KOTCHANY INTEGRATED GEOTHERMAL PROJECT

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ABSTRACT: *Integrated direcr upplication geothermal project "Kotchany" is rhe biggest one in Macedonia and uniong the largest in whole the Europe. At the moment, it is composed of the healing systems for 180,000 sq.m glasshouses, a large rice drying unit. a puper production industry, a vehicle parts production factory and six buildings with dwellings. Further developnient is orientated towards larger share of industrial uses, covering the needs for sanitary warm water for the industry and dwellings and introduction of very low temperature hearing system for greenhouses, using the effluent water of other users. In conibinution with the existing and new boilers for peak loadings. the whole system sliould reach the maximal heat power of about 70-80 MWt.*

Main problerirs in exploitation of tlie systeni are con - nected to rhe reservoir engineering. poor and incom - plete heat supplv regulation system of glasshouses, dif - ficulties in regular supply of the small users at big dis - lances (connected with large pipes, designed for future big heat supply). difficulties in payment of the used heal by agricultural producers. etc.

A state-of-the-art summary of the integrated project is presented in rhe paper, followed with the results of re - alised techno/economic feasibility studies for the possi - ble and ecoomically justified developnient in the next 5 years.

Fig.1. Main geotectonic areas in Macedonia

1. GEOTHERMAL FIELD KOTCHANY

Geothermal field **Kotchany** is the most important field in exploitation **in** tlie Republic of Macedonia. which is situated in the southernmost part of the Bosniaan-Serbian-Macedonian geothermal area, comprising **the** mountains of the internal Dinarides and parts of the **Serbian-Macedonian** massif (Fig.**1**). The teritory is characterised by numerous thermal springs indicating an area of potential sources of geothermal energy. The exploration drilling programme located 7 main geothermal areas of which three of major and four of minor importance (Fig.2).

Kotchany valley is a tectonic depression formed during the Neogene and Quaternary periods by the subsidence of blocks at the intersection of two geological zones. Two major faults (Fig.3) trend E-W, but the subsided blocks between them are divided by smaller faults into a mosaic of small blocks. Both of the major faults are seismically active (Kotevski, 1985).

Three main geothermal localities have been delined in the Kotchany valley:

Podlog is located in the middle of the valley, where thick sediments of Neogene and Quaternary age are underlain by schists. Pyroclastic deposits originate from the adjacent volcanic area of Kratovo-Zletovo.

The first well. EBMP-I. was drilled in 1967 to a depth of 70 m, giving 5 **l/s** free water water flow at **60** "C. In 1980 a deeper well was drilled near by. At 307 m an aquifer was intersected yielding over 150 **l/s** free flowing water at 79 "C.

In the period 1980-1986, 18 exploitation and production wells were drilled in the area, resulting in

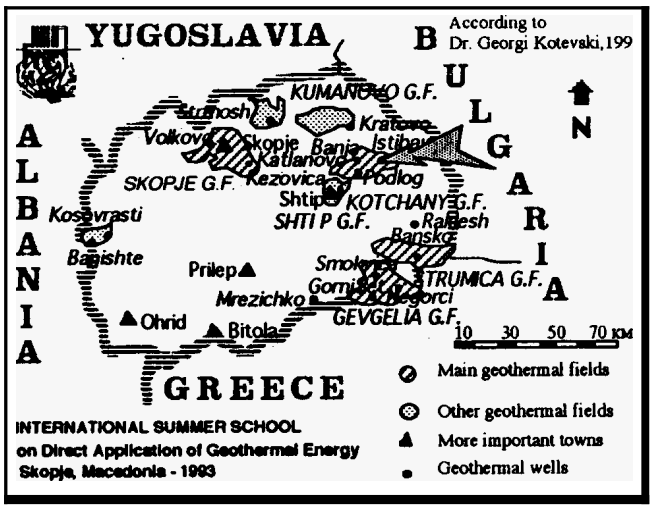

Fig.2. Location **of** geothermal fields arid thermal springs in Macedonia including **the** Kotchany geothermal field

a **total** possible yield of 600 **l/s** and water temperatures between **57** "C and 79 "C (Fig.5).

