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High Efficient Cascaded Use of Geothermal Energy in Reality

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ABSTRACT

For the first time in the 50 year old history of Hungarian geothermal exploration an unconventional three-pipe district heating network was carried out and put into operation in a small city recently. Already design of the system required innovative approach and during the implementation some other local capabilities were utilized. Combination of pioneer methods in planning and construction resulted as high energetic efficiency as it has only been accustomed related to the use of geothermal energy in horticultural applications. This paper describes how the idea of cascaded use for heating of public buildings located in different parts of the settlement was transferred to reality. It also contains experiences of the first full capacity heating season and the conception for enlarging the geothermal network.

The investor of the project was the local community of the city. As financial contribution to the project 60% of the total cost of implementation was provided by the EU based, so called, Environment and Energy Operative Programme, through which a number of geothermal district heating (and cooling) networks have already been constructed and will, hopefully, be implemented. Anyhow, taking the interest in the support programme for renewable energies by both the public and private sector is great. It has definitely started up the geothermal sector in Hungary.

It is a promising initiation for the next 50 years.

1. INTRODUCTION

Bóly is a 3800 inhabitant small city in south part of Hungary some 200 km away from Budapest, the capital (Fig. 1).

The town, which lies in a flat area, is very famous for the extremely fruitful soil and the good weather conditions.

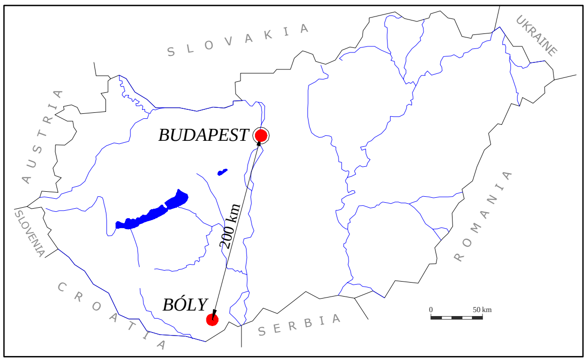

Figure 1. Location of Bóly in Hungary

Growing the corns and seeds by local farmers is known Europe over. The town takes special care of the preservation of the row of wine cellars with 353 press-houses. The Mohács-Bóly White wine route Association was founded in 1999 to preserve the traditions of viticulture and wine culture.

The Batthyány-Montenuovo mansion was built in the 18th century for the landlord of the city. The castle and an 11 hectare nature conservation park are situated in the centre of Bóly and, as a hostel for handicapped children it became the biggest consumer of the geothermal district heating network in 2008.

2. HYDROGEOLOGICAL CONDITIONS

In the south and south-west parts of Hungary, the endowments of finding geothermal water significantly differ from those in the Great Hungarian Plain. While in the Great Hungarian Plain and especially in its south-east territories the characteristic thermal aquifers are very deep, sedimentary and porous, this type of thermal aquifer is non-existent in the surroundings of the town of Bóly. A mineral exploration borehole made in 1982 proved that geothermal water was available at a distance of some 2.5km west of the town. Since the geology of the area was relatively unknown at the time, even the experts were pleasantly surprised by the appearance of geothermal water. It was especially favourable that the bottom hole temperature exceeded 80^{o}C and that the productivity index of the well was very high. It is obvious that the borehole happened to be driven into a fracture and therefore the immediate vicinity of the well had a low resistance.

The idea of harnessing this geothermal water was put forward at once of course. The initial concept was a balneologic application, because Harkány – one of the oldest and most popular spas in Hungary – is very close, only about 30km from the town. However, after almost twenty years, the management of the town council chose an energetic utilisation instead of using the water in a bath.

In 2004, the local council won a European Union grant for drilling a new geothermal well and establishing a geothermal heating system. From this grant, water exploration commenced in the centre of the town, but the results were unfavourable, because the thermal aquifer located west of the town earlier could not be found below the centre of the town. Although the hole was drilled to a depth of 1800m, the fractured limestone stratum was missing there. Fortunately, while drilling the hole, such younger age measures were traversed in a 700m depth, from which 300 l/min (18m^3/h) geothermal water of 42^{o}C temperature could be obtained. This water volume and temperature were sufficient to supply a small, low temperature district heating grid for floor heating system users only (primary school, library, youth centre). Spent water was used in a pool located in the school courtyard.

