

Multiple integrated uses of geothermal fluids of medium enthalpy and high content of dissolved gas in Kiskunság – Hungary

Dr. Miklós Árpási¹

¹ Hungarian Geothermal Association H-1026 Budapest, Lupény u. 3/B
e-mail: officeca@freestart.hu

Abstract:

The Carpathian basin centered by Hungary has an abundant of geothermal resources in a territory, where abandoned CH-wells exist in large numbers. Part of the wells is after recompletion suitable for production of geothermal fluids of high temperature (100–171°C) at the surface and high production rate (up to 4000 cu.m/day). One prospective area of great potential is the “Kiskunság” area, located in the Southern part of Hungary between the Danube and Tisza rivers.

The paper provides information on the geological and geothermal background of the area, data of doublets of CH-wells suitable for integrated utilization of geothermal fluids in cascaded energy systems (power generation, absorption cooling, direct use, balneology, aquacultura, etc.). Some new geothermal pilot projects on energetical use and thermal water management are now being started in area.

Keywords: *abandoned CH-wells, cascaded use, binary, electricity generation, well repairs*

1. Introduction

The heat flow density [1] and geothermal gradient of the Carpathian Basin are characteristic of the favourable endowment of geothermal energy-sources of Hungary (Fig. 1). The former values are between 80 and 100 mW/m² or twice higher, than the world average. For example the calculated and measured maximum is: 113 mW/m² existing in the closed district of Szeged City (The European average is 62 mW/m²).

In course of hydrocarbons exploration in last century among the more than 10.000 exploration wells were drilled. In a number of cases and places slug test and DST only resulted in an “influx of thermal water” like a secondary product. Over 3000 wells were therefore qualified as “abandoned oil wells” contrary to production oil and natural gas wells.

Within the territory of Bács-Kiskun county more than 400 abandoned wells were identified. The Kiskunság area is located inside borders of the county (Fig. 2.).

2. Geological background

In the “Mélykút-Északkelet” territory’s exploration area some wells were drilled between 1970 and 1990. Among them was well Mélykút-Ék-3, (Settlement Balotaszállás), which started its activity as an oil production well (Fig. 3.).

During the oil production from a small closed oil reservoir in Middle Triassic dolomites, it was observed that the formation pressure had not reduced despite large quantities of produced water (3500 cu.m/day).

On the basis of pulsation test data interpretation carried out in 1984 and the oil production it was determined that the system, which is in Middle Triassic dolomites, was a very large geothermal reservoir. The stratigraphy and the results of the pulsation and production testing that were carried out between 1984 and 1990 are given in Table 1.

Table 1: Stratigraphy and production test data of well MÉÉK-3

Depth m-m	Geological age	Lithology
1.489–1.970	Midde Triassic	Dolomites
1.970–2.068	Lower Triassic	Sandstones
Measured data (parameters)		Perforations m-m 1.824–1.930
Formation pressure at depth 1820 m, MPa		17,44
Formation temperature at depth 1820 m, °C		109
Out-flow temperature of fluid °C		101
Flow-rate of geothermal fluid cu.m/day (l/sec)		265,0 (30,6)
Dynamic well-head pressure (annulus), MPa		0,17
Production of dissolved gas at 0,1 MPa ¹⁾ , cu.m/d		12 400
Gas-fluid ratio ²⁾ cu.m/cu.m.		4,68
Salt content of produced fluid mg/l		12 290

¹⁾ Calculated on base of gas/fluid ratio (GFR)

²⁾ GFR was determined by sampling in the well at 1.820 m depth

A prefeasibility study was compiled for MÉÉK-3/MÉÉK-7 doublet in area [3].

Quite a few abandoned wells were found to be suitable for production of large quantity of geothermal fluids from Middle Triassic dolomites. Geothermal water at temperature higher than 100°C at the surface exist in “Pusztamérgeš” and “Kömpöc” areas located within the border of the “Kiskunság area”.

The “Kömpöc” geothermal area is located NE from “Mélykút-Pusztamérgeš” area.