Banja is located about 5 km north of Podlog, on the same major fault. Direct connection was proved by the reduction of the thermal water flow of the natural spring. during the periods of overpumping **from** the wells in Podlog. One successful well yields about 50 l/s thermal water at 65 "C, but the latest borehole (450m)

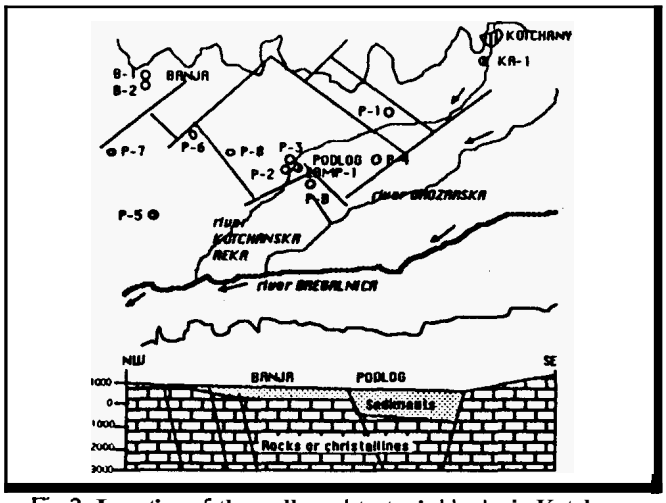

Fig.3. Location of the wells and tectonic blocks in Kotchany geothermal field

was unsuccessful.

Vinica (or Istibanja). tlie third geothermal site is also north of Podlog (Fig.4). Hot water emerges from Precambrian gneisses and schists. After electrical resistivity measurements, 12 shallow wells (up to 30 m deep) were drilled to locate tlie upflow zone. The water temperature in all of them is between 30" and 40°C. In addition, a 180 m deep borehole was drilled and yielded 3 l/s of 60 "C thermal water and another at 190 m well yielded 6 l/s at 60 "C. The latest production wells have been drilled to between 200 and 350 m and resulted in a total llow of around 60 l/s at 60 "C.

2. DEVELOPMENT OF THE KOTCHANY INTEGRATED GEOTHERMAL PROJECT

15 geothermal projects are in operation in th Republic of Macedonia. Four of them are of major importance (Kotchany, Gevgelia, Bansko and Vinica) of which tlie Kotchany integrated project is the biggest one. Its develoment began in 1980, after the borehole EBMP-I was completed. Its maximum flow rateof 150 l/s (100 l/s for continuous use) offered the possibility to resolve the difficult energy situation of neighboring greenhouse complex "Kotchansko pole" of 12 ha and

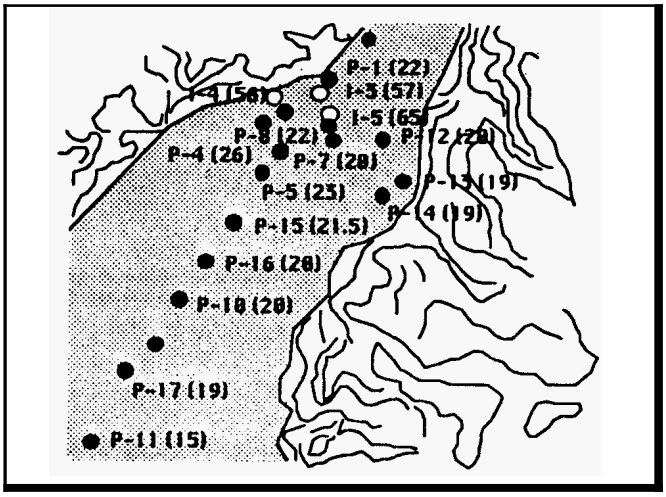

Fig.4. Location of the Vinica geothermal field. wells and exploratory drillholes

36 MW design heat power, due to the world energy crysis during that period. With very minor modifications of the heatiug installations (originally designed for temperature regime of 110/70 "C) and construction of a 3 km long pipe-line, the connecting was carried out in one year and the problems have been practically solved. Existing boilers were used partially for covering the peak heat demands during the first season, but immediately it was found that "they were not necessary". By the use of large thermal water flow through the installation, it was possible to use only the upper part of temperature difference at disposal and to keep internal air temperature rather satisfactory, even for lowet outside temperatures.

