GEOTHERMAL DEVELOPMENT IN HUNGARY COUNTRY UPDATE REPORT 1995-1999

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ABSTRACT

Information is provided on the status of geothermal direct heat use in Hungary, with emphasis on developments from 1995 to 1999.

During the four years since WGC'1995 there have been 6 new geothermal developments in Hungary, but several dwellings were stopped.

The geothermal energy was utilized in direct use, no electricity has been generated.

Geothermal energy utilization is estimated to 179.1 MW_t of geothermal capacity and to currently supply 1545,1 TJ/yr. of heat energy through direct heat application in Hungary, by January 1, 2000.

Geothermal heat pumps represent 4.0 MW_t of installed capacity.

The quantity of the produced thermal water for direct use in year 1999 was approximately 15.63 million cu.m. with average utilization temperature of 31 ºC.

The main consumer of geothermal energy is in agriculture (67%).

The proportion of geothermal energy utilization in the energy balance of Hungary, despite the significance proven reserves, is low (0.16%).

INTRODUCTION

This paper represents results of the geothermal development in Hungary between 1995 and 1999.

Geothermal development covers the thermal water management and utilization of the geothermal energy represented by geothermal fluids for direct use.

1. BACKGROUND

Hungary is well known as a country of favorable conditions in terms of geothermal gradient higher than the World average.

According to a results of the different assessments (Boldizsár, 1967 and Bobok, 1988) of the geothermal reserves Hungary has the biggest underground thermal water reserves and geothermal energy potential of low and medium enthalpy in Europe.

2. GEOTHERMAL UPDATE (Geothermal statistics)

The main data of geothermal energy utilization for direct use in Hungary by January 1, 2000 are shown in Table 1. and in Fig.1.

There are two main areas of utilization of thermal waters (surface temperature more than 30˚ C) in Hungary.

1. Thermal water management (drinking water supply and balneology)

The main data of utilization of thermal water management are shown in Table 2.

Some statistical data of thermal water management by January1, 2000.

- Number of medicinal baths: 61
- Number of public baths: 350
- Number of swimming pools: 1200
- Number of wells and springs of medicinal waters and mineral waters, respectively: 106 and 81

The number of spas or baths utilising geothermal heat for direct use was 4 by January 1, 2000 (heat pumps with installed capacity 4.0 MWt).

2. Direct use of geothermal energy

In result of analysis of the geothermal update on direct use of Hungary by January 1, 2000 the following conclusions can be drawn:

a) the geothermal energy utilized in form of direct use, no electricity has been generated from geothermal energy

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*** supplemented with thermal water management data (2000. June 30.)**

b) areas of the thermal water management and direct use are shown Table 2 and Fig.1.

- agricultural utilization (greenhouses)
- communal use (space heating and domestic hot water supply)
- bathing (balneology)

The number of geothermal heat utilizing organizations was 70 in 1999, the number of the settlements utilizing geothermal energy was 44, and the number of spas utilizing geothermal heat for direct use was 4 in 1999.

c) In Hungary geothermal energy utilization is an economically profitable enterprise as shown in Table 3. With regard to direct heat utilization, according to a survey (Árpási, 1998) the geothermal power was 324.5 MW_t. Concerning the utilized geothermal heat quantity 2804 TJ/year**,** by comparing it with the World's data of 1995, Hungary is the 5^{th} (fifth) in the World's list, while concerning specific geothermal heat utilization, Hungary is the 3^{rd} (third) in the World (33.1 W_t/person, 31 Dec. 1997).

As for the agricultural purpose geothermal heat utilization, however, Hungary is the first in the World's list (207 $MW_{t,}$, and 1786 TJ/year).

d) As was analyzed in a study (Árpási, 1998) the current situation of geothermal heat utilization in Hungary as indicates in Table 2 shows that the quantitative utilization is good in the World comparison, but with respect to efficiency, we lag considerably behind.

The main cause of this regrettable fact is that geothermal energy utilisation, with regard to its regulation, **does not have the necessary legal bases**. In some respects we can rather speak of **legal unregulated status** instead of regulated status. This unregulated status is on the one hand due to the fact that the effect of Act No. LVII of 1995 on water management (the "Water Management Act") does not include the utilisation of thermal waters for energetic purposes, and does not deal with the energy content of the geothermal fluids from any aspect, while on the other hand Act No XII of 1997 "Mining Code" excludes from its own effect the exploration and production of subsurface waters carrying geothermal energy.

The above mentioned Act No. XII of 1997 is, by the way, in contradiction with the provision of Act No. XVI of 1991 on concession, being relevant from the point of view of this topic, which regulates the basic rules of the cession of exploration and production and the related auxiliary mining activities within the frame of a concession contract.

