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RESEARCH ARTICLE

# Role of geothermal energy in district heat supply in Hungary

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***Abstract***

*The proportion of geothermal energy in Hungarian district-heating is very low. In the next century the usage of renewables must be at least tripled regarding the heating of buildings, which can be achieved mainly by using thermal water. By this method a large amount of natural gas can be replaced, and the increasing rate of district-heating costs can be slowed. The basic heat will be provided by geothermal energy and the gas boilers will be peak heat suppliers. Our Department has taken part in the construction of the largest geothermal district-heating system in Szentes, Hungary, where already four districts are supplied with thermal water. In this project 32000 GJ/a heat usage is accomplished.*

***Keywords***

*geothermal energy · district-heating system*

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## 1 Introduction

The Budapest University of Technology and Economics, Department of Building Energetics and Service Systems participated in the tender called by the Hungarian Committee for Technological Development for improvement of utilisation of geothermal energy for district heating. Within it, a study has been prepared in co-operation with the Energy Supervision Board in which Hungarian geothermal capabilities have been analysed and development opportunities of the available thermal water capacities for building heating have been explored. As an organic continuation of this work, in the town of Szentes, a concrete practical district heating system has been switched over to thermal water.

Utilisation of recovering energy sources has come increasingly to the fore in Hungary, where geothermal energy as a geological opportunity plays an extraordinary role. In its difficult economic and technological situation, district heating in Hungary can utilise geothermal energy in particular areas advantageously as an additional heat energy carrier to basic ones, even more so in settlements with excellent natural resources as a basic energy source. This is a sophisticated problem as not only the utilisation of the heat energy needs to be solved, but also a lot of environmental issues are generated by placing the energy carrier medium, i.e. thermal water on the surface.

## 2 Geothermal Energy Production

The carrying medium of thermal energy is thermal water available in large quantities in reservoirs; it is cheap and can easily be taken to the surface. In most cases, its reservoir rock is Upper-Pannon sandstone with a specific heat of 0.855 kJ/kgK. Ground water can be brought to the surface with the usual fluid mining methods via deep bored wells. Modern production systems work with pumps within a controlled process. Thermal water production aims at exploiting internal energy of the reservoir rock. As a consequence, pressure prevailing in reservoirs may reduce with time as an unfavourable circumstance. For avoiding this disadvantageous pressure drop and preventing contamination of surface areas the cooled thermal water should be returned to the original water containing layer as the best solution.

Water repressing is a technologically solved process, however, it is cost-intensive. Power consumption of a repressing pump reaches the output of a 30 to 50 kW electric engine. As a transition solution, production and repressing of thermal water can be realised by boring one thermal well equipped with double piping. Such a test well is operated in Szentes.

## 3 Geothermal Energy in District Heating Systems

Geothermal district heating systems are working in nine settlements in Hungary. In total 42,800 flats are heated – indirectly – by thermal water making 6.7% of the total quantity of district heated flats. Total quantity of used energy carriers equals 2,941,500 GJ a year with an annual share of geothermal energy of 330,531 GJ. The share of geothermal energy usage varies between 0.4 and 85.8% in settlements. On a country level, the share of the usage of thermal water for heating buildings is rather low; therefore each reference development is of high importance. Setting up a reference plant makes sense in locations where typical problems of thermal water exploitation and reservoir pressure drop characteristic of Hungarian Upper-Pannon layers can be observed. Most important is the thermal water reservoir system of the Great Hungarian Plain, within it, Southern areas of the Great Plain where heat carriers with 80-95°C surface water temperature are available from deep-bored wells. The largest reservoir pressure drop is in the Southern Great Plain, thermal water systems are open and cooled water runs away on the surface. In general, only single-stage heat and water utilisation is realised, the temperature of waters running away reaches 40-60°C in the heating season.

## 4 Optimum Utilisation of Geothermal Systems

The best heat and water utilisation can be realised in large complex systems. It is advantageous to set up a plant with several exploitation wells and repressing wells, supplemented by a fossil-heated furnace plant, possibly with a heat pump for the cooled thermal waters, i.e. to realise additional peak-time heating. Advantages of such a system are the acceptable investment costs, and in the fact that the supplementary furnace system requires low quantities of fuel.

