Proceedings World Geothermal Congress 2005
Antalya, Turkey, 24-29 April 2005

Reconstruction and Redesign of the Project "Istibanja" - Vinica

Sanja Popovska Vasilevska, Kiril Popovski

St. Kliment Ohridski University - Bitola

Faculty of Technical Sciences - Bitola, Macedonia

E-mail: isskiril@sonet.com.mk

Keywords: Reconstruction, optimization

ABSTRACT

The main problem for the proper work of the geothermal project "Istibanja" has always been the improper completion of it plus the wrongly designed heating system in the heated greenhouse complex of 6 ha for vegetable production.

Detailed description of the newly defined strategy for final completion of the project is given in the paper, explanation of the reconstructions made, new technical solutions introduced, and positive and negative (very few and marginal ones) consequences to the work of the system.

Realization of the project and analysis of resulting consequences is interesting because being a kind of "school work" for renewal of bigger geothermally heated greenhouse complexes in formerly socialist countries.

1. INTRODUCTION

Geothermal project Vinica has been one of the worst in the country due to the improper completion, bad maintenance and exploitation. It was the first greenhouse complex using geothermal energy as source and was bankrupted in 1995.

By realization of two parallel projects, both problems have been resolved during the last three years and a production complex put in regular exploitation. (1) With the financial help of the Austrian government, complete redesign and recompletion of the heat supplying and distribution system has been made. Submersible pumps with frequency converters have been put in the wells, new monitoring system has been installed for regulation of their work, reservoir for collection of geothermal water from the wells reconstructed and reequipped, new pumps in the central pumping station installed, installation of the heat accumulation tank of 500 m^3, proper connection of the peak loading boiler, division of the geothermal from the heating soft water in the greenhouse heating installations made by installation of two plate exchangers and installation of 4 automatic heat supply regulation stations in greenhouses blocks. (2) With the cofinancing of Netherlands government, new production technologies (roses and pot plants) have been introduced, plus complete redesign and installation of the internal heating installations.

Fig. 1. Greenhouse complex of 6 ha in Vinica Makedonska

Fig. 2. Location of the town of Vinica Makedonska

2. HYDROTHERMAL SYSTEM ISTIBANJA-VINICA

The hydrothermal system Istibanja-Vinica and its thermal springs are located near the Village Istibanja, at the East part of Macedonia.

From the geological point of view, the geothermal field is located between two geotectonic blocks (Serbian/Macedonian mass at East and Vardar zone at West). It is a system separated from the Kocani geothermal system, where belonging before (Micevski, 2004). Its composition is of old pre-Cambrian and Cambrian masses. Pre-Cambrian ones are represented by two sides pressed micagneisses, different micaschists and amphibolits.

By structural analysis of the neotectonic structures (from satellite photos and tectonic map of Macedonia of Dr. Arsovski of 1:200,000), it is possible to follow the clear difference between the Vardar zone from one side and Serbian/Macedonian mass from the other. It is also possible to see that the Istibanja geothermal field belongs to the latter. Also, that the Vardar belt with deep anomalies has strong seismic activities, opposite to the relatively stabile Serbian/Macedonian mass.

Numerous ring structures are characteristic for both systems. They have been composed during the neotectonic period as inherent types of neotectonic processes, plutonic volcanic and postvolcanic appearances.

The reservoir of the Istibanja - Vinica hydrogeothermal system is composed of fractured Paleozoic gneisses and granites. Gneisses, micaschists and schists below the mountains Golak and Krsa and North/East side of Osogovo mountain are the feeding zones of the system. The emptying zone is represented with contemporary appearances of natural springs near the village Istibanja and exploitation boreholes I-3, I-4 and I-5, near the river Bregalnica, at the South part of the village..

According to the type of the system, it is a half-open one with fractured gneisses of Paleozoic age with the emptying zone located in the zone of anomaly. The feeding zones of the system are at the sides of stone collectors at the terrain surface and local superficial flows. That means that the system Podlog Banja (Kocani geosystem) is a karst rift and the system Istibanja-Vinica a half-opened geothermal system. It is necessary to underline that the Kocani geothermal system is of very complex and interesting nature. That is conditioned by the position of the valley, which is a border between the Vardar zone and Serbian/Macedonian mass. More generally said, the zone between these two geotectonic units is a subduction zone from the time of alpian orogenesis. The Serbian/Macedonian mass is a block with the continental crust characteristics, and the Vardar zone with oceanic crust ones. During the time of Neogen, a side to the previous subduction pressure appeared, resulting in dislocation of fissures, and then to active volcanism and trench structures creation, as it is the case with the Kocani valley.

