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Multipurpose Utilisation of Thermal Water in Hungary Prospect and Future

György Ákoshegyi[1], and Miklós Árpási[2]

[1] Director-General of the Chief Administration on Medical Balneology of Hungary

[2] Founder Chairman of the Hungarian Geothermal Association – Independent Expert

officeca@freestart.hu

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ABSTRACT

The main thermal water reservoir systems of Hungary are the Mesozoic carbonate-karstic basement rocks and the Pliocene-Upper Pannonian porous sedimentary formations with more than 1200 thermal water wells, mostly in the low temperature range (30 °C to 100 °C). The thermal water management drinking water (water supply, balneological applications etc.) and the direct energy use (agricultural utilization, space heating, SHW etc.) has to be in harmony with the possibilities and the requirements of the protection of water resources and the environment.

The present status of geothermal heat utilization in medical baths and spas is outlined. The potential uses of the geothermal heat of thermal waters with subsequent use for balneological use are estimated.

The integrated multipurpose utilization of geothermal fluids in energy cascade use in framework of geothermal pilot projects is playing an very important role, too.

Contribution of geothermal energy to the energy balance of Hungary, despite significant proven reserves (with reinjection) of 380 million m^3/year, with a heat content of 63.5 PJ/a at ΔT = 40°C, remained very low (0.29). Despite the fact that geothermal fluids with temperatures at the surface higher than 100°C are available, no electricity has been generated. The geothermal water is used only in some spas for space heating and SHW supply although there are 260 spas in the country, and the thermal water produced has an average surface temperature of 68°C. The total heat capacity installed in the spas is approximately 1250 MW_t; this is not provided by geothermal but could be, i.e., geothermal could provide more than three times the geothermal capacity utilized in direct uses by 31 December 2003 (342.5 MW_t and 2905.3 TJ/year).

INTRODUCTION

Hungary is well-known as a country of favourable conditions in terms of thermal and mineral water resources with a geothermal gradient higher than the World average.

As a consequence of the abnormally thin lithosphere the heat flux is above the average for the continent and the mean geothermal depth-step of 20 m/°C is steeper than the normal 30–33 m/°C value.

Hungary has one of the biggest underground water reserves and geothermal energy potential of low and medium enthalpy in Europe.

The leaders of the Hungarian thermal water management are being supported a multipurpose utilization of thermal waters – i.e. installation of heat exchangers (in upstream) and heat pumps (in downstream) – in territory of medical baths and spas.

For significant spreading of geothermal heat utilization with balneological use in territory of baths and spas of Hungary a following coercive measures for the present must be taken:

1. Unification and harmonization of the legal background concerning thermal water management and utilization of geothermal energy including the direct use and geothermal based power generation;

2. Insurance in necessary financial support by Governmental bodies for:

- spreading of geothermal heat utilization in territory of the balneological units (medical baths and spas);
- implementation of geothermal pilot projects for multipurpose, integrated use of geothermal fluids including geothermal based power generation, utilization for direct use and balneological use.

From the technical aspects the following measures have to be carried out:

- completely implementation of bathing water changing equipments in territory of baths and spas;
- implementation of heat exchangers (in upstream) and heat pumps (in downstream) in the baths and swimming pools.

1. GEOTHERMAL BACKGROUND

The traditional thermo-mineral springs feeding the most notable spas are at the foothills of the Mesozoic carbonate mountains, representing the natural tapings of the karstic underflow-heat convection-systems. The hottest thermal water wells (with 70–100°C outflow temperature) were drilled to the Mesozoic basement rocks of the basins surrounding the Transdanubian Central Range, the Mecsek, Villányi, Bükk mountains and to the other carbonatic Mesozoic belts with 1000–3000 meters depth. These Ca-Mg bicarbonate type thermal karstic waters are used mainly for balneological applications. (Lorberer et al., 1994; Korim et al., 1996)

The major geothermal reservoir (87% of the utilized thermal water resources) is located in the Upper Pannonian (Pliocene) sandstone formations, the depth of which reaches 2800 meters. (Fig. 1.) The temperature of the outflowing water obtained from this reservoir may have ranging from 30 to 99°C depending on the aquifer depth and the local geothermal gradient. The waters of the Upper Pannonian porous sediments are of alkaline bicarbonate type with low mineralization (in general the TDS less then 3000 mg/l).

