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DOUBLET IN KOCANI FOR INCREASING THE ANNUAL HEAT SUPPLY CAPACITY

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Abstract:

Completion of the first (partial) reinjection of waste geothermal water back to the aquifer in year 2000 proved the need of installation of full reinjection in Kocani district heating system. By returning back of only 25% of the total flow of the water, stopping of water level decrease have been reached, i.e. balance of the use of 1,350,000 m^3/year with the average natural recovering capacity of the aquifer. According to the measurements and calculations made, full collection of the waste water from the greenhouse "Mosa Pijade" heating should increase the capacity of the system to 1,700,000 m^3/year, and collection of whole waste water to 2,000,000 m^3/year.

With support of the Austrian Development Cooperation (ADC), the project for realization of the collection of waste water from one of the greenhouses complexes heating system and introduction of indirect connection of heat users to geothermal system is under realization. Related geological, technological, technical and economic aspects of the project are discussed in the paper.

Fig.1. Geographycal location of the Kocani geothermal system

Introduction

Intensive hydro-geological exploration works in Kocani valley during the period 1973-1985 under organization of the Council of Municipality of Kocani (geological service) and Republic Fund for mining exploration works of Social Republic of Macedonia, gave exceptionally significant results. After making a synthesis from results of the study made by "Geoterm–Ex"- California and of of exploration the exploration works, the aquifer "Podlog- Banja" with temperature of 75-80°C and potential reserves of 157.000.000 m^3 was verified. That justified development of the district heating "Geoterma", the biggest one in Macedonia.

After 20 years of development and exploitation, full planned completion is still not reached. Meanwhile, the knowledge about the reservoir capacity and consequences of different rates of discharge has been improved and the need for introduction of reinjection confirmed.

1. Hydrogeological Setup

Kocani thermal aquifer is a paleozoic carbonatic formation (limestones, dolomites) with the formation top in a depth of appr. 318 m below the ground (well EB4 at D. Podlog). It is overlain by volcanic andesitic effusive and tuffitic rocks (194 - 318 m) of tertiary age and the quarternary fill of the depression of Kocanska Valley (0 - 194 m). The outcrops of the reservoir formation are in the mountainous margins north and south of the Kocani valley. These are the recharge areas of the aquithermal system. (Fig.2.)

Excellent permeability with local well capacities of more than 100 l/s (altogether up to 300 l/s) is the effect of extensive fracturing of the paleozoic carbonates in connection with the tectonic features of the geological zone where extensional block faults after the compressing orogenic phase took place. Karst phenomena may play a role too.

Water temperature reaches up to 80 °C. Temperature is an effect of the local geothermal anomaly in coincidence with the overlaying volcanic rocks and sediments which act as isolating layers.

Due to the pumping of thermal water over the natural recovery capacity of geothermal reservoir since the 1980-ies, the static water level changed from significantly artesian (hydraulic head up to 6,5 bar) to slightly under-hydrostatic (static water table appr. 48-56 m below ground level). In order to stop the decrease the water level, partial re-injection has been introduced.

