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New Economy System - New Design of the Organization for Exploitation of the Geothermal System "Bansko"

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Abstract:

Political and economy transition process in flow influenced also the conditions for exploitation of geothermal systems in Macedonia. Typical is the example of geothermal system "Bansko", once being example of a good organized and successful direct application project at world level. Free of charge supply of geothermal water in combination with the absence of law regulative for the "right" for geothermal field exploitation, provoked "explosion" of interest of new consumers. Not having the possibility to connect to the existing distribution system, or doing it in un-proper way, they began to drill new (shallow but also dipper) boreholes near to the existing exploitation well. Resulting decrease of the its capacity has not been important when the connected greenhouse complex was not working (1998-2003), however its reconstruction and reconnection at the end of 2003 resulted with a complete decay of the previous organization of the system exploitation, based on the discipline of users for proper extraction of water according to defined schemes.

Results of the realized pre-feasibility study are discussed in the paper, consisting:

- Determination of the possibilities to increase the energy source capacity by drilling and completing new exploitation wells;
- Redesign of the exploitation system, accommodated to the new heat requirements;
- Description of the composition of the system and technical and technological innovations which should be incorporated in order to enable a proper work of it;
- Centralization of the system government and introduction of payment of the used water, enabling proper maintenance and development of it;
- Economical and technical consequences to the users, resulting of the centralization and payment of heat supply;
- Accepted plan for introduction of technical recompletion of the system and new organization of exploitation.

All the reached (and planned) results are of particular interest because the system plays a role of a kind of "demonstration" successful project not only in Macedonia but also in the neighboring countries (Albania, Bulgaria, Greece and Albania).