The town council management was not brought to heel by the partial failure of water exploration. Immediately after the completion of low temperature district heating in 2005, they made the decision to set up a geothermal heating system supplying most public institutions of the city, based on these secure geothermal water resources. A firm foundation for this was provided by a new call for project proposals, which enabled the applicants to receive up to 60% investment grant for local heating systems based on renewable energy sources. The local council of Bóly town appointed Porció Kft. to draw up the project proposal documents and the applications for the required regulatory permits.

3. FEASIBILITY STUDY

3.1 The concept of obtaining and disposing of geothermal water

Both in theory and practice, the exploration well drilled in 1982 was suitable for yielding thermal water. However, due to the small diameter liner, no submerged pump to be fitted in the well existed which could have compensated the friction pressure loss arising at a desirable yield. It became obvious that a new producing well was badly needed. Geologists identified the immediate vicinity of the existing exploration well as the best place for this. Located about 1.5km north of the producing wells, the boring site of the reinjection well could be identified after the reassessment of geological and hydrogeological data. The locations of the exploration borehole with the geothermal field and the town are shown in Fig. 2.

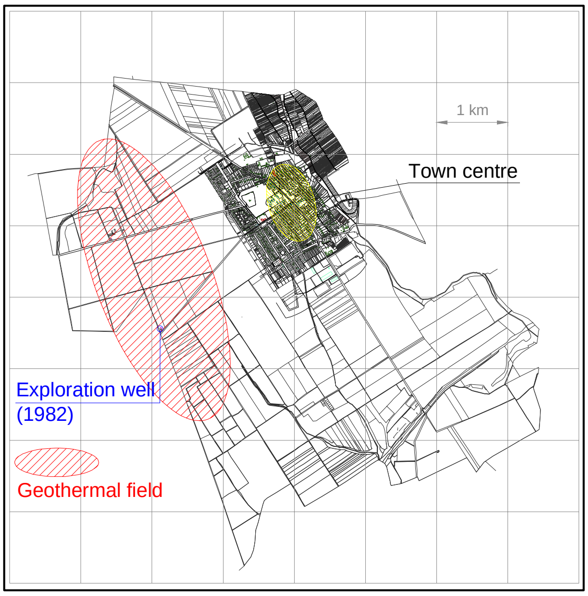

Fig. 2. - Town and the geothermal field

3.2 The concept of energetic utilisation

There are several public institutions which are potential candidates for harnessing geothermal energy in the town of Bóly. Of these, the largest is the disabled children's home, which had an extremely outdated heating system. At the same time, thanks to the construction and refurbishing activities in recent years, there are buildings which have low temperature heating. Therefore, to make the most efficient use of geothermal water enthalpy, it was almost child's play to connect in series on the geothermal water side the high temperature and low temperature heating system consumers. To do so, the only required precondition was to make sure that spent geothermal water – of course in the required volume and temperature – was supplied to a low temperature consumer maybe situated at quite a different location of the town. The conceptual circuitry of harnessing geothermal water is shown in Fig. 3.

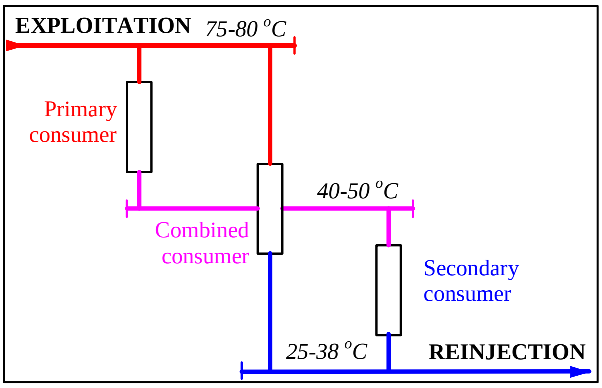

Fig. 3. – Connection concept

Index to Fig.3.

- **primary consumer:** these buildings are mostly characterised by radiator based high temperature heating circuits,
- **combined consumer:** these buildings are able to utilise themselves the heat of geothermal water in two phases,
- **secondary consumer:** these buildings have floor heating and other low temperature heating

Location of the different consumers for the geothermal heat is shown in Fig. 4.

