GEOTHERMAL AGRICULTURE IN HUNGARY

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GEOLOGIC CONDITIONS

Hungary, a country of 36,000 square miles (93,000 sq km) or about the size of Indiana, is situated in Central-Europe in the Pannonian Basin. The Danube River cuts through the country separating it into two main parts: the Transdanubian Central Range with Lake Balaton in the northwest and the Great Hungarian Plain in the east and south.

In Hungary, there are two main hydrological systems that are associated with geothermal fluids. One, the more significant, is the Upper-Pannonian (Pliocene) series, and the other is in the fractured, carbonatic formations (Ottlik, 1989). The Upper-Pannonian series consists of clastic porous sedimentary rock, mainly sandstones. These porous and permeable sandstone strata contain immense quantities of water, oil and gas deposits of commercial value. The geothermal bearing portions of the formations have a maximum depth of more than 8,00 feet (2,500 m) in the Great Hungarian Plain. These calstic, porous formations are mainly confined aquifers without any recharge (Ferenc and Liebe, 1987). Overlying this formation are Pleistocene sediments nearly 3,300 feet (1,000 m) thick, containing cooler geothermal waters.

The carbonate formations consist of limestones, dolomites and marls of Mesozoic age, from which natural thermal springs issue along the border of the mountainous area (Figure 1). These thermal springs in the Transdanubin Central Range and in Budapest have a long historical record of use, especially for bathing and balneology. These springs have a temperature ranging from 86 to 140°F (30 to 60°C), yield from a few gallons per minute to 8,000 gallons per minute (500 l/s), have a total discharge estimated at 13,000 gallons per minute (830 l/s), and a total dissolved solid content usually less than 1,000 ppm (mg/l)(Ferenc and Liebe, 1987). They are also high in CO_2; thus, they are considered aggressive waters. Recharge for these aquifers is from precipitation in the karstic, mountainous area with an estimated residence time of thousands of years. The majority of these thermal reservoirs are confined since they are overlain by thick sediments. Where they are situated far from mountainous area, the NaCl content is nearly 50,000 ppm (mg/l). The high NaCl content and large depth to the formation (over 3,000 feet - 1,000 m), limit the utilization of this geothermal resource.

The average geothermal gradient is 3°F/100 feet (50°C/km) with a heat flow of 2.1 to 2.4 hfu (90 to 100 mW/m^2)(Horvath, et al., 1983). With the exception of the mountains, the average formation temperature at 3,300 feet (1,000 m) depth is 140°F (60°C) and at 6,600 feet (2,000 m) reaches 230°F (110°C).

Figure 1. Carbonate formation in Budapest with numerous hot springs.

HISTORY OF GEOTHERMAL DEVELOPMENT AND UTILIZATION

The earliest use of geothermal waters in Hungary was from the springs for bathing. This use dates back to the Roman and Turkish periods. Several famous hotels pools and Turkish baths are still popular in Budapest. Drilling for geothermal fluids started in the latter part of the last century, and in the 1920s, artesian wells of nearly 3,300 feet (1,000 m) depth were completed in the southeast (near Szeged) with flowing water temperatures from 140 to 158°F (60 to 70°C)(Ferenc and Liebe, 1987). Since this time, numerous "dry" oil exploration wells have been completed as geothermal producing wells. Approximately 1,000 of these "dry" wells are available; however, less than half are worth completing. By the early 1970s, there were 131 geothermal wells in Hungary, producing over 50,000 gallons per minute (3,300 l/s) with a peak load of 770 MW and an annual load of 260 MW (Boldisar, 1974).

Today, there are over 1,000 geothermal wells producing water above 86°F (30°C). A summary of these wells and their use is presented in Table 1 (Karai, et al., 1990), and a map of the utilization locations shown in Figure 2 (Ottlik, 1989).

The use of low-temperature geothermal water for drinking purposes occurs in areas where drinking water is not available at shallow depth. The most prevalent use is the balneological-therapeutical purposes in indoor and outdoor bath and swimming pools (Figure 3). A very important use is for agriculture and horticulture for the heating of greenhouses, plastic tents and tunnels, discussed in detail below. District and space heating is provided at several selected sites, such as Szeged and Budapest, where over 2,000 and 5,000 flats, respectively, are heated. In the past four years, the