Hydrogeothermal appearances of both systems are with a direct hydraulic connection, that means both are of the same subduction location. However, the appearances in Istibanja do not show any direct connection with the Podlog Banja system. That means that still a possibility for existence if two geothermal reservoirs exist. These two geothermal fields are presently the biggest (proven) potential in Macedonia. However, that does not mean that they are a sufficiently investigated and known geothermal resource.

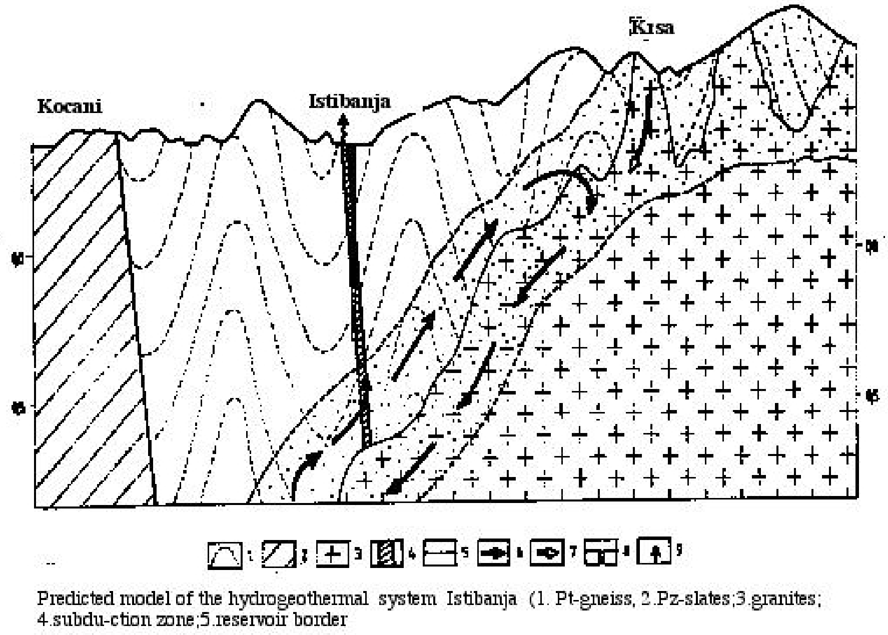

Fig. 3. Predicted model of the hydrogeothermal system Istibanja.

3. GEOTHERMAL PROJECT VINICA

The greenhouse complex in Vinica, which is the user of geothermal energy from the neighboring system of wells in Istibanja, consists of 8 “Venlo” 1.5 ha blocks, each one with the following dimensions:

length:	58 x 3,2 = 185,6 m
width:	27 x 3,0 = 81,0 m
average height:	2,8 m
surface:	15.000 m^2 (1,5 ha)
volume:	42.000 m^3

6 ha of greenhouses are of Bulgarian (galvanized steel construction) and 6 of Dutch (aluminium construction) production.

Heat demand of one Bulgarian block, for indoor temperature of 18°C and outdoor temperature of -12°C amounts 21,000 kW/6 ha (350 W/m^2). This figure is near to the original one, declared by the Bulgarian producer, however, due to the weak quality of the assembling (very weak tightening) the real demand is about 20% higher (Popovski, 1985). Design (and real) heat demand of the greenhouses of Dutch origin for the same design conditions is much lower, i.e. about 220 W/m^2, or 13,200 kW/6 ha.

The crop composition in the greenhouses has been of changeable character but mainly consisting tomatoes, cucumbers and some flowers (carnation, roses).

When originally completed, the greenhouses have been heated by heavy oil boilers, located in two boilerhouses for the 8 blocks of greenhouses, one with capacity 17,4 MW (3 x 5,8 MW) for the Dutch and one of 24 MW for Bulgarian greenhouses.

Heating fluid: Hot water 110/90 °C.

Fuel: Heavy oil

Heating system: Aerial steel pipes 51/47 mm in heating “registers” along the cultivation rows. Total length of heating pipes per one block is 19.256 m. Total heating surface, including distributive pipes, per one block: 3.500 m^2. The system has not been enlarged for application of geothermal energy.

