# GEOTHERMAL ENERGY IN HUNGARY

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## Introduction

All over the world the utilization of geothermal energy has been concentrated primarily around the exploration and exploitation of high-temperature (appr. 100 °C) steam and hot-water resources. Such high-temperature water can only be found, however, in a few post-volcanic territories of the world, such as in Japan, Iceland, Italy, USA, and New Zealand. On the other hand, the results of geological explorations have shown that relatively low-termperature thermal water resources exist in abundance in many areas of our Earth. The total thermal energy of these moderate-temperature, deep-seated waters surpasses with several orders of magnitude that of the known high-temperature steam and hot-water resources and, what is more important, their frequent occurrence offers more opportunity for the utilization of geothermal energy.

**Table 1**

Geothermal wells in Hungary in January 1977, their number and temperature structure

| °C | Number of wells | % | m³/min | % |
|---|---|---|---|---|
| 35–44 | 226 | 41.4 | 131.010 | 28.9 |
| 45–49 | 156 | 28.7 | 118.372 | 25.9 |
| 60–69 | 64 | 11.7 | 69.778 | 15.2 |
| 70–79 | 44 | 8.1 | 52.144 | 11.4 |
| 80–89 | 25 | 4.6 | 33.760 | 7.4 |
| 90– | 30 | 5.5 | 51.196 | 11.2 |
| Total: | 545 | 100.0 | 456.260 | 100.0 |

There are no high-temperature volcanic steam or hot-water resources in Hungary but a considerable quantity of moderate-temperature (below 100 °C) thermal water is available. Hungary, like many other countries poor in traditional sources of energy, has been long ago compelled to take steps for the utilization of geothermal energy. The first plants of this type were established in Budapest some 40 – 50 years ago but they have spread all over the country only during the past 10 to 15 years.

Table 1 shows the number of the operating geothermal wells in Hungary up to early 1977, their temperature and flow-structure. They are the result of a large-utilization program initiated in 1961 by the State Office of Technical Development.

In general for heating purposes only the thermal waters above 60 °C come into account. They present 29.9% and their flow 45.2% of the total amount of wells.

## Engineering and Development

Hungary has good possibilities for the production of geothermal energy. The values of the "geothermal gradients" are favourable; in many districts 1 °C increase of temperature is registered for every 15 to 20 m of depth. (In the neighbour countries the corresponding characteristics are between 30 to 40 m/°C.) This fact may be explained by the relative thinness, in Hungary, of the earth's crust above the magma (24 to 26 km).

In addition to this favourable geothermal feature another hydrogeological factor must be considered, namely that at a depth of 1500 to 2500 m below the surface many milliard cubic meters of water are stored in sedimentary layers. This water takes up the temperature of the neighbouring layers and when opened up, will emerge on the surface as thermal water of 70 to 98 °C temperature. The total quantity of this deep-seated water is estimated to amount to 400 to 500 milliards of cubic meters, of which — according to expert opinions — 50 to 300 milliard cubic meters can be usefully exploited. For the time being the annual yield is 160 million cubic meters of thermal water of varying temperatures. This quantity is only 2 to 3 per mil of the total possible production. The heat contained in the now-produced 160 million cubic meters of water with a temperature above 30 °C is equivalent to 1.2 million tons of oil.

As to regional distribution, on about two-thirds of the territory of Hungary, it is possible to exploit thermal water. In the South Eastern part of the country there are considerable supplies of relatively high-temperature thermal water. For example, 21 thermal wells around Szentes, in the South-Hungarian plain, produce in total 2000 cubic meters of 80 – 98 °C water per hour. For the country as a whole the average yield and the water temperatures are lower. These reduced values will determine the possible utilization as well as their technical and economic conditions.

## The Present Use of Geothermal Water

In the area around Budapest many wells have supplied the inhabitants with thermal water for thousands of years; hence the European fame of the city as a watering place. The thermal baths of Budapest were the first to use natural hot water for the heating of buildings. In addition, as early as in 1953, in 16 000 homes, a number of hospitals, and in some other buildings thermal water was supplied in bathrooms and kitchens. For space heating, however, thermal water has almost never been used because of the relatively low-water temperature.

