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# Direct utilization of geothermal energy 2010 worldwide review

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ABSTRACT

This paper presents a review of the worldwide application of geothermal energy for direct utilization, and updates the previous survey carried out in 2005. We also compare data from 1995 and 2000 presented at World Geothermal Congresses in Italy and Japan, respectively (WGC95 and WGC2000). As in previous reports, an effort is made to quantify ground-source (geothermal) heat pump data. The present report is based on country update papers prepared for WGC2010 and other sources of data available to the authors. Final update papers were received from 70 countries of which 66 reported some direct utilization of geothermal energy. Twelve additional countries were added to the list based on other sources of information. Direct utilization of geothermal energy in 78 countries is a significant increase from the 72 reported in 2005, the 58 reported in 2000, and the 28 reported in 1995. An estimate of the installed thermal power for direct utilization at the end of 2009 is used in this paper and equals 48,493 MWt, almost a 72% increase over the 2005 data, growing at a compound rate of 11.4% annually with a capacity factor of 0.28. The thermal energy used is 423,830 TJ/year (117,740 GWh/yr), about a 55% increase over 2005, growing at a compound rate of 9.2% annually. The distribution of thermal energy used by category is approximately 47.2% for ground-source heat pumps, 25.8% for bathing and swimming (including balneology), 14.9% for space heating (of which 85% is for district heating), 5.5% for greenhouses and open ground heating, 2.8% for industrial process heating, 2.7% for aquaculture pond and raceway heating, 0.4% for agricultural drying, 0.5% for snow melting and cooling, and 0.2% for other uses. Energy savings amounted to 250 million barrels (38 million tonnes) of equivalent oil annually, preventing 33 million tonnes of carbon and 107 million tonnes of $CO_2$ being release to the atmosphere, this includes savings for geothermal heat pumps in the cooling mode (compared to using fuel oil to generate electricity).

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## 1. Introduction

Direct-use of geothermal energy is one of the oldest, most versatile and a common form of utilization of geothermal energy (Dickson and Fanelli, 2003). The early history of geothermal direct-use has been reviewed for over 25 countries in the *Stories from a Heat Earth – Our Geothermal Heritage* (Cataldi et al., 1999), that documents geothermal use for over 2000 years. The information presented here on direct applications of geothermal heat is based on country update papers published in the World Geothermal Congress 2010 (WGC2010) proceedings and covers the period 2005–2010. Papers from 70 countries were received, 66 of which reported some geothermal direct-use with 12 additional countries added from other sources such as from WGC2005 and personal communications for a total of 78 countries – an increase of six countries from WGC2005 (Bosnia & Herzegovina, El Salvador, Estonia, Morocco, South Africa and Tajikistan). In the cases where data are missing or incomplete, the authors have relied on country update reports from the World Geothermal Congresses of 1995, 2000 and 2005 (WGC95, WGC2000, WGC2005), as well as from two *Geothermics* publications (Lund and Freeston, 2001; Lund et al., 2005), and personal communications. Data from WGC2010 are also compared with data from WGC95, WGC2000 and WGC2005.

## 2. Data summary

Table 1 is a summary, by country, of the installed thermal capacity (MWt), annual energy use (TJ/yr and GWh/yr) and the capacity factor to the end of 2009. The dataset on wells drilled, professional person-years and investment in geothermal projects during 2005–2009 is incomplete, but significant information can be obtained from the individual papers submitted to WGC2010. The total installed capacity, reported through the end of 2009 for geothermal direct utilization worldwide is 48,483 MWt, a 72% increase over WGC2005, growing at an annual compound rate of 11.4%. The total annul energy use is 423,968 TJ (117,778 GWh), indicating a 55% increase over WGC2005, and a compound annual growth rate of 9.2%. The worldwide capacity factor is 0.28 (equiv-

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**Table 1**
Summary of direct-use data worldwide, 2010.

