Results Achieved in Hungary in the Utilization of Geothermal Energy

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ABSTRACT

Post-volcanic territories rendering hot water and steam at temperatures of 100°C are found only in a few places on earth. Ever growing importance is being granted to geothermic areas rendering large quantities of water of 30°C to 100°C temperature which may be found in many areas all over the world. Hungary is one of the countries which possesses exceptionally large resources of thermal water. The exploitation of thermal water in Hungary was started several decades ago.

The exploitable thermal water resources of Hungary have been estimated to be 50 to 300 milliards of cubic meters (50 to 300 × $10^9 m^3$). Approximately 400 thermal wells annually supply 160 million cubic meters of water with temperatures between 30°C and 98°C; the heat content of this quantity of thermal water is the equivalent of that of 1.2 million tons of oil.

With the developed thermal water many thousands of homes, public institutions, horticultural glasshouses, foil-covered greenhouses, and numerous pig and poultry barns are heated. There are also 135 thermal open-air bathing pools and medicinal baths in operation.

According to data derived from presently operating establishments, the cost of investment of geothermic heating plants is, in general, identical with that of oil-fired plants, while operational costs amount to only about 25 to 50 percent of the oil-fired plants' costs.

Many harmful effects originating in the chemical composition of thermal waters can be eliminated, but for practical large-scale industrial application of geothermic energy a number of fundamental problems must still be solved. For example, the quantity of geothermic energy exploitable on a site of given surface area is limited. Geothermal energy can be utilized only on the site of recovery or very close to it. Because of the low specific heat of thermal water, the quantity of water needed for a large heating requirement would be excessively large. The efficiency of the yearly thermal exploitation of a well, if only used for heating, will be very low and the chief problem will be how to utilize more of the produced thermal energy. This problem may be considerably lessened by establishing expedient approaches for fuller exploitation.

In Hungary very good technical and economical results have been attained in the exploitation of geothermic energy. Based on these experiences and aiming at further economy in the use of geothermic energy, a much larger program for the utilization of geothermic energy is planned. The goal is to employ geothermic energy for all horticultural production and to also use it in other sectors of agriculture. The introduction of a warm water supply and the partial heating of an additional 200 000 homes is also planned. A considerable program for the utilization of thermal waters in medicinal baths, thermal open-air bathing pools, and in connection with tourism should be realized.

Geothermal installations in Hungary have been visited and studied by many foreign experts and good international cooperation has been established. It may be hoped that additional research work will lead to the direct "mining" of geothermic energy, without the employment of thermal water.

INTRODUCTION

All over the world, the utilization of geothermal energy has been concentrated primarily upon the exploration and exploitation of high-temperature (about 100°C) steam and hot water supplies. Such high-temperature water may 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 exploration have shown that relatively low-temperature thermal water resources are found in great abundance in many areas of our earth. The total thermal energy contained in these moderate-temperature, deep-seated water supplies is some orders of magnitude greater than that of the known high-temperature steam and hot-water resources and, what is more important, they may render—owing to their frequent occurrence—more opportunity for the exploitation of geothermal energy.

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 exists. Hungary, like many countries which are poor in traditional sources of energy, was long ago compelled to take steps for the utilization of geothermal energy. The first plants of this type were established in Budapest 40 to 50 years ago but have spread all over the country only during the past 10 to 15 years.

ENGINEERING AND DEVELOPMENT

Hungary has great possibilities for the exploitation of geothermal energy. The values of "geothermic gradients" are favorable; that is, there are districts where, for every 15 to 20 m of depth, 1°C increase of temperature is registered. (In the surrounding countries the corresponding characteristic has values 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 favorable 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. This water assumes the temperature of the neighboring layers and if 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 may be exploited. Current yield is 160 million cubic meters of thermal water of varying temperatures. This quantity represents not more than 2 to 3 per mil of the total possible exploitation. The heat contained in 160 million cubic meters of water with a temperature above 30°C is equivalent to the heat energy released by the combustion of 1.2 million tons of oil.

From the point of view of regional distribution, there exists the possibility for exploitation of thermal water in half the area of Hungary. In the southeastern part of the country great supplies of high-temperature thermal water are situated. For example, 21 thermal wells around Szentes, in the south Hungarian plains, produce 2000 cubic meters per hour of water at 80 to 98°C. For the country as a whole the average yield and water temperature are lower. These reduced values will determine the possible utilizations as well as the technical and economic conditions of them.

PRESENT USES 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 and spa. Budapest thermal baths were the first to employ 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 general heating, however, thermal water has not been much used because of the low water temperature (69°c).

In 1963 a large-scale research program was started for utilizing the geothermic 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 equalization of peak loads. In rapid succession larger geothermic heating installations have been established in other towns and, as a side benefit, domestic warm water supplies were introduced.

Experience has shown, however, that the most important application of geothermic energy is in agriculture. In 1966 very few horticultural greenhouses (total area 1000 to 2000 square meters) were heated by geothermal energy. By 1972 total area had increased to half a million square meters, and 1.2 million square meters of foil-covered vegetable growing houses have geothermal heating. Development has continued and currently Hungary has more horticultural greenhouses heated by geothermic energy than any other nation.

In such horticultural plants the uncirculated thermal water is first introduced into the greenhouses, which require high temperatures. Next, the water, still retaining a temperature of 30 to 40°C, is secondarily circulated through pipes under the plant beds to heat the soil. Finally, the water is let out of the beds at a temperature of 20 to 25°C. Parallel with horticultural applications geothermic energy is widely used for heating poultry and pig farms as well as for drying roughage and corn fodder or vegetables.

