to 1,0 ha geothermally heated plastic-houses around the village

Bansko. They use very simple heating installations (mainly soil heating ones) made of baked clay or cement , metallic or plastic pipes of different diameters, and plastic pipes positionned on the soil surface during the recent years.

Then, in 1985, the new director of the hotel "Tsar Samuil" decided to improve the financial situation of it by decreasing all possible costs of the hotel exploitation. It has been evident at once that the ones for heating the hotel are the highest. He ordered design documentation and got an excellent technical solution of the "Cyril & Methodius" University - Faculty of Mechanical Engineering (Prof. I. Cerepnalkovski), consisting indirect connection to the spring and heat use in cascades. Even the agricultural combine has been against it (heat power of the spring has been "too small" to allow it), he connected the hotel to the main geothermal spring in 1986. Resulting "war for water" was resolved by the local government with a temporal division of the rights. That was the real birthday of the geothermal system "Bansko". Resulting continual complications of the exploitation (never enough water!) stimulated completion of the neighboring active borehole B1, design and completion of the distribution station at the well head, construction of new distribution line to the glasshouse complex, etc.

Finally, also the other resthouses and hotels put their candidatures to join the project, escorted with small growers, which have been lost their small thermal flows when B1 has been put into operation.

Design heat power of the users

Design heat power of the existing plus possible heat users (without surrounding dwellings, shops and similar objects) is about 22 MW. That is far more than the existing 8,5 mW on disposal (Table 1). On the other hand, it is not justified to cover very short lasting peak loadings of greenhouse's heating installations and hotel's central heating by geothermal energy, conditioning high exploration and investment costs. That is taken in account by the technical design of the heating installations of greenhouse's complex ,hotel "Tsar Samuil"and resthouse "Spiro Zakov" by the designed peak boiler plants. However, only the one in hotel "Tsar Samuil" is already built. Other users (greenhouse complex) didn't built it or even don't have prepared the technical documentation to do that. The background is in the intention to press the government and other users with present critical situations, and in that way to keep the right for covering total heat demands only by geothermal energy (up to this year free of charge). Small heat accumulator of the greenhouse complex helps only for very short lasting peak loadings.

By careful study of the local climate conditions, technical documentation of heat users on disposal, reached experience of 25 years exploitation and economy of the investments in technical solutions on disposal, some interesting conclusions has been extracted, such as are:

- justification of covering the base heat demand of central heating systems by geothermal energy (about 50%of the design heat power for hotels, 40-60% for greenhouses depending on the construction and culture in question, and 100% for other types of users), but not the peak loadings which must be covered by other heat sources;
- need to find possibilities to use the accumulation possibilities of the material of heated projects (hotels) in order to "iron" the day heat supply curve and to minimize the number of peak points when the additional heat source should be switched on;
- impossibility to enable convenient heat supply for all the candidates for connection to the geothermal distribution system due to the limited heat power of the geothermal source. That is the background of the proposed division of maximal thermal water flow on disposal (Table 1), i.e. a trial is made to accommodate optimally the needs to the possibilities.

Heat accumulation

Heat accumulation of the material of heated objects and introduction of it for some type of users (heating of greenhouses and hotels) can improve the situation with