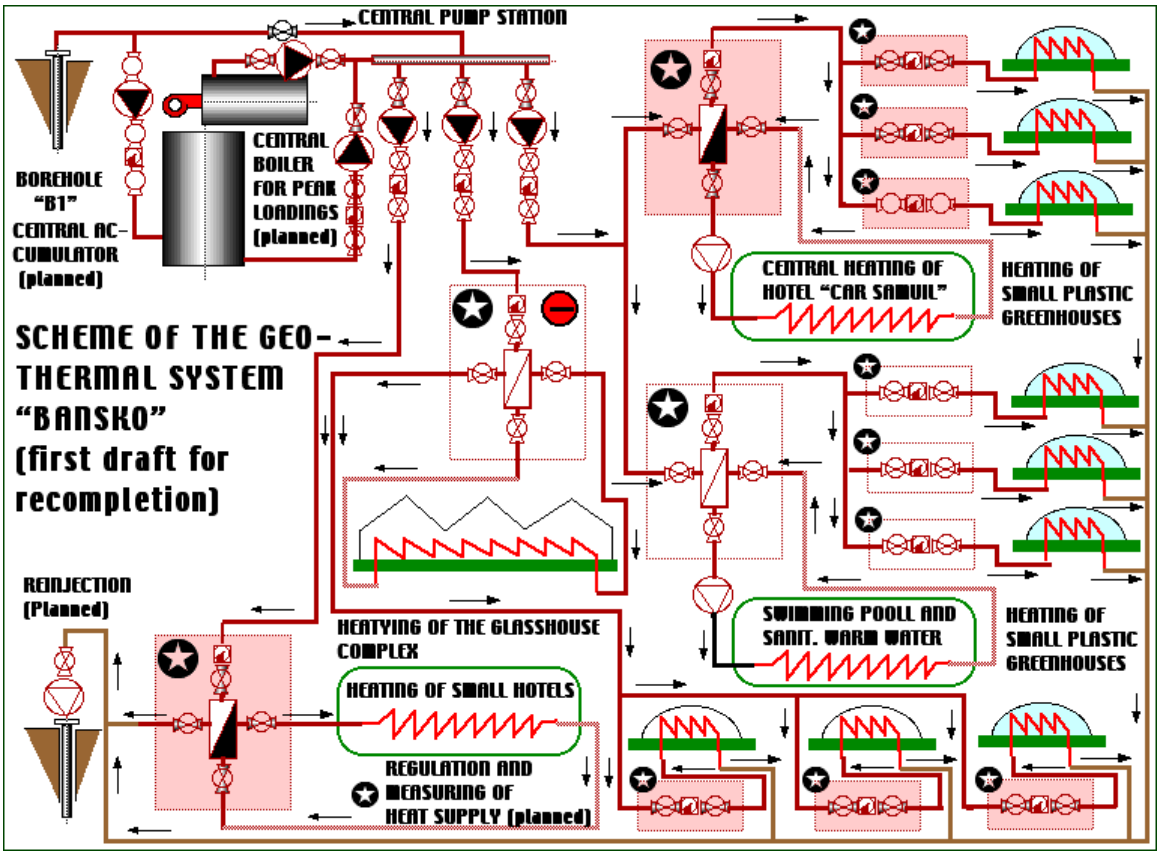

Fig.1. Simplified scheme of the geothermal system "Bansko"

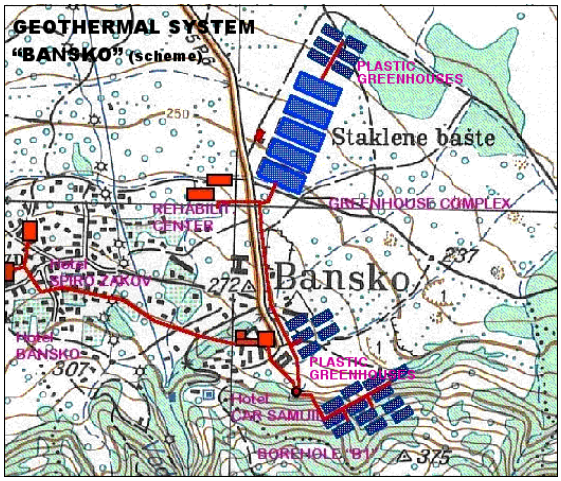

Fig.2. Geothermal system "Bansko" – location of the consumers

INTRODUCTION

The Bansko geothermal project is located in the southern side part of the Strumica Valley in the south eastern side of Macedonia, close to the boundaries of Greece and Bulgaria. Even without the use of modern regulation equipment, it was a good example for possibilities to use geothermal energy for district heating systems, composed of different type of users. Anyhow, during the 80-es of last century, it was planned to reorganize it and to improve the quality of the geothermal water exploitation. However, during the recent 10-15 years, the process of reorganization of the "integrated" geothermal system has been disturbed by the political changes in the country. Previously state owned glasshouse and hotel complexes came into an undefined property position. Small farmers (owners of the complex of small soft plastics covered greenhouses) pressed to get their "rights" for the geothermal water exploitation. They began to use the water in an uncontrolled way and the existing, (even roughly) organization of water distribution system, was destroyed.

As a consequence of the "war for water" among the different uses, the system didn't work properly for the last 6 years. Therefore, no one was, and still is not, satisfied, with the quantity and quality of energy, which is supplied to users. Practically, the project doesn't work anymore as an organized system.

On the other side, several studies maid meanwhile showed that with the stabilization of new economic system and proper interventions (technical, institutional and organizational) is however possible to re-organize the project in a economically and technically correct way. It is justified by the important contribution of the geothermal resources on the whole economy of the areas.

1. CAPACITY OF THE GEOTHERMAL RESOURCE

From the structural-tectonic point of view, the Strumica Valley and its borders belong to two tectonic units: Serbian/Macedonian Mass and Vardarian Zone and can be divided into four structural-geological units: Belasica horst, Ograzden batolit, Smrdea horst and Strumica graben. Other secondary structures are also the deformations Belasica, Bansko, Gabro, Ilovica, as well as the

Fig.3. 3,2 ha glasshouse heated by geothermal energy

hydrogeothermal changes in the Drvos-Çanakale zone. The Strumica graben originates from the associated depression along the Belasica and Ograzden mountains during the Pliocene age. The depth is still not precisely known but, according to the geophysical investigations, it can be assumed to be between 800 and 1,000 m.

Thermal waters are present in the village Bansko, where a natural spring of 30-35 l/s with temperature about 72ºC and the borehole B1 with 55 l/s with temperature about 69.5ºC are present, together with several small flows.