The following changes have been introduced when the complex has been connected to the geothermal energy source in Istibanja in the 1980s:

a) Connection to 3 boreholes (wells) with submersible pumps with total capacity of 29+13+14 = 56 l/s. Temperature of water: 67°C.

b) Collecting tank with a volume of 100 m^3. In practice, it was proven that the volume and position of the tank does not meet the needs of the system. The operation of submersible pumps is automatically controlled by the level of the tank.

c) The pump station for transport of the water from the wells to the greenhouses, with (2+1) pumps (30 l/s; 5,2 bar; 30 kW). The pumps are also controlled by the level in the tank. Before the last reconstruction, they have been in a very bad working condition.

d) Pipeline with length of 3,25 km, NO 200 mm laid above the ground, insulated with glass wool and Al sheet. The available capacity of geothermal water, entering the greenhouses was 50 l/s with temperature of 61°C. Before the last reconstruction, the insulation has been very much damaged along all the length of the pipeline.

Unfortunately, the system has not been properly completed and has never been fully operational. Beside a list of mistakes of the technical design for reorientation to the use of geothermal water as heating fluid, there were also a list of mistakes in the assembling, exploitation and maintenance of the system.

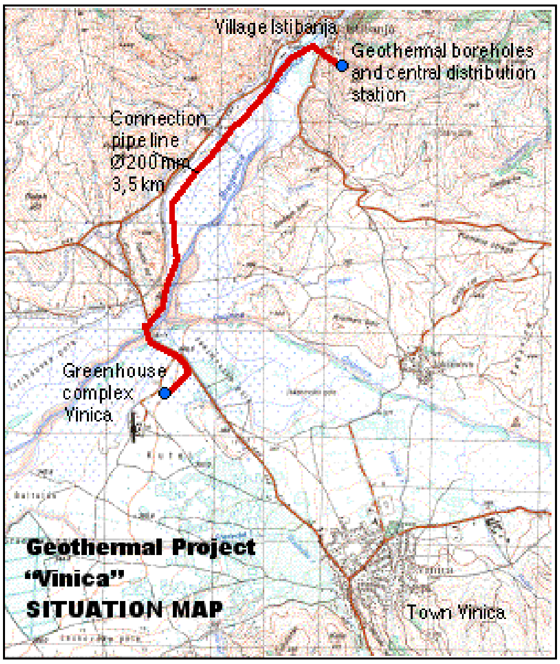

Fig. 4. Situation map of the geothermal system

Mistakes have been recognized immediately after the beginning of the system completion for geothermal energy use (Andrejevski, Popovski,1985). Obvious mistakes of the nonprofessional approach to the problem have been pointed to the user and a change of the design proposed. The following two main changes have been of major importance:

1. In order to get a larger heating surface (requested by the change of the temperature regime) it was necessary to install a system of additional heating pipes (plastic polypropylene pipe, size 3/4"). Total length of the pipes per block: 38.048 m with heating surface (together with distribution pipes) 5350 m2.

2. Accumulation of the geothermal water in existing two tanks for fuel oil, with a volume of 1000+500 = 1500 m^3, in order to increase the heating fluid flow from 50 l/s (12,5 l/s per block) up to 86 l/s (21,5 l/s per block). The accumulation is possible during the daylight hours, when the heat demand of greenhouses is lower then the available heat capacity of 50 l/s geothermal water.

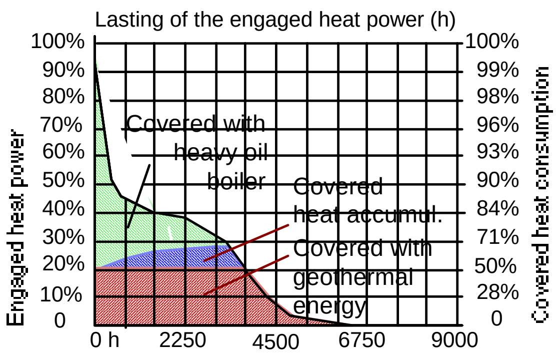

Fig. 5. Covering the heat demand of greenhouses from different heat sources (for 6 ha Dutch block)

The new geothermal heating system design (Andrejevski, Dimitrov, 1985) planned installation of an additional low temperature system, enabling a cascaded use of the geothermal water.

The increased water flow of 21,5 l/s have been planned to pass through the steel heating pipes under these conditions:

- initial temperature: 61°C
- final temperature: 46°C
- heat output: 1,350 kW.