Local hydrothermal reservoirs have also been discovered in the Miocene and Paleozoic (Devonian and Carboniferous)

formations and overpressured fossile saline-gaseous reservoir fluids (brines) in the basement, too.

The health use of natural hot springs in Hungary has been know since the time of the Roman Empire. (Fig. 2.) The curative effects of thermal karstic springs in the Carpatian basin – among them the natural thermal lake of Hévíz, one of the greatest hot springs in the world (Fig. 3.) – was known by the Romans as the remains found in the sites and stemming from the Empire period been suggested it (Cohut, et al.). In the period of the Ottoman-Turkish occupation of the central part of the country (1541–1686) the Moslems were built baths at the springs, are still in use after 400 years e.g. the Király spa in Budapest (Fig. 4.).

The first thermal wells were drilled also at the thermal karstic springs in the XIX. century by V. Zsigmondy (Harkány, Budapest-St. Margaret island: 1866), the exploitation of thermal waters from the Upper Pannonian sequence started with the CH-exploration well Hajdúszoboszló N^{o} 1. in 1924 by F. Pávai-Vajna. The widely utilization for agricultural purposes began in the early 60-is.

The main data of the registered thermal water wells are given in Table 1. The number of actually operating wells are about 800 (Lorberer, Á. et al.).

2. THERMAL WATER MANAGEMENT AND ENERGETICAL USE OF GEOTHERMAL ENERGY

2.1. History of the medical balneology

The first settlements of the conquering Magyars were established around thermal springs. The area of the country is extremely rich in thermal and spa waters. There may not be another country in the world where nearly 70% of the earth underneath the country contains thermal waters. The most well-known baths of a historical value can be found in Buda. Some of these were built during the period of Turkish domination and are still frequented today. The famous and internationally noted medicinal centres in the country, including Balatonfüred, Hévíz and Harkány, were established at the turn of the 18th and 19th centuries. These medical centres, spas built around medicinal springs, hotels and guesthouses represent an important part of the country's tourism profile.

2.2. Geothermal reserves and present utilization data for Hungary

The geothermal reserves of Hungary have been identified by geological exploration and by wells drilled for thermal water management (over 85% of Hungary's drinking water comes from deep wells) and for hydrocarbon exploration. Over 1200 geothermal and approx. 10,000 oil and gas wells have provided reliable information on the existence of geothermal reserves. Main data on geothermal reserves and on their utilization in direct uses, referred to 31 December 2003, are given in Table 2.

Geothermal energy is a very important renewable energy source (RES) in Hungary, as shown in Table 3.

In 2003 the production of geothermal fluids (Árpási) was >22 million m^3, 68% of which is represented by thermal water with temperatures of 30–50^{o}C (utilized for health and recreational bathing and drinking water supplies), the remaining 33% being utilized for greenhouse heating, space heating, sanitary hot water supplies, etc.).

The largest number of medical baths and swimming pools located in the southern part of the Great Hungarian Plain (Fig. 5.).

Situation on multipurpose integrated use of thermal water is miserable, now.

The utilization of heat content of thermal water exists in territory of some spas only, e.g.:

- Harkány Spa: direct use (heat pump) + balneology; 2200 kW_t;
- Bük Spa: direct use (heat exchanger) + balneology; 250 kW_t;
- Tiszaújváros Spa: direct use + balneology; 500 kW_t;
- Hódmezővásárhely Spa: direct use (communal heating and SHW supply) with reinjection) + balneology; 1100 kW_t;
- Kalocsa Spa: heat pump; 150 kW_t;
- **Total: 4200 kW_t**

The main data of as a good example, multistage utilization system of thermal water, in city Hódmezővásárhely given in Table 8.

Process diagram of the utilization of thermal heat (1st and 2nd Phases) in City Hódmezővásárhely is shown in Fig. 6. and Fig. 7.

2.3. Legal aspects and financing policy

Current regulations in Hungary on the utilization of thermal waters as a thermal water management as a direct use are full of contradictions. For example, The Mining Act, 1997, states that: *"Geothermal energy exploited with thermal water is not geothermal energy, because it entails thermal water production"*. Therefore, it is not covered by The Mining Act, but by the Water Management Act, but the latter also does **not** include the terms *geothermal energy utilization* and its *heat recovery*.

