INDUSTRIAL USES OF GEOTHERMAL ENERGY IN KOCANI
(Former Yugoslav Republic of Macedonia)

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ABSTRACT: *Industrial uses of geothermal energy are rather new in the Kocani integrated geothermal project. During the recent years technological and heating systems of the local paper industry und a factory for production of vehicle spare parts have been connected to the central system.*

A description of stute of the urt industrial users is made in the paper, accomplished with Short description of integrated geothermul project Kocani, followed with energy data.

1. INTRODUCTION

Already 15 geothermal projects are in operation or under development in the Republic of Macedonia. The Kocani geothermal project is of major importance and has a general influence on the development of geothermal energy use in agriculture, industry and the district heating. It is located in the east part of the Country, as a part of the Serbian-Macedonian massif. Kocani valley is a tectonic depression formed during the Neogene and Quaternary periods by the subsidence of blocks at the intersection of two geological zones. In the period 1980-86, 18 exploration and production wells were drilled in the area, resulting in a total possible yield of 600 l/s and water temperatures between 57 and 79 °C.

1.1 Main Data of Kocani Geothermal Field

Basic possibilities of the main geothermal springs are:
- constant discharge temperature: 78°C;
- high but variable discharge capacity: 100-250 l/s, depending on the period of discharge;
- non-aggressive water, with low level of total dissolved solids: pH=6.8; carbonic hardness = 23.9 °G; (425 mg/l $CaCO_3$ equivalent); the water is potable.

The main borehole is 328 m deep. It passes through 192 m of unconsolidated fluvial sediments, then from 192 m to 314 m penetrates alternating tuff and tuffaceous sand. Sands are consolidated and did not collapse during drilling. Water first appeared at 240 m depth; pressure rose slowly to the final depth of 328 m. when the well begin to discharge. It is possible to draw some conclusions concerning geothermal field:
- the well is sited in an aquifer with advantageous hydrogeological parameters, but with limited dimensions;
- the production well reaches only the upper part of the aquifer and its thickness is still not established;
- the aquifer is bounded horizontally by several aquifers of lower transitivity, and there are hydraulic boundaries at different distances,
- the aquifer has limited recharge, the capacity and characteristics of which are as yet undefined.

1.2. Development of the Kocani Geothermal Project

The first users of geothermal energy were in a greenhouse complex, heated with geothermal water, in the scope of enterprises "Kocansko Pole" with 120 000 m^2, and "Mosa Pijade" with 60 000 m^2. The first greenhouse complex is connected with supplying well by 3.6 km pipeline with diameter ND 300, insulated by glass-wool. The second complex is connected to the well with pipeline in the length of 150 m, with diameter ND 250. 60 % of the available thermal water flow now covers 90% of total heat consumption on average.

A successful new borehole which improved the possibility of a geothermal source yielding up to 450 l/s, opened the way for geothermal energy in industry and heating dwellings. Depending on the thermal water flow necessity and local ground conditions, for the optimisation of the distribution system the following parameters were considered:
- total investment cost of distribution pipe-line (mechanical and civil engineering works);
- total investment cost of pump stations to overcome the resistance in distribution system;
- total cost of heat insulation materials and labour;
- total annual electricity cost for pumping of geothermal water;
- total annual expenses of heat losses through the insulation layer.

The first part of distribution pipeline, from borehole and pump-station to the town of Kocani, has a length of 1773 m. A small part is above ground, but mostly is under ground made. A pre insulated pipeline is chosen, with diameter of steel pipe 406 mm and 500 mm the diameter of covering enabled the investment cost to be decreased by 66000 US $.

The second part of distribution pipeline through the town of Kocani, with length of 2650 m, in concrete canals is set. The diameter of steel pipe is 324 mm and the diameter of PP covering pipe is 400 mm.