After passing the steel heating pipes system, water should continue to flow through the plastic pipes system, where the initial temperature should be of 46°C, and the final one 31°C, which results with an additional heat output of 1,350 kW.

Total heat output of the steel and plastic pipes was planned therefore to reach 2,700 kW. That enables to cover the heat requirements of one block for the external air temperature of -6°C (temperature difference 24°C).

For the external temperature below -6°C, it is necessary to reheat the geothermal water up to temperatures higher than 61°C (in heat exchangers by means of warm water of 110/90 °C from the heavy oil boiler).

For the outdoor winter design temperature in Vinica (-12°C), the heat demand per one greenhouse block of 1.5 ha amounts 3,250 kW, i.e. to cover the difference of 3,250 - 2700 kW = 550 kW, geothermal water should be reheated to 69°C.

As a result of the reheating to 69°C, the working characteristics of the heating systems are therefore slightly changed, i.e.:

Steel heating pipes:

- initial temperature: 69°C
- final temperature: 51°C
- heat output: 1,620 kW

Plastic heating pipes:

- initial temperature: 51°C
- final temperature: 33°C
- heat output: 1,620 kW

Therefore, the total heat output of the pipes: 3,240 kW.

In that way, the heat gained from the geothermal water amounts 21,5 x 3600 x 1,163 (61-33) = 2,520 kW, where the heat transferred from the hot water of 110/90 °C produced in the heavy oil boilers by means of heat exchangers, is 720 kW. Total capacity of the plate exchangers for reheating the geothermal water for 4 blocks is therefore 3,000 kW.

The daily variation of the heat demands of greenhouses could be compensated with accumulation of the geothermal water in two tanks of 1,500 m^3.

Benefit of such an approach can be followed in Fig. 5, i.e. with only 20% of the maximal heat power necessary to heat the 6 ha greenhouse block, geothermal energy covers 70-80% of the annual heat consumption - depending on the outside climate changes.

As already said, the reconstruction has been only started but never finished. Some trials to use the geothermal system partially have been made, however without a real practical use. Before the last recompletion, the project was only in a partial use (6 ha) but without a real regulation of the heat supply.

4. RECONSTRUCTION AND RECOMPLETION OF THE GEOTHERMAL PROJECT

In 1999, with the financial support of the Austrian Chancellery, a project for partial recompletion of the Vinica project has been agreed. Following actions have been planned (Fig.6):

- Introduction of a computerized monitoring and regulation system for pumping the water from geothermal exploitation boreholes;
- Installation of two new submersible pumps in the boreholes 2 and 3;
- Removal of the existing compensation tank of 100 m^3 with a new one of 500 m^3;
- Removal of the old distribution pumps and installation of new ones, completed with automatic regulation equipment;
- Recovering of the heat insulation of the main connection pipe;
- Reconstruction of the corroded distribution lines between the greenhouses the geothermal source and greenhouses;
- Reconstruction of the main substation by introduction of a plate-heat exchangers system, i.e. indirect use of geothermal water;
- Proper connection of the existing boilers to the centralized heating system;
- Proper connection of the greenhouse blocks; and
- Reconstruction of the heating systems in Dutch greenhouses with proper incorporation of “on the soil surface" corrugated pipes heating installation.

That was far from the necessary completion of the project because it did not take into account possibilities for new exploitation boreholes, now introduction and reinjection of the used thermal water. However, it should enable at least a partial use of the geothermal system and, in that way, should open possibilities for later final completion.

Also, a new dimension in the geothermal field exploitation has been introduced, i.e. division of the responsibility for the geothermal resource exploitation and development from the use of the geothermal heat. In that way, geothermal heat should no longer be free of charge, it does not matter if the concession holder shall be the user of heat or somebody else.

The project realization took place in 2000 and 2001 and consisted logical phases, i.e.:

Project preparation

Before starting the project realization, an international workshop was organized in order to get the data on disposal for the project design and history of experiences get. Then, an Austrian/Macedonian team has been composed, which should realize all the project phases.

Compilation of data, evaluation and interpretation

Collected data have been arranged, analyzed and provided for technical planning and as data basis for the geothermal modelling and design of project reconstruction and optimization.