However, such a "good situation" lasted a very short time. Neighbouring agricultural combine "Mosha Pijade" decided to built a new greenhouse complex of 6 ha and 15 MW design heat power, expecting also that all the heat demand could be covered with energy of geothermal origin. During the first ye-

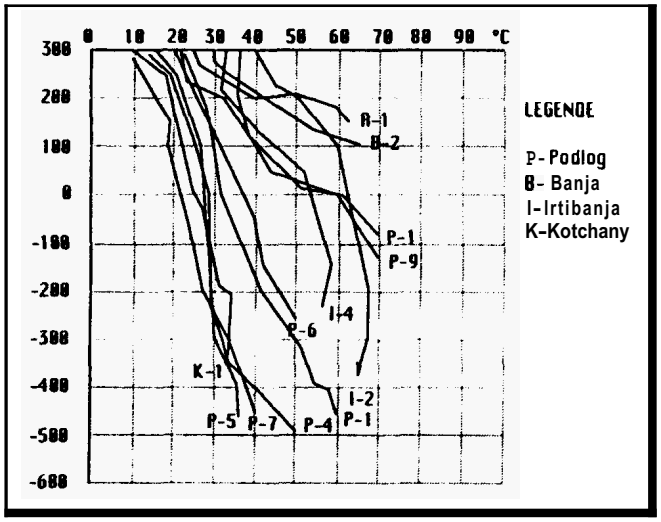

Fig.5. Temperature profiles of the wells in Kotchany (and Vinica) geothermal field

ar of joint exploitation the initial artesian pressure of 6.5 bars dropped to 0, due to the overdemand of thermal water by the growers.

The well in Banja. in the same geothermal field, ran dry and the existing balneological use had to be stopped. This provided the first parctical lesson in the joint use of geothermal energy sources in Macedonia. The following season a contract between the users was signed, regulating the division of available heat flow. "Mosha Pijade" adapted its greenhouse production program, to use 40% of the flow, and "Kotchansko pole" adopted tlie technical solution of peak heat demand covering by the existing boiler. On average 60% of the available thermal flow covers 90% of total heat consumption on average.

In 1983 a rice drying plant of 1.36 MW was connected to the geothermal system, improving its annual heat loading characteristics.

The last successful borehole of 450-600 l/s, opened the way for geothermal energy introduction also in the other economy sectors and different general uses in the Kotchany valley.