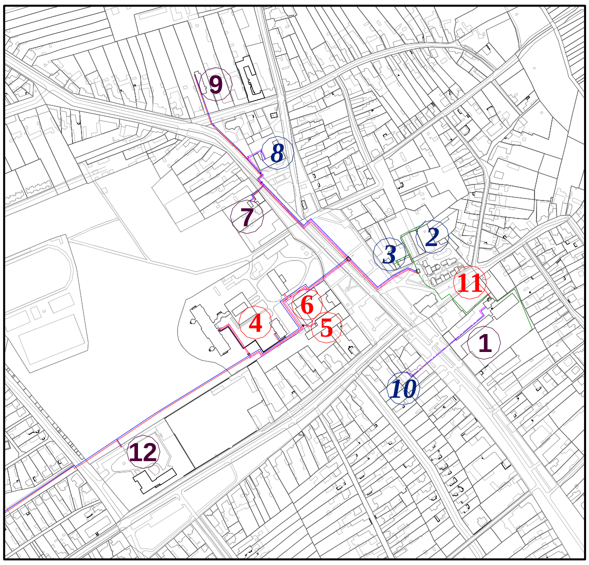

Fig. 4. – Consumers of the geothermal heat

Index to Fig. 4.

1	Primary School	**7**	Health Centre
2	Library	**8**	Culture House
3	Youth's House	**9**	Dormitory
4	Handicapped's Home	**10**	Town Hall
5	Kindergarten	**11**	Kolping House
6	Old People's Home	**12**	Office-block

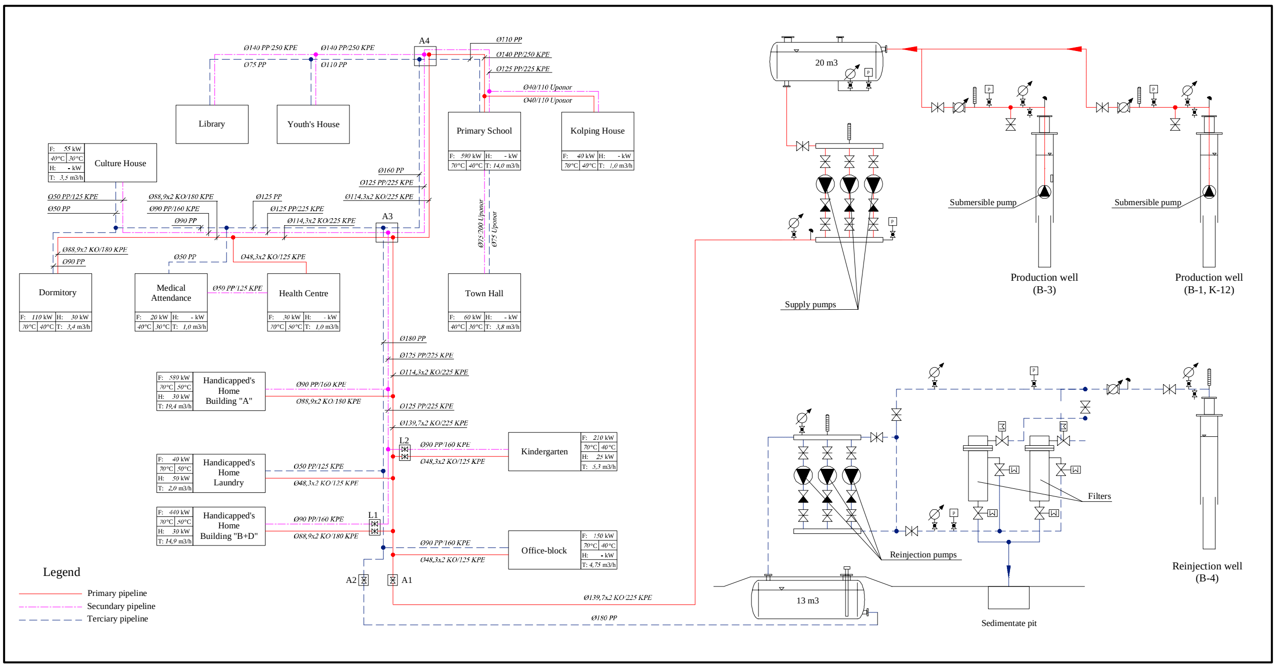

Fig. 5. – Connection diagram of the total geothermal loop

Fig. 5. shows the connection diagram of the geothermal loop with all the most important data, such as:

- thermal flow rates for the consumers,
- heat demand for heating (F) and dhw production (H),
- forward and return temperatures for heating,
- pipeline types and dimensions.