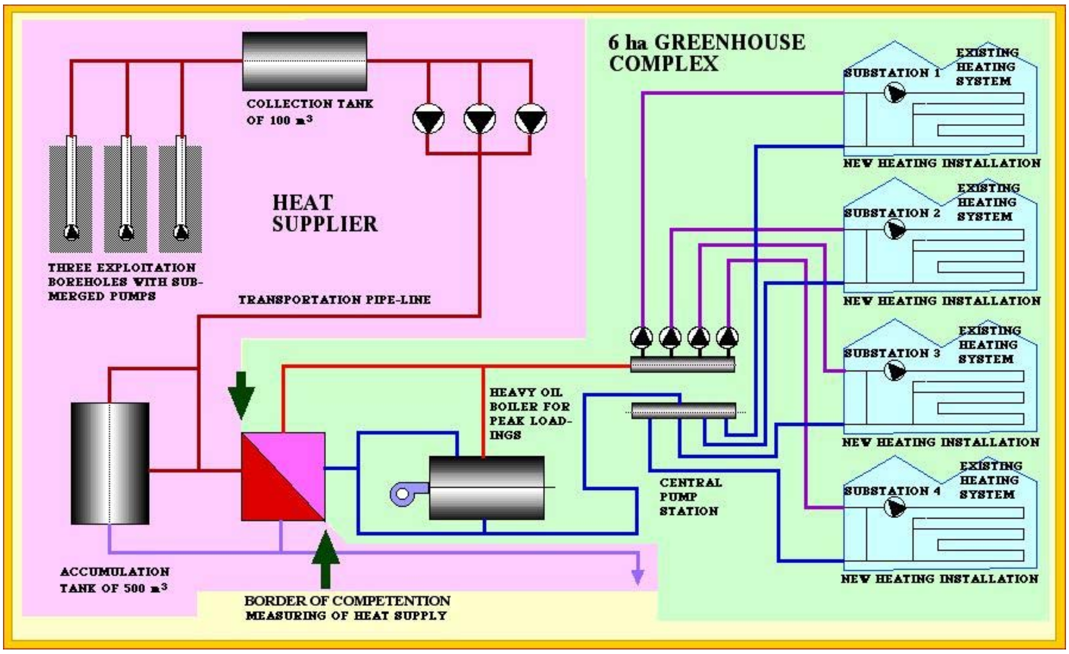

Fig. 6. Simplified scheme of the geothermal system

Modeling of the geothermal reservoir

For the assessment of the hydrothermal potential in the area of Istibanja a numerical modelling was performed. After setting the boundaries of the model area and the determination of the boundary conditions of the flow model and the definition of input parameters the stationary flow model and the heat transport model were elaborated. Modelling was performed with the PC-based program MODFLOW and the module MT3D. Modelling results indicated that at a total flow rate of 56 l/s a sustainable use of the hydrothermal resource is possible.