We have to evidence that further development of the exploration could considerably change the present geothermal model and potential in terms of temperatures, water availability and reservoir characteristics. By the way, for the comprehensive knowledge of the geothermal field, it should be necessary to check (with one or two deep wells in the central part of the valley), the possible presence of medium enthalpy fluids able to produce electricity through binary-cycle power plants. For the estimation of the total potential of the presently available hydro-geothermal flows only, it is necessary to underline the existing interactions between the borehole Bl, the main natural thermal spring and the other small springs. When the flow from B1 is over 40 l/s, the main springs become dry and the small ones gradually disappear. When B1 is closed, the main spring has a fairly continual flow (with small seasonal changes) and the changes of the small springs are within known limits. According to the experience of many years, the following production parameters can be taken as indicative:

Table 1. Capacity of the geothermal resource

	Production	Temperature
Maximal continual flow of the main natural hot spring (with the borehole B1 closed)	35 l/s	72°C
Maximal flow from the borehole B1	52 l/s	69.5°C
Maximum flow from the borehole B1 under forced overpumping conditions (up to 12 h).	55 l/s	69.5°C
Maximal stabilised flow from the borehole B1 under continual exploitation conditions.	50 l/s	69.5°C
Available flow from the small thermal springs and temperature	No reliable data available	No reliable data available

The interference effects among the well B1 and the natural springs are clearly due to their concentration in the same area while the temperature fluctuations during the pumping appear due to the dragging of colder water from the border of the graben.

The composition of the borehole and spring thermal waters is natrium-sulphate, with a total mineralization of 1,157.2 mg/l. High concentration of B (Boron) and F (Fluorine) indicates the presence of deep interactions among rocks and waters.

From the theoretical point of view, considering the temperature interval between the hot springs / well B1 (~70°C) and 25°C (minimum temperature of disposal water) as economically feasible for the existing composition of users, **the maximum geothermal heat power available is about 10.3 MW**.

2. HEAT CONSUMERS OF THE GEOTHERMAL SYSTEM

The list of the present users with the relevant heat demand is shown in Table 2. The design maximum heat demand of the above users is about 7.5 MW almost 91% of which is supplied by geothermal water.

Fig.4. Complex of the hotel "Car Samuil"

Table 2. Existing consumers

A. EXISTING USERS						
N°	USER	MAXIMUM HEAT DEMAND		MAXIMUM HEAT POWER OF GEOTHERMAL ORIGIN		NECESSARY GEOTH-ERMAL WATER FLOW
		KW	°C	KW	°C	l/s
01	ZIK "Strumica"					
-	Greenhouse complex of 3.0 ha	3984	70/40	3984	70/40	31.72
02	Hotel "Zar Samuil"					
-	Heating Rooms	1563	80/40	800	70/40	6.37
-	Sanitary warm water	500	50/38	500	70/25	2.65
-	Swimming pool	150	40/25	150	40/25	2.39
-	Medical balneology		38			
03	Hotel "Spiro Zakov"					
-	Sanitary warm water	220	50/40	220	70/25	1.17
04	Hotel ZIK "Strumica"					
-	Sanitary warm water	120	50/40	120	70/25	0.64
05	Private farmers					
-	Complex of small soft-plastic covered greenhouses	1000	40/25	1000	40/25	15.93
	TOTAL A	7437		6774		60.87

Table 3. Potential consumers

B. ADDITIONAL (INCOMPLETE) USERS						
N°	USER	MAXIMUM HEAT DEMAND		MAXIMUM HEAT POWER OF GEOTHERMAL ORIGIN		NECESSARY GEOTHER-MAL WATER FLOW
		KW	°C	KW	°C	l/s
01	Hotel "Spiro Zakov"					
-	Heating rooms	380	80/40	200	70/40	1.59
02	Hotel ZIK "Strumica"					
-	Heating rooms	200	80/40	120	70/40	0.98
03	Open air swimming pool					
-	Sanitary warm water	60	40/25	60	40/25	0.96
-	Swimming pool	150	40/25	150	40/25	2.39

04	Children's rehabilitation centre					
-	Heating rooms	450	80/40	250	70/40	1.99
-	Sanitary warm water	250	50/40	250	70/25	1.33
	TOTAL B.	1490		1030		9.22