3.3 Environmental and cost efficiency issues

The environmental benefit of envisaged development is mainly manifest in reducing air pollution. The drop in CO_2 emission is – taking into due consideration the electricity required for running the geothermal system, and also the rather insignificant volume of gases released into the atmosphere during the degassing process of geothermal water – higher than 1300 tonnes annually.

On the basis of the budget featuring in the feasibility study, the total investment cost including the drilling of the two wells and the laying of the approx. 7 km long pipeline reached 400 million HUF (1.5 million Euro). The annual balance of heating cost savings resulting from the replacement of natural gas and the extra cost stemming from the need to run the geothermal system is roughly 34 million HUF (125,000 Euro). This means that the investment pays off in 12 years.

4. CARRYING OUT THE INVESTMENT PROJECT

After the successful competition phase, the investment was carried out in 2007-2008. First the reinjection borehole was made as a result of the higher geological risk. By the end of the year 2007, the well was drilled successfully and early 2008 saw the completion of hydrodynamic measurements. Next came the drilling of the producing well, which was finished in June 2008. The geothermal ducts were set up and the geothermal heating stations were fitted in the consumers' boiler plants on an ongoing basis during 2007 and 2008. The whole system was subjected to a test run in October 2008, followed by the continuous operation of the geothermal energy supply system up to this day.

5. EXPERIENCE GAINED IN THE FIRST HEATING SEASON

The heating season 2008-2009 proved to be successful and trouble-free from the aspect of running both the geothermal system and the energy utilisation system. Fully automatic control enabled on the one hand the cost efficient management of geothermal water, and on the other the continuous collecting and storing of operational parameters. By processing the latter, we have plotted Fig. 6., which shows the primary, secondary and tertiary temperatures as well as the volumetric flow of geothermal water.

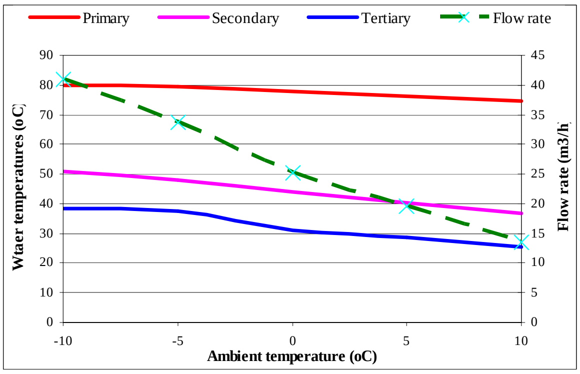

Fig. 6. – Parameters of operation in the first heating season

It is clearly depicted by the figure that geothermal water was perfectly able to meet the heating and domestic hot water making requirements even on the coldest days. In January 2009, bitterly cold weather lasted for about two weeks in the area. In spite of this, there was no need to switch on the boilers exactly in harmony with the calculations of the feasibility study. It was a surprise, however, that demands were fully covered with a water volume much lower than predicted, and only up to $41m^3/h$ was needed.

Fig. 7. and Fig. 8. contain pictures from the implementation phase: a short part of the 7 km long partially three-pipe

system and construction of thermal station at the production wells.

Fig. 7. – Part of the three pipe system

- Primary: pre-insulated stainless steel
- Secondary: pre-insulated polypropylene
- Tertiary: non insulated polypropylene

Fig. 8. – Construction of pump house and the 20m^3 water tank made of fibreglass polyester

6. SUMMARY

Experience gathered in the first year of running geothermal utilities in Bóly is very favourable indeed. Demands were fully met with a lower geothermal water volume than calculated, and efficiency was extremely high.

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