Secure heat supply can be realised by retaining the existing furnace capacities to be available as reserves.

Quantity of peak thermal energy depends on the temperature of the available thermal water and on the temperature jump for which the central heating secondary system is dimensioned.

Geothermal energy consumption of the system can be increased by enlarging surfaces of heat transfer appliances. This can be realised, first of all, in new buildings.

As another option, buildings can be improved by architectural means: subsequent heat insulation, reduction of filtration loss (exchange of windows and doors, elimination of heat bridges).

With low-temperature heating systems, heating can also be realised in the medium temperature range, e.g. radiator heating and floor heating. Precondition of their operation is the complex utilisation where heating of buildings, swimming pools, horticulture plants and other heat utilisers is realised within a system with several temperature jumps.

Our department participated in preliminary planning works and preparation of the working plans of the geothermal heat and water utilisation system in Szentes. The objective of this work was to improve the utilisation capacity of the existing thermal water well and to reduce gas consumption of the central district heating furnace plants.

Flats and buildings to be heated are existing system-built dwelling houses and old public buildings erected with traditional technologies in the centre of the town.

## 5 Switchover of the City Centre Housing District of Szentes to a Geothermal Basic Heat Supply

The housing area called Kertváros, was supplied by heat energy from a gas heated furnace plant before the reform. This district heat system supplied both heating and hot water for the buildings. Total output of the three gas-burning furnaces of type TP 1200/8-MF was 4.2 MW. The direct heating system operated with a 78/65°C temperature drop, and the total volume heated was 72.980 $m^3$.

1986-87, a deep-bored thermal well was developed for test purposes with a double piping system for both exploitation and repressing. This thermal well was only partially used until now, however, the thermal water utilisation yielded considerable gas savings in the Kertváros dwelling district (as per data of 1995):

| | |
|---|---|
| consumption of gas as energy supply: | 5,009 GJ a year |
| geothermal energy consumption: | 22,536 GJ a year |

Share of energy types used annually:

| | |
|---|---|
| gas: | 18.2% |
| geothermal energy: | 81.8% |

The other district included in the geothermal energy utilisation was the city centre office district, called Kurca-part, traditional brick buildings which previously obtained heat energy exclusively from the gas-burning heating plant.

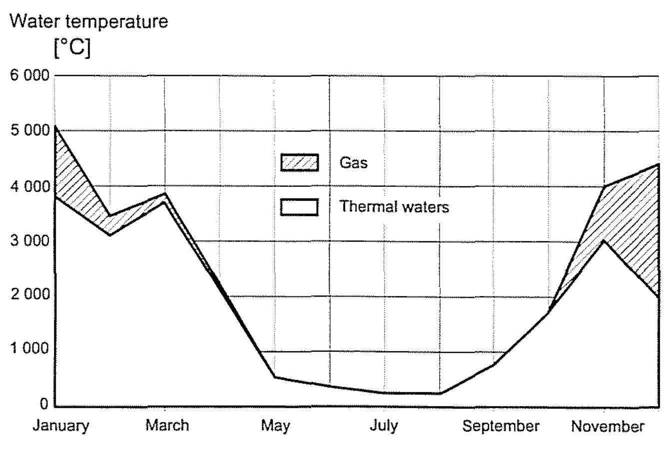


**Fig. 1.** Energy consumption

Heat source properties:

| | |
|---|---|
| 4 gas based furnaces: | type CKF 1000 |
| possible maximum heat output: | 4.0 MW |
| temperature jump of the direct system: | 90/70 °C |
| actual heat output: | 2.6 MW |
| heated volume of buildings: | 79,500 $m^3$ |

Until the switchover, the annual quantity of consumed gas was 440,630 $m^3$ a year with a calorific value of 15,260 GJ a year. Furnace plant efficiency was 0,82.

## 6 Geothermal Energy (Thermal Well) Utilisation before Modernisation and Extension

Thermal water exploitation in the winter heating season was 30 $m^3$/h, cooling within thermal water utilisation: Dt = 42 °C in winter, Dt = 18 °C in summer (hot water production). Specific utilisation: 0.156 GJ/$m^3$ in winter, 0.068 GJ/$m^3$ in summer.