- There is no mention of concessions for the research and utilization of geothermal energy;
- The proprietary aspects of abandoned oil and gas wells are not clarified.

The Hungarian State has **not** given any support to geothermal energy utilization since 1985. On the contrary, it has applied sanctions, levies and multiple taxes: a tax on the quantity of thermal water produced (VKJ) of about 3 cent/m^3, a royalty for used geothermal heat, a "waste water" penalty.

Geothermal energy is an environmentally benign renewable energy source, and a stable energy source that is independent of climate and time of day, which distinguishes it from hydro, wind and solar energy. Geothermal energy also plays a significant role in the reduction of air pollution (CO_2, SO_2, NO_x emissions).

There are a large number of obstacles to the advancement of geothermal energy in Hungary, as regards environmental safety measures; he need to conform with EU standards of clean air is not adequately emphasized. The low GMP and the tight national budget discourage any systematic support schemes for geothermal energy, e.g. the Environmental Protection Target Fund (KAC) is supporting the extension of natural gas networks by 20% but gives no financial help for utilizing geothermal energy, which is a main renewable energy source of the country.

3. POSSIBILITY OF POSSIBILITY OF THERMAL WATERS IN HUNGARY (UTILIZATION FOR DIRECT USE AND BALNEOLOGY)

3.1. Utilization of heat content of thermal waters in medical bath and spas in Hungary

Of the 260 public baths and spas currently in operation (the waters in 89 of these is classified as "medical" and is 140 as "mineral"), in five different spa areas the heat content of their thermal waters is utilized for space-heating and sanitary hot water supplies, using heat exchangers and/or heat pumps (in Bükfürdő, Zalakaros, Harkány and Hajdúszoboszló spas). Only these five of the above-mentioned 260 enterprises are running at a profit, the remaining 255 operating at a loss.

Why are these 255 spas and baths operating at a loss? Mostly because the thermal water is too hot (40–99^{o}C) and has to be mixed with cold tap water to make it suitable for bathing. This has an adverse effect on the quality of the medical water and results in extra cost; after its use in bathing the water discharged still has a significant heat content (~25^{o}C), which is wasted. Furthermore, all the buildings housing the public baths, hotels, etc. are heated with mainly imported natural gas from Russia.

According to estimates of the geothermal heat potential of the thermal water produced in Hungarian spas, a huge capacity (1250 MW_t) could be utilized, more than three times the current level of geothermal use in country (Table 3.).

3.2. Multipurpose utilization of the geothermal fluids in the geothermal pilot projects

The plant of multistage utilization of geothermal energy is being constructed by Aquaplus Ltd. in city Zalaegerszeg with planned geothermal capacity 8,0 MW_t. (Fig. 8.)

The multipurpose utilization of geothermal fluids (power generation + direct use + balneology) in integrated system stands to reason, because of efficiency of utilization thermal water significantly higher than in one-step utilization e.g. in open systems without reinjection what is common in Hungary, now. (Árpási, M. et al., Rodi)

In the hydrocarbon exploration wells with measured data (slug test and DST) of geothermal indications mainly from Middle Triassic dolomites and the basement rocks, with outflow temperature more than 100^{o}C.

According to preliminary assessment about 80 abandoned CH-wells as suitable after recompletion of there into doublets for multistage integrated use of geothermal heat with production + utilization + reinjection.

3.3. Environmental aspects

Concerning the conception of the utilization of geothermal energy in Hungary 3 studies were compiled (Árpási, M. et al., 2002; Lorberer, Á. et al., 2004; E. Unk Jánosné et al., 2004).

The estimated reduction of greenhouse effect in result of increasing of utilization of geothermal energy of greenhouse effect in result in Hungary in year 2010, satisfying the EU directives (Regulation 2001/77) are given in Table 4. (E. Unk Jánosné et. al.)