As opposed to this, Act No. XII says that it is **not** allowed to issue a mining concession tender for the exploration of geothermal energy and its production for power engineering purposes, if it goes together with the production of thermal water.

- By the amendment comprising Act No.XII of 1997 of Act No. XLVIII of 1993 ("Mining Code") became totally inadequate from the point of view of geothermal energy utilisation, because Act No. XII of 1997 is in contradiction with itself, the Concession Act, and the regulations existing in its professional environment (Act on Water Management, Act on Environmental Protection, etc.), in its concept it contains abortive, discriminative elements, and consequently it is not suitable for the legal regulation of geothermal energy utilisation.
- This unregularised legal status strongly **embarrasses** the practice of the utilisation of thermal water for direct use and **hinders the environment sound, economically viable energetic utilisation** of considerable quantity thermal water reserves in Hungary which would comprise advancement, and would guarantee its renewable nature.
- This situation is unmaintainable, it requires an **urgent solution**, and it is reasonable to create an expedient legal regulation for the utilisation of geothermal energy by the enaction of an independent "**Geothermal Act**", the main principles of which are as follows:
  - the Act should provide a legal basis to the utilisation of geothermal energy for direct use in a system having a **renewable** character, which **protects** the geothermal water **reserves**, and **does not** pollute the environment,
  - thermal water is utilisable **mineral resources**, for the exploration and production of which a ground of mine can be laid, and according to the provisions of the Concession Act, the **concession rules** shall apply to this activity,
  - the water purpose utilisation and the power engineering purpose utilisation of thermal waters should be performed in a totally co-ordinated way.
  - this Act shall ensure legal opportunity for governmental measures promoting and extending the power engineering utilisation.
  - There is no subsidising policy from the Government for the utilization of geothermal energy, moreover, triple taxation is imposed as a punishment on users (mainly horicultural) of geothermal energy.

- the thermal water production and direct use are of extensive nature,
- the efficiency of the mostly only seasonal type of geothermal heat utilization is low,
- fundamentally no reinjection is applied.

3. GEOTHERMAL DEVELOPMENTS

The research of new possibilities for the direct use is first of all reasonable due to the fact that it is mostly seasonal in Hungary, too, i.e. traditional applications are mainly used only in the heating season.

Regardless of the fact whether the geothermal energy is utilized in the agriculture, industry or for the district heating, it can be equally stated that the old systems by now became physically outdate and obsolete.

As indicated in papers (Korim, 1997 and Árpási, 1998) the integrated, multipurpose thermal water utilization in energy cascade use should play especially important role.

3.1. Possibility of geothermal based power generation

At the SE part of Hungary (Nagyszénás-Fábiánsebestyén), define CH explorations there were some high temperature and high pressure indications referring to the existence of geopressured type thermal water reservoir systems. In well # Nsz-3 located in this area, during the formation testing 171ºC wellhead temperature was measured, which is the highest geothermal wellhead temperature measured until now in Hungary. Upon the utilization of such type of reservoirs it is expedient to use also the kinetic and pressure energy of the geothermal fluid in addition to its thermal energy for power production.

Table 4 shows the comparison of the main data of geopressured reservoirs located in Hungary and in USA (Gulf Coast) as indicated in TGC, (1996).

3.2. The problem of reinjection of the spent water

In Hungary both the thermal water management and direct use is implemented in an open drain systems e.g. without reinjection of spent water which is stored in surface aquifers and after it drained into surface waters.

The reasons for the reinjection of the spent water after the utilization into thermal water aquifers or formations being in hydrodynamic connection with them are as follows:

- protection of the thermal water reserves, i.e. stopping the depletion of the thermal water reserves (reserve protectional aspect),
- prevention or avoidance of potentional environmental pollution of surface areas and surface waters (environmental protectional aspect),
- enforcement of the renewable character of thermal water as energy carrier by the creation of the artificial heat extraction–natural reheating cycle.

Under the Hungarian geological and hydrogeological conditions the questions of water reinjection appears in two ways:

- The reinjection into the fractured, carbonated reservoirs the thermal water is a technically realizable and not too costly solution.
- The experiences of reinjection into porous, clastic (sandstone) formations up to now indicated that the results were uncertain and could not be regarded to be the preffered basis for commercial application. The technical solution of this question can be obtained by the application of the water disposal experiences obtained from the oil industry. Despite the unfavorable or lacking international experiences the **planning of the pilot application** is providing the basis of the results for commercial application (**Szeged-Felsőváros**).