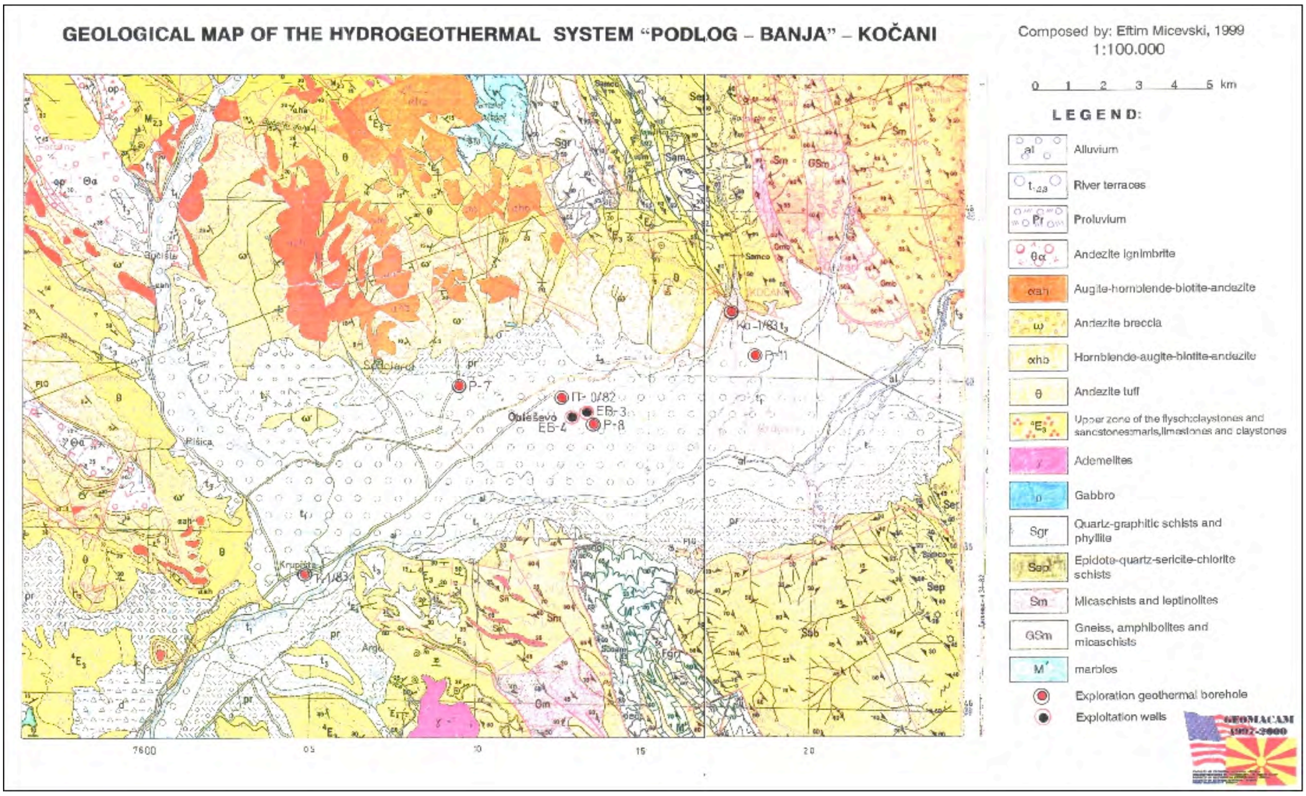
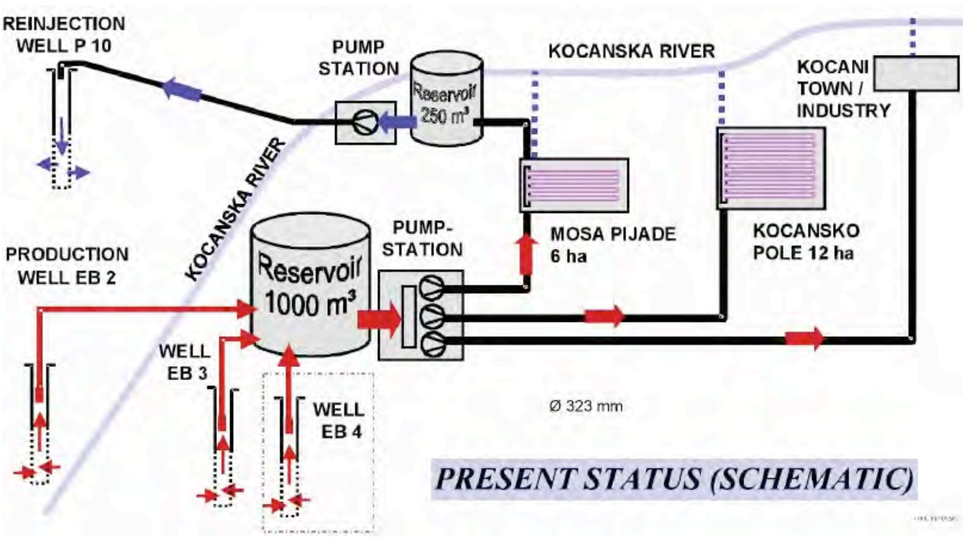


Fig.2. Hydrogeothermal field Podlog-Kocani

2. Present status

Presently, geothermal district heating system "Geoterma" is composed of three active exploitation wells, three distribution lines and one re-injection well (Fig.3 and Table 1)). Rate of pumping is changeable, depending on changes of the heat demand of connected users (Fig.4). Uneven distribution of pumping is consequence of the of the heat demand distribution of the main users, i.e. greenhouse complexes "Kocansko pole" and "Mosa Pijade". No one of the heat users use back-up boilers or heat accumulators for "ironing" the winter and morning peak loads which results with temporal overloadings of the system.



(Niederbacher, Popovski, 2000)

Fig.3. Geothermal district heating system "Geoterma" in Kocani

3. Reservoir behavior

Initially artesian (up to 6,5 m high water columns above the boreholes) static water level in the reservoir decreased very soon due to the over-pumping, i.e. use of the thermal water above the natural recovery capacity of geothermal aqui-fer (Table 2). The underground water level reached up to -56 m, with further intention to go down (Fig. 7). Obviously, it was a question of time when it shall be lost as an heat resource.