REFERENCES

1. Lorberer-Szentes, I., Lorberer, Á., Mauche, L. (1994): Hydrogeological research of karstic aquifers in Hungary; "Ground waters in carbonate rocks of the Carpathian-Balkan Mountain Range" CBGA-IGC Project 299, School of Mining and Geology, Belgrade – Allston Holding Co., Jersey, pp. 175-201.
2. Korim, K., Lorberer, Á. (1996): Hydrogeologic patterns of regional thermal water occurrences in the Little Hungarian Plain and the possibilities of their further development IAH Commission on Mineral and Thermal Waters – Scientific meeting in Dax, France Internal communications.
3. Árpási, M., Cohut, Il (1995): Ancient uses of geothermal energy in the Precarpatian area and in the Pannonian Basin, World Geothermal Congress, 1995 Florence, p. 381-384.
4. Árpási, M., Lorberer, Á. (1998): Thermo-mineral water management and utilization of geothermal energy in Hungary. Congreso Latinoamericano de geologia, 8 al 13 de Noviembre de 1998, Buenos Aires, Argentina
5. Lorberer, Á. et. al (2004): Conception of development of geothermal energy utilization in Hungary up to 2010. VITUKI Ltd., Budapest
6. Árpási, M. (2004): Geothermal update of Hungary 2000–2004 (Draft), WGC 2005, Antalya,Turkey
7. E. Dr. Unk Jánosne et. al. (2004): The cost analysis of increasing of RES utilization in Hungary up to 2010 Study of Pylon Ltd., pp. 120. Budapest