It was a positive well operated without a pump. Heat utilisation level was so low that the temperature of the thermal water running away might have been 60°C in summer. Temperature of thermal water brought to the surface was 94°C without a pump.

Temperature of primary water during the partial repressing was 74°C, with a value of Dt = 23°C, thus reaching a well output as low as 594 kW.

In 1996 this operation with repressing resulted in a surface temperature drop of water exploited by the well and in excess electric energy consumption due to pumping and extra gas consumption in the heating system.

## 7 As-planned and As-is Development

The most important development was the enhancement of the geothermal energy production proposed by us and included in the study, then in the working plans. Exploitation of thermal water was developed with the help of a wet-pit pump, leading to an increase of the exploited thermal water to 60 $m^3$/h.

75% of the produced primary water goes to Kertváros dwelling district via a new heat exchanger where heating and hot water are produced by geothermal energy. Nominal heating output from thermal water has increased to 1.29 MW.

25% of the primary water is led to Kurca-part district and is mixed with the primary water already used in Kertváros. Thus, primary water of 76°C is transported by pipelines to the existing heating centre in Kurca-part. Thermal energy is utilised here with a new heat exchanger.

Cooled thermal water already used in two stages is piped to the swimming pool, utilising it in the third stage for heating water for basins and warming hot water.

The new, modernised thermal water supply is achieved in accordance with thermal water's primary temperature based control chart as shown in Fig. 2.

Heat output of thermal energy is given in Fig. 3, showing in summer the heat demand for hot water. Left of the intersection of both curves there is a gas–geothermics mixed operation in a value of about 1000 hours yearly. Gas operation may be 0-2.2 MW in this case.

Total energy consumption: 7,651 MWh; from which
geothermal energy: 6,651 MWh (86.8%)
gas energy: 1,000 MWh (11.32%) = 3600 GJ.

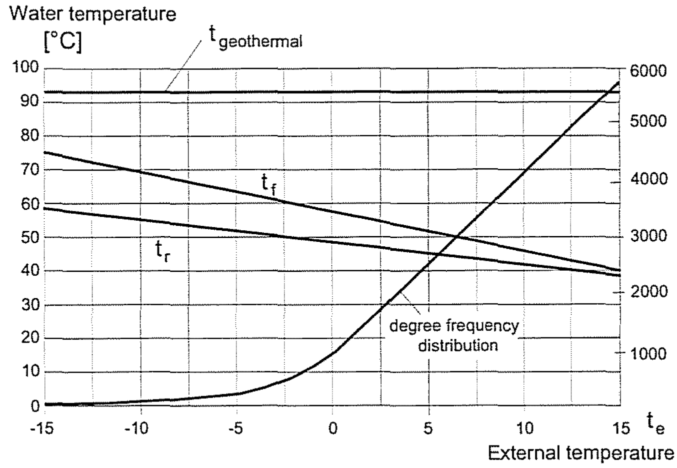


**Fig. 2.** District Kertváros

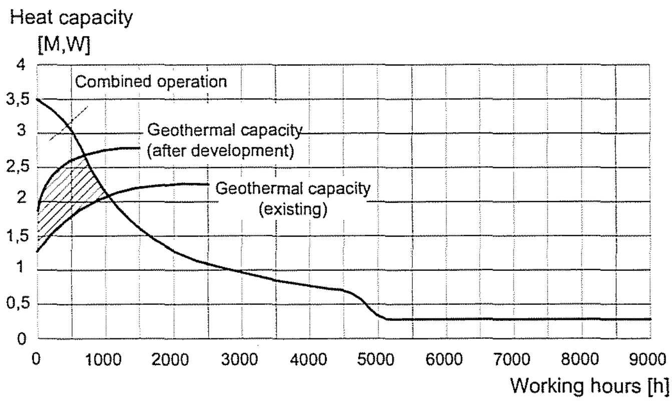


**Fig. 3.** District Kertváros Heating Characteristics

In accordance with our proposal, geothermal energy has been supplied to Kurca-part district, i.e. 60 $m^3$/h of thermal water with a temperature of 76°C has been piped here. The control chart of the system can be seen in Fig. 4 while output values are contained in Fig. 5. This figure demonstrates the relation of geothermal energy and heat demand, including the thermal water–furnace mixed operation of about 1200 hours.

