TRENDS IN GEOTHERMAL APPLICATION

Geothermal Trend Report 2012
48 pages, with 20 tables and 21 figures

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INTERNATIONAL ENERGY AGENCY
Geothermal Implementing Agreement
Annex X: Data Collection and Information

TRENDS IN GEOTHERMAL APPLICATIONS

Survey Report on Geothermal Utilization and Development in IEA-GIA Member Countries in 2012
with trends in geothermal power generation and heat use 2000 - 2012
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1 Introduction

1.1 About IEA Geothermal

The International Energy Agency (IEA) is an intergovernmental organization which acts as an energy policy advisor to 29 member countries in their efforts to ensure reliable, affordable and clean energy for their citizens. Founded during the oil crisis of 1973-74, the IEA’s initial role was to coordinate measures in times of oil supply emergencies. While this continues to be a key aspect of its work, the IEA has evolved and expanded. Today, the IEA’s four main areas of focus are: energy security, economic development, environmental awareness, and engagement worldwide.

To promote international scientific collaboration and to foster research, development and deployment of particular technologies, the IEA created a legal contract, the Implementing Agreement, and a system of standard rules and regulations. The Geothermal Implementing Agreement (GIA), or IEA Geothermal, provides an important framework for wide-ranging international cooperation in geothermal R&D. The GIA went into effect for an initial period of five years in 1997 and is now in its fourth term of operation, which will take its mandate to February 2018. Efforts concentrate on encouraging, supporting and advancing the sustainable development and use of geothermal energy worldwide, both for power generation and direct use applications (Figure 1).

The management of the organization is conducted by an Executive Committee with one participant from each country and each sponsor member, while the management of the various major activities (Annexes) is the responsibility of the Operating Agents and their Annex Leaders. At present, the GIA has 20 members: 14 country members - Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Norway, Korea, Spain, Switzerland, the United Kingdom, and the United States; the European Union, and five sponsors: the Canadian Geothermal Energy Association, Geodynamics Limited, the Geothermal Group of the Spanish Renewable Energy Association, Green Rock Energy Limited and ORMAT Technologies Inc.


The main objective of Annex X is to collect essential data on geothermal energy uses, trends and developments in GIA member countries and to publish these data in an annual report, the Geothermal Trends Report. This report provides a brief overview of data such as installed capacities and produced electricity and heat, as well as relevant political and economic information. Individual reports from each country, which are based on a standardized questionnaire, provide the basis for the data collection presented here. To illustrate trends and a comparison with geothermal uses worldwide, additional data sources, such as the publications associated with the World Geothermal Congress, are also evaluated.

This report “Trends in Geothermal Applications” (2012) presents the third annual collection of standardized data from the 14 GIA member countries. These efforts extend the information provided in the more general GIA Annual Reports. Future trend reports will supply substantial information on geothermal applications and help to illustrate trends in geothermal energy use on an international scale.

For further information see the GIA’s website http://iea-gia.org.

Figure 1: Geothermal energy uses.
1.2 Units and abbreviations

Units for Energy and Capacity

Capacity (thermal, electric): watt \([W_t]\), \([W_e]\)

Energy produced: watt-hour \([Wh]\); joule \([J]\)

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<td>1 million watt-hours ([Wh])</td>
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Exchange rates and country codes

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<td>United States of America</td>
<td>USA</td>
<td>US Dollar (USD or US$)</td>
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Abbreviations

IEA International Energy Agency
GIA Geothermal Implementing Agreement
R&D research and development
RD&D research, development and demonstration
COP coefficient of performance
SPF seasonal performance factor
GSHP/GHP ground source heat pump/geothermal heat pump
BHE borehole heat exchanger
na (data) not available
M million
EGS enhanced/engineered geothermal system
RES renewable energy sources
CAGR compound annual growth rate
TVD total vertical depth
1.3 Glossary

**CAPACITY FACTOR:** Indication of the amount of use over a given period of time, usually one year. For power generation, the capacity factor is the ratio of the actual output of a power plant to its output if operated at full nameplate capacity over a given time. A capacity factor of 1 would indicate a year-round use, and 0.5 would indicate a use of 4,380 full-load hours per year (Lund et al., 2005).

**COEFFICIENT OF PERFORMANCE (COP)/SEASONAL PERFORMANCE FACTOR (SPF):** The COP describes the efficiency of ground source heat pumps. It is the ratio of the output energy divided by the input energy (electricity) and usually varies from 3 to 6 (Curtis et al., 2005). In Europe, this is frequently referred to as the SPF, which is the average COP over the heating and cooling season and takes into account system properties.

**GEOTHERMAL ENERGY:** Heat energy which is contained within the Earth. Geothermal energy derives from residual heat from the original formation of the Earth and from decay of naturally occurring radioactive isotopes. Heat from radioactive decay is estimated to contribute about half of Earth’s total heat flux in newer studies (KamLAND Collaboration, 2011). Figure 2 shows a manifestation of geothermal heat in New Zealand.

**GEOTHERMAL POWER PLANTS:** Hot steam can be used directly from a geothermal reservoir, or after separation from the fluid to drive a geothermal electric turbine, alternatively the turbine can be operated by a working fluid in a second cycle. Three basic plant types are used for electric power generation by geothermal sources:

**Dry steam plants** use hot steam piped directly from a geothermal reservoir to drive the turbines which spin a generator to produce electric power.

**Flash steam plants** are the most common form of geothermal plants. They use high-pressure hot water and convert it to steam to drive the turbines. The cooled steam condenses to water which is injected back into the ground to avoid a depletion of the reservoir.

**Binary cycle power plants** transfer the heat from geothermal hot water to another liquid with a lower boiling point in a second cycle. By passing the geothermal fluid through a heat exchanger, the working fluid is vaporized. The vapor is used to drive a turbine, which again spins a generator to produce power. The vapor is then condensed and reused in a closed cycle. ORC plants use organic working fluids; Kalina Cycle plants use a mixture of water and ammonia.

**HIGH/MEDIUM/LOW ENTHALPY GEOTHERMAL RESERVOIR:**

The enthalpy of a reservoir is used to express the thermal energy content of a system and is the most common criterion to classify geothermal resources (Dickson & Fanelli, 2004). A standard terminology to define low, intermediate or high enthalpy geothermal systems does not exist. The IPCC geothermal report 2008 (Fridleifsson et al., 2008) specifies a reservoir fluid temperature of 180 °C as the boundary between medium and high enthalpy and may serve as a guide value. The threshold for low/medium enthalpy is frequently given at 100 °C.

**INSTALLED CAPACITY:** Nameplate energy output of a power plant or thermal power station.

**OPERATING CAPACITY:** Actual energy output of a plant.

**THERMAL WATERS/BRINES:** Naturally occurring waters with temperatures > 20 °C.

![Figure 2: Whangaparaoa-Atiamuri hot spring in New Zealand.](image)
1.4 Geothermal applications data: an overview

Geothermal energy can be used for a wide range of applications from standard 12 kWt heat pump systems in residential buildings up to geothermal power plants with electric capacities of 100 MWt and more. The application depends mainly on the system’s heat content (enthalpy) and on the designated use of the geothermal source. For geothermal power generation usually a minimum fluid temperature of 100 °C is required.

With the signing of the IEA Geothermal Implementing Agreement, the current 14 GIA member countries have declared their intention to promote the sustainable utilization of geothermal energy worldwide. Accounting for 60% of the world’s geothermal power generation and about half of the geothermal heat produced worldwide, GIA countries contribute a considerable share of the global geothermal energy use. Figure 2 gives an overview of the geothermal energy produced in GIA countries in 2012.