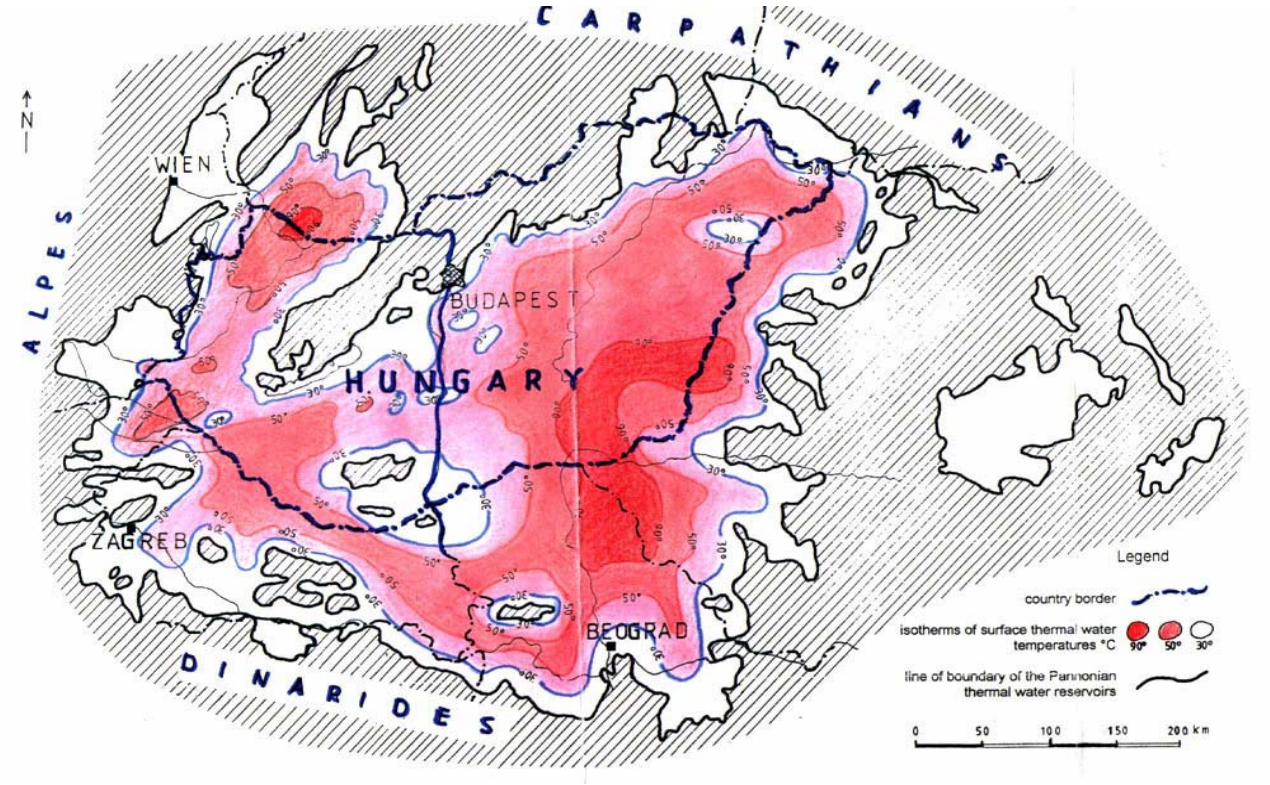

Fig. 1. The area of the main thermal water reservoir (The Upper-Pannonian sandstone) in the Carpathian basin.

Fig. 2. The ruins of ancient Roman Thermal Bath in Aquincum. Budapest (in the reign of Emperor Tiberies Claudius Nero, A.D. 14-37.)

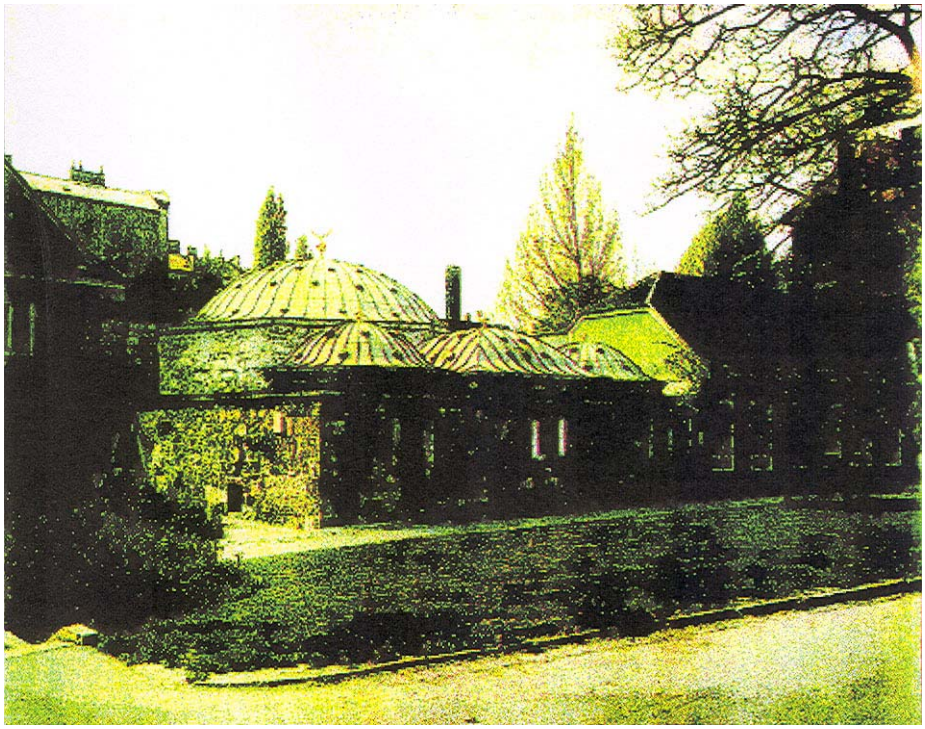

Fig. 3. The Turkish bath "Király" of 16th century, Budapest

Fig. 4. Thermal water lake "Hévíz"