	TOTAL A + B	8927		7804		70.09

Moreover, other potential users have been identified in the area, for a total heat demand of about 22 MW. The additional requests for connection from new customers are:

- Meat industry "Phoenix" (4.0 l/sec)
- Other plastic greenhouses farmers (15 l/sec)
- Rest-house MVR (1.0 l/sec)

The total currently exploited geothermal capacity (around 6.7 MW) is lower than the theoretically exploitable capacity (10.3 MW). This fact doesn't mean at all that the presently available geothermal resources is under exploited. In effect, it's exactly the contrary. This is due to the fact that at present the system cannot operate efficiently [mainly due to lack of maintenance of the geothermal system components (well casing, pumps, piping, valves, etc.)], which causes heat losses and water leakage. The exploitable capacity is therefore hardly sufficient to the demand due to the above losses and also to the extreme variability of the same during the day and the seasons.

On the other hand, the **estimation of the possible future demand (22 MW)** is far more than the total which is presently **theoretically** available (10.3 MW).

The consequence is that with the present situation is not possible to satisfy the whole future demand (22 MW) and scarcely also the present one.

Fig.5. Geothermal swimming pool in hotel "Car Samuil"

3. OPTIMIZATION OF THE PRESENT SITUATION

The problem related to the exploitation of the geothermal resources in Bansko due to the increasing demand for hot water led the entity in charge of the greenhouse complex to study for the definition of the rational use of geothermal water of the Bansko reservoir. The study was carried it out at the beginning of 1992, based on the results of all previous investigations and experiences on the operation. Other studies were performed successively (1999, Popovski-Lund). All the studies were performed according the criteria to **optimise the management of the presently available water.**

The focal critical point which was studied, was the insufficient quantity of hot waters to the different users. However, the main aspect of this insufficiency is not the total quantity available during the day which is, anyhow, at the limits of sufficiency and, in every case, insufficient for future expansions of the exploitation. The most evident aspect, instead, is the high variability of the heat demand during the day. It is, in fact, evident that both the greenhouses and space heating uses follow the same heat demand behavior. The request of heat in both cases is higher during the early morning hours and lower in the later hours of the day and night.

The first criteria at the base of the above proposals was to "iron the demand curve" by means of proper adjustments of the plant design. The second criteria at the base of the proposals was to consider the management of the geothermal resource not separately plant by plant but as a complex of different plants to be managed as a unitary system.

Two possible solutions to the problem can be envisaged according to two different approaches:

- *Optimization of the management of the limited thermal water presently available, and*
- *Increase of the availability of thermal water.*

Fig.6. Hotel "Bansko"

3.1 *Optimization of water management*

Presently, the philosophy of the system, and of all the users, is to satisfy both the base and the peak heat loads of the different plants only with the geothermal water. Peak loads, unfortunately occur at the same time in the early morning.

Without increasing the availability of thermal water (which will require additional investments in investigations and well drillings) and **maintaining the present situation**, the system should be optimized in order to better manage and distribute the 50 l/s of thermal water presently available. In other words, another conceptual design should be applied, involving:

- the installation of peak load boilers fuelled by a conventional source of energy,
- installation of a large heat storage tank,
- expansion of the cascade use of the thermal water,
- reduction of the present losses of water and heat due to the bad conditions of the equipment and to

the uncontrolled exploitation of the resource.

These adjustments would leave the geothermal resource to satisfy the heat base load only, and would be possible to slightly increase the number of users to supply.

At present only the Hotel "Zar Samuil" and the center for rehabilitation have light oil boilers for peak load but, due to the cost of fuel, they are never in operation.

Fig.7. Center for rehabilitation

3.2. *Increase of the thermal water extraction*

This option represents the second possible solution to satisfy the thermal water hunger of the Bansko economic operators and has to be carefully considered for the following reasons:

- It is probable to meet scarce attitude of the users toward the installation of oil fired boilers, due to the high investment and operating costs of this solution, and by the fact that the geothermal resource is up to now free of charge.
- It can be also expected a scarce attitude toward the use of exhaust lower temperature water (cascade use) because primary water allows cheaper and simplest heating equipment with higher efficiency.
- The whole heating system is now, strongly dependent from the well B1 and, in case of problems on the same well, will come in critical situation.
- It can solve the existing problem of pollution and reservoir recharge due to the lack of re-injection of exhaust water.