In 1982, Popovski organized some measurements and produced an equation and several diagrams (Fig.5 and Fig.6) which gave a valuable information that annual recovery rate of the reservoir is well bellow 100 l/s. Since then, it was clear that actual discharges of about 1.250.000 m^3/year (or 140 l/s annual average) cannot be naturally recovered.

PRESENT STATUS WITH MONITORING

GEOTHERMAL SYSTEM "GEOTHERMA" KOCANI

EXPLOITATION

WELL	flowrate	level*	temperature	pressure
	l/sec.	m	°C	bar
EB-2	110	-48.6	72	no pressure
EB-3	150	-46.3	78	no pressure
EB-4	90	-47.13	80	no pressure

DISTRIBUTION

	level	flowrate	temperature	pressure
	m	l/sek.	°C	bar
TOWN****	-	20	65	3
M.PIJADE	-	60	72	2.5
K.POLE	-	110	70	4
RESERVOIR	**	-	73	no pressure
PIPELINE	-	-	-	6.4

REINJECTION

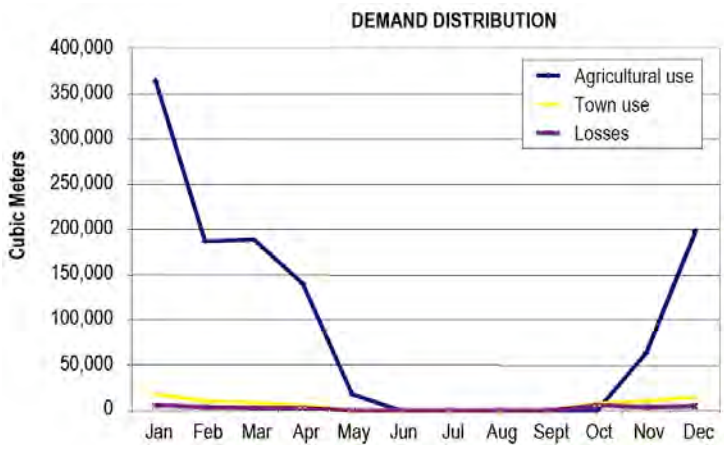
***	flowrate	level	temperature	pressure
	l/sek.	m	°C	bar
P-10	50-60	-75.1	26	3

Note

* water level in all wells are measuring manualy
for EB-4 the monitoring water level is not functioning and for EB-2 and EB-3 is not existing

**** Flowrate to the greenhouses and the city are measured but not connected to SCADA System

Table 1. Present status of the geothermal system “Geoterma” (Naunov, 2007)



(Naunov, 2007)

Fig.4. Annual change of the geothermal water use

	Users of geothermal water	2004 m^3	2005 m^3	2006 m^3
1	Agricultural complex- greenhouses	1.064.246	1.145.850	1.218.333
2	City area consumers	55.500	47.050	52.560
3	Filling station for mineral water	6.882	5.487	4.340
4	Total m^3	1.126.628	1.198.387	1.275.233
5	Unit price den./m^3	18.61 = 0.54 den./kWh (0,88€c/kWh)	18.61 = 0,54 den./kWh (0.88€c/kWh)	20.72 = 0,60 den./kWh (0,98€c/kWh)
	Total denars (4 x 5)	20.966.547,00	22.301.982,00	26.422.827,00
6	Public consumption – fountain and e.t.c.	39.960	45.424	44.829
7	Total distributed water in m^3	1.166.588	1.243.811	1.320.062

(Naunov, 2007) 1 Euro = 61,3 MKD

Table 2. Annual discharge of geothermal reservoir, price of heat and annual income of geothermal system “Geoterma”

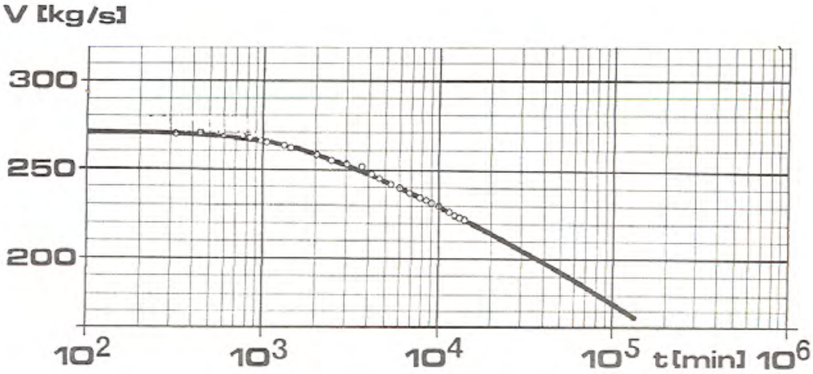


Fig.5. Interdependence between the flow and period of discharge (Popovski, 1982)