Gas power input equals about 1.95 MW, gas consumption during mixed operation reaches 4,140 GJ a year.

Total heat consumption: 3,473 MWh (12.503 GJ), from which
gas: 1,150 MWh; 33.1%
geothermal heat: 2,323 MWh; 66.9%

The calorific value of geothermal energy allows replacement of 2,700 MWh gas as energy carrier, allowing for the system's efficiency.

With inclusion of the swimming pool, thermal water savings of the system yield 121,000 m$^3$ a year.

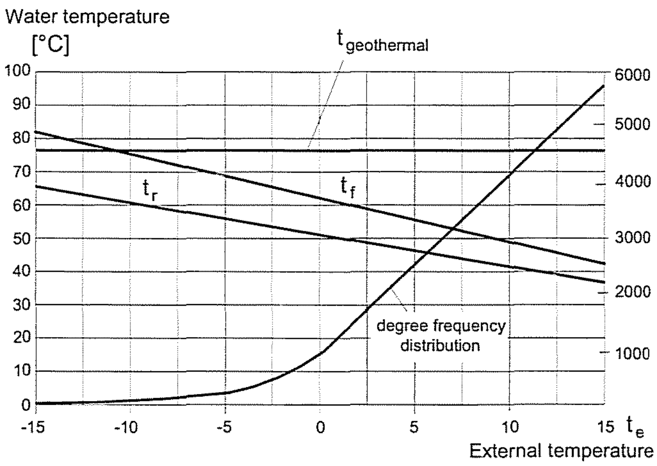


**Fig. 4.** District Kurca-part

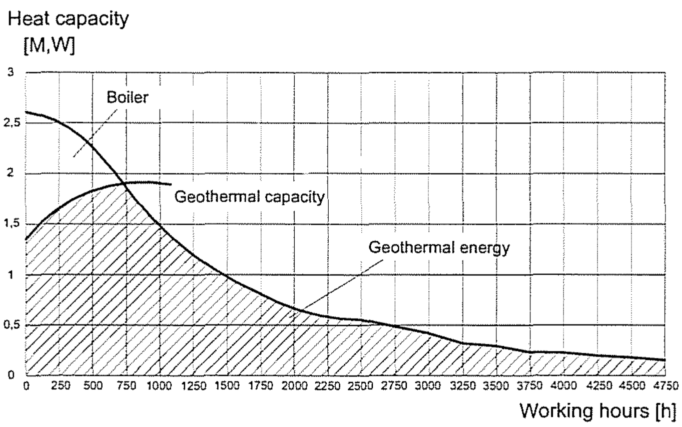


**Fig. 5.** District Kurca-part Heating Characteristics

### 8 Costs of Energy Savings

Geothermal energy consumption after the development:

| | |
|---|---|
| in Kertváros dwelling district: | 23,944 GJ/year |
| in Kurca-part district: | 8,368 GJ/year |
| in total: | 32,307 GJ/year |

Specific consumption: 0.188 GJ/m$^3$

Total heat quantity of gas replaced by geothermics, considering furnace plant efficiency: 26,167 GJ/year.

Electric energy input of the wet-pit pump, mining annuity and water utilisation fee to be paid for thermal water occur as additional costs.

Net cost savings: HUF 14.5 million a year.

### 9 Conclusion

The main task and further research aim is to assure the surface flow of cooled thermal water, which means complying to the environmental regulations. In the planning of district-heating systems in other towns the methods in Szentes are to be used. The perfect solution is the combined usage of heat and water, when the discharged, partially cooled water of the heating system is used by the adjacent pool or gardens. Only the combined usage of heat and water provides total annual exploitation

The operation of peak boilers in Szentes was economically efficient, however the use of heat pumps with regard to the cost of electricity in Hungary were not.

With establishing controlled heat centres based on geothermal energy, in Southern Hungary the expansion of further thermal water systems is possible.

Our calculation was proved by the first two years' winter operation of the district-heating in Szentes.

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