3.3. The role of the oil industry of Hungary

The Hungarian Oil and Gas Company (MOL Co.) started a program in 1995 to promote the development of geothermal energy (Árpási, 1993). MOL Co. has compiled pre-feasibility study of the three geothermal pilot projects. The geological-technical data for them are summarized in Table 5.

Fig. 3. shows the process diagram for the cascaded use of geothermal energy utilisation in Hungary as indicated in Krete-Porció (1996).

3.4. Conception of geothermal energy utilization in Hungary

A conceptual study a conception was undertaken for geothermal development in Hungary (Árpási, 1998)

The objective basis of this study was a very considerable geothermal reserves in Hungary.

The total energy consumption of Hungary was 1055 PJ in 1998. The proportionate rate of geothermal energy, based on the status on January 1, 1999, was **2.8 PJ**, which represent a **0.26%** proportionate rate in the total energy consumption of the country.

It was a realistic objective to enhance the proportionate rate of thermal energy in the national energy balance to **1%**, which means **10.5 PJ/year** geothermal heat energy utilization being projected to the total energy consumption of 1998.

The time period of this objective was between **1999-2001** (3 years).

The extension of the utilization to the planned extent can be realized in two ways:

- By the increase of the efficiency of the existing heat utilizing systems,
- By the establishment –by investment– of new geothermal heat utilizing systems.

The total capital cost in the case of new geothermal heat utilization investments is 216 million USD, based on specific capital cost of 500 USD/kW$_t$ (Árpási, 1999)

The **10.5 PJ** geothermal heat quantity can be produced in the utilization systems with calculated geothermal power **540 MW.**

The aim to increase of the geothermal energy use would consequently results the considerable reduction of air pollution (e.g. reduction of CO_2 emission is 806 kt/year).

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Table 1.: Actual data of the geothermal energy utilisation for direct use in Hungary by January 1, 2000

Heat Utilisation area	**Quantity of the produced thermal water Mm^3/year**	**Utilisation heat stage, ΔT* °C**	**Utilised heat TJ/year (PJ/year)**	**Thermal power MW_t**
1.	2.	3.	4.	5.
1. Agriculture	26.24	34.1	1 040.7 (1.041)	120.43
2. Communal heating and SHW and industrial	14.763	26.6	507.3 (0.507)	58.7
3. Bathing and balneology	58.327	25.0	1619.2 (1.619)	187.3
Total	**99.33**	**31.1**	**3167.2 (3.167)**	**366.5**

* Weighted average.

Table 2. Geothermal reserves and utilization data in Hungary

Reserves of geothermal fluids			**Thermal water production**	**Type of thermal water utilization (thermal water management and direct use)**	**Percentage according to the type of the utilization**	**Utilized geothermal energy**	**Percentage in heat content of dynamic reserves**
Static volumetric reserves,	**Dynamic reserves, (at ΔT=40 °C)**						
	Volumetric	**Heat content, PJ/a**					
cu.km	**Mcu.m/a**		**Mcu.m/a (kg/s)**		**%**	**PJ/a**	**%**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
4000	**380**	**63.5**	**99.33*** **(3149.7)**	**1. Balneology** **2. Agriculture** **3. Space heating, SHW and industrial**	**59.0** **26.3** **13.7**	**-** **-** **3.16**	**2.8**

* Total thermal water production (with drinking water supply): 124.1 Mcu.m/a (3935.1 kg/s)

Table 3.: Cost of energy generated by different sources in Hungary by 31 May 2000.

Specific cosz of energy, USD/GJ		
Geothermal energy [1]		Natural gas [2]
1		2
1) In open system (no reinjection) 1.1. artesian well 1.2. artificial thermal water production production (gaslift, submersible pump) 2) in closed system (with reinjection) artificial thermal water production [3]	 **0.18** **0.9** **1.83**	**3.67**

[1] Based on the utilization data (May 2000)
[2] Based on the price of natural gas (May 31, 2000)
[3] Data of Aquaplus Ltd. (Hungary)

Table 4.: Comparison of the Hungarian (Nagyszénás-Fábiánsebestyén) and (USA) geopressured type geothermal reservoirs

Reservoir Parameters	**USA (Texas, Lousiana)**	**Hungary (Nagyszénás-Fábiánsebestyén)**
Depth, m	*4,800*	**3,165-4,034**
Reservoir rock type	*Clastic rocks (sandstone)*	**Carbonate rocks (dolomite) quartz porphyry**
Formation temperature, °C	*150*	**~190**
Reservoir porosity, %	*20-30*	**3-4**
permeability, mD	*20-120*	**11-120**
fluid volume, Mm^3	*10^3*	**10^5**
pressure gradient, MPa/km	*13.5-18.1*	**20.0**