Geothermal heat and power in 2012 - an overview

![Geothermal energy map](image)

2 Geothermal power generation

2.1 Introduction

The designed output of a power plant is indicated by its installed capacity which is denoted in watts [W]. How much energy is actually produced is given by the plant’s capacity factor, which is the ratio of the actual output of a power plant to its output if operated at full nameplate capacity over a given time.

In 2012, nine of the 14 GIA countries produced geothermal electricity. With 3,386 MWₑ installed, the USA contributed the largest share to geothermal capacities in GIA countries, followed by Mexico, Italy, New Zealand, Iceland, and Japan (Table 3, Figure 5).

The total installed capacity in the reporting countries reached about 7,250 MWₑ in 2012. Geothermal power generation amounted to approximately 41,700 GWh, with the USA being the biggest producer. Based on numbers given in Bertani (2012) and a compound average growth rate (CAGR) of 3.2 %, geothermal power worldwide was estimated to have reached an installed capacity of about 11,600 MWₑ and an electricity production of about 71,500 GWh in 2012 (Table 4, Figure 6). About 60 % of the geothermal power generation in the world is thus attributed to GIA countries.

![Figure 4: Geothermal electric turbine. This turbine was the first geothermal turbine operating on the American continent and is today exhibited at the Los Azufres geothermal field, Mexico. The 3.5 MWₑ turbine was installed in Pathé (federal state Hidalgo) in 1956.](image)

### Table 3: Geothermal power generation in GIA countries and worldwide in 2012. cf = capacity factor.

Data: Annex X country reports 2012. World data estimated on an annual growth (CAGR) of 3.2 % based on the numbers given in Bertani (2012).

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Bertani (2012) gives the average worldwide capacity factor for 2010 as 0.7, similar to that for GIA countries in 2012, indicating that average geothermal plants were being operated at about 6,000 full load hours per year. A capacity factor of 1 indicates year-round use, or 8,760 full load hours. Among the GIA countries, capacity factors ranged from 0.24 in Germany to 0.89 in Iceland. Low capacity factors indicate that units were not in full operation during part of the year. Downtimes can be due to maintenance, repair work, legal reasons, or the commissioning of new plants late in the reference year.
2.2 Trends 2000 - 2012: installed capacity

From 2000 to 2010, the installed capacity for geothermal power generation worldwide grew from 7,974 MWₜ to 10,898 MWₜ (Huttner, 2001; Bertani, 2005, 2007, and 2012). Based on a compound annual growth rate (CAGR) of 3.17 %, geothermal power generation in the world is estimated here to have reached 11,600 MWₜ in 2012. In the same period, the installed capacity in GIA countries increased from 4,926 MWₜ in 2000 to 7,247 MWₜ in 2012, contributing about 62 % to the geothermal power generation worldwide (Table 4, Figure 6).

Among the non-GIA countries, the Philippines with an installed capacity of 1,904 MWₜ and Indonesia with 1,197 MWₜ were the major producers of geothermal power in 2010, but El Salvador, Kenya and Turkey also contribute a considerable amount to the worldwide installed capacity (204 MWₜ, 202 MWₜ and 91 MWₜ, respectively; Bertani, 2012). These five countries together with the GIA Member countries account for about 95 % of the worldwide installed electric capacity and annual power production (Figure 6 and 8). This confirms that a rather small number of countries contribute significantly to the world’s geothermal power generation.

The United States accounted for the largest proportion of total increase and installed capacity in GIA countries from 2000 on. The installed capacity in the USA grew from 2,228 MWₜ in 2000 to 3,386 MWₜ in 2012, a total increase of 1,158 MWₜ. Significant growth was also reported from Iceland with 495 MWₜ, New Zealand 357 MWₜ, Mexico 203 MWₜ, and Italy with 90 MWₜ newly installed capacity since 2000 (Table 4, Figure 5).


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</table>
Trends in geothermal power generation: installed capacity in GIA countries 2000 - 2012

Figure 5: Installed capacities in GIA countries 2000 - 2012.

Trends in geothermal power generation: installed capacity in GIA countries, selected non-GIA countries and worldwide 2000 - 2012

Figure 6: Installed capacity in GIA countries, selected non-GIA countries and worldwide 2000 - 2012.
2.3 Trends 2000 - 2012: electricity produced

From 2000 to 2010, the electricity produced by geothermal power plants worldwide increased from 49,261 GWh in 2000 to 67,246 GWh in 2010 (Huttrer, 2001; Bertani, 2005, 2007, 2012). Given a compound annual growth rate of 3.2 % over the past decade, geothermal power generation worldwide is estimated at about 71,565 GWh in 2012. Geothermal power generation in the GIA member countries grew from 33,006 GWh in 2000 to 41,661 GWh in 2012, a compound annual growth rate of 2.2 % (Table 5, Figure 8).

In 2012, geothermal electricity produced in nine GIA countries made up nearly 60 % of the world’s total geothermal power generation, a slight decrease compared to 66 % in 2000. Significant growth was reported from Iceland, where power generation was 1,138 GWh in 2000 and reached 5,210 GWh in 2012, an annual growth rate of nearly 15 %. New Zealand also showed a considerable development in geothermal power generation which reached 5,843 GWh in 2012 compared to 2,756 GWh in 2000, an annual growth (CAGR) of 7 %.

The decrease in power production in Mexico is due to the shutdown of four units (37.5 MW each) at Cerro Prieto because of lack of steam. Also two binary units with a total capacity of 3 MW in Los Azufres were turned off because of technical difficulties.

Geothermal power production in Italy was rather constant over the last ten years with a total annual production of about 5,200 GWh.

In Japan no geothermal power plants were damaged by the big earthquake disaster and the followed nuclear power plant accident. The increase power production of about 36 GWh in 2012 was due to the completion of the repair of the power generation facility in the Uenotai geothermal power plant.

While installed capacities in the United States have increased significantly in the past ten years, reported geothermal power generation in the US remained rather constant until 2011 (Table 5, Figure 7).

Electricity produced 2000 - 2012 [GWh/a]

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<tr>
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<td>1.5</td>
<td>1.5</td>
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<td>19.0</td>
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<td>2,631</td>
<td>2,981</td>
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<td>3,354</td>
<td>3,966</td>
<td>4,589</td>
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<td>15,000</td>
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<td>na</td>
<td>na</td>
<td>55,709.0</td>
<td>na</td>
<td>59,676.6</td>
<td>na</td>
<td>na</td>
<td>67,246.0</td>
<td>69,372.0</td>
<td>71,564.7</td>
</tr>
</tbody>
</table>
Geothermal electricity produced in GIA countries 2000 - 2012

Figure 7: Geothermal power generation in GIA countries 2000 - 2012.

Geothermal electricity produced in GIA countries, selected non-GIA countries and worldwide 2000 - 2012

Figure 8: Geothermal power generation in GIA countries, selected non-GIA countries and worldwide 2000 - 2012.
3 Direct use of geothermal heat

3.1 Introduction

Direct use of geothermal energy is not only one of the oldest but also the most common form of utilization. Thermal waters suitable for direct use applications of geothermal heat usually originate from deep geothermal aquifers. In high enthalpy fields required water temperature may be reached near the Earth’s surface due to a high geothermal gradient. Separated waste water from geothermal power plants can also be used for heating or other purposes.

In this report, we distinguish between centralized installations which directly use geothermal heat in a more exact sense, such as greenhouses, district heating and thermal spas, and geothermal heat pumps.