ECONOMICS OF GEOTHERMIC HEATING

In respect to economy, the costs of both investment and operation of geothermic heating equipment must be separately examined by comparing them with the costs of oil-fired equipment of the same capacity. There is no possibility within this study to analyze the costs in a detailed manner but, based upon comparison of investment costs and average costs over many years of operation it may be ascertained that with favorable basic conditions and very careful planning, the costs of investments will not exceed those of oil-fired boilers. Under less favorable conditions a proportion of 1:2 or 1:3 may result. On the other hand, costs of operation with geothermal energy will not amount to more than 25 to 50 percent of oil-fired equipment; thus, the additional costs of the equipment will be amortized within 2 to 5 years. Life of the equipment may be estimated at 20 to 25 years.

Considerable advantages are connected with geothermic heating plants. In towns and cities it will be the most hygienic type of heating as it is entirely smokeless. In the countryside—as a source of local energy—it will aid in the development of an intensive agricultural economy.

PROBLEMS OF GEOTHERMAL INSTALLATIONS

Thermal waters rushing up from the depths of the earth not only contain thermal energy but may also—depending on the composition of the surrounding strata—contain minerals and gases which may make utilization impossible. If Ca, Mg, or HCO_3 are present the deposition of solid scale crusts may grow to such proportions that pipe systems can become plugged as soon as after 6 to 8 days of operation. Solid scales may block well pipes down to depths of 50 to 60 m, and, under unfavorable conditions, even 200 m. For the removal of crusts or the prevention of encrustation, certain techniques and procedures have been developed, and trouble-free operation of heating equipment for homes, hospitals, and horticultural plants is a reality.

In Hungarian thermal waters the 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. Using protective measures, considerable expenses connected with heat-exchangers and large-sized radiators may be avoided.

The design and operation of heating equipment for the utilization of geothermic energy has posed a number of more or less serious technical problems not normally encountered with conventional equipment and which have to be solved to ensure safety and economy of operation. These problems include the control of water intake, the improved design of heating equipment, and special questions of financial and legal settlement and the like. As examples I will mention a few problems which, where the economical and extensive exploitation of geothermic energy is required, must be solved.

The following basic problems will very likely require settlement in most projects of this type:

1. Geothermic energy (that is, thermal water) cannot practically be transported; this means that it must be adjusted to the site of exploitation (which is generally fixed) if economical operation is required.
2. For any thermal well—even those of high water temperature and considerable yield (for example, 80 or 100 cubic meters per hour), only a small proportion of heat can be exploited; hence, if great quantities of heat are required (heating of an entire district) a series of thermal wells must be started. Between the individual wells sufficient intervals must be kept (1 to 1.5 km) to prevent mutual interference; thus a system of long interconnecting pipe lines becomes inevitable and limits economy.
3. Owing to the low heat content of thermal waters as compared with that obtainable from hydrocarbon fuels, many thousand cubic meters of thermal water must be brought to the surface, pumped and stored. This in itself represents a considerable problem.
4. If thermal wells are employed for heating purposes only, the utilization factor for a year of operation will be 20 to 30 percent. It is very difficult to develop a system which will, during the greater part of the year, profitably employ the thermal capacity of the wells.
5. The exploitation of the thermal energy yielded by a well may be improved by the reduction of the heat to a low temperature level 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 necessary to prevent them from becoming uneconomical.
6. As the number of thermal wells increases, difficulty will arise with the storage of great quantities of spent thermal water in small areas. Together with problems of environmental protection the justification for the exploitation of geothermic energy may sometimes be questioned.

As a matter of fact, the aforementioned problems may not present themselves at the same time or with the same intensity. One of the tasks of planning is to size up the situation correctly, to eliminate difficulties, and thus to establish the requirements for the positive utilization of geothermic energy.

FUTURE DEVELOPMENT

In Hungary the utilization of geothermic energy has gone through considerable development and has brought good technical and economic results. On the basis of these results an increase in exploration and exploitation of Hungarian geothermic energy resources has been envisaged.

According to plans, in the next decade it is intended to use geothermic heating for all horticultural greenhouses and to increase the use of geothermic energy in the heating of animal barns and in fodder drying and, at the same time, to introduce geothermic energy for the operation of cold storage plants.

It is further planned to introduce warm water space heating and household warm water supply in existing and proposed urban settlements, with maximum exploitation of local geothermic possibilities. This means the utilization of various levels of geothermic energy in about 200 000 homes.

Within the framework of the complex utilization of thermal energy, water which has partially cooled in the course of room heating may be employed for bathing purposes. The national geothermic energy program includes the establishment of bathing facilities for the working masses, for medicinal baths, and for the development of watering places for tourists.

The realization of this program may result in saving many hundreds of thousands of tons of oil yearly and utilizing a natural source of energy which up to the present has been untapped. New technical and other problems may arise, but after these have been settled, it will be possible to increase the effectiveness and economy of geothermics. Based on the experiences gained up to the present, there are good possibilities that solutions for these problems also will be found.

Many foreign experts have visited Hungarian geothermic installations and, as a consequence, we have served as consultants in planning geothermic projects for the Soviet Union, Bulgaria, Czechoslovakia, Austria, France, Japan, and other countries. Cooperative activity of this type will greatly facilitate the economical exploitation of this new form of natural energy and lead to the direct "mining" of geothermic energy—independent of thermal water as a carrier of energy.