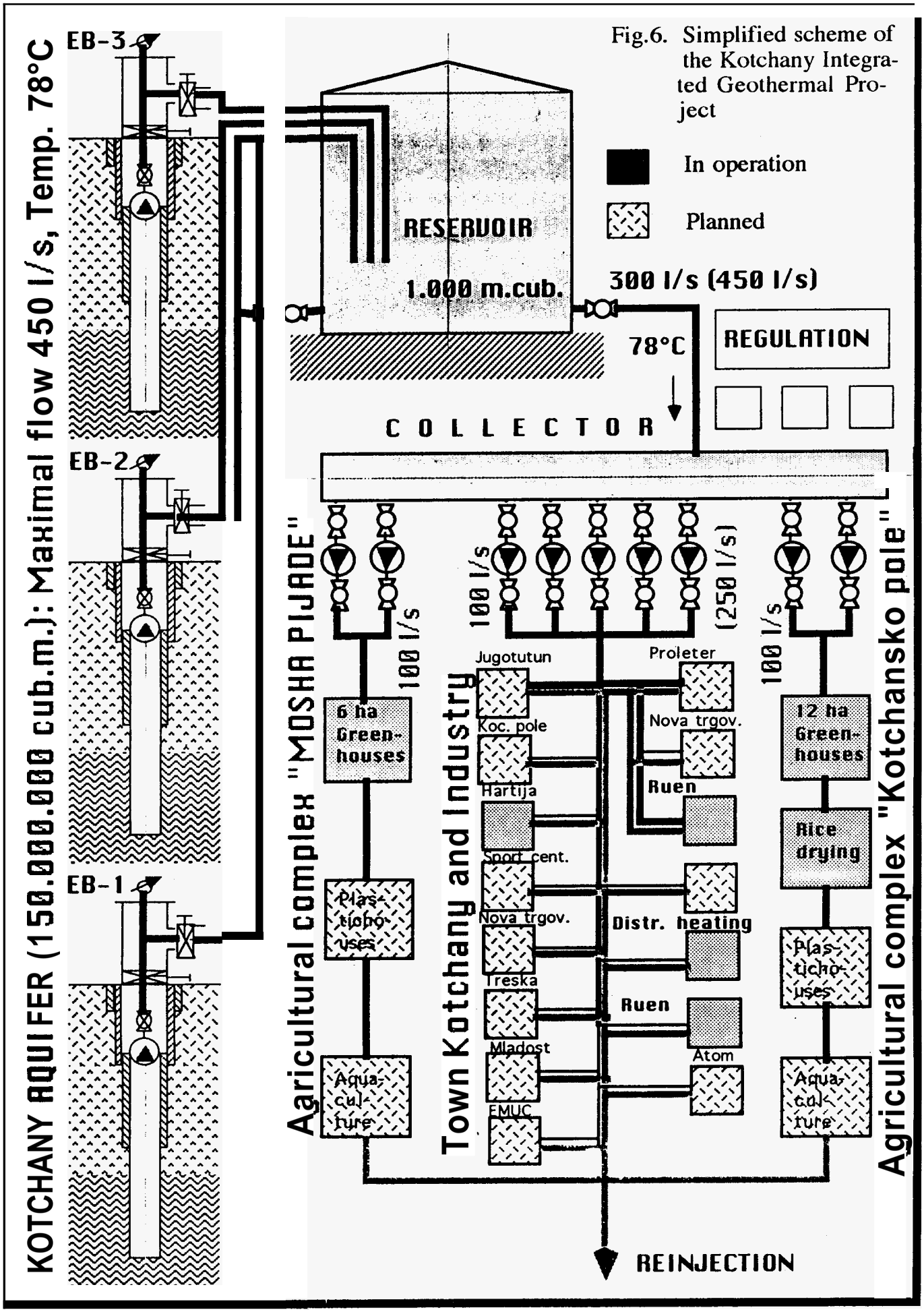

Fig.6. Simplified scheme of the Kotchany Integrated Geothermal Project

The development proceeded slowly due to tlie difficult economic situation in the country but anyhow, during tlie last 5 years it was continuous. Firstly a paper industry decided to connect the installations of the sanitary warm water. Good experience in one year of exploitation resulted with tlie connection of the other low-temperature euergy users. The factory for vehicle parts "Ruen" followed it in the same way. In parallel, one after tlie other. six buildings with 10 to 50 dwellings began to use geothermal water as heating fluid. For the next season connection of three new users is expected.

At tlie end of tlie heating season 1993/1994 the integrated system consists of different heat users of about 60 MW design lieat power (Fig.6).

3. PROBLEMS

The development of tlie Kotchany integrated geothermal systeni has presented tlie following main problems:

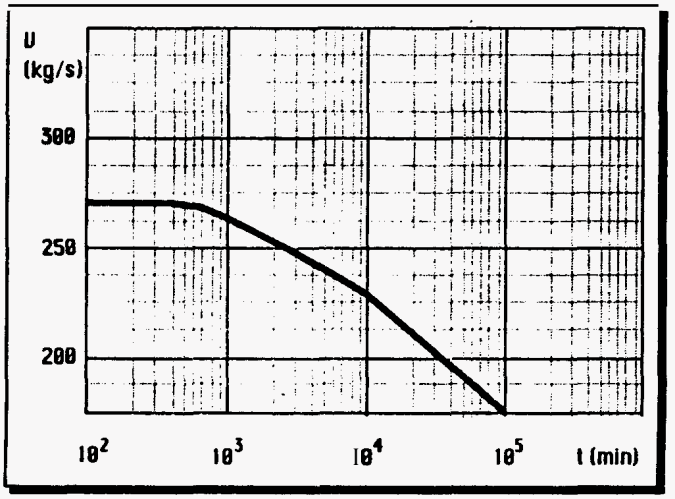

Fig.7. Interdependencebetween the flow and discharge period of the well EBMP-I

3.1. Reservoir behaviour

Maximum possible llow rate of 600 l/s is far above tlie real renewal capacity of the reservoir. Interdependence between flow and period of discharge (Fig. 7) has been found very early (Popovski. 1982). Particularly illustrative are tlie curves of pressure change (Fig. 8) during tlie discharge and after it (Popovski, 1983).

3.2. Submerged pumps

Temperature of tlie thermal water of 78 "C is too liigli for tlie known types of submerged pumps. The technical maintenance team continually has troubles witli changes and repairing of the pumps in exploitation.

One of tlie most important conclusions from experience of tlie over 10 years esploitation period is that not only tlie spare pumps but also reserve wells are necessary lor secure exploitation.

3.3. Heating installations

The main problem with heating installations, connected to the geothermal system, is that all of them were previously designed for the use of heat from light or heavy oil boilers. Design temperature regime for the greenhouses was 110/70 °C, and for the other 90/70 "C. Introduction of larger heat exchange surfaces in buildings solved only partially the problem. It enabled to reach the required temperature in most of the heated rooms but temperature of tlie effluent water was normally over 40 "C (in some cases even over 50 °C), resulting in overloading of the geothermal resource during the colder months of the year.