Table 5.: The geological-technical data of the Hungarian geothermal pilot projects

Parameters of projects	Pilot projects		
	"Andráshida-Nagylengyel"	"Mélykút-Pusztamérges"	"Nagyszénás-Fábiánsebestyén"
1. Characteristic of reserves*			
• heat content	low enthalpy	low and medium enthalpy	medium and high enthalpy (geopressured)
• production method	pumping	artesian	artesian
• fluid quantity, cu.m./day, (min)	2600	2650	1891**
• well-head temperature, ºC (min)	93	108	171**
• well-head press. during production, bar	–	1-5	450**
2. Number of possible doublets	20	10	5
3.The planned utilization data			
1.1. Potenctial heat capacity of production well, TJ/year	241	289	575*
1.2. Step of heat utilization, ºC	63	78	141
of it:			
a) for electric production	-	28	91
b) for direct use	63	50	50
3.3. Installed electric capacity, MW_e	-	1-2	64
4. Planned timelife of projects, years	25		
5. Estimated geological-technical feasibility of project, %	95	80	***

* On base of oil industry measurements

** On base of Nagyszénás-3 well measurements data (July, 1991)

*** It could be estimate after the feasibility period, only

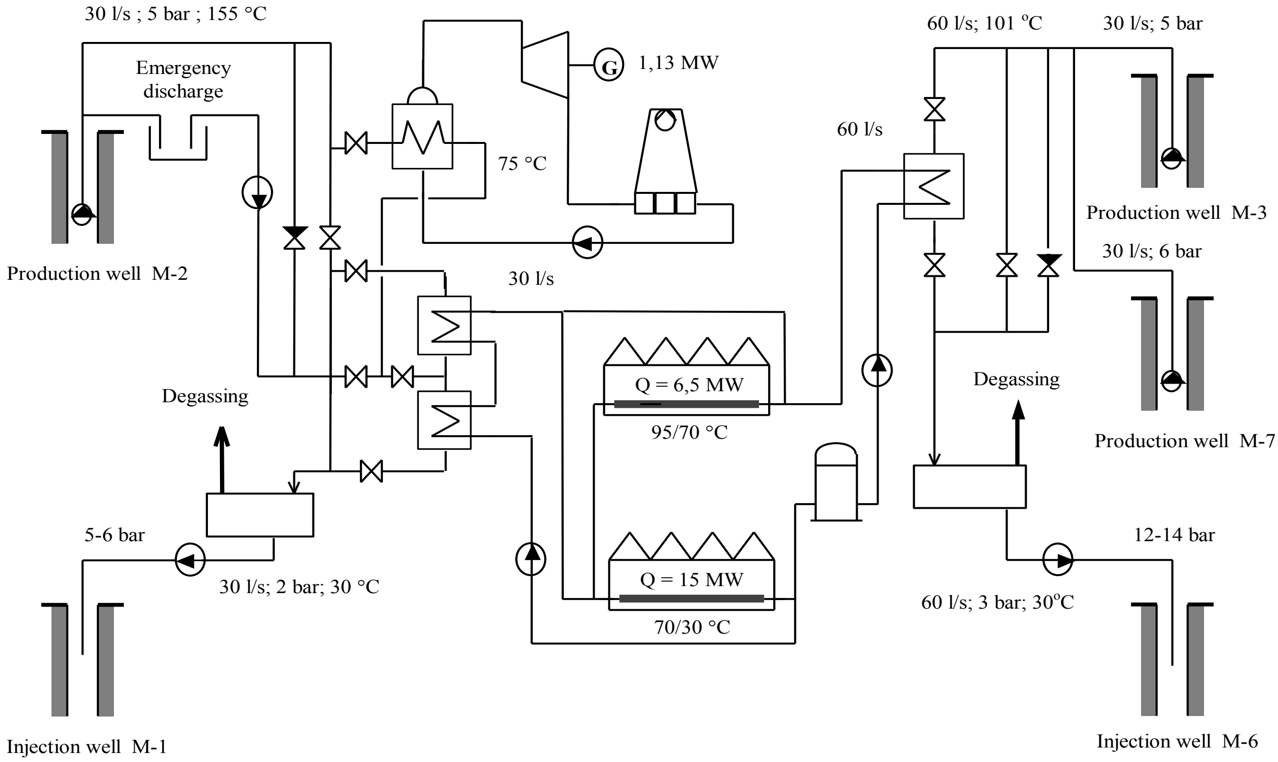

Fig. 3. The process diagram for the cascaded use of geothermal energy (Geothermal pilot project Mélykút, - Pusztamérges Hungary)