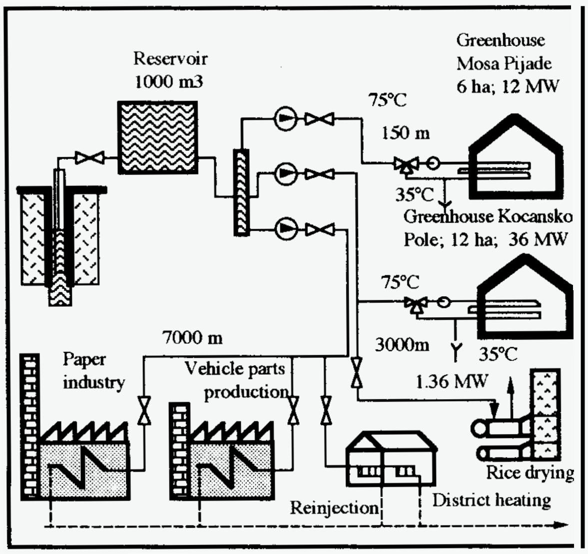

Figure I. Simplified scheme of Kocani geothermal system

The system is with open end of the pipeline - used geothermal water is thrown out into river. Volumetric capacity of the aquifer is limited and so the discharge rate is restricted. The recovery period is much greater than the discharge time to exhaustion. Now, there are three submersible pumps, pumping thermal water to the system.

The reinjection of outlet thermal water is an obligation, if we want to extend the well life, or to make it unlimited. All necessary investigations and practical experiments are done. The recurrent pipeline is under construction. The well for reinjection is about 3 km from the exploitation wells.

2. INDUSTRIAL USES OF GEOTHERMAL ENERGY

Industrial users connected to the geothermal systems are: a paper production industry "Hartija", a vehicle parts production factory "Ruen" and a large rice drying unit as a part of "Kocansko Pole". Other industrial users: a textile factory "Proleter" and a farm producing mushrooms (1000 t per year), are preparing to connect to the system.

2.1. Application in Paper Industry

The heat from geothermal water covers some heat needs in technology and the services. Actual application of geothermal heat during last three years gives complete satisfaction for the predicted vision.

The balance of geothermal water, for technological needs, in accordance with Cerepnalkovski (1993), in Table 1. is given. Hot water at temperatures of 50-70 "C is used. The consumption of geothermal water depends on production programme, temperature difference At of geothermal water utilisation and continuous and long period yearly production process. The large results from the fact that the greater amount of geothermal water heat consumption is utilised directly in the technological processes as a hot water input.

Table 1. Heat consumption for technological needs covered with geothermal energy

Item	1986	After re-construc-tion	Prospect
Flow rate l/s	9,7	20,8	40,3
Geothermal water consumption, yearly $10^3 m^3$/year	280	600	1163
Temperature difference of geothermal water utilization At °C	52	52	52
Heat flux, day average MW	2,1	4,5	8,8
Heat consumption, yearly GWh/year	16,9	36,2	70
Heavy oil substitution for η_k=0,85, Hd=40000 kJ/kg t/year	1790	3830	7400

Most of the process heat requirements are in the range of 121 to 168°C and the heating is accom-plished by way of steam . Most of the steam is passing through a back pressure turbine to generate electricity and pass-out steam at proper pressure, which is utilised in the process. Geothermal fluid could partly accomplish heating of air for paper drying, and preheating of water. With the temperature of 75°C of the geothermal water, it is covered 18 % of the total energy requirements.

For heating and air conditioning systems, geothermal water heat can be used till external temperatures of t_e = -4,75°C. For local climate conditions and heat capacity of the system of Q_h=2500 kW, heat consumption yearly is E_h = 3,92 GWh/year, what corresponds on heavy oil substitution of B_h = 400 t/year.

Additional geothermal water heat consumers are:

Heavy oil heating with E_{oil}=1,6 GWh/year and B_{oil}= 160 t/year;

Feed water heating with E_f=2,9 GWh/year and B_f=280 t/year.

Cerepnalkovski **(1993)** suggested an improvement of the system with application of two heat pumps. The first heat pump uses heat from super-heated vapour after the thermo compressor and from geothermal water with 70°C inlet temperature at the cooler. The second one is based on warm moist air heat recovery. In such a way, it is possible to satisfy the needs for energy till 70 % from geothermal origin.