3.2 Centralized installations for direct heat uses

In 2012, direct use of geothermal heat by centralized installations in GIA countries accounted for an installed capacity of 6,474 MW (Table 6). Germany and Iceland report an increase of 28.2 MW, and 38.4 MW, respectively. Most of the other reported values were similar to the last three years. The reason for this seeming stagnation is mainly due to poor data bases on direct use in the reporting countries. Only a few countries like Germany and Switzerland have annual statistics on heat utilization, most other GIA countries provided annual estimates; however, most data for 2012 were based on data from the previous years.

The same applies for data on produced heat, which shows a slight increase in 2012 compared to 2011 (Table 7). Altogether, capacities and heat production by centralized installations for direct use in GIA countries can be considered more or less stagnant in the three reference years; however, reliable up-to-date statistics were mostly unavailable.

Figure 9: “Geothermal cheese”: Cheese dairy using heat from the San Martino geothermal power plant, Italy.

Common direct use applications are district and space heating (which are not always clearly separated in national statistics), bathing, and the heating of greenhouses. In some regions, geothermal heat is used for snow melting, aquaculture/fish farming or industrial applications. In the Larderello geothermal field in Italy, waste heat from the San Martino power plant is used as cheap and eco-friendly process heat in a nearby dairy for cheese production.

The most widespread application of geothermal heat is by geothermal heat pumps. They contribute the major part of geothermal heat use in the world (Lund et al., 2011). As they use auxiliary energy to raise the fluid’s energy level, they do not actually use geothermal heat in a “direct” way, though they are often summarized with other direct use applications.

Table 6: Installed capacities for direct heat applications (other than heat pumps) in GIA countries 2010 to 2012.

Data: Annex X National Reports 2010 to 2012.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>AUS</td>
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<td>10.3</td>
<td>10.3</td>
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<tr>
<td>CAN</td>
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<tr>
<td>CHE</td>
<td>39.0</td>
<td>33.3</td>
<td>34.5</td>
</tr>
<tr>
<td>DEU</td>
<td>160.8</td>
<td>183.3</td>
<td>211.5</td>
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<td>ESP</td>
<td>22.3</td>
<td>20.6</td>
<td>20.6</td>
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<td>FRA</td>
<td>345.0</td>
<td>345.0</td>
<td>345.0</td>
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<tr>
<td>GBR</td>
<td>na</td>
<td>2.8</td>
<td>2.6</td>
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<td>2,061.3</td>
<td>2,099.7</td>
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<td>500.0</td>
<td>500.0</td>
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<tr>
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<td>2,086.2</td>
<td>2,093.5</td>
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<td>KOR</td>
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<td>43.7</td>
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<td>0.0</td>
<td>0.0</td>
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<tr>
<td>NZL</td>
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<td>563.9</td>
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<td>Total GIA</td>
<td>6,455.7</td>
<td>6,385.4</td>
<td>6,473.7</td>
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</table>
In 2012, geothermal direct heat uses (other than heat pumps) in GIA member countries amounted to 25,348 GWh (Table 7), an increase of 276 GWh from 2011.

If values for installed capacity were stated but values for the produced heat were not provided, annual heat use was calculated using capacity factors for the various categories of use given in Lund et al. (2011) by the following equation (Pester et al., 2007):

\[ E = \left( \frac{P \cdot 8760 \cdot \text{capacity factor}}{1000} \right) \]

where \( E \) = annual production in GWh, \( P \) = installed capacity in MWt, 8760 hours = 1 year

Among the categories, the application of thermal waters for thermal spas and for swimming was the most common geothermal utilization with 10,119 GWh in 2012. The main share was attributed to the widespread use of thermal springs for bathing and swimming in Japan which amounted to 5,759 GWh. Space and district heating together amounted to over 8,200 GWh.

Iceland and Japan, each with a direct heat use of over 7,000 GWh, were the largest producers of geothermal direct heat among GIA countries in 2012, followed by Italy with about 3,000 GWh, New Zealand with 2,600 GWh and the USA with about 2,300 GWh (Table 7).
### Table 7: Direct use of geothermal heat in GIA countries in different categories (other than heat pumps) 2010 - 2012. Heat use in a) GWh and b) TJ/year. Data: Annex X country reports 2010 to 2012.

#### a) Category uses (other than heat pumps): heat produced 2010 to 2012 (GWh/yr)

<table>
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<th>Use (other than heat pumps)</th>
<th>AUS</th>
<th>CAN</th>
<th>CHE</th>
<th>DEU</th>
<th>ESP</th>
<th>FRA</th>
<th>GBR</th>
<th>ISL</th>
<th>ITA</th>
<th>JPN</th>
<th>KOR</th>
<th>MEX</th>
<th>NOR</th>
<th>NZL</th>
<th>USA</th>
<th>Total GWh/yr 2010</th>
<th>Total GWh/yr 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>District heating</td>
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<td>1.8</td>
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<td>548.6</td>
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<td>0</td>
<td>0</td>
<td>173.4</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>336.0</td>
<td>0</td>
<td>302</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>5,177</td>
<td>298.6</td>
<td>305.4</td>
<td>14.8</td>
<td>0</td>
<td>57.0</td>
<td>237.7</td>
<td>6,084</td>
<td>6,098</td>
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<td>Bathing/swimming</td>
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<td>16.6</td>
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<td>3.0</td>
<td>438.0</td>
<td>1,167</td>
<td>5,759</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>898.0</td>
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<td>165</td>
<td>711</td>
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<td><strong>Total/country 2011 (GWh/yr)</strong></td>
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<td>730</td>
<td>67</td>
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<td>20</td>
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<td>3,028</td>
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<td>711</td>
<td>2,593</td>
<td>2,287</td>
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<tr>
<td><strong>Total/country 2012 (GWh/yr)</strong></td>
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<td>77</td>
<td>233</td>
<td>731</td>
<td>67</td>
<td>1,095</td>
<td>12</td>
<td>7,021</td>
<td>3,028</td>
<td>7,250</td>
<td>165</td>
<td>711</td>
<td>2,624</td>
<td>2,287</td>
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</table>

