Direct Heat Utilization of Geothermal Resources Worldwide 2005

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SUMMARY

Direct utilization of geothermal energy consists of various forms for heating and cooling instead of converting the energy for electric power generation. The geothermal resources that can be utilized are in the lower temperature range that are more wide-spread than the higher temperature resources used for electricity generation. The major areas of direct utilization are: heating of swimming pools and for balneology; space heating and cooling including district heating; agriculture applications (greenhouse heating and crop drying); aquaculture applications; industrial processing; and geothermal heat pumps. Direct utilization projects are reported in 72 countries with an installed capacity of 28,268 MWt and annual energy use of 273,372 TJ (75,943 GWh) reported in 2005. The equivalent annual savings in fuel oil amounts to 170 million barrels (25.4 million tonnes) and 24 million tonnes in carbon emissions to the atmosphere. Recent trends are to combined geothermal heat and power projects in order to maximize the use of the resource and improve the economics of the project. With the recent increases in fossil fuel prices, it is estimated that direct utilizations will more than double in the next 10 years.

Key words: Geothermal, direct use, balneology, space heating, district heating, greenhouses, aquaculture, industrial processes, heat pumps

INTRODUCTION

Direct or non-electric utilization of geothermal energy refers to the immediate use of the heat energy rather than to its conversion to some other form such as electrical energy. The primary forms of direct use include swimming, bathing and balneology (therapeutic use), space heating and cooling including district heating, agriculture (mainly greenhouse heating, crop drying and some animal husbandry), aquaculture (mainly fish pond and raceway heating), industrial processes, and heat pumps (for both heating and cooling). In general, the geothermal fluid temperatures required for direct heat use are lower than those for economic electric power generation.

Most direct use applications use geothermal fluids in the low-to-moderate temperature range between 50° and 150°C, and in general, the reservoir can be exploited by conventional water well drilling equipment. Low-temperature systems are also more widespread than high-temperature systems (above 150°C); so, they are more likely to be located near potential users. In the U.S., for example, of the 1,350 known or identified geothermal systems, 5% are above 150°C, and 85% are below 90°C (Muffler, 1979). In fact, almost every country in the world has some low-temperature systems; while, only a few have accessible high-temperature systems.

UTILIZATION

Traditionally, direct use of geothermal energy has been on small scale by individuals. More recent developments involve large-scale projects, such as district heating (Iceland and France), greenhouse complexes (Hungary and Russia), or major industrial use (New Zealand and the U.S.). Heat exchangers are also becoming more efficient and better adapted to geothermal projects, allowing use of lower temperature water and highly saline fluids. Heat pumps utilizing very low-temperature fluids have extended geothermal developments into traditionally non-geothermal countries such as France, Switzerland and Sweden, as well as areas of the mid-western and eastern U.S. Most equipment used in these projects are of standard, off-the-shelf design and need only slight modifications to handle geothermal fluids (Gudmundsson and Lund, 1985, and Geo-Heat Center Quarterly Bulletin, 19(1), 1997).

Worldwide (Lund *et al.*, 2005a), the installed capacity of direct geothermal utilization is 28,268 MWt and the energy use is 273,372 TJ/yr (75,943 GWh/yr) distributed among 72 countries; the leading countries are presented in Table 1. This amounts to saving an equivalent 25.4 million tonnes of fuel oil per year (TOE). The distribution of the energy use among the various types is listed in Table 2 and shown in Figure 1 for the worldwide installed capacity, and Figure 2 for the annual energy use. For comparison, the installed capacity in the U.S. (2005) is 7,817 MWt and the annual energy use is 31,239 TJ (8,678 GWh), saving 4.53 million TOE (Lund *et al.*, 2005b). Internationally, the largest uses are for geothermal heat pumps (32%), and swimming, bathing and balneology (30%); whereas, in the U.S., the largest use is for geothermal heat pumps (71%). In comparison, Iceland's largest geothermal energy use is 73% for district heating 17,900 TJ/yr (4,973 GWh/yr) (Ragnarsson, 2005). As can be seen from Tables 1and 2, heat pumps have low load factors (USA), whereas industrial uses have high load factors (NZ) due to the more continuous use in industrial processing.

The Lindal diagram (Gudmundsson *et al.*, 1985), named for Baldur Lindal, the Icelandic engineer who first proposed it, indicates the temperature range suitable for various direct use activities (Fig. 3). Typically, the agricultural and aquacultural uses require the lowest temperatures, with values from 25° to 90°C. The amounts and types of chemicals such as arsenic and dissolved gases such as boron, are a major problem with plants and animals; thus, heat exchangers are often necessary. Space heating requires temperatures in the range of 50° to 100°C, with 40°C useful in some marginal cases and ground-source heat pumps extending the range down to 4°C. Cooling