2.2. Geothermal Rice drying Plant

Geothermal water from exploitation well is used as a heat source for direct heating of rice drying plant in

the Agricultural Combinate "Kocansko Pole". The technical data of the rice drying plant are as follows:
- production capacity: 10 t/h, rough or milled rice;
- heating capacity: 1360 kW;
- moisture content of rice: at starting 20%, and the final - 14%;
- temperature of the heating air 35°C;
- relative humidity of 60% at an outdoor temperature of the air of 15°C;

The system of dryer is cross flow continuous system. The sections of the dryer (shown on Fig. 2.):

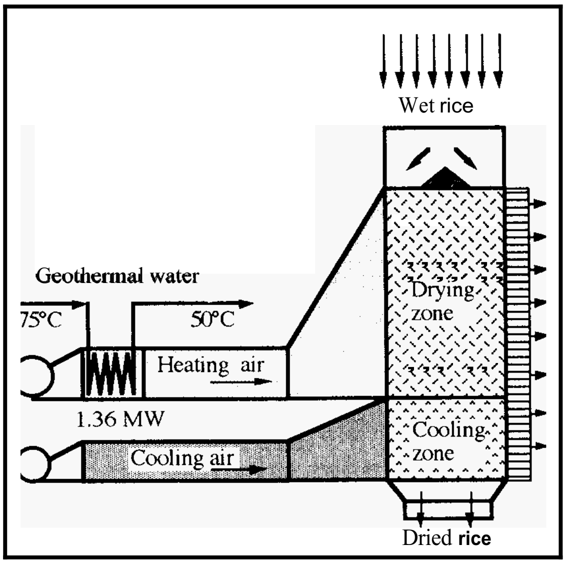

Figure 2. A Schematic Flow Diagram of the Geothermal Rice Drying Plant in Kocani

- wet grain feeding bin, at the top,
- upper cells in the drying zone, connected with sections for the warm air (warm air duct, heat exchanger and fan),
- lower cells of the dryer-cooling zone connected with duct and fan for fresh air,
- discharging device at the bottom of the dryer.

The rice moves downward with constant velocity at all points of the cross section. There is gravitation mixing as the grain column moves downward. In order to prevent cracking of the rice, the temperature of the warm air is automatically kept at a value bellow 40°C. Geothermal water has already been used as a heating source for this rice drying plant for e decade, and the experience gained in this period is quite satisfactory.

Average annual geothermal heat load is 800 MWh, with the maximum flow rate of 13 l/s.

3. DISCUSSION

Involving industrial users in the geothermal system was an imperative for better future of the system in whole. Heat requirements of industry are mainly constant all year around. That's not happened always, because some industrial users are using geothermal energy in the winter time only for heating purposes, as the factory for vehicle parts is doing. The technological users are ensuring consumption of geothermal water even during summer time, protecting the distribution pipeline from corrosion. If the pipelines are empty during the summer time, there is the possibility for intensive corrosion. The problem with the regulation of heat consumption is more easier, in comparison with the regulation of supplying with heat energy of greenhouses, or dwellings heating, especially for the geothermal system in Kocani, which is still "open one".

It has to be underlined that from the technical point of view, there is no difference compared with plants using fossil fuels. In the rice drying plant, the hot water prepared in oil fired boilers was simply substituted with geothermal water. It was very easy to be made, because of the quality of the water - it is potable, producing no scaling or corrosion problems in the drying unit. In the paper factory, the geothermal water is used everywhere depending only on the temperature level . If there was the need for higher temperature level, then geothermal water was used for preheating of the supplying water. With application of heat pumps, it is expected to satisfied bigger quantity of heat energy with energy from geothermal origin.

4. CONCLUDING REMARKS

With coordination of heat consumption by different users, an economic improvement of geothermal energy use is enabled. It is already competitive in comparison to liquid fuels. With proper combination of heat consumers - greenhouses, industry, heating of dwellings and preparation of sanitary warm water, which are with different heat requirements, the total geothermal system enables to increase the annual heat load factor two times.

It is very important to increase the number of industrial users connected to the geothermal system, whose heat demands are concentrated in the "slack" periods of the system. This significantly increases the total efficiency of the system.

In this moment, because of political circumstances around Republic of Macedonia - 2 years under economic blockade, the economic situation is bad and is influencing very much the development of the geothermal system, especially decouraging new industrial consumers. Paper industry was dimensioned for the needs of whole ex-Yugoslavia, and lost its base for raw materials. The similar situation is with the vehicle parts production industry. It has been a part of the vehicle production chain, which doesn't function anymore. Rice production lost the ex-Yugoslavia market, and the same is with greenhouse production. In that way, the main geothermal energy users of the integrated system, are dramatically reduced their production, and the needs for energy.

However, the integrated geothermal system already passed numerous constraints and it is to believe that this one shall be passed, too. The acceptable price of geothermal energy and its environmental advantages give us the right to believe in prosperous future of wider direct application of geothermal energy in industry.

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