#### b) Category uses (other than heat pumps): heat produced 2010 to 2012 (TJ/yr)

<table>
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<th>Use (other than heat pumps)</th>
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<th>DEU</th>
<th>ESP</th>
<th>FRA</th>
<th>GBR</th>
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<th>ITA</th>
<th>JPN</th>
<th>KOR</th>
<th>MEX</th>
<th>NOR</th>
<th>NZL</th>
<th>USA</th>
<th>Total TJ 2010</th>
<th>Total TJ 2012</th>
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<td>0</td>
<td>6.5</td>
<td>0</td>
<td>1,255</td>
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<td>31.5</td>
<td>0</td>
<td>1,975</td>
<td>0</td>
<td>31.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>624.2</td>
<td>7,542</td>
</tr>
<tr>
<td>Cascaded uses</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,210</td>
<td>0</td>
</tr>
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<td>Space heating</td>
<td>0</td>
<td>0</td>
<td>28.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>18,637</td>
<td>1,075</td>
<td>1,099</td>
<td>53.3</td>
<td>0</td>
<td>0</td>
<td>205.2</td>
<td>855.7</td>
<td>21,903</td>
<td>21,954</td>
<td></td>
</tr>
<tr>
<td>Bathing/swimming</td>
<td>131.2</td>
<td>277.6</td>
<td>811.8</td>
<td>1,347</td>
<td>59.8</td>
<td>10.8</td>
<td>10.8</td>
<td>1,577</td>
<td>4,200</td>
<td>20,731</td>
<td>507.6</td>
<td>6,258</td>
<td>0</td>
<td>1,782</td>
<td>2,425</td>
<td>36,057</td>
<td>36,429</td>
</tr>
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<td>Greenhouses</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>182.9</td>
<td>41.4</td>
<td>673</td>
<td>1,500</td>
<td>373.3</td>
<td>1.4</td>
<td>0</td>
<td>0</td>
<td>352.8</td>
<td>1,133</td>
<td>4,383</td>
<td>4,258</td>
</tr>
<tr>
<td>Agriculture, crop drying</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>76.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>305.3</td>
<td>379</td>
<td>382</td>
</tr>
<tr>
<td>Aquaculture/Fish farming</td>
<td>40.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>173.9</td>
<td>0</td>
<td>1,825</td>
<td>1,800</td>
<td>123.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2,798</td>
<td>6,754</td>
</tr>
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<td>Industry</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>796</td>
<td>349.9</td>
<td>30.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5,893</td>
<td>76.7</td>
<td>7,103</td>
<td>7,146</td>
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<tr>
<td>Snow Melting</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,768</td>
<td>0</td>
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<td>0</td>
<td>16.6</td>
<td>2,333</td>
<td>2,216</td>
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<td>Other</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3.6</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total/country 2010 (TJ/yr)</strong></td>
<td>1,275</td>
<td>na</td>
<td>980</td>
<td>2,561</td>
<td>184</td>
<td>5,430</td>
<td>na</td>
<td>24,599</td>
<td>10,900</td>
<td>25,630</td>
<td>594</td>
<td>2,558</td>
<td>0</td>
<td>10,116</td>
<td>8,233</td>
<td>90,260</td>
<td>91,253</td>
</tr>
<tr>
<td><strong>Total/country 2011 (TJ/yr)</strong></td>
<td>172</td>
<td>na</td>
<td>886</td>
<td>2,626</td>
<td>243</td>
<td>3,810</td>
<td>73</td>
<td>25,200</td>
<td>10,900</td>
<td>25,632</td>
<td>594</td>
<td>2,558</td>
<td>0</td>
<td>9,335</td>
<td>8,233</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total/country 2012 (TJ/yr)</strong></td>
<td>172</td>
<td>278</td>
<td>839</td>
<td>2,631</td>
<td>243</td>
<td>3,940</td>
<td>44</td>
<td>25,276</td>
<td>10,900</td>
<td>26,099</td>
<td>594</td>
<td>2,558</td>
<td>0</td>
<td>9,446</td>
<td>8,233</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Note:** The table data includes all categories of direct use of geothermal heat in GIA countries, excluding heat pumps. The heat use is presented in GWh/yr for 2010-2012 and TJ/yr for 2010-2012. The data is derived from Annex X country reports for the years specified.
3.3 Geothermal heat pumps (GHP)

Residential space heating using ground source heat pumps (GSHP) or geothermal heat pumps (GHP) is the most common application of geothermal energy. According to Lund et al. (2011), geothermal heat pumps accounted for 69.7 % of the total installed capacity and 49 % of total geothermal energy used in 2010.

Geothermal heat pumps use near-surface heat as a renewable heat source. Common systems are horizontal heat collectors, borehole heat exchangers (brine/water systems, Figure 11), and groundwater systems with extraction and injection well(s) (water/water systems). Typical capacities of geothermal heat pumps for residential requirements range from about 10 to 14 kW (GZB, 2010). For heating and cooling of larger buildings, such as offices, commercial buildings and schools, ground source heat pump systems using borehole heat exchangers (BHE), groundwater wells, or energy piles are becoming increasingly popular. Systems for heating and cooling of larger buildings often have installed capacities of several 100 kW.

For the GIA Trend Report, we aimed to distinguish between individual use of small heat pumps in private houses and utilization in commercial and public buildings. Furthermore, we also tried to collect data on geothermal cooling with GHPs. However, as most countries statistics on heat pumps are poor and reliable data were often not available. Therefore, data on small residential systems and larger systems are combined in this report.

Figure 11: Principle of GSHP Systems using borehole heat exchangers. The yellow arrow shows the average geothermal gradient. The enthalpy of near-surface systems, indicated by the shallow cavities on the left side, derives mainly from solar radiation. Image: Courtesy of State Authority for Mining, Energy and Geology, Lower Saxony, Germany (LBEG).

GHP numbers

As not all countries reported current numbers of total and newly installed GHP units, the total number of 1.65 million units given in Table 8 is only a rough approximation of the total number of geothermal heat pumps in operation in GIA countries in 2012. In 2012, the majority of heat pumps were operating in the United States with about 1 million units, followed by Germany (265,000), France (162,303), Canada (89,186) and Switzerland (84,722). Numbers on newly installed heat pumps in 2012 were poorly documented but added up to a total of about 41,000 new heat pumps in seven countries, with the largest increase reported from Germany (22,300 new GHPs) and France (10,365).

Calculation

1. Annual heat use: The annual heat use can be calculated using the installed capacity and the annual full load hours of geothermal heat pumps, which differ due to regional aspects and modes of use. If data for annual heat use were not provided, values were calculated for a given number of heat pumps assuming an average installed capacity of 12 kW, and a mean runtime of 2,200 full load hours/year; stated average values for common heat pump systems worldwide according to Lund et al. (2011).

2. Geothermal contribution: Heat pumps need auxiliary power - usually electricity - to operate. For this report, we outline the geothermal heating contribution of GHP installations (the renewable share of the produced heat). The geothermal contribution can be calculated according to Annex VII of the EU Directive “Renewable Energy” by the equation:

\[ E_{\text{geothermal}} = Q_{\text{usable}} \times (1 - 1/\text{SPF}) \]

where \( E_{\text{geothermal}} \) = geothermal energy in kW, \( Q_{\text{usable}} \) = the estimated total usable heat delivered by heat pumps in kW, \( \text{SPF} \) = seasonal performance factor

For the calculation, a mean SPF of 3.5 and a COP of 4 were used, following various authors (GZB, 2010; Sonnenfroh et al., 2010). The SPF equates to the average coefficient of performance (COP) of the heating and cooling season and takes into account system properties (Curtis et al., 2005).
Heat pump utilization 2012

In 2012, the total installed capacity of geothermal heat pumps in GIA countries amounted to 22,132 MW, with an estimated geothermal contribution of 16,993 MW, almost three times the capacity of all other thermal uses (Tables 6 and 8). The annual heat use was 34,232 GWh or 123,234 TJ. The worldwide capacity of GHPs was 33,134 MW; in 2010 (Lund et al. 2011) with 55,597 GWh produced. Thus, GIA countries contribute a large share of the installed capacity and heat use by geothermal heat pumps worldwide (Table 8).

Geothermal cooling with heat pumps is a low-emission form of air conditioning and a very common use of geothermal heat pumps, which can be used for both heating and cooling. Most countries lack reliable statistics on geothermal cooling, however. Only two countries, Australia and Korea, provided data on geothermal cooling for this report. The data indicate that in warm climate zones, such as experienced in Australia, cooling is by far the more important option of GHP use with 9,828 GWh/yr in 2012. In Korea, cooling equates to nearly half of the heat use with 250 GWh/yr.

Table 8: Geothermal heat pumps in GIA countries: installed capacity and energy use 2010 and 2012. Data: Annex X country reports 2010 and 2012; world data from Lund et al. (2011). Calculation methods see above. This table contains only data for the heating mode. * = data of previous years.