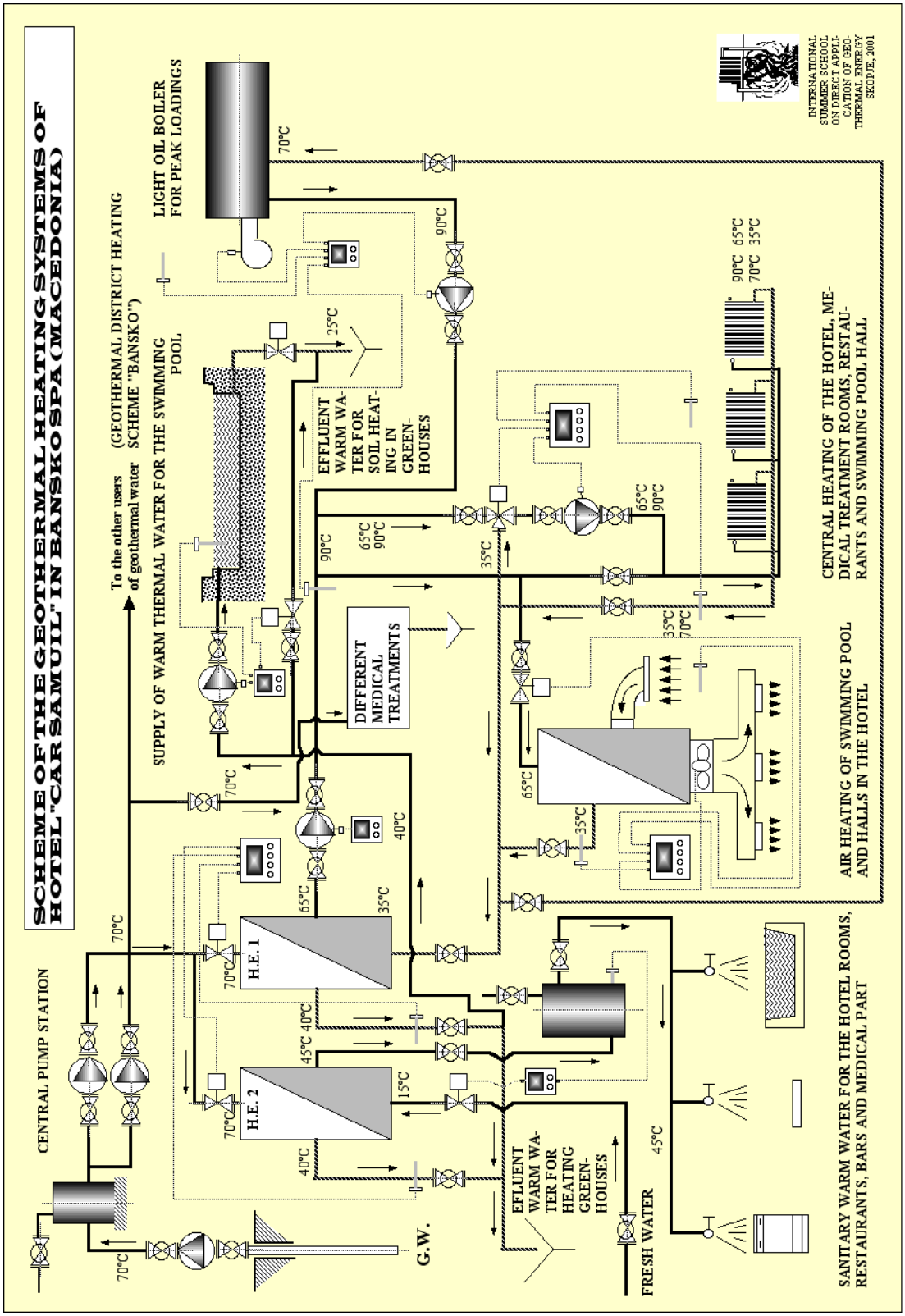

Fig 2. Scheme of the heating installations of the hotel "Tsar Samuil"

peak loadings very much, without disturbing the requested quality of the heat supply .

Building material of the hotel "Tsar Samuil" enables to stop the heat supply for about three hours without disturbing the

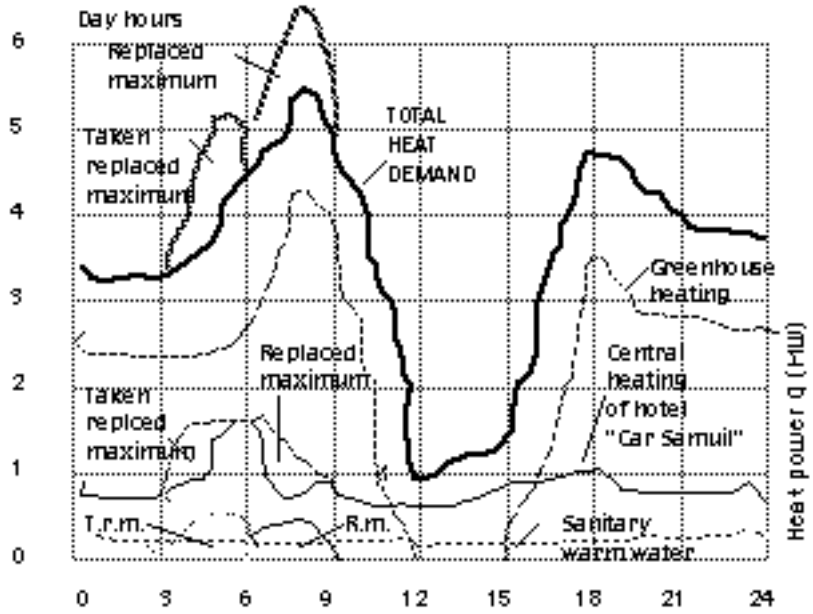

Fig.3. Effect of the proper use of thermal inertia of the buildings

inside temperature conditions, even during the lasting of worse outside climate conditions. That enables replacement of the peak loading before the appearance of the one of the glasshouse complex.