3.4. Energy price

It has been one of the most difficult problems during all the period of exploitation. Users are of the opinion that geothermal energy is free of charge and

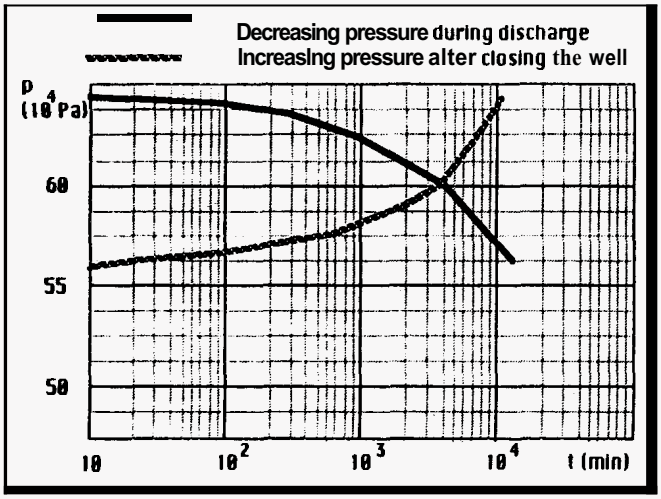

Fig.8. Pressure changes during and after discharge for a thermal water flow of V = 105 l/s of the well EBMP-1

that they should not pay for its use except possibly something for the distribution and maintenence costs.

Another problem is the tendency to use only the upper part of the available temperature difference in order to reduce investment costs for adapting the heating installation.

3.5. Legislative aspects

Uncertainty on ownership of the geothermal water creates continuous problems in the operation of the system. Even if 90% of the exploration and development costs have been covered by the State, initial users (Combines "Kotchansko pole" and "Mosha Pijade") intend to have some particular rights, i.e. to have the energy free of charge. The municipality gave the exploitation rights to the communal organisation "Vodovod" (in charge of water management in the town of Kotchany) which has no particular interest for additional problems in its activities.

3.6. Environemental impact

Kotchany thermal water is potable. i.e. with low mineralisation and content of harmful minerals. However, high temperature of the return water from the greenhouses disturbs the balance of fauna and flora life conditions in the river.

Up to now this problema has been completely neglected by the geothermal energy users.

4. SOLUTIONS

4.1. Reservoir engineering

The initial negative experiences led to quick reactions of tlie system users. Taking into account the character of annual heat load of the Connected greenhouses (Fig. 9). it was easy to conclude that the maximum load during tlie winter months should be limited to certain defined levels (see part 2) in correlation with the time necessary for the reservoir recovery.

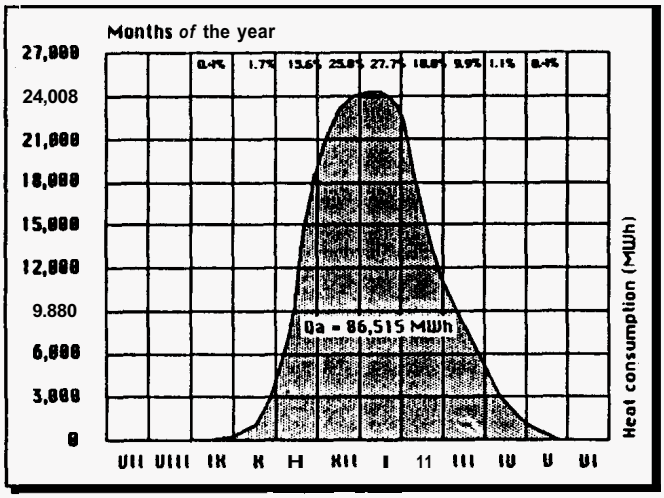

Fig.9. Annual heat loading curve of greenhouses coilnected to the geothermal system "Geoterma"

However, results have been of questionable value. First of all, tlie initial artesian pressure is definitively lost and. secondly. the reservoir behaviour has changed. This is tlie reason why a first reinjection well has been drilled. but it is not enough to reach a real equilibrium of tlie reservoir.

This is tlie most important question lo be resolved in the coming years.

4.2. Submerged pumps

Spare pumps have been purchased and the existing ones repaired. However, it is not eiiough. More reserve wells should be completed in order to ensure proper continuous supply for tlic system.