<table>
<thead>
<tr>
<th>Country</th>
<th>Total number of GHP 2012</th>
<th>Number of new GHP in 2012</th>
<th>Installed capacity (geothermal contribution) MW, 2010</th>
<th>Installed capacity (total) MW, 2010</th>
<th>Annual heat use (geothermal contribution) GWh/yr, 2010</th>
<th>Annual heat use (geothermal contribution) TJ, 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUS</td>
<td>390</td>
<td>40</td>
<td>26</td>
<td>26</td>
<td>11</td>
<td>40</td>
</tr>
<tr>
<td>CAN</td>
<td>89,186</td>
<td>6,960</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CHE</td>
<td>84,722</td>
<td>5,224</td>
<td>916</td>
<td>1,129</td>
<td>1,327</td>
<td>1,581</td>
</tr>
<tr>
<td>DEU</td>
<td>265,000</td>
<td>22,300</td>
<td>2,057</td>
<td>2,400</td>
<td>2,880</td>
<td>3,200</td>
</tr>
<tr>
<td>ESP</td>
<td>280</td>
<td>53</td>
<td>60</td>
<td>70</td>
<td>84</td>
<td>140</td>
</tr>
<tr>
<td>FRA</td>
<td>162,303</td>
<td>10,365</td>
<td>1,254</td>
<td>1,339</td>
<td>1,671</td>
<td>1,785</td>
</tr>
<tr>
<td>GBR</td>
<td>14,919</td>
<td>2,437</td>
<td>na</td>
<td>355</td>
<td>355</td>
<td>na</td>
</tr>
<tr>
<td>ISL</td>
<td>10</td>
<td>0</td>
<td>3</td>
<td>1,5</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>ITA</td>
<td>na</td>
<td>na</td>
<td>500</td>
<td>500*</td>
<td>500</td>
<td>472</td>
</tr>
<tr>
<td>JPN</td>
<td>1,113*</td>
<td>na</td>
<td>13</td>
<td>10*</td>
<td>13</td>
<td>13*</td>
</tr>
<tr>
<td>KOR</td>
<td>2,665*</td>
<td>na</td>
<td>171</td>
<td>372</td>
<td>234</td>
<td>509</td>
</tr>
<tr>
<td>MEX</td>
<td>na</td>
<td>na</td>
<td>0</td>
<td>na</td>
<td>0</td>
<td>na</td>
</tr>
<tr>
<td>NOR</td>
<td>26,000*</td>
<td>na</td>
<td>1,000</td>
<td>1,000*</td>
<td>1,000</td>
<td>3,000</td>
</tr>
<tr>
<td>NZL</td>
<td>150</td>
<td>30</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>USA</td>
<td>1,000,000*</td>
<td>na</td>
<td>9,000</td>
<td>9,000*</td>
<td>12,000</td>
<td>18,857</td>
</tr>
<tr>
<td>Total GIA</td>
<td>1,646,458</td>
<td>47,636</td>
<td>14,996</td>
<td>16,993</td>
<td>19,729</td>
<td>22,132</td>
</tr>
<tr>
<td>World</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
</tbody>
</table>
3.4 Trends in geothermal heat use 2000 - 2012

Due to different methods of collecting data, GIA Annex X heat use data can differ from specifications by other authors, though we use categories common in other publications (e.g., Lund et al., 2011) to obtain comparable data. Furthermore, data collections do not always cover exactly the same period. This makes an approach for showing trends for GIA countries from 2000 on much more complicated than for geothermal electricity, where data are generally better documented in national statistics. However, we tried to outline trends in geothermal heat use based on our own data and numbers from other publications.

In 2000, geothermal heat use in the world amounted to an installed capacity of 15,145 MW, and 53,000 GWh produced heat (Lund & Freeston, 2001). In 2010, 78 countries worldwide reported geothermal heating utilizations with a total installed capacity of 48,493 MW, and an annual use of 117,740 GWh/year (Lund et al., 2011). Based on average growth rates from 2000 to 2010, we estimated the worldwide geothermal heating capacity to have reached about 61,000 MW, in 2012, with a heat production of about 138,000 GWh (497 PJ).

In the GIA member countries, the installed thermal capacity was 8,927 MW, in 2000 and reached 28,593 MW, in 2012, with an estimated geothermal contribution of 23,457 MW, (Table 9). Geothermal heat production increased from 25,894 GWh in 2000 to 59,559 GWh (214,411 TJ) in 2012. Altogether, the 14 GIA countries in 2012 accounted for about half of the worldwide geothermal heat production and capacity. Figures 12 and 13 show installed capacities and heat use of geothermal energy worldwide (based on data from Lund & Freeston, 2001 and Lund et al., 2005 and 2011) and in GIA countries. Presumably, the 2010 and 2011 slowdown in growth in the GIA countries resulted from the attempt to include only the geothermal contribution of heat pumps in the Annex X data.

Overall, efforts to show trends for geothermal heat use in GIA countries are based on miscellaneous data sources. We tried to collect standardized data within the GIA from 2010 on, however these data show that reliable and up-to-date statistical data on geothermal heat use is often not available in the reporting countries. Based on the available data, Table 9 provides the best possible estimates of geothermal heat use in the GIA countries. It is the aim of Annex X and Annex VIII (Direct Use of Geothermal Energy) to further improve the GIA’s data base on geothermal heat use in the coming years.

Table 9: Geothermal heat use in GIA Countries 2010 and 2012. Data from Annex X country reports (2010 and 2012); world 2010 from Lund (2011), world 2012 estimated assuming an annual growth rate of 12 % (capacity) and 8 % (heat produced), respectively.

<table>
<thead>
<tr>
<th>Country</th>
<th>Installed capacity (geothermal contribution) MW</th>
<th>Installed capacity (total) MW</th>
<th>Heat use GWh/yr</th>
<th>Heat use TJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUS</td>
<td>132</td>
<td>30</td>
<td>132</td>
<td>38</td>
</tr>
<tr>
<td>CAN</td>
<td>na</td>
<td>811</td>
<td>na</td>
<td>1,079</td>
</tr>
<tr>
<td>CHE</td>
<td>955</td>
<td>1,163</td>
<td>1,366</td>
<td>1,616</td>
</tr>
<tr>
<td>DEU</td>
<td>2,218</td>
<td>2,612</td>
<td>3,063</td>
<td>3,412</td>
</tr>
<tr>
<td>ESP</td>
<td>75</td>
<td>81</td>
<td>92</td>
<td>105</td>
</tr>
<tr>
<td>FRA</td>
<td>1,599</td>
<td>1,684</td>
<td>2,016</td>
<td>2,130</td>
</tr>
<tr>
<td>GBR</td>
<td>na</td>
<td>358</td>
<td>na</td>
<td>358</td>
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<tr>
<td>ISL</td>
<td>2,064</td>
<td>2,101</td>
<td>2,065</td>
<td>2,102</td>
</tr>
<tr>
<td>ITA</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>JPN</td>
<td>2,100</td>
<td>2,094</td>
<td>2,100</td>
<td>2,094</td>
</tr>
<tr>
<td>KOR</td>
<td>215</td>
<td>416</td>
<td>277</td>
<td>553</td>
</tr>
<tr>
<td>MEX</td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
</tr>
<tr>
<td>NOR</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>NZL</td>
<td>374</td>
<td>388</td>
<td>375</td>
<td>388</td>
</tr>
<tr>
<td>USA</td>
<td>9,564</td>
<td>9,564</td>
<td>12,564</td>
<td>12,564</td>
</tr>
<tr>
<td>Total GIA</td>
<td>21,451</td>
<td>23,457</td>
<td>26,207</td>
<td>28,593</td>
</tr>
<tr>
<td>World</td>
<td>48,493</td>
<td>60,929</td>
<td>117,740</td>
<td>138,137</td>
</tr>
</tbody>
</table>
Figure 12: Installed capacity (MWt) of geothermal heat uses in GIA countries and worldwide 2000 - 2012. Figure based on data from Lund & Freeston (2001) and Lund et al. (2005 and 2011); GIA Annual Reports (Executive Summaries) 2007, 2008, 2009, and GIA Annex X country reports: data for 2010 and 2011; world 2011 and 2012 estimated assuming a compound annual growth rate (CAGR) of 12 %.

