GEOTHERMAL ACTIVITY IN HUNGARY PROSPECTSAND FUTURE

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ABSTRACT

Hungary is well-known as a country of favourable conditions in terms of geothermal resnurces having a geothermal gradient higher than the world average

As a consequence of the abnormally thin lithosphery the heat flux of 80-100 mW/m^2 is above the average for the continent and the mean geothermal gradient of 20 m/°C is steeper than the normal 30-33 m/°C value.

The highest surface temperature of low enthalpy thermal waters is 97°C and geothermal brine from geopressured reservoirs 171°C, the highest aquifer temperature registered 140°C and 220°C. respectively.

The utilization of geothermal energy in Hungary has to be in harmony with geothermal and hydrological possibilities of supplies of thermal water. protection of hydrological reserves and the requirenients of environmental protection.

The utilisation of geothermal energy in Hungary would be profitable in case of multi-stage utilisation, in energy-cascading system, with electric power generation for direct use. Also increase of the efficiency of heat conversion froin abandoned CH-wells and establishment of new forms of undertaking

1. GEOTHERMAL BACKGROUND

Hungary has one of the biggest geothermal energy potentials ior low and medium enthalpy in Europe.{1-4}. The conceptual gothermal model of Hungary is shown in Fig. 1.
Most of the thermal water resources occur in the Upper Pannonian as high temperature waier-dominated systems which consists of rand and sandstone and to a minor extent clays and silts Owing io the lacustrine. littoral facies, as well as lo the oscillating rate of subsidence of the Pannonian Basin, the porosity and permeability of the layers very in an irregular pattern, both horizontally and vertically, thus forming a multi-aquifer reservoir system. The maximum depth of the boundary of the Lower/Upper Pannonian is more than 2.500 m in the Great Hungarian Plain and in the North of the Little Hungarian Plain. The thermal water is of alkali bicarbonate type and the total dissolved solids normally amount to 500 to 5000 ppm. At some places exceptional values of 15000 ppm do occur.

In basement of Great Hungarian Plain, geopressured reservoirs have been found. These systems are characterized by high reservoir presures and temperatures and the presence of dissolved natural gas (3 to 12 grams per liter in the liquid phase).

Thus, in well Nagyszénás-3 (South-East part of Hungary) before and during the flow test were measured

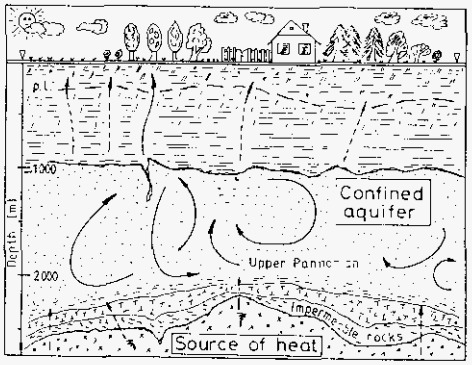
Well-head temperature (in static conditions): 115°C
Well-head pressure (in static conditions): 400 bars

- Reservoir temperature at depth 3011 m: 198°C
- Well-head temperaiure (in dynamic Conditions): 171°C
- Well-head pressure (in dynamic conditions): 45 bars
- Flow-rate of geothermal brine: 2000 cu.m/d

Fig. 1

THE CONCEPTUAL GEOTHERMAL MODEL OF HUNGARY

1 High temperature water dominated system. with confined aquifer (Upper Pannonian reservoirs)



2. Geopressurized systems (above 200 °C reservoir temperature at depth 3000 m)
Well Nagyszénás-3 -- test already carried out but futher experimentation is needed

Figure 1, The conceptual geothermal model of Hungary

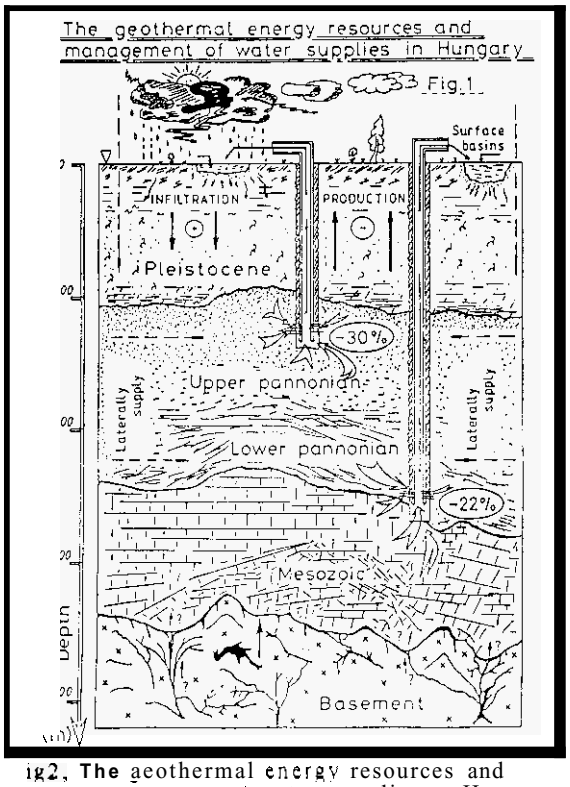
2. USING GEOTHERMAL RESOURCES

In the study finished in 1993 [1] the well-known fact has been emphasized again that the geothermal potential of Hungary is excellent but not as great as the possibilities in

magmatically overheated zones of the Earth (Italy, Iceland, countries of the Pacific volcano belt, etc).