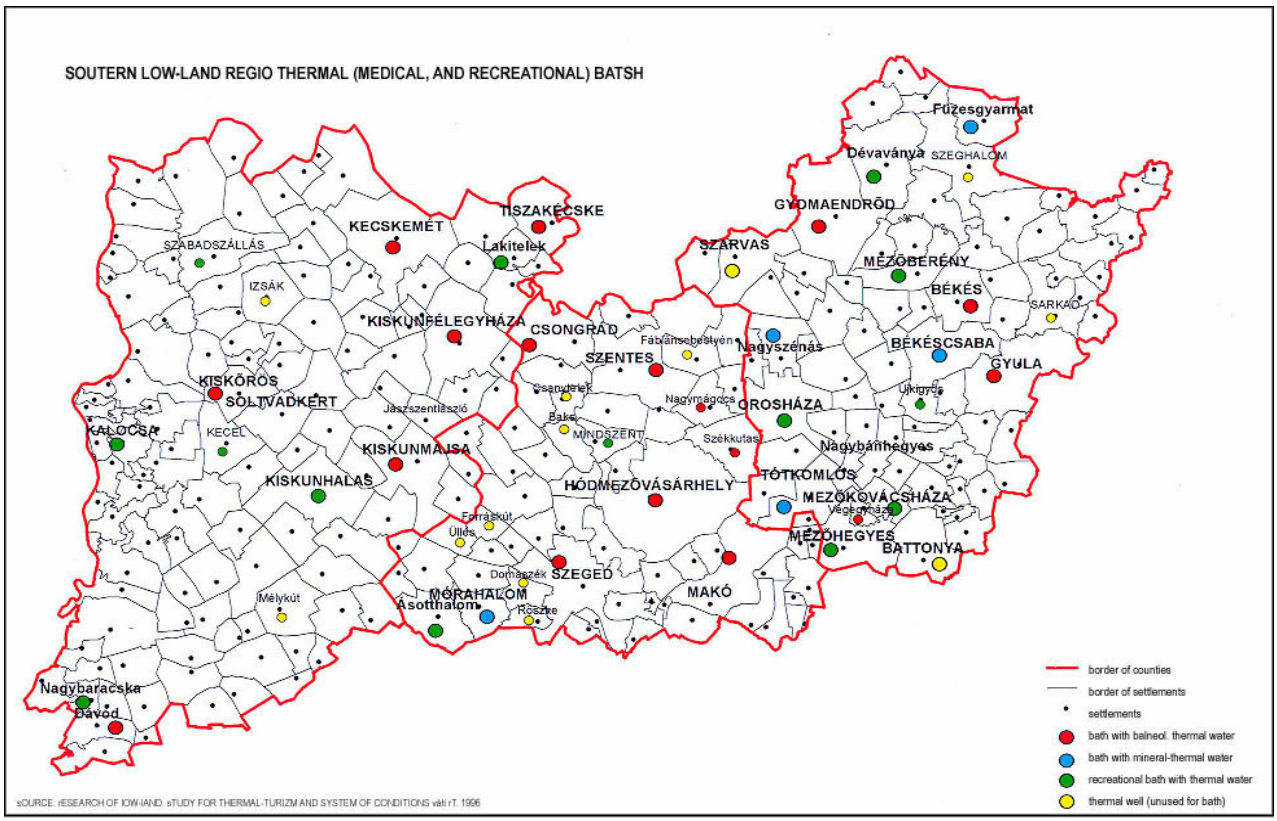

Fig. 5. Medical and thermal water baths and spas in the Southern part of the Great Hungarian Plain