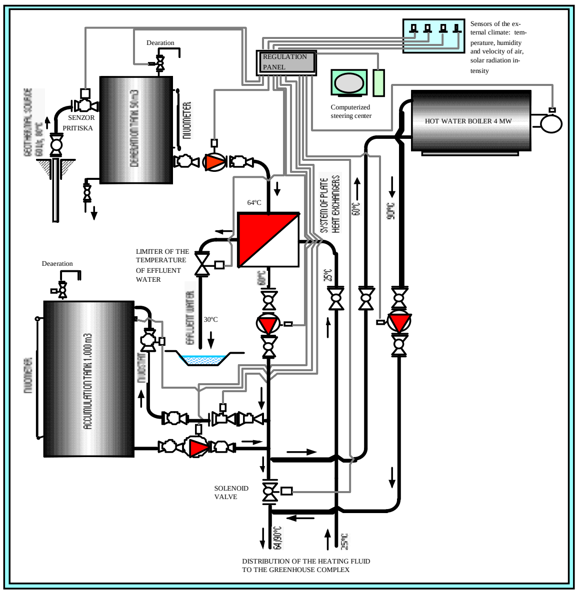

Fig. 7. Recompleted "production" part of the system

Fig. 8. Two plate heat exchangers in the central station

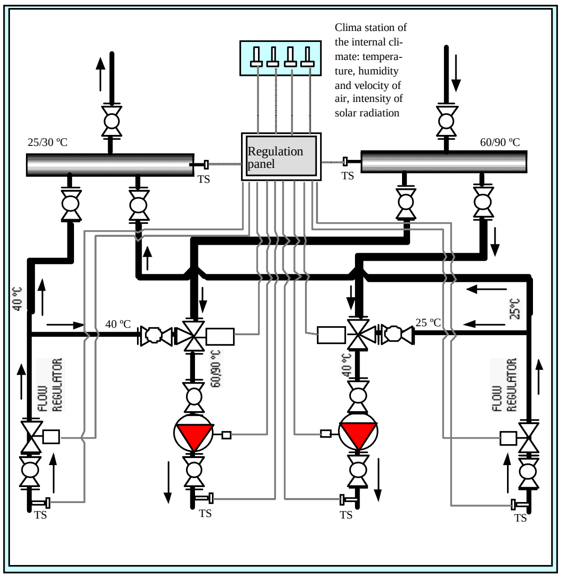

Fig. 9. Scheme of the connection stations of the greenhouse blocks of 6 ha

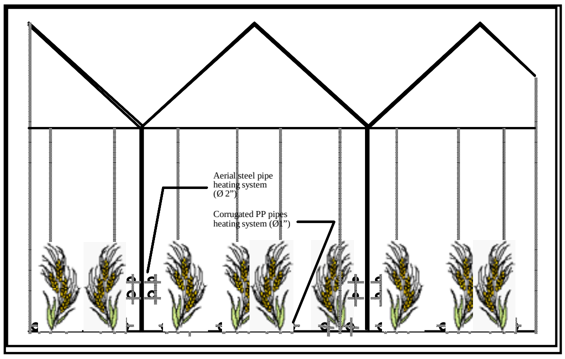

Fig. 10. Location of heating pipes in greenhouses (high and low temperature system)

Fig. 11. Cultivation of roses

Fig. 12. Bench for pot plants cultivation

Feasibility study preparation

Based on the financial funds on disposal, a feasibility study has been prepared in order to determine the most urgent interventions that guarantee the best technical and technological results in project reconstruction and optimization.

Project implementation (Fig. 6)

The detailed planning, tendering and realization performance, based on the implementation of the defined optimization concept, referred to the following functional sections which were separated for tendering:

a) Submersible pumps and control systems (Wells I-3, I-4 und I-5, Istibanja). Installation of new submersible pumps, the old ones kept as functional reserve (only one operational).

b) Riser and monitoring facilities (Wells I-3, I-4 und I-5, Istibanja). Existing risers checked and new monitoring facilities installed, enabling water level control and computer programmed switching on/of of the pumps.

c) Adaptation of the collecting and distribution facilities at Istibanja including the pipeline to Vinica. Existing collection tank of 100 m^3 repaired and covered with an light metal construction in order to protect it from freezing and rain. All connections replaced with new ones and new water level gauge installed. New distribution pumps with frequency regulators and better efficiency installed (old ones repaired and kept as functional reserve). Connection line (3.5 km) checked and repaired where corroded. Heat insulation repaired everywhere where being demolished.

d) Redesign of the central heating and distribution station Vinica (Fig.7). Cleaning one of the existing heavy oil tanks of 500 m^3 and its adaptation in a hot water accumulation tank. Installation of two plate heat exchangers (Fig.7 and 8) in order to separate the geothermal water flow from the soft water flow in heating systems in greenhouses. Reconstruction of two heavy oil boilers in order to enable peak loadings covering. Reconstruction and recompletion of all the connections.

e) Adaption of the heating system at the greenhouses (Vinica). In order to meet the technological requirements of new cultures in greenhouses (roses and pot flowers) and to enable better use of temperature difference on disposal, complete reconstruction and recompletion of heating installations has been performed. Existing steel pipes installation (Fig.10 and 11) has been cleaned and partially removed to the position above the ground surface. Additional low-temperature heating system made of steel and PP pipes positioned above the ground surface has been installed in all the greenhouses.

f) Installation of a heating control system. In each one of the 4 greenhouse blocks of 1.5 ha an automatic mixing station and pump station (Fig.9) has been installed, enabling to regulate the heat supply to greenhouse interior depending on the outside and inside climate changes.

g) Rearrangement of the production technology in the greenhouses. With a separate project, complete change of production technology has been performed, i.e. except vegetables production of roses for export has been introduced.

5. EVALUATION OF REACHED RESULTS

Reached results can be evaluated from different points of view, i.e.