Figure 13: Annual heat use (GWh/year) in GIA countries and worldwide 2000 - 2012. Figure based on data from Lund & Freeston (2001) and Lund et al. (2005 and 2011); GIA Annual Reports (Executive Summaries) 2007, 2008, 2009, and GIA Annex X country reports: data for 2010 and 2011; world 2011 and 2012 extrapolated assuming a CAGR of 8 %.


4 CO₂ and fossil fuel savings

Energy and CO₂ savings by geothermal applications were calculated using the GIA conversion (Mongillo, 2005).

4.1 Fossil fuel savings by geothermal applications

The fuel oil savings factors used to calculate the savings in the following table are based on the GIA conversion (Mongillo, 2005) assuming an efficiency factor of 35 % if the competing energy is used to replace electricity, and an efficiency factor of 70 % for direct burning to produce heat according to Lund et al. (2005). Fossil fuel savings (Table 10) were estimated using the values for produced geothermal electricity and heat given in the previous chapters.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AUS</td>
<td>119</td>
<td>11,514</td>
<td>11,633</td>
</tr>
<tr>
<td>CAN</td>
<td>0</td>
<td>222,852</td>
<td>222,852</td>
</tr>
<tr>
<td>CHE</td>
<td>0</td>
<td>278,107</td>
<td>278,107</td>
</tr>
<tr>
<td>DEU</td>
<td>6,436</td>
<td>620,931</td>
<td>627,367</td>
</tr>
<tr>
<td>ESP</td>
<td>0</td>
<td>28,748</td>
<td>28,748</td>
</tr>
<tr>
<td>FRA</td>
<td>12,811</td>
<td>481,709</td>
<td>494,520</td>
</tr>
<tr>
<td>GBR</td>
<td>0</td>
<td>74,791</td>
<td>74,791</td>
</tr>
<tr>
<td>ISL</td>
<td>1,320,214</td>
<td>889,687</td>
<td>2,209,901</td>
</tr>
<tr>
<td>ITA</td>
<td>1,326,549</td>
<td>443,437</td>
<td>1,769,986</td>
</tr>
<tr>
<td>JPN</td>
<td>681,347</td>
<td>918,527</td>
<td>1,599,874</td>
</tr>
<tr>
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<td>0</td>
<td>93,233</td>
<td>93,233</td>
</tr>
<tr>
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<td>1,474,028</td>
<td>90,034</td>
<td>1,564,062</td>
</tr>
<tr>
<td>NOR</td>
<td>0</td>
<td>380,100</td>
<td>380,100</td>
</tr>
<tr>
<td>NZL</td>
<td>1,480,616</td>
<td>333,453</td>
<td>1,814,069</td>
</tr>
<tr>
<td>USA</td>
<td>4,254,839</td>
<td>2,678,957</td>
<td>6,933,796</td>
</tr>
<tr>
<td>Total 2012</td>
<td>10,556,959</td>
<td>7,546,082</td>
<td>18,103,042</td>
</tr>
<tr>
<td>Total 2011</td>
<td>10,576,449</td>
<td>7,162,621</td>
<td>17,739,070</td>
</tr>
<tr>
<td>Total 2010</td>
<td>10,167,782</td>
<td>5,787,236</td>
<td>15,955,018</td>
</tr>
</tbody>
</table>

Table 10: Fossil fuel savings by geothermal energy uses in GIA countries in 2012. Calculation based on values for produced electricity and geothermal heat (all uses) given in the Annex X National Reports 2012. toe = tonnes of oil equivalent

4.2 CO₂ emission savings

CO₂ savings for geothermal power generation

The following CO₂ savings (Table 11) were calculated using savings factors given by Lund et al. (2005) assuming an efficiency factor of 35 % for production of electricity. The savings were calculated by the equation:

\[ \text{energy produced} \times \text{savings factor}. \]

Table 11: CO₂ savings for geothermal electricity in GIA countries in 2012.

Calculation based on values for produced electricity from Annex X National Reports 2012.

<table>
<thead>
<tr>
<th>Country</th>
<th>CO₂ emission savings for geothermal power generation [tonnes of CO₂]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gas</td>
</tr>
<tr>
<td>AUS</td>
<td>91</td>
</tr>
<tr>
<td>CAN</td>
<td>0</td>
</tr>
<tr>
<td>CHE</td>
<td>0</td>
</tr>
<tr>
<td>DEU</td>
<td>4,902</td>
</tr>
<tr>
<td>ESP</td>
<td>0</td>
</tr>
<tr>
<td>FRA</td>
<td>9,757</td>
</tr>
<tr>
<td>GBR</td>
<td>0</td>
</tr>
<tr>
<td>ISL</td>
<td>1,005,530</td>
</tr>
<tr>
<td>ITA</td>
<td>1,010,355</td>
</tr>
<tr>
<td>JPN</td>
<td>518,942</td>
</tr>
<tr>
<td>KOR</td>
<td>0</td>
</tr>
<tr>
<td>MEX</td>
<td>1,122,681</td>
</tr>
<tr>
<td>NOR</td>
<td>0</td>
</tr>
<tr>
<td>NZL</td>
<td>1,127,699</td>
</tr>
<tr>
<td>USA</td>
<td>3,240,663</td>
</tr>
<tr>
<td>Total 2012</td>
<td>8,040,620</td>
</tr>
<tr>
<td>Total 2011</td>
<td>8,055,464</td>
</tr>
<tr>
<td>Total 2010</td>
<td>7,152,854</td>
</tr>
</tbody>
</table>
Figure 14: CO₂ emissions of different plant types (Klaus et al. 2009, modified).
(Background picture: Coal plant in Germany © 2006 Bruno & Lígia Rodrigues, from www.flickr.com)

Figure 14 shows the CO₂ emissions of different conventional plant types as stated by the German Federal Environment Agency (Klaus et al., 2009). If the energy source is brown coal, modern plants emit about 0.94 kg CO₂ per kWh produced. CO₂ emissions from burning hard coal are about 0.73 kg CO₂/kWh, and for gas 0.35 kg CO₂/kWh.

A rather small coal-fired plant with 200 MWₑ installed and operating at 6,000 full load hours/year thus would produce over 1 million tonnes CO₂/year, and a gas plant of the same size about 400,000 tonnes of CO₂/year.

Total CO₂ savings by geothermal power generation in GIA countries in 2012 accounted for nearly 40 million tonnes of CO₂ for the replacement of coal, 34 million tonnes of CO₂ for oil, and 8 million tonnes for the replacement of gas, similar to 2011 with an increase of about 6 % compared to savings in 2010.

**CO₂ savings for geothermal heat**

CO₂ savings calculations in Table 12 are based on CO₂ savings factors according to Lund et al. (2005), assuming an efficiency factor of 70 % for direct burning to produce heat and based on the values for geothermal heat production in the previous chapter. The savings were calculated by:

\[
\text{energy produced} \times \text{savings factor.}
\]

In 2012, total carbon dioxide emission savings by geothermal heat uses in GIA countries amounted to about 28.4 million tonnes of CO₂ from coal replacement, 24.4 million tonnes of CO₂ from oil, and 5.8 million tonnes from gas replacement, an increase of about 5 % and 17 % compared to savings in 2011 and 2010, respectively.