In 1961 a large-scale research and development program was started for utilizing the geothermal energy supply of the whole country. First at Szeged, a city on the South-Hungarian plain, approximately a thousand newly built homes have been connected to a thermal well yielding 90 $m^3/hr$ of 90 °C water. Later 11 blocks of the Medical University buildings were provided with thermal water heating. In both cases the old boilers have been left for peak loads. In rapid succession larger geothermal heating installations have been established in other towns and, as a side benefit, warm water has been supplied to households.

Experience has shown, however, that the most important applications field of geothermal energy was in agriculture. In 1966 only very few greenhouses (total area 1000 to 2000 square meters) were heated by geothermal energy. Since that time the total area has increased to half a million square meters, and 1.2 million square meters of foil-covered vegetable-growing houses are heated with geothermal energy. Development has continued and currently Hungary has more greenhouses heated with geothermal energy than any other country in the world.

In these horticultural plants the circulated thermal water is first introduced into the greenhouses which require high temperatures. Next, the water, still 30 to 40 °C warm, is secondarily circulated through pipes under the plant-beds to heat the soil. Finally, the temperature of the outgoing water will be 20 to 25 °C. Geothermal energy is also widely used for heating poultry and pig farms, as well as for drying roughage and corn fodder or vegetables. The energy utilization structure is shown in the following table

**Table 2**

Utilization structure of geothermal energy in Hungary

| Field of utilization | Number of installations | % | Flow, l/min | % |
|---|---|---|---|---|
| agricultural heating | 81 | 70 | 118 000 | 76 |
| communal heating | 9 | 8 | 12 000 | 8 |
| industrial purposes | 15 | 13 | 12 000 | 8 |
| reinjection | 10 | 9 | 12 000 | 8 |
| Total: | 115 | 100 | 154 000 | 100 |

## The Economics of Geothermal Heating

With respect to economy, the costs of both the investment and the operation of geothermal heating equipments must be separately examined and compared to the costs of an equivalent oil-heated equipment. In this study we cannot analyze the costs in detail but, based on the comparison of investment costs and average costs over many years of operation it may be said that in case of favourable basic conditions and careful planning, the investment costs will not exceed those of oil-heated boilers. Under less favourable conditions the proportion can be 1.2 or 1.3. On the other hand, operational costs with geothermal energy will not amount to more than 20 to 25 per cent of an oil-heated equipment including amortization; so the additional costs of the equipment will be amortized within 2 to 3 years.

The useful life of the equipment is estimated to be 20 to 25 years.

Considerable advantages are connected with geothermal heating plants. In towns and cities they are the most hygienic type of heating as they are entirely smokeless. In the country-side — as a source of local energy — they will help to develop an intensive agricultural economy.

## The Problems of Geothermal Installations

Thermal waters rushing up from the depths of the earth contain not only thermal energy but — depending on the composition of the surrounding strata — they may also contain minerals and gases which may make their utilization more difficult, in some cases even impossible. If Ca, Mg, or $H_2CO_3$ are present the deposition of solid scale crusts may grow to such proportions that pipe systems can become plugged as soon as within 6 to 8 days of operations. Solid scales may block well pipes down to depths of 50 to 60 m, and, under unfavourable conditions, even 200 m. For the removal of crusts or the prevention of encrustation, certain techniques and procedures have been developed, and the troublefree operation of heating equipments for homes, hospitals, and horticultural plants has become a reality.

In Hungarian thermal waters corrosive effects were mainly encountered with thermal waters containing $CO_2$ and $H_2S$; in these cases it was necessary to develop suitable protective measures to avoid the need for very expensive pipe systems made of special materials.

The result of the research aimed at the prevention of scale deposition was that the direct use of thermal waters for warm water supply and heating became possible without the risk of harmful consequences. With these protective measures considerable expenses due to heat-exchangers and large-sized radiators may be avoided.