The slag test and DST were carried out in wells Kömpöc-5 (K5) and Kömpöc-6 (K6) during CH-exploration by Hungarian Oil and Co. – Rotary, a measured data are given in Table 2.

Table 2 Slag and DST test results for wells Kömpöc-5 (K5) and Kömpöc-6 (K6)

Parameters	K-5 well	K-6 well
1. Interval of perforations, m	3.350-3.510	3.031-3.039
2. Lithology: clays and marles of Jurassic and dolomites of Middle Triassic	3.407-3.510	2.990-2.500
3. Measuring depth, m	3.325	2.840
4. Choke, dia, mm	6	10
5. Flow-rate of water, cu.m./d (l/sec)	148,8 (16,7)	414 (4,8)
6. Production rate of natural (dissolved) gas, cu.m./d	1.200	2.260
7. GFR, cu.m./cu.m	8,06	5,46
8. Pressures, MPa		
8.1. formation pressure in static conditions	37,702	33,052
8.2. well-head pressure in closed conditions (tubing)	7,023	6,096
8.3. well-head pressure in dynamic conditions (tubing)	6,586	5,135
9. Formation temperature, °C	164 (at 3.325 m)	144 (at 2.840 m)
10. Estimated flow-rate of water, cu.m./day (34,7)	3.000 (34,7)	3.000 (34,7)
11. Out-flow temperature at estimated water flow-rate, °C	155	155

3. Pilot projects on multipurpose use of geothermal fluids in the territory of the “Kiskunság” area

According to our preliminary assessment for production and utilization of geothermal fluids, about 8 doublets or triplets could be implemented using abandoned CH wells showing presence of medium enthalpy geothermal fluids from Middle Triassic dolomites in “Kiskunság” area (Fig. 4.). Based on this geothermal fluid production potential, a multiple integrated application of the resource could be implemented within the framework of pilot projects [1–4].

The effective viability of these systems can further be improved, provided adequate support is given. This is due to the fact that the high well yield (1500–4000 m³/day) also contains a large amount of dissolved gas (mostly methane) (15–28.000 m³/day), which through traditional separation (from the primary fluid will yield additional income for the project.

The methane gas separated from the geothermal fluid may be used in a gas engine and/or an absorption cooling system (Fig. 5.) (Appendixes 1, 2).

The calculations relating to the doublet (M1, M2) for electricity production showed water yield of 30 liters per second. The temperature of the output water is projected to be 135°C.

Based on the preliminary technical calculations and estimations [3], the installed electric capacity of the Mélykút-Balotaszállás geothermal based power plant is 1.0–1.3 MW and its geothermal potential for direct use is 21,5–30,0 MW_t. The electric energy would be utilized on one hand by supplying it to the existing medium-sized voltage network (20 kV), whereas the thermal energy would be supplied to local greenhouses and small entrepreneur heat consumer-group in form of district heating system (heating + SHW). The significant amount of gas dissolved in the water (main data in Figure 5.), could for instance be used after separation in parallel with the ORC system for the production of electric energy produced by a special gas generator. According to preliminary calculations the output would generate an additional 0,8 to a maximum of 1,35 MW_e. For details see process diagram of the project depicted in Fig. 5. [2]

The economic calculations of the prefeasibility study (1997) to which we referred are out of date. These need to be recalculated taking account of the priority given to domestic combined energy developments and renewable energy resources. The small and medium-sized power plants are expected to become competitive generally speaking. In our specific case, taking into consideration the positive aspects of the M2-M1 power plant (with extended functions). This would apply even with the added investment and other costs of the new installations accompanying the extended functions, especially if the reimbursement period could be reduced to acceptable levels.

Operating aspects favouring local small power plants are for instance the proximity of electric transmission mains and medium-size distribution networks for energy transport. Medium-size voltage distribution networks (20 kV) suffice for the purpose of receiving small scale electric power, while for larger power levels access to the national main distribution network (120 kV) is needed.

The 20 kV networks, originating from the Kiskunhalas in part, and the Szeged 120/20 kV transformer stations are sufficient for receiving the smaller power levels calculated from power plants located in the Balotaszállás area.