4.3. Heating installations

Design of tlie installations of new geothermal energy users is under control and proper temperature parameters of return water have been defined. However, the problem of the biggest users (greenhouses) is still iiot solved. Complete reconstruction of the installations is necessary (Popovski, 1989) and new very low temperature users (aquaculture, soil heating, etc.) are needed in order to reach design temperatures of the return water and to enable connection of new users.

4.4. Energy price

A new State regulation has been enacted: The energy of geothermal origin has a price which should be paid by the users. It is composed of the costs of exploration and drilling, project development and maintenence and should be not lower than 40% nor higher than 60% of cost of heat of heavy oil origin. In order to ensure proper use of the available temperature difference, used energy should not be paid on the basis of heat extracted but according to the volume of used thermal water.

4.5. Legislative aspects

The right to exploit geothermal energy of the whole "Kotchany" geothermal field has been given to a firm under State control. Technical and economic rules for using heat of tlie integrated system "Geoterma", have been established ensuring proper technical solutions for connected heating installations and regulation of tlie heat supply.

However, the choice of the operator has been wrong. It is a communal organisation without particular interest for development of a side activity which needs people of other qualifications and much higher investments than its core business. It resulted in the unproper use of the funds given by the state for system development or earned ones of its exploitation. Out of the integrated geothermal system, it was invested in the development of the town water supply network.

Political balance in the town administration still doesn't allow separation of geothermal and water activities, but it is obvious that it is the only feasible and justified solution.

4.6. Environmental impact

As already said, no attention has been paid to this problem up to now. However, a pressure of the "greens" can be expected very soon and some measures should be taken.

Necessary technical measures for new users are already in place through the introduction of the technical regulations lor connecting to the system. However, it is not enough and old users are not included.

The only real solution consists in development of the planned reinjection system (Fig.6), providing tlie collection of all the effluent water and its return to the geothermal reservoir. Unfortunately. necessary investment costs are very high and a long period before completion can be envisaged.

5. DISCUSSION

Even tlie operational problems aiid those for further developnient have been evidenced and possible solutions defined. it is necessary to stress that the most important question for the system survival and growth is the problem of annual heat load factor. Installed heat power of the users is used very little during the year (Fig.9). High investment costs in long pipe-lines and large heating installations should be repaid with a full use limited to the three winter months and partial use during other three-four.

The solution was indicated long years ago (Popovski, 1985). It is a combination of known possibilities. such as are tlie introduction of cascade uses whenever possible (Fig.6 - agricultural uses), covering peak load with heavy oil boilers and maximizing connections of heat users with different annual lieat load characteristics. This last point is particularly important. The example of the rice drying unit is an excellent example of the niost economical way for enlarging tlie system and improving tlie heat load factor. Heat for drying is needed in September, when greenhouses practically don't utilized it. In this way. it is possible to use the pipe-lines and connecting system for new application, without additional investments.

The task for tlie near future is to improve tlie present annual heat load factor of about 0.25 to a level of 0.35, which shall halve the price of the used heat unit.

6. CONCLUSIONS

Development of a large geotliermal system is neither simple nor easy. Particularly if it has been built under the most negative possible combiliation of political and economic influencing factors. like was the case with the Kotcliany integrated system. It was a real school, where tlie Macedonian geothermists learned most of necessary lessons.

Tlie most important result, reached during the 13 years of development. is that the system passed all the Scilae aiid Haribdae. is working successfully. and continues to develop.

Unfortunately. further fate of the project is still uncertain and doesn't depend on the work. knowledge and enthusiasm of tlie technicians and economists responsible for its functioning and development. Even all tlie problems and possible solutions are defined and found technically and economically feasible, it is not only the energy price which shall determines tlie future of the project.

Republic of Macedonia is already 3 years under economic blockade, which particularly hurts the export orientated production sector The greenhouse complex in Kotchany lost its market in tlie other parts of ex-Yugoslavia and is part of a production sector which is very over-dimensioned for the needs of Macedonia itself. The paper industry is in the same situation and, in addition, lost its base for raw materials. The vehicle parts production industry was part of the vehicle production chain "Crvena zastava", which doesn't function anymore. Rice production lost the ex-Yugoslav market and is not competitive with the Asian producers in the world market. In that way, all the principle geothermal energy users of the integrated system "Geoterma" could very soon be out of work, and the system would cease to function

However, tlie integrated geothermal system "Kotchany" already passed numerous constraints and one can believe that also this last and most difficult one will be overcome. It was all the time an illustration of how difficult is to develop a new energy source but also one of the rare successful examples which give hope for a prosperous future of direct application of geothermal energy.

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