| Country | Capacity, MWt | Annual use in TJ/yr | Annual use in GWh/yr | Capacity factor |
|---|---|---|---|---|
| Albania | 11.48 | 40.46 | 11.2 | 0.11 |
| Algeria | 66.84 | 2.098.68 | 583.0 | 1.00 |
| Argentina | 307.47 | 3906.74 | 1085.3 | 0.40 |
| Armenia | 1 | 15 | 4.2 | 0.48 |
| Australia | 33.33 | 235.1 | 65.3 | 0.22 |
| Austria | 662.85 | 3727.7 | 1035.6 | 0.18 |
| Belarus | 4.5 | 44.43 | 12.3 | 0.31 |
| Belgium | 117.9 | 546.97 | 151.9 | 0.15 |
| Bosnia & Herzegovina | 21.696 | 255.36 | 70.9 | 0.37 |
| Brazil | 360.1 | 6622.4 | 1839.7 | 0.58 |
| Bulgaria | 98.3 | 1370.12 | 380.6 | 0.44 |
| Canada | 1126 | 8873 | 2464.9 | 0.25 |
| Caribbean Islands | 0.103 | 2.775 | 0.8 | 0.85 |
| Chile | 9.11 | 131.82 | 36.6 | 0.46 |
| China | 8898 | 75,348.3 | 20,931.8 | 0.27 |
| Columbia | 14.4 | 287 | 79.7 | 0.63 |
| Costa Rica | 1 | 21 | 5.8 | 0.67 |
| Croatia | 67.48 | 468.89 | 130.3 | 0.22 |
| Czech Republic | 216.5 | 1290 | 358.4 | 0.19 |
| Denmark | 200 | 2500 | 694.5 | 0.40 |
| Ecuador | 5.157 | 102.401 | 28.4 | 0.63 |
| Egypt | 1 | 15 | 4.2 | 0.48 |
| El Salvador | 2 | 40 | 11.1 | 0.63 |
| Estonia | 63 | 356 | 98.9 | 0.18 |
| Ethiopia | 2.2 | 41.6 | 11.6 | 0.60 |
| Finland | 994 | 7966 | 2213.0 | 0.25 |
| France | 1345 | 12,929 | 3591.7 | 0.30 |
| Georgia | 26.51 | 689.24 | 191.5 | 0.82 |
| Germany | 2485.4 | 12,764.5 | 3546.0 | 0.16 |
| Greece | 134.6 | 937.8 | 260.5 | 0.22 |
| Guatemala | 2.31 | 56.46 | 15.7 | 0.78 |
| Honduras | 1.933 | 45 | 12.5 | 0.74 |
| Hungary | 654.6 | 9767 | 2713.3 | 0.47 |
| Iceland | 1826 | 24,361 | 6767.5 | 0.42 |
| India | 265 | 2545 | 707.0 | 0.30 |
| Indonesia | 2.3 | 42.6 | 11.8 | 0.59 |
| Iran | 41.608 | 1064.18 | 295.6 | 0.81 |
| Ireland | 138.45 | 691.91 | 192.2 | 0.16 |
| Israel | 82.4 | 2193 | 609.2 | 0.84 |
| Italy | 867 | 9941 | 2761.6 | 0.36 |
| Japan | 2099.53 | 25,697.94 | 7138.9 | 0.39 |
| Jordan | 153.3 | 1540 | 427.8 | 0.32 |
| Kenya | 16 | 126.624 | 35.2 | 0.25 |
| Korea (South) | 229.3 | 1954.65 | 543.0 | 0.27 |
| Latvia | 1.63 | 31.81 | 8.8 | 0.62 |
| Lithuania | 47.6 | 411.52 | 114.3 | 0.27 |
| Macedonia | 47.18 | 601.41 | 167.1 | 0.40 |
| Mexico | 155.82 | 4022.8 | 1117.5 | 0.82 |
| Mongolia | 6.8 | 213.2 | 59.2 | 0.99 |
| Morocco | 5.02 | 79.14 | 22.0 | 0.50 |
| Nepal | 2.717 | 73.743 | 20.5 | 0.86 |
| Netherlands | 1410.26 | 10,699.4 | 2972.3 | 0.24 |
| New Zealand | 393.22 | 9552 | 2653.5 | 0.77 |
| Norway | 1000 | 10,800 | 3000.2 | 0.34 |
| Papua New Guinea | 0.1 | 1 | 0.3 | 0.32 |
| Peru | 2.4 | 49 | 13.6 | 0.65 |
| Philippines | 1.67 | 12.65 | 3.5 | 0.24 |
| Poland | 281.05 | 1501.1 | 417.0 | 0.17 |
| Portugal | 28.1 | 386.4 | 107.3 | 0.44 |
| Romania | 153.24 | 1265.43 | 351.5 | 0.26 |
| Russia | 308.2 | 6143.5 | 1706.7 | 0.63 |
| Serbia | 100.8 | 1410 | 391.7 | 0.44 |
| Slovak Republic | 132.2 | 3067.2 | 852.1 | 0.74 |
| Slovenia | 115.6 | 1015.1 | 282.0 | 0.28 |
| South Africa | 6.01 | 114.75 | 31.9 | 0.61 |
| Spain | 141.04 | 684.05 | 190.0 | 0.15 |
| Sweden | 4460 | 45,301 | 12,584.6 | 0.32 |
| Switzerland | 1060.9 | 7714.6 | 2143.1 | 0.23 |
| Tajikistan | 2.93 | 55.4 | 15.4 | 0.60 |
| Thailand | 2.54 | 79.1 | 22.0 | 0.99 |
| Tunisia | 43.8 | 364 | 101.1 | 0.26 |
| Turkey | 2084 | 36,885.9 | 10,246.9 | 0.56 |
| Ukraine | 10.9 | 118.8 | 33.0 | 0.35 |
| United Kingdom | 186.62 | 849.74 | 236.1 | 0.14 |
| United States | 12,611.46 | 56,551.8 | 15,710.1 | 0.14 |
| Venezuela | 0.7 | 14 | 3.9 | 0.63 |
| Vietnam | 31.2 | 92.33 | 25.6 | 0.09 |
| Yemen | 1 | 15 | 4.2 | 0.48 |
| Total | 48.493 | 423,830 | 117,740 | 0.28 |