The morning peak loading of sanitary warm water preparation coincidences with the ones of the central heatings of the hotel "Tsar Samuil" and greenhouse complex. By the introduction of a heat accumulator (already existing from the previous technical solution), it is also possible to replace it some hours in advance, without disturbing the requested quality of the warm water supply.

The same case is for the heating system of the swimming pool. It is by itself a heat accumulator, and stopping the heat supply during the early morning hours completely doesn't disturb the temperature regime of it.

Introduction of a heat accumulator in the glasshouse complex of AK "Strumica" can also improve very much the exploitation conditions of the heating system. It is much easier and cheaper to use such a solution in practice (particularly for short lasting peak loadings) than to use the peak boiler plant (which is anyhow necessary for longer cold periods).

Altogether, conclusion of the study has been (Popovski, 1989) to recommend strongly the introduction of possibilities offered by heat accumulation. However, it's evident that such an action can be performed only if the regulation of the heat supply from the geothermal source to the users is centralised, and continually under control of experienced workers (understanding well the nature and requirements of different heat consumers). It is also obvious that it can be really introduced only if the use of geothermal energy is payable, i.e. saving the energy should be stimulated. Nobody is interested to invest for something which is "free of charge".

Unfortunately, many trials meanwhile have been without success. The "war" for the hot thermal water still lasts. Onliest difference is that presently the possition of the small farmers, using the water to heat small plastichouses, is much stronger than before. They have a case in court against the hotels and ZIK "Strumica"

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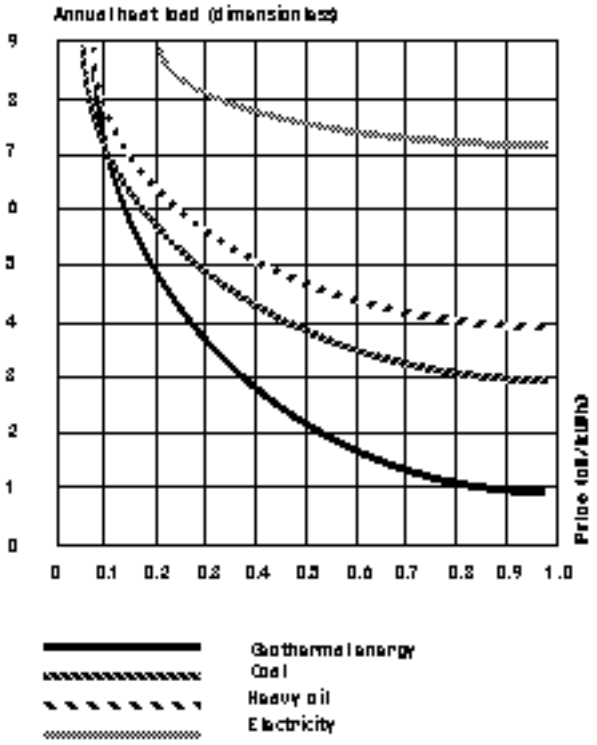
Economy of geothermal energy use in the integrated project "Bansko"

Economy of the geothermal energy use has been out of question until the connection of installations of hotel "Tsar



(Popovski, 1987)

Fig.4. Changes of the used heat price for different energy sources

Samuil" to the system. The introduction of borehole B1 and invested funds for explorations of geothermal field Bansko, realisation of exploration drillholes and completion of the exploitation borehole B1 changed the situation completely. That was not anymore an energy "free of charge", but one whose use should be economically compared with the other possible energy sources, particularly fossil fuels.

It was found already in 1987 that the onliest valuable criteria for estimation is the final price of the used heat by its users, i.e. comparisons should take in account not only the price of energy raw material itself, but also the additional investment costs to complete the heat "producer", exploitation and maintenance costs. When that was done for locally available energy sources, resulting characteristical diagram (fig.4) showed strong dependence of the economy of geothermal energy use on the annual heat loading factor. Up to the values of 0,08-0,15 its economy is under question, at least when comparing with the heavy oil and coal use; but after 0,2-0,22 it becomes the most economical solution without anyquestion. That is result of the above mentioned necessary high capital investment costs.