Technical state of the project

For the first time, the geothermal project is completed to the state that guarantees a continous and safe supply of energy. Experiences of the first two years of exploitation are rather good and encouraging. However, some further improvements are necessary, namely:

a) The problem of reinjection of used water is still not resolved and water is flowing directly into the neighboring river which further on irrigates the rice culture in the fields.

b) The field is still not sufficiently investigated, which limits the use of geothermal resource. Two or three new exploitation boreholes can improve the situation very much, enabling supply of geothermal water to the other 6 ha of greenhouses and the town center.

c) Technical solution of the thermal insulation of the connection pipeline between the wells and the user cannot be estimated as good, i.e. Al sheets are continuously stolen and the insulation demolished. A lot of energy is lost in that way and a new solution should be introduced as soon as possible.

d) Completion of heat supply stations in greenhouse blocks cannot be estimated as satisfactorily for keeping the necessary programmed internal climate. A computer-supported control should be introduced.

Technological state of the project

Technology of geothermal energy supply and use is very much improved. Geothermal water extraction is now controllable, depending on the needs of the consumer. Introduced plate heat exchangers enable division of the geothermal water flow from the heating fluid flow in greenhouses. In that way, easier reinjection back to the reservoir is enabled. Introduced accumulation of thermal water enables improvement of geothermal energy use (Fig. 5) by increase of the annual heat loading coefficient. Introduction of the additional low-temperature heating installation (cascade use of geothermal water) also improves the annual heat loading factor and improves the efficiency of available temperature difference use. All together, a geothermal water flow covering only 20% of the design heat power covers more than 70% of the annual consumption of the user.

Economic state of the project

About 800.000 Euro investment has been necessary to put the geothermal system into proper operational status. Taking into account the valid price of about 0.3 Euro/l fuel oil, the investment has been repaid after two years of exploitation. That opens the gate for further investments, enabling better efficiency of use and environmentally more safe exploitation.

CONCLUSION

Investment in reconstruction and recompletion of the geothermal system Istibanja-Vinica has been performed under the very difficult organizational and economic surroundings of a country in transition. Luckily, a foreign investor found interest to organize an export-orientated flower production, based on the convenience of local climate, very cheap greenhouse construction and possibility to use geothermal energy as a principal heating fluid. The investor is still facing different legal constraints, however orientation towards geothermal energy use has been a big success. Cleverly composed design for reconstruction and recompletion of the system enabled the investor to decrease the heating costs far more than expected.

The project success has been very important for further destiny of geothermal development in Macedonia. Previous orientation towards large agricultural projects has been confirmed also in the new economic conditions in the country, and increased the interest of other users to improve the completion of existing projects and to develop new ones. The Ministry of Economy also confirmed support for these activities, by looking for foreign investors to finance them. However, legal constraints still do not allow a real beginning of new development.

REFERENCES

Proceedings of the Workshop: Concept for Optimization and Proposal for Implementation of the project Geothermie Vinica, Vinica 02.2000:

- Gnjezda: Geotermalna rabotilnica - Voved, Sostojba, Pregled (Geothermal Workshop – Introduction, State and Review)
- Gnjezda & Voss: Model na podzemni vodi i trans-port na toplina (Model of Underground Waters and Heat Transfer)
- Niederbacher & Wiese: Tehnicka sostojba - Mozni podobruvanja i resenija (Technical State - Possible Improvements and Solutions)
- Popovski i Popovska-Vasilevska: Koncept za zagevanje na oranzeriite na ZIK Bregalnica – Potrebi i Snabduvanje (Concept for Heating the Greenhouses of ZIK Bregalnica Vinica – Needs and Supply)
- Popovski i Popovska-Vasilevska: Koncept za zag-revanje na oranzeriite na ZIK Bregalnica – Zag-revni sistemi (Concept for Heating the Greenhouses – Heating Systems)

Arge Geothermie Mazedonien, G.U.T GmbH – ZT-Büro Dr. NiederbacherOZA Project # 7632/-00/99 „Geothermie Vinica“: Izvestaj - Konecen izvestaj za proektot „GEOTHERMIE VINICA“ (Final Report for Realization of the Project “Geothermie-Vinica”, Skopje, December 2003)

POPOVSKI, K., LUND, J.: Geothermal Energy in Macedonia, Scientific Project financed by the Ministry of Science of Macedonia and US Dpt of Energy, Skopje 1998-2000

POPOVSKI, K.: Numerous papers presented at different conferences, symposiums and congresses, prefeasibility studies, reports, etc. for the geothermal project Vinica, Skopje 1979-2004

WB and Cesen S.p.A.: Investment possibilities in Geothermal Sector in Macedonia, Feasibility study, Chapter 8 and 11, Responsible K. Popovski, Skopje 2001