



# Direct application of geothermal energy: 2005 Worldwide review<sup>☆</sup>

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## Abstract

This paper is a review of worldwide direct applications of geothermal energy. It attempts to update the surveys presented at and after the World Geothermal Congresses of 1995, 2000 and 2005. Seventy-two countries report direct utilization of geothermal energy. In May 2005, the direct-use projects had an estimated installed thermal capacity of 28,268 MWt. The thermal energy usage is 273,372 TJ/year (75,943 GWh/year), a 43% increase over 2000; the annual compound growth rate is 7.5%.

The distribution of thermal energy used by category is approximately 32% for geothermal heat pumps, 30% for bathing and swimming (including balneology), 20% for space heating (of which 83% is for district heating), 7.5% for greenhouse and open-ground heating, 4% for industrial process heat, 4% for aquaculture pond and raceway heating, <1% for agricultural drying, <1% for snow melting and cooling, and <0.5% for other uses. 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.

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## 1. Introduction

Direct use of geothermal energy is one of the oldest, most versatile and also most common form of utilization of geothermal energy (Dickson and Fanelli, 2003). The information presented

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here on direct applications of geothermal heat has been updated with respect to the address given at the World Geothermal Congress 2005 (WGC2005) held in April 2005 in Antalya, Turkey (Lund et al., 2005a,b). Data from 72 countries have been gathered and analyzed. The comparisons made here with information from the World Geothermal Congress 1995 (WGC'95) are based on the report by Freeston (1996), while comparisons with data from the World Geothermal Congress 2000 are based on the paper by Lund and Freeston (2001).

## 2. Data summary

Table 1 is a summary, by country, of the installed thermal capacity (MWt), annual energy use (TJ/year and GWh/year) and the capacity factor referred to 2004. The dataset on wells drilled, professional person-years and investment in geothermal projects during 2000–2005 is incomplete, but significant information can be obtained from the individual papers submitted to WGC2005. The total installed capacity, reported in May 2005 for geothermal direct utilization worldwide, is 28,268 MWt, almost a two-fold increase over the 2000 data, growing at an annual compound rate of 13.3%. The total annual energy use is 273,372 TJ (75,943 GWh), indicating a 43% increase over 2000, and a compound annual growth rate of 7.5%.

Compared to 1995, the capacity has increased 12.6% per annum and the use 9.3% per annum. Thus, it appears that the growth rate has risen in recent years, despite the low cost of fossil fuels, economic downturns and other factors. It should, however, be noted that part of the growth between 2000 and May 2005 is to some extent a reflection of improvements in collecting and collating the data, and includes some countries that were missed in previous reports. The capacity factor is an indication of the amount of use during the year (i.e., a factor of 1.00 indicates that the system is used at a maximum the entire year, whereas 0.5 corresponds to 4380 equivalent full-load hours per year). The worldwide average for the capacity factor is 0.31, down from 0.40 in 2000. This decrease is a consequence of the rise in the use of geothermal heat pumps, which have a worldwide capacity factor of 0.18 in the heating mode.

The growing awareness and popularity of geothermal (ground-source) heat pumps have had the most significant impact on direct use of geothermal energy. The annual energy use for these pumps grew at a compound annual rate of 30.3, compared to 2000, and 19.6%, compared to 1995. The installed capacity grew 23.8 and 23.6%, respectively. This is due, in part, to the ability of geothermal heat pumps to utilize groundwater or ground-coupled temperatures anywhere in the world.

The countries with the largest installed capacity and annual energy use are the USA, Sweden, China, Iceland and Turkey, accounting for about 66% of the total installed capacity and 59% of the annual energy use. Sweden, a new member of the “top five”, achieved this position as a result of its increased use of geothermal heat pumps. However, an examination of the data in terms of land area or population shows that the smaller countries dominate. The “top five” then become Iceland, Israel, Switzerland, Denmark and Georgia (TJ/area), or Iceland, Sweden, New Zealand, Georgia and Denmark (TJ/population). The largest increase in geothermal energy use over the past 5 years has been that of Norway, Denmark, Chile, Netherlands and Portugal, and the largest increase in installed capacity that of Norway, Denmark, Netherlands, Chile and Belgium/Czech Republic, mostly because of the increased use of geothermal heat pumps. These rankings are summarized in Table 2.

In 1985, only 11 countries reported an installed capacity of more than 100 MWt. By 1990, this number had increased to 14, by 1995 to 15, and by 2000 to 23. At present (May 2005) there are 33 countries reporting 100 MWt or more of installed capacity. An additional 11 countries, with respect to 2000, now report some geothermal direct utilization.

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