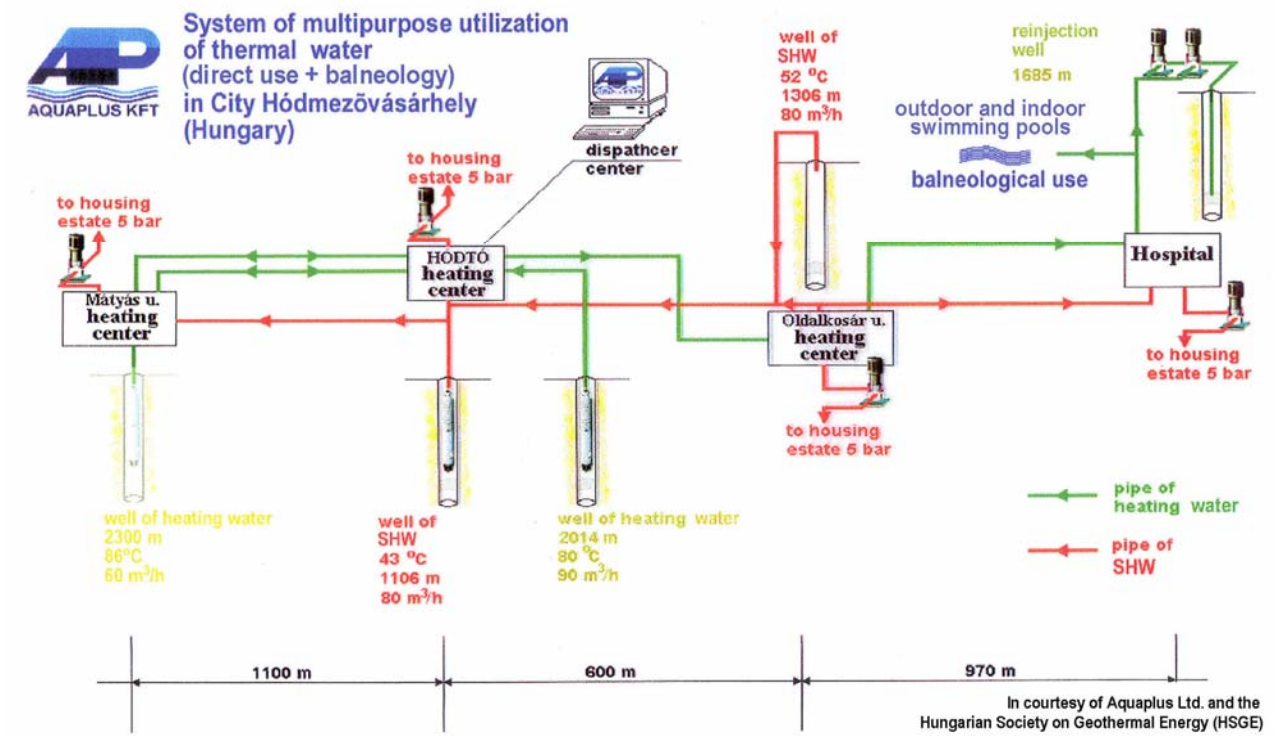

Fig. 6. System of multipurpose utilization (direct use + balneology) of thermal water in city Hódmezővásárhely (Hungary)

Fig. 7. Indoor swimming pool with multipurpose utilization (direct use + balneology) in city Hódmezővásárhely (Hungary)