**Table 12: CO₂ savings by geothermal heat uses in GIA countries in 2012.** Calculation based on values for geothermal heat from Annex X country reports.

<table>
<thead>
<tr>
<th>Country</th>
<th>Gas (tonnes CO₂)</th>
<th>Oil (tonnes CO₂)</th>
<th>Coal (tonnes CO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUS</td>
<td>8,815</td>
<td>37,169</td>
<td>43,349</td>
</tr>
<tr>
<td>CAN</td>
<td>170,613</td>
<td>719,387</td>
<td>838,992</td>
</tr>
<tr>
<td>CHE</td>
<td>212,915</td>
<td>897,755</td>
<td>1,047,015</td>
</tr>
<tr>
<td>DEU</td>
<td>475,378</td>
<td>2,004,427</td>
<td>2,337,682</td>
</tr>
<tr>
<td>ESP</td>
<td>22,009</td>
<td>92,802</td>
<td>108,231</td>
</tr>
<tr>
<td>FRA</td>
<td>368,790</td>
<td>1,555,003</td>
<td>1,813,536</td>
</tr>
<tr>
<td>GBR</td>
<td>57,259</td>
<td>241,433</td>
<td>281,573</td>
</tr>
<tr>
<td>ISL</td>
<td>681,134</td>
<td>2,871,998</td>
<td>3,349,494</td>
</tr>
<tr>
<td>ITA</td>
<td>339,490</td>
<td>1,431,459</td>
<td>1,669,452</td>
</tr>
<tr>
<td>JPN</td>
<td>703,213</td>
<td>2,965,095</td>
<td>3,458,069</td>
</tr>
<tr>
<td>KOR</td>
<td>71,378</td>
<td>300,967</td>
<td>351,005</td>
</tr>
<tr>
<td>MEX</td>
<td>68,929</td>
<td>290,640</td>
<td>338,962</td>
</tr>
<tr>
<td>NOR</td>
<td>291,000</td>
<td>1,227,000</td>
<td>1,431,000</td>
</tr>
<tr>
<td>NZL</td>
<td>255,287</td>
<td>1,076,418</td>
<td>1,255,382</td>
</tr>
<tr>
<td>USA</td>
<td>2,050,978</td>
<td>8,647,937</td>
<td>10,085,736</td>
</tr>
<tr>
<td><strong>Total 2012</strong></td>
<td><strong>5,777,190</strong></td>
<td><strong>24,359,490</strong></td>
<td><strong>28,409,478</strong></td>
</tr>
<tr>
<td>Total 2011</td>
<td>5,483,616</td>
<td>23,121,638</td>
<td>26,965,822</td>
</tr>
<tr>
<td>Total 2010</td>
<td>4,931,605</td>
<td>20,794,087</td>
<td>24,251,295</td>
</tr>
</tbody>
</table>
5 Employees, costs, investments

Costs for geothermal installations

Information on costs for geothermal plants was reported by four countries. Plant costs can vary widely as they may include different installations, technologies and services, and depend strongly on the individual sites and conditions. The average costs per mega-watt installed electric capacity for geothermal power plants was about US$4.5 million per MW_e in 2012. Reported plant costs ranged from US$3.0 to about 6 million per MW_e (Table 13). Costs for heating plants were not reported for 2012.

Table 13: Plant costs in million US Dollars per MW installed capacity in selected countries. Data from Annex X country reports 2010 to 2012.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DEU</td>
<td>na</td>
<td>2.1</td>
<td>-4.0</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>FRA</td>
<td>na</td>
<td>2.5</td>
<td>-3.0</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>ISL</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>MEX</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>NZL</td>
<td>3.0</td>
<td>4.7</td>
<td>3.6</td>
<td>3.7</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>USA</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>6.2</td>
<td>na</td>
<td>na</td>
</tr>
</tbody>
</table>

Two countries reported costs for geothermal heat pumps in residential buildings that ranged from US$1,440 per kW_t in Korea to US$3,159 per kW_t in Switzerland.

Employees

Reliable numbers of employees in geothermal related jobs were often not available or could only be roughly estimated. The total number of about 41,000 people (Table 14) employed in the geothermal sector in nine reporting countries in 2012 is thus only a rough approximation of professional personnel in the geothermal sector in GIA member countries.

Table 14: Professional personnel employed in geothermal related jobs in selected countries. Data from Annex X country reports 2010 to 2012.

<table>
<thead>
<tr>
<th>Country</th>
<th>Professional personnel in the geothermal sector in million US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>2011</td>
</tr>
<tr>
<td>CAN</td>
<td>na</td>
</tr>
<tr>
<td>CHE</td>
<td>1,200</td>
</tr>
<tr>
<td>DEU</td>
<td>13,000</td>
</tr>
<tr>
<td>ESP</td>
<td>415</td>
</tr>
<tr>
<td>FRA</td>
<td>8,029</td>
</tr>
<tr>
<td>ISL</td>
<td>210</td>
</tr>
<tr>
<td>ITA</td>
<td>1,250</td>
</tr>
<tr>
<td>JPN</td>
<td>500</td>
</tr>
<tr>
<td>KOR</td>
<td>130</td>
</tr>
<tr>
<td>NZL</td>
<td>320</td>
</tr>
<tr>
<td>USA</td>
<td>18,300</td>
</tr>
<tr>
<td>total</td>
<td>43,354</td>
</tr>
</tbody>
</table>

Capital investments

Seven countries contributed information on investments in geothermal power generation, heating plants, in the heat pump market, or the total investment for the year 2012 (Table 15).

While in the previous year total investments added up to US$3.8 billion, the investments in 2012 went back to the year 2010 level of US$2.7 billion. This decrease can be observed in each of the reporting countries and could be seen as a general trend, however it is not representative of the global situation.

Table 15: Capital investments in the geothermal market in selected countries as reported in Annex X country reports 2012.

<table>
<thead>
<tr>
<th>Country</th>
<th>Investment in the geothermal market in 2012 in million US$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>power</td>
</tr>
<tr>
<td>CAN</td>
<td>1</td>
</tr>
<tr>
<td>CHE</td>
<td>0</td>
</tr>
<tr>
<td>DEU</td>
<td>1,230</td>
</tr>
<tr>
<td>FRA</td>
<td>na</td>
</tr>
<tr>
<td>KOR</td>
<td>na</td>
</tr>
<tr>
<td>NZL</td>
<td>500</td>
</tr>
<tr>
<td>USA</td>
<td>327.1</td>
</tr>
<tr>
<td>total</td>
<td>2,058.1</td>
</tr>
</tbody>
</table>
6 Energy market and national policy

6.1 The role of geothermal in national policy

Geothermal energy can contribute to a more sustainable energy supply as it is an eco-friendly, low-emission form of energy. In some countries, geothermal energy forms part of national energy strategies and greenhouse gas emission plans. An overview of how geothermal fits into the national energy strategy, if it is part of policy concepts to reduce greenhouse gas emissions, and of support mechanisms and legal regulations in selected GIA member countries is presented here.