Every user tends to cover his heat needs exclusively by geothermal energy of higher "quality". On the other hand, if could be possible to satisfy this wish, the users will get benefits and this will have positive effects on the local general economy.

According to this second option, it should be necessary to increase the exploitation of the Bansko geothermal field.

In this hypothesis, new exploration activities should be performed. The activities should include:

- geological and hydro-geological surveys,
- geophysical surveys to reconstruct the geometrical parameters of the cover formation and reservoir,

Table 3. Definition of the optimization approach

APPROACH (OPTIONS)	DESIGN AND OPERATIONAL/ MANAGEMENT CONSEQUENCES	POSITIVE ASPECTS	NEGATIVE ASPECTS
OPTIMISATION OF THE MANAGEMENT OF PRESENTLY AVAILABLE RESOURCE	• Installation of oil fired boilers to cover the peak load. • Installation of heat storage tanks after the well head. • Expansion of the cascade use of thermal water (minimum temperature of final exhaust water). • Centralisation of the heat distribution and management. • Payment of the heat by the users.	• Smoothing the daily demand curve. • Limited investments costs. • Solve (even if temporarily) the heat demand problems. • Lower tariffs for heat supply.	• The problem of final disposal of effluent remains unsolved. • Probable scarce attitude toward new investments in boilers and toward lower quality water use. • Limited possibilities for additional connections to the system • The whole system continues to be critical and strongly dependent from the well B1.
INCREASING OF THE AVAILABILITY OF THE RESOURCE	• Execution of surveys studies. • Drilling and equipment of new wells also toward the centre of the graben (exploitation, exploration, re-injection). • Centralisation of the heat distribution and management. • Payment of the heat by the users.	• Higher availability of primary hot water. • Guarantee of heat supplying also in case of failures of the well B1. • Solution of the re-injection problem. • Possibility to satisfy future candidates to geothermal resource exploitation (22 MW). • Possibility to ascertain the existence of medium enthalpy resources (electricity production).	• Higher investment costs. • Higher tariff for heat supply.

- elaboration of a reliable geothermal model,
- drilling of exploration and exploitation wells to increase the presently limited (50 l/s) available amount of thermal water,
- the drilling of re-injection well to avoid pollution and favor the reservoir recharge.

Both options will require proper investments and to change the present habit to consider the geothermal one as a free of charge energy resource.

Positive and negative consequences of both options can be summarized as follows:

It is necessary to underline that the two solutions are not antagonist or alternative; the second one includes the most interventions of the first, giving only more emphasis to the increase of the resource availability than to the exasperated research of technical and operational measures to reduce the consumes.

In effect, the first solution can be considered only a temporary way to remedy to the present situation avoiding, for the moment, to invest about half a million Euro in surveys and new drillings.

In any case, it appears evident that the effective management of the heat system can be performed **only if the supply and regulation are centralized, and systematically monitored** by experienced technicians, according to a management and operation programme tailored on the requirements of the different heat consumers.

Centralized management and operation of the extraction, storage and distribution requires **that the supplied heat is paid by the users.** The relative income can permit the maintenance of the unitary system and to invest in improvements in the components of the same (well equipment, pumping system, control and regulation devices, storage and pipelines, etc.).

Fig.8. Hotel “Termica”

4. REGULATORY AND LEGAL PROBLEMS, TECHNICAL AND ECONOMICAL PROBLEMS

Until when a new legal regulation system will not be properly established, the past experience makes clear that legal aspects highly influence negatively the organization, exploitation, economy and operation of the "Bansko" integrated geothermal system. The present situation depends from the past order which has not been adjusted to the new behavior of the national economy.

Previously, all the heat users, except the small farmers, were public owned bodies and, among them, it was possible to define (in a co-ordinated way) the rights and responsibilities on the water supply. At the same time, also the management and organization of the system, as well as the financing the works to maintain and improve the system, was clearly managed.