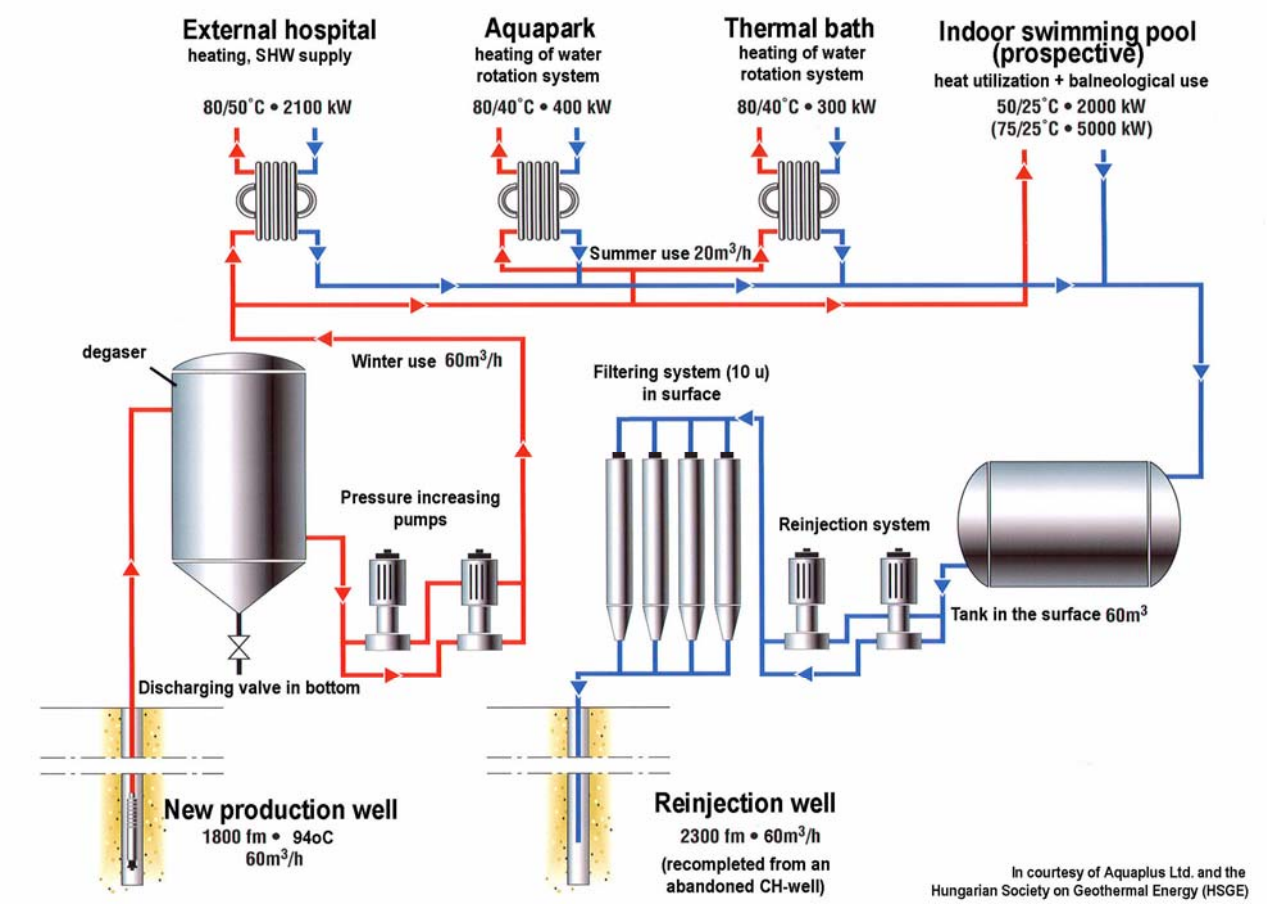

Fig. 8. Process diagram of multipurpose utilization in city Zalaegerszeg (under construction)

Table 1. Temperature and utilization of thermal wells in Hungary (2004)

Range of temperatures °C	UTILIZATION METHOD										Quantity of wells in operation °C	Proportion of thermal water wells % in operation
	WS	SPA	AGR	IND	COMM	MULT	REINJ	OBS	CLOS	ELIM		
30–39,9	203	73	73	44	1	6	-	44	117	113	386	
40–49,9	30	110	17	17	2	17	-	33	43	-	187	
50–59,9	7	50	15	11	2	13	5	10	21	10	102	
60–69,9	-	33	17	6	1	29	8	3	20	13	89	
70–79,9	-	9	17	6	5	16	2	4	20	1	53	
80–89,9	-	3	20	3	1	5	1	1	6	1	31	
90–99,9	-	1	33	1	5	-	-	-	3	-	40	
>100,0	-	-	1	-	-	1	-	-	1	-	2	
Total	**260**	**279**	**193**	**78**	**17**	**87**	**16**	**95**	**231**	**138**	**889**	**58,1**

WS – drinking water supply; SPA – spas and hospitals; AGR – agriculture; IND – industrial; COMM – communall; MULT – multipurpose; REINJ – reinjection well; OBS – observation wells; CLOS – closed well; ELIM – liquiated well

Medical water wells: 111 wells in 77 settlements + Lake Hévíz + 4 spas in Budapest + 2 groups of springs in city Eger

Mineral waters: 88 wells in 44 settlements

Table 2. Geothermal reserves and utilization data for Hungary

Geothermal reserves		Heat content of the dynamic reserves with reinjection ($\Delta T = 40^oC$)		Utilized geothermal heat on 31 December 2003	Utilized heat vs. dynamic reserves
Static (km^3)	Dynamic (Mm^3/year)	*PJ*	Mtoe	PJ	(%)
4000	380	*63.5*	1.5	2.9	4.4

Table 3. Possibility of geothermal heat utilization in balneology of Hungary (without reinjection)

Number of thermal water production wells, pc	*Well-head (outflow) temperature °C*	*Yield of thermal water 10^4•cu m/d*	*Summarized production cu.km*	*Possible capacity of the geothermal heat utilization MW_t*	*Capacity of direct use MW_t*
1	2	3	4	5	6
64	30-39,9 (20-23)	200	1,0	303	
242	40-49,9 (25)	95	0,4	17	
420	50-100,0	205	1,2	754	
726	**30-100,0**	**500**	**2,6**	**1250**	**342,5**
			According to IGA recommendations:	1590 MW_t	
			Growth, %	467	