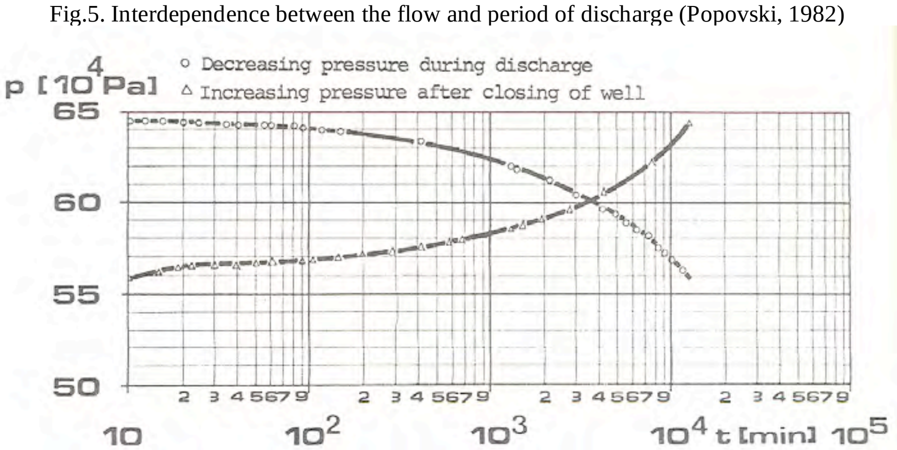
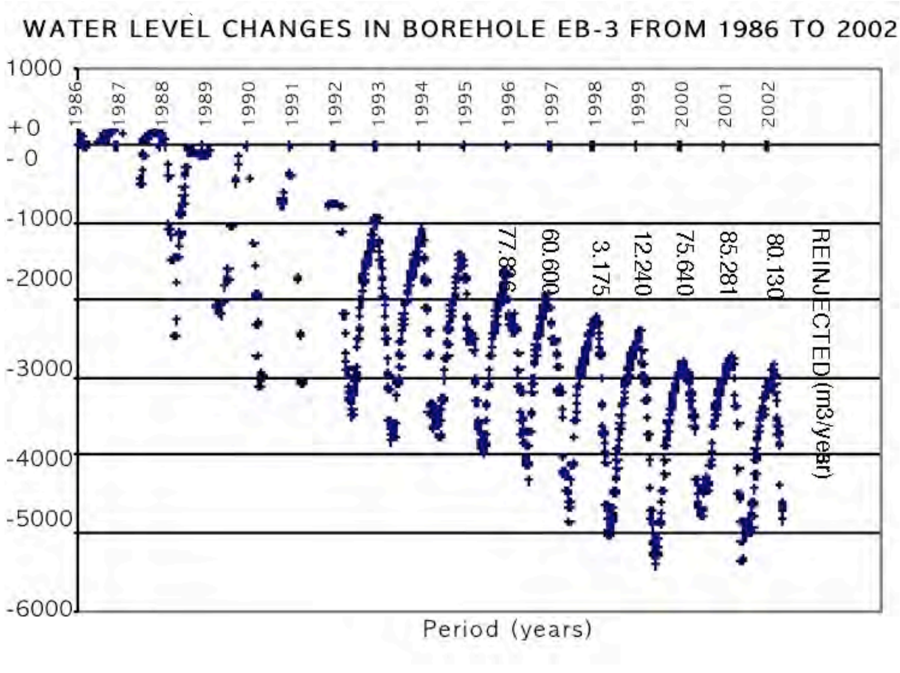


Fig.6. Changes of pressure during and after discharge (V=105 l/s) (Popovski, 1982)



(Naunov, 2004)

Fig.7. Annual static water level changes during the exploitation of Kocani aquifer

In 1996 first trials with partial re-njection of the waste water were introduced. Full completion of the system was realized in 2000, when also first results have been noticed. Decrease of the water level has been practically stopped. That followed up to this year. No change of thermal water temperature has been followed, what was a proof that thermal capacity of the aquifer is bid enough to cover bigger water flows.

Positive results of the installation of partial re-injection stimulated activities to reconstruct the whole system in the way to enable full re-injection of the waste water (Fig.8). Due to the financial difficulties, it was decided to go step by step in full completion of the new design of the system. First, to install an indirect connection of the users to the system, except the existing direct one. In that way, collection of the waste water shall be feasible and better control of the heat consumption reached. Then, a system of re-injection wells shall be introduced, enabling bigger consumption of thermal water.