The design and operation of heating equipment for the utilization of geothermal energy raised a number of more or less serious technical problems normally not encountered with conventional equipment; they must be solved for the sake of safety and economic operation. These problems include the control of water intake, the improved design of heating equipment, and some special financial and legal questions. I will mention a few such problems which must be solved for enabling the economical and extensive exploitation of geothermal energy.

The following basic problems will very likely require thorough attention in most projectors of this type:

1. Geothermal energy (that is, thermal water) as a diluted form of energy cannot be transported: this means that it must be used on the spot for economical operation.

2. In any thermal well — even in those with relatively high-water temperatures and considerable yield (for example, 80 or 100 cubic meters per hour), only a small proportion of the heat can be utilized; hence, if great quantities of heat are required (heating of an entire district) a series of thermal wells must be installed. Between the individual wells the distance should be appr. 1 to 1.5 km to prevent mutual flow interference; thus a system of long interconnected pipe-lines is inevitable and increases the costs.

3. If thermal wells are utilized for heating purposes only, the utilization factor for a year of operation will be no more than 20 to 30 per cent — at least in the first couple of years —. It is very difficult to develop a system which during the greater part of the year will profitably utilize the thermal capacity of the wells.

4. Owing to the low heat content of thermal waters as compared to hydrocarbon fuels, many thousand cubic meters of thermal water must be brought to the surface, pumped, stored and disposed of. This in itself represents a considerable problem.

5. The exploitation of the thermal energy yielded by a well can be improved by using a greater part of the heat, by going down to lower temperatures and, in addition, by the combination of heat supply with other sources of thermal energy. In such applications very careful preliminary calculations and considerations are required to ensure economicalness.

6. With the increasing number of thermal wells it will be difficult to dispose great quantities of spent thermal waters in small areas. Environmental considerations may sometimes question the justification of the use of geothermal energy.

Naturally the afore-mentioned problems will not present themselves at the same time or with the same intensity. Planning should size up the situation correctly, eliminate difficulties, and satisfy the requirements of the economic utilization of geothermal energy.

## Future Developments

In Hungary the utilization of geothermal energy has progressed considerably and the technical and economic results are good. On the basis of existing results an increase of the exploration and exploitation of Hungarian geothermal energy resources has been envisaged.

According to our plans, in the next decade geothermic heating will be used for all horticultural greenhouses, more geothermal energy will be used for the heating of animal barns, for fodder drying and, for the refrigeration of storage plants.

Further plans will extend to the use of warm for space heating, and warm water will be supplied to existing and new urban settlements with the maximum utilization of local geothermal possibilities. This means in the next ten years the utilization of geothermal energy at various levels in about 200 000 homes.

Within the framework of the complex utilization of thermal energy water which has cooled down partly in the course of space heating may be employed for bathing purposes. The national geothermal energy program includes the establishing of bathing facilities for the public, for medicinal balneological purposes and the development of watering places for tourists.

The implementation of this program may save yearly an increasing amount of fuel oil and lead to the utilization of an almost untapped source of energy. New technical and other problems may arise, but after their solution it will be possible to increase the effectiveness and economy of geothermics. Based on the experiences gained so far, it can be hoped that solutions to all these problems can and will be found. Many foreign experts have visited Hungarian geothermal installations, and we in turn, have served as consultants in geothermal planning projects for the Soviet Union, Bulgaria, Czechoslovakia, Austria, France, Japan, and other countries. Cooperative activity of this type will greatly contribute to the economical exploitation of this new form of natural energy.

## Summary

About two thirds of the Hungarian territory has special geothermal features. The thermal gradient is 15 to 20 as against 30 to 40 m/°C in neighbouring countries. In most regions, sedimentary rocks at depths of 1000 to 2500 m, contain hot water. About 15 years ago wide-range energy-utilization schemes have been launched resulting actually in about 1,000.000 sq.m. of greenhouses, 1,200.000 sq.m of plastic sheet-covered greenhouses, and thousands of dwellings heated with thermal water. The construction and operation of special wells and installations offered ample experience in the economy of utilization, in the solution of technical problems. Still, research and development are progressing with regard to special problems.

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