If covering the design heat powers of any one of possible heat users (or of all of them) is planned by geothermal energy only, it comes that it cannot be an economical solution because their annual heat loading factors are in the measures of 0,13 (greenhouses) to 0,23 (heating installations). Different values for the sanitary warm water preparation, swimming pool heating or balneological uses do not change the total situation because their influence to the total economy of the system is of minor importance. That is the main reason why only covering the base heat demands of heat consumers by geothermal energy is economically justified. By the introduction of proposed users composition and the use of possibilities of heat accumulation, it is possible to reach a significant correction of the annual heat

loading factor of the system, and in that way the price of used heat of it. If it is L=0,139 for the connected glasshouse complex (6,25 c$/kWh) and L=0,19 with the addition of hotel "Tsar Samuil" (5,85 c$/kWh), it becomes L=0,35 for the proposed composition (4,00 c$/kWh) and possibilities to reach even L=0,55 (2,80 c$/kWh) with the use of possibilities of heat accumulation. Differences are evident. If "doubtfullly" economical for heating only the greenhouse complex, or with the addition of the heating installation of hotel "Tsar Samuil", it is really the most economical solution if proposed composition of heat users and the use of optimised regime of heat extraction is introduced.

The situation in 1987 is taken as representative in the study, because the present one is too much influenced by non-economic factors.

Discussion on the present situation

Problem of the integrated geothermal project "Bansko" is that it is developed without initially defined conception, and that not consisting the minimally technically conditioned completion of the connected heat users. The first resulted with very bad composition of the heat users (daily and annual diagrams of heat consumption of the biggest ones are practically the same), and the second with still completely unsolved difficulties of the heat supply regulation.

It is practically the question of project organisation which is the most important factor for its further destiny and development. Further "war for water" between the already connected users results only with unsatisfactory heat supply to all of them. On the other hand, it is practically stopping the further possible and necessary development of the project in order to reach better economy of geothermal energy use and heat supply stabilisation.

Existing and possible heat users of geothermal field "Bansko" doesn't allow composition of an "atractive" integrated project. Very similar daily and yearly diagrams of main heat users limit possible values of the annual heat loading factor and in that way the economy of geothermal energy use. Anyhow, by a careful study of the characteristics of heat users and particularly of the reached experience and realised experiments in the system, possibilities for its optimisation has been located. Even very simple and already known from the experience of other projects, they were not used during the initial period of project development. Main reason is that initial users wanted to use the benefits of this free of charge energy without high investments and any limitation of the "freedom" of use.

The study for definition the optimal use of geothermal energy of the field Bansko focused the following possibilities to improve and stabilise the situation:

- ***Centralisation*** of the heat supply regulation in order to avoid further misunderstandings between the users. It should be performed by experienced technicians and by an independent organisational unit of any one of the users;
- ***Introduction of the payment*** for used energy. It is not justified to follow to use the fruits of expensive explorations and well arrangement free of charge. That is also the onliest way to collect necessary funds for further exploration and geothermal system completion;
- ***Obligation for installation of additional heat sources*** for peak loadings covering. As it is already said, avoiding the use of peak boilers is the main reason for the "war for water" between the users;
- ***Obligation and right to perform centralised regulation*** in the way that heat accumulation possibilities of heated objects shall be used; and
- ***Obligation for all the users to complete*** the connection installations in the way that enabling a regulated supply of geothermal water, protection of over extraction of it, measurement of the momental and cummulative thermal water consumption, and protection of the environment of thermal and chemical pollution.

Introduction of proposed optimizations should enable a better economy of the project, stabile long years supply of users and its economically and technically justified development.

Financial benefits of the geothermal energy use for heating purposes

Finally, after 10 years stop of any activities on the project proper completion and optimization, the World Bank financed preparation of a pre-feasibility study for the project rehabilitation and organization. It confirmed the planned activities enabling a proper organization of the exploitation of the natural energy source, its maintenance and further development.

Community of Murtino shall finally take the responsibility for distribution of the geothermal water flow to the users in technically and technologically justified quantities, according to their needs but also according to the possibilities of the reservoir. In that way, preventive reservoir engineering and use shall be introduced (taking care about the national energy source) and payment of the used energy (necessary funds for governing, exploitation, maintenance and further development of the system).

Planned activities shall enable, at the first step, proper supply of heat to the present users (about 13.000 MWh/year = 1.250 t/year heavy oil with 90% efficiency) and increasing the system with new users (altogether about 15.000 MWh/year = 1.450 t/year heavy oil with 90% efficiency).

If taking into account that the present price of heavy oil in Macedonia is 0,23 $/kg, that means annual substitution of 1.450 t, i.e. saving of **333.500** US$/year.