As a first step, with the help of ADC (Austrian development cooperation), activities to complete collection and re-injection of waste water from the greenhouse complex "Mosa Pijade" began in 2006 and should be completed in 2008. In addition to the existing re-injection of about 50 l/s, new up to 100 l/s shall be returned continually to the aquifer, enabling exploitation of about 1.650.000 to 1.700.000 m^3/year thermal water, i.e. increase of the annual capacity for about 30-35%.

As a second step, also re-injection of the waste water for greenhouses "Kocansko pole" shall be introduced (up to 150 l/s), which should enable total annual exploitation of about 2.000.000 m^3/year or 60% of the actual one in last 5 years.

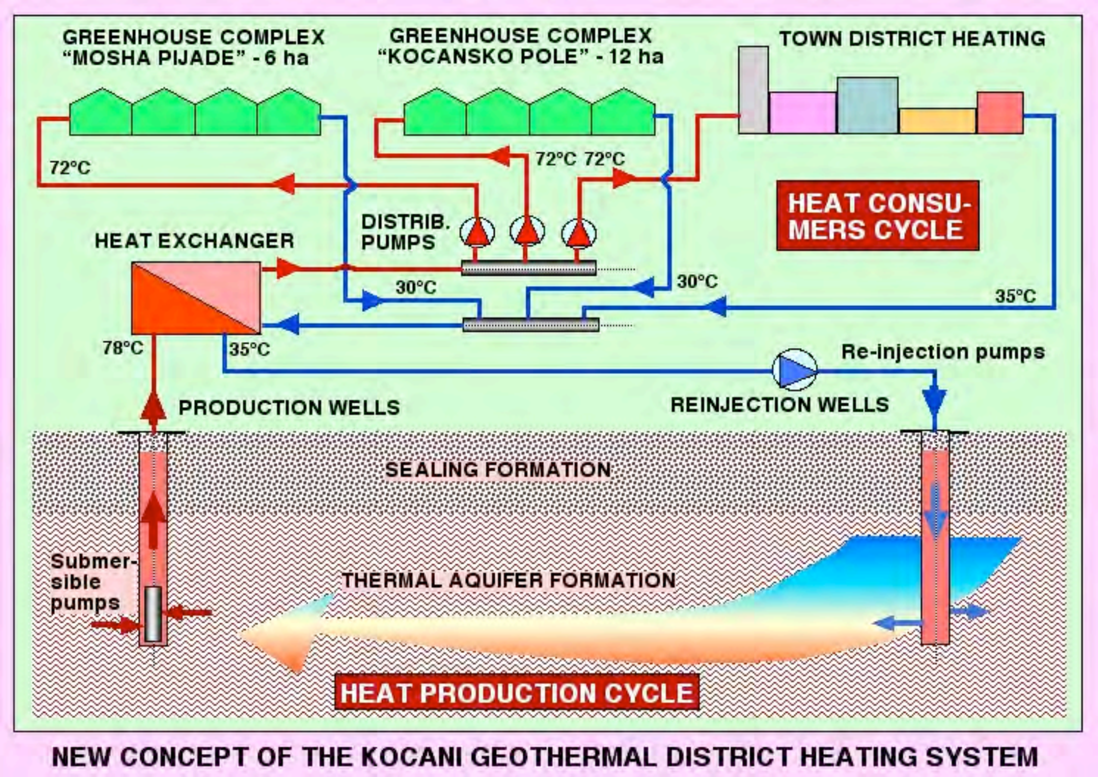


Fig.8. Introduction of indirect connection and full re-injection in the Kocani district heating system

4. Discusion

Introduction of re-injection of the waste water in the district heating system "Geoterma" - Kocani should result with a total increase of annual exploitation of about 60%, compared to the existing one. That should resolve the problems of further development of it because enabling wider introduction of geothermal heating in the town area and industry, resulting with correction of the daily and annual heat demand curve. Taking into account the level of necessary investment cost in comparison with the capacity increase, that should result also with the decrease of the price of supplied heat to consumers, i.e. with better economy of the whole system exploitation.

It is necessary not to forget that the final completion shall depend on the results of the action in flow, i.e. introduction of re-injection of the waste water from the heating system of greenhouse complex "Mosa Pijade". Changes of the water level and in the reservoir and thermal water temperatures at the top of boreholes shall be followed in order to identify the influence of re-injection. Particularly interesting shall be eventual changes of temperatures, giving eventually some information for the thermal capacity of the reservoir and, in that way, limits of positive consequences of the final stage of planned development with introduction of a full re-injection.

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