Presently, the geothermal heat source and the common elements of the integrated project (well, central station, distribution pipes, etc.) are on undefined property conditions. The ownership is not clear and nobody of the users considers himself responsible for assuring the proper maintenance and exploitation.

The situation of the installation is really in bad conditions and the well is over-pumped continually during the winter time because every user looks only to his “un-doubtful” needs and claims for “older” rights than the others for the free of charge energy use. As already mentioned, practically, there is a kind of “war for water” in the system, with all the escorting problems (i.e. arbitrary connections, continual contrasts and fights between the users, a list of appeals to the local court, etc.).

In synthesis, the main regulatory problems appear to be the following ones:

- the absolute need for definition of the ownership (or the right to exploitation) of the geothermal energy source (concession to one single legal person);
- definition of the ownership, rights and obligations arising from the “common” parts of the integrated geothermal system;
- definition of the right of the owner of the system (or the holder of the right to exploitation) to define and impose to the users connected to the integrated system, the minimal technical standards and quality characteristics of their heating systems. This power appears necessary in order the different heating systems are compatible both with the available resource and with the common parts of the integrated systems;
- introduction of the right to price the energy used.

However, the energy should not be free of charge in any case. **In order to stimulate the proper use and further development of the system, the price of geothermal energy should be lower than for conventional energy services. Moreover, it is recommended to adopt a pricing system able to stimulate the use of the lower part of the temperature range of available data in order to improve the total efficiency of the integrated geothermal system.** The income should be devoted to the maintenance and improvement of the pumping/ distribution/regulation system and of the geothermal field but also allowing further users to be connected to the system.

Some of the aspects listed above are of a legislative nature and should be resolved by the state (ownership, right to "sell" the energy, pricing by the supplied energy, etc.). Some others aspects are of an organizational nature (definition of interrelations between the heat supplier and users, responsibility for minimal technical completion of the users installations, division of responsibilities for maintenance of the "common" parts of the system, etc.).

The national government has been charged of the above mentioned present problems and seems that the legal aspects will be solved by the end of the year 2004. It is envisaged that new laws will enable appropriate solutions for all of the problems listed. However, without a final solution for the privatization of the geothermal system, it is not possible to solve the organizational problems, nor to define any effective organization of the exploitation, maintenance and development of the integrated project, composed of different heat users, with different daily and annual heat loading factors.

The solution of the above listed legal problems is a priority in respect to the solution of the technical problems because, without the solution for them, any technical intervention to put the system into proper operation will not be effective.

Together with the solution of the technical problems, it is necessary to front other two mainly economic problems:

The first is the introduction of the payment for the geothermal heat which is the only way to:

- save energy;
- collect the funds necessary for further exploration of the field;
- guarantee the maintenance and improvement of the system.

The estimation is of the final price of the heat should take into account not only the extraction and distribution costs but also the additional costs, necessary for the maintenance and management of the system. A price estimation according to the above criteria for different energy sources shows that the geothermal energy price is strongly dependent from the annual heat loading coefficient (or factor). Up to values around 0.1 the competitiveness of geothermal energy is not evident, at least when comparing with the heavy oil and coal use but if the loading factor increases from 0,2 ahead, it becomes the most economical solution. This behavior is due to the specificity of the geothermal resources which generally require initial high investment costs but are successively characterized by very low operation costs.

In the case of Bansko where the yearly heat loading factors range between 0.13 for the greenhouses and 0.23 for the heating installations, the competitiveness, even not being very high (due to the fact that greenhouses are the greatest consumer), competitiveness is assured.

By the introduction of the proposed system optimization, including the heat accumulation, it is possible to reach a significant increasing of the annual heat loading factor of the system and, consequently, a higher competitiveness of the geothermal resource.

Another technical, but economically driven decision to be taken, is the already mentioned need to solve the problem of the dependence of the whole system only by the well B1. The extension of the geothermal field should allow further and quantitatively higher extraction rates. Moreover, the drilling of new exploration wells appear necessary for the guarantee of supply and for any further expansion. The same is for the re-injection of the exhaust water. However, this option means need to invest in drillings and related services for about 53% of the total budget for the rehabilitation and expansion works as described in the following pgf. If this investment should not be possible, the first step could be limited, only to optimize the water management postponing the works relevant to the geothermal field.