4. Conditions for realization of pilot projects

The fossile energy prices that applied at the time, the economic calculations and financial assessments of the prefeasibility studies [5] were carried out have to be updated.

4.1. Process of realization of pilot project

- 1) After attaining the necessary approvals and licenses from the authorities the next step is to update the pre-feasibility study previously completed (economical data, financial assessment etc.).
- 2) Execution of the feasibility stage of project (“long term production test”)
 - a) Controll of situation in production well (well repair)
 - b) Production flow test in production well
 - c) Controll of situation in reinjection well (well repair)
 - d) Carrying out of a pulsation interference test between production and reinjection wells to determine the existence or absence of hydrodynamic connection between 2 wells.

In case the existence of hydrodynamic connection between the wells is proven:

- 3) Laying down a permanent insulated pipeline between the 2 wells and construction of surface water storage facility with sufficient capacity to accommodate 10 days of waterproduction.
 - a) To carry out a long-term testing between 2 wells (60 days).
 - i) Production test (free flow, reduced flow) for determination of geothermal fluid properties
 - ii) Reinjection test with pumping
- 4) Interpretation of results of all measurements carried out in feasibility stage of the project, assessment of power and heat consumers in the area.
- 5) Compilation of the feasibility study of the project.

In case of absence of the hydrodynamic connection:

- a) Opening new intervals in reinjection well by perforations and/or recompletion of other abandoned oil wells in the area.
- b) Carrying out operations according to 2–5.

5. Recommendations

The realization of the small scale power plant presented, which is designed for a region possessing special location specifics might be an excellent reference and also provide motivation to developers in other regions, particularly since no geothermal power plant have been built in Hungary so far. Based on the country’s well-known potential endowments, another 10 plants with similar outputs could potentially be established by 2010 under Phase I. (in total resulting in 10–30 MW_e + min. 600 MW_t). This solution would improve the level of renewable energy-resource utilization and simultaneously improve the renewable energy ratio within the national energy resource structure, thus reducing the percentage of fossile imports needed.

References

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Appendix 1

Lab № = 873

Thermal water analysis

Well	: Kömpöc-5	Pressures, MPa	: 6,5 (tubing)
Data of sampling	: May 9, 1986		: 5,4 (casing)
Site of sampling:	: 3325 m	Open (perforated) interval, m	3350-3510 m

		Salt content, g/l	
pH	6,29	NaCl	23,95
Alkalinity, eqv. mg /l	14,49	Ca(HCO ₃) ₂	0,97
Total hardness, gCaO/cu.m.	496,04	Na ₂ SO ₄	0,38
Changing hardness, gCaO/cu.m.	334,66		
Permanent hardness, gCaO/cu.m.	161,38		
		Total	25,96

	mg/l
Na+ (K+)	9548,31
Ca ⁺⁺	293,09
Mg ⁺⁺	36,92
NH ₄ ⁺	53,32
Fe ⁺⁺	70,64
Cl ⁻	14529,70
HCO ₃ ⁻	89,50
SO ₄ ²⁻	655,60
Br ⁻	586,90
H ₂ SiO ₃	260,00
Others	176,40
Total	26941,50

Nagykanizsa, June 25, 1986

Appendix 2

Gas analysis

Content and composition data of gas thermal water

Well	: Kömpöc-5
Depth	: 3325 m
Pressure in surface	: 6,5 MPa (tubing)
	: 5,4 MPa (casing)
	: 37,44 (separator)
Air temperature	11°C
Temperature (separator)	164 °C
Date of sampling:	: May 9, 1986

Gas content (without O ₂)	cu.m./cu.m.	g/n.cu.m.
C ₁	0,8267	592,2
C ₂	0,0332	44,95
C ₃	0,0042	8,56
N ₂	0,0103	12,87
CO ₂	0,1234	243,96
Gasoline	: 2,19	
Density relative	: 0,703 (air)	
absolute	: 0,909 g/l	
Combustion	: 35953 kJ/cu.m.	
Heating value of gas	: 32452 kJ/cu.m.	

Nagykanizsa, June 2, 1986