The present situation of geothermal energy utilization in Hungary has been snalysed. It was concluded that the quantitive parameters of utilization are on a worldclass level but the efficiency is very poor, because of
1.) the production of thermal water is extensive (about 200 Million cu.m/year in 1990)
2.) direct reserve consumer
3.) the water reinjection is nowhere used, water disposal being is into surface basins.

Illustration of this fact is shown in Fig.2 The thermal water reserves of Upper Pannonian formations as a main geothermal reservoirs are directly consumed.



ig2. The geothermal energy resources and management of water-supplies in Hungary

The water supply from a depth of 2500 m is more than 20% less than the volume of the thermal water production, this is over erploitation. Moreover,

- the heat utilization has a seasonal character and low efficiency;
- no electricity generation to date using geothermal resources;
- most of the utilization evades the commercial turnover:

The possibility of electricity generation by binary Organic Rankine Cycle System (ORC) was analysed on the basis of thermal water producing wells and abandoned CH-wells.

The basement areas in Hungary with high enthalpy reservoirs (geopressurized systems) suitable for electric power generation have been mapped (Árpási,1993)

A preliminary analysis has established that the electric power generation by ORC method and other methods from geothermal energy would result in:

- Potential installation capacity: 25 MW
- Generated electric power: 215 GWh/a
- The quantity of saved imported
  crudeoil: 500 thousand tla
  its price: 50 MillionUSD/a

- The reduction of annual emissions of:
  810 thousand CO_2
  1100 t NO, .
  3500 t CO ,

The investment and operational costs of geothermal power generation have been compared with domestic power plant types and imported electric power. This comparison has given favourable results.

The utilization of geothermal energy in Hungnry has the following special characteristics:

2.1 Inconveniences

- Geothermal energy as an additiv type of energy source of low energy level is local and it s utilisation is possible only with special types of heat utilisation systems;
- Scaling in some places causes special problems with increased costs

2.2 Advantages

Hungary has a big geothermal energy potential;

Geothermal energy is an enviroment friendly type of energy without air pollution:

The dependency on imported energy sources would be decreased:

Number of working sites would be increased;

Competitiveness of geothermal energy is increasing because of the incered doamestic prices of fossil energy fuels.

3. FUTURE OF GEOTHERMAL ENERGY UTILISATION

In present day Hungary. geothermal energy utilisation is a promising enterprise, but starting it has some difficulties for contractors with small investment capital because of high rate of interest in the granting of credits.
(about 30% in September, 1994)

The profitability conditions of the participation of Hungarian Oil and Gas Industry in the geothermal energy utilization were also investigated.

If thes following conditions are fulfilled the utilization of geothermal energy can be profitable to the oil and gaa industry.

Such conditions are:

1/ the petroleum industry recompletes abandoned CH-wells (about 2000 wells in

1993) for thermal water production and acts as a contractor;

21 the utilization of geothermal energy will include at least **two** stages of **energy cascading** (electricity generation + direct heat utilization):

3/ the contractor completes and operates the geothermal energy utilization system in an up-to-date form of venture (sharing of the common profit).

For utilization, it would be expedient to start with establishment of **reference plants** in Hungary

Four (4) typical utilization **projects** have been developed taking into account the geological and technical conditions [1]

The preliminary geological, technical and economic planning of these four projects was accomplished using data **from** existing surface heat utilization equipment. Proposals were worked out to improve the efficiency of this equipment and lo develop new two stage facilities for electric power generation and direct heat use.

According to preliminary technical and commercial estimations, implementation **of** the recomended projects utilising geothermal energy will be **profitable** for contractors.

To illustrate this some results of the estimations for Geothermal Project **Mélykut-ÉK-3,4** for direct heat use are given in Table 1.

Table 1 **The economy of a Geothermal Project** (1993)

1. Well data	
1.1 Yield of geothermal brine, cu.m/hour:	120
1.2 Well-head temperature during production, °C:	110
1.3 Potencial heat capacity of well, GJ/d:	790
1.4 Temperature range (AT) of utilization (projected), °C:	80
1.5 Realizable volume of generated electric power, kWh/a:	$4,5x10^6$
2. Costs of investment	
2.1 Time life of project, years:	25
2.2 Cost of investment, MM USD	
2.2.1 Fesibility study	0,2
2.2.1 Full investment	2,0
2.3 Gros investment cart (investment+ +expenses without amortisation, MM USD	4,9
3. Income data	
3.3 Gross income, MM USD:	7,9
3.4 Net present value, NPV, MM USD:	3,1
3.5 Rate of return. ROR. %	29
3 6 Time of payback, year	1
3 7 Profitability Index, USD/USD	2,6

The characteristics of this project:

- utilization in two stage, of energy cascade system (electric power generation + direct heat utilization);
- discounted prices (15 %);

The commercial and economical estimations are very conservative because the following factors increasing efficiency of project were **not** taken into consideration:

- the multi-purpose utilization (removing of salts, dissolved gases etc. from geothermal brine, balneology, the tourism etc.);

  direct profit from returns of sales of the different products produced bv geothermal energy utilization;

  absence of damages caused by air pollution related to utilization of fossil energy sources;

- price of saved oil and/or natural gas

The **first** step towards development of these geothermal projects is preparation of **feasibility studys** on baaes of acquisition and analysis of geothermal data obtained by programmed measureremens e.g. flow-tests at the well sites, such compiled feasibility studies can be a bases for decisions concerning geothermal development.

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