5. REORGANISATION OF THE INTEGRATED PROJECT

The analysis from different points of view of the situation of the integrated project Bansko permitted to sketch a plan for the reorganization of the project itself.
All the critical factors which have been highlighted are summarised together with the relevant adjustments and rehabilitation works which are envisaged as necessary:

a) ***Property of the system***: One entity should be charged of the right to exploit the geothermal water and to sell it to different users under known technical and financial conditions.

b) ***Regulatory aspects***: Introduction of defined rights and obligations between the supplier and users, defined conditions for exploitation, maintenance and development of the geothermal source and integrated system of users, defined tariff system for different categories of geothermal water users depending on the quantity and quality (temperature interval) of the supplied water. All these aspects should be defined before and during the project organization and completion.

Fig.9. “War” for thermal water of the small producers in plastic covered greenhouses

c) ***Organization of the legal*** with a proper technical team for exploitation, maintenance and development of the integrated geothermal system "Bansko". That is an essential pre-condition for the project re-organization and realization.

d) ***Technical conditions***: Defined regime of the heat supply to each one of the heat users, defined minimal technical completion of the central distribution and connection stations of heat users, installed equipment for measuring the heat supply, defined maintenance obligations of the supplier and heat users.

e) ***Re-completion of the installations of heat supplier***: Organization and completion of the heat source and central heat supply station, comprising: installation of a water accumulator of 1,000 m^3 for covering the short lasting peak loadings and protection of the overloading of the system, installation of pumps with frequency variators, installation of a pressure control system.

f) ***Rehabilitation of the pipe distribution system***: Taking into account that the complex is located in a spa center, it is necessary to reconstruct the distribution lines according to landscape protection criteria (part of the distribution line to Hotel "Spiro Zakov" is above the ground surface).

g) ***Rehabilitation of the heat users installations***: Beside the regular maintenance, i.e. change of old parts and equipment, all the connection stations should be re-completed or newly installed (small greenhouse producers), existing oil boilers should be used for covering the peak heat demands of users, and technically rational heating equipment should be installed by all users.

h) ***Rehabilitation of the glass greenhouse plant***, including new heating installations with different regime of heat use (already done!);

i) ***Connection of new heat users***: The reorganization of the integrated geothermal system "Bansko" shall enable connection of new heat users improving the total economy of the system itself.

The possibilities of expanding the system will be very limited if the first development option is adopted, while could be much more if the second option could be applied.

Project realization will enable a proper exploitation of the natural energy source, the safeguard of the field, the maintenance of the equipment and further development.

It is evident that one of the first decision of the new entity will be what of the two possible development options have to be adopted in the short and long period.

According to the first option, considering an annual heat loading factor of 0.192 (about 1700 hours) as an average among the different users and uses, we can consider a heat supply of about 13,000 MWh/year, which correspond to 1,242 t/year fuel oil with 90% efficiency.

If also heat supply of potential identified users is considered, the overall heat supply will reach about 15,000 MWh/year, which is close to the maximum theoretical potential of the well and springs (10.3 MW).

Taking into account the present price of heavy oil in Macedonia (0.25 Euro/kg) this means the annual substitution of about 1,450 t corresponding to the saving of about **377,000** Euro/yr.

According to the second option, if the possible heat supply to future users is considered (22 MW), the overall heat supply will reach about 37,000 MW/yr, corresponding to a 3,218 t/yr fuel oil with saving of about **805,000** Euro/yr.

Necessary investments in the geothermal system including new exploitation wells with relevant equipment and one re-injection well for wastewater are about Euro **950,000**

Necessary investments in geothermal system without new exploitation and re-injections wells but including new pumping equipment for well B1 and a deep rehabilitation of the same well (well head, casing, etc.) Euro **500,000**

As a consequence, the average heat price, in order to cover the annual costs, the reserve funds, development of the system and the established profit of 7 %/yr, could be **0.017** Euro/kWh for the first variant or **0,013** Euro/kWh for the second. In both cases, the price of the heat is very attractive and the government decided to finalize the privatization process and to give the concession to the best offer-er (guarantee for realization of necessary investments in shortest possible time) until the end of 2004.

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