Australia

Geothermal Energy policy is addressed in the Australian Government’s wider policies on Renewable Energy and Climate Change largely captured in its Clean Energy Plan. This includes:

- The introduction of a Renewable Energy Target (RET) of 20% renewable energy generation by 2020.
- The introduction of a Carbon Tax of AU$23 (US$23.55) per tonne on 1st July 2012 with the intention of transitioning to a flexible price cap-and-trade ETS on 1st July 2015 with an interim link to the European Union Emissions Trading Scheme (ETS).
- The creation of the Australian Renewable Energy Agency (ARENA) in 2012 to manage all Australian Government funding for renewable energy generally.
- The creation of the Clean Energy Finance Corporation (CEFC) also in 2012, to invest in renewable energy, low pollution and energy efficiency technologies via loans on commercial or concessional terms and equity investments.

Canada

The lack in both strategy and direction for the geothermal energy industry on the federal level in Canada continued in 2012 and there does not appear to be change on the horizon. Due to the division of legislative powers in Canada, geothermal resource regulation is primarily within the purview of provincial governments. Currently, British Columbia is the only province that has geothermal-specific legislation. However, Government of BC documents openly acknowledge existing deficiencies with the province’s geothermal leasing processes. In Alberta, there remains no avenue whatsoever to obtain a geothermal exploration permit or geothermal lease. Without creating new legislation the Northwest Territories and Saskatchewan have established interim approaches. In the Northwest Territories some permitting is available through the Mackenzie Valley Land & Water Board and in Saskatchewan development is being facilitated through the utilization of Use of Space Agreements that are borrowed from oil and gas legislation.

There have been both provincial and federal programs aimed at promoting renewables. Geothermal power was included under past clean power incentive schemes, specifically, Alberta’s Small Research and Development Act and the Federal ecoENERGY for renewable power program. The problem remains that a developer cannot take advantage of incentive programs if the processes to obtain leases and permits are broken or absent. Ultimately, the programs expired before geothermal developers could make use of them.

Figure 15: 140 MW, Nga Awa Purua triple flash power station near Taupo, New Zealand
On the federal front geothermal energy development remains a lower priority in the context of other energy resources such as oil & gas, hydroelectric, wind, and solar power. Through active policy work and advocacy the Canadian Geothermal Energy Association is making headway in attracting interest and progressive policy to advance the industry. One example of an asymmetrical policy that CanGEA aims to address involves tax incentives designed to promote development, which are afforded to the mining and oil & gas industries, but fail to include the geothermal industry.

**France**

- In 2009, France set a **target of 23 % of renewable energies** in its energy mix for 2020. This objective was written in the European Renewables Directive 2009/28/EC and in the French law (law 2009-967 "Programmation relative à la mise en œuvre du Grenelle de l’environnement").
- France has defined precise **objectives for geothermal heat** in 2012 and 2020:
  - Direct use: from 1.5 TWh in 2006 to 2.3 TWh in 2012 and 5.8 TWh in 2020.
  - Geothermal heat pumps: from 1.0 TWh in 2006 to 3.9 TWh in 2012 and 6.6 TWh in 2020.
  - Geothermal heat use is thus expected to increase by a factor of 5 between 2006 and 2020, whereas the general objective for renewable heat is a factor of 2.
- A **renewable heat fund** has been put into place to fund projects related to industry, collective housing and commercial buildings. US$1.5 billion has been allocated to cover the 2009 to 2013 period, for all renewable energies. The principle is to bridge the financial gap between a project using renewable heat and a reference solution (natural gas). Development of heating networks and subsidies for feasibility studies can also be funded. In addition, there is a tax reduction for heating networks using more than 50 % renewable energy (the tax paid by the customer is 5.5 % instead of 19.6 %).
- **Geothermal electricity** is expected to reach 80 MWₑ in France in 2020. There are two main priorities for this objective: 1) To reduce the reliance on fossil fuel generation in the French West Indies and La Réunion by introducing low carbon technologies at a reasonable cost, and 2) to increase the deployment of EGS by 2050, geothermal research will focus on EGS projects and technologies.

- A higher **feed-in tariff** was put in place in July 2010. It is now US$168/MWh overseas and US$259/MWh on the mainland, with a bonus of up to US$104/MWh if co-produced heat is utilized.
- At the end of 2011, the French Government has organized a call to fund innovative deep geothermal demonstration projects for heat and/or power generation.

**Germany**

Germany has set itself ambitious climate protection targets and resolved to phase out the use of nuclear energy by 2022. By the middle of this century, the German Government aims for an energy supply based predominantly on renewables, meeting 80 % of electricity consumption and 60 % of final energy consumption by 2050.

The share of renewable energy sources in Germany’s gross electricity consumption rose significantly again in 2012 to reach 22.9 %. This represents an increase of nearly two and a half percentage points against the previous year (20.5 %). At 136 million kilowatt-hours (kWh) electricity generation from solar, wind, hydro, biomass and geothermal was around 10 % higher than in 2011.

![Figure 16: Drill rig at Kirchstockach, Germany.](image-url)
The use of geothermal energy offers significant potential, and could theoretically meet Germany’s energy demands several times over. Considerable efforts have already been made to tap into this potential, from the exploration and development of particularly suitable regions and the development of drilling technologies, through to systems for converting extracted geothermal heat into electricity.

In Germany, there are three regions particularly well positioned to use geothermal energy – the North German Basin in the northern third of Germany, the Upper Rhine Graben in the south-west, and the Molasse Basin in the south.

In 2012, two sites in these regions were developed for electricity generation: Sauerlach (Bavaria) and Insheim (Rhineland-Palatinate) joined the existing sites in Landau (Rhineland-Palatinate, 2007), Unterhaching (Bavaria, 2008/2009) and Bruchsal (Baden-Württemberg, 2009).

Three further geothermal projects to generate electricity are currently under construction: Kirchstrockach, Kirchweidach (both in Bavaria) and Oberhaching (likewise Bavaria, electricity as secondary use only). According to the German Geothermal Association (GTV), in October 2012 there were 20 geothermal CHP plants in operation in Germany which supply households, companies and public buildings with thermal energy via district heating networks.

**Iceland**

It is the policy of Iceland’s Government to further increase the utilization of renewable energy resources in power intensive industries, direct use and the transport sector, in harmony with the environment. A broad consensus on conservation of valuable natural areas has been influenced by social opposition, increasing over the last decade, against large hydropower and some geothermal projects.

- The Icelandic National Renewable Energy Action Plan (NREAP) was published in 2012 in accordance with Directive 2009/28/EC which outlines the strategy for 2020 especially in terms of increasing the share of renewable energy in transport. A parliamentary resolution was passed which categorizes geothermal and hydro resources to be exploited, protected or further researched in accordance with Act No. 48/2011 for the utilization and protection of energy resources which sets up the legal framework for the Master Plan (ranking of potential power projects). There has also been a governmental effort to search for geothermal resources in areas where geothermal energy has not yet been found.

- Two major amendments were made in 2012 to the **energy legal framework** in Iceland that effect geothermal exploration and utilization:
  1. Grants to new geothermal heat utilities were increased from being the equivalent of the accumulation of space heating subsidization with oil or electricity of 8 years to 12 years. In addition, if the project receives other grants it will not effect in any way this lump sum payment (Act No. 78/2002).
  2. Promotion of the use of energy from renewable sources was further stipulated by changing law no. 30/2008 taking into consideration Directive 2009/28/EC.

**Italy**

Geothermal energy is included in the national energy strategy to reduce greenhouse gas emissions. Italian policy supports development through a **new law on incentives for renewable electricity** which came into force in July 2012. Feed-in tariffs for renewable resources are calculated using a different approach depending on the size of the plants. The incentives will apply only to a limited number of plants which will be officially shortlisted. It is possible to bid for lower incentives in order to enter into the renewable energy sources (RES) quota. This process can be penalized in case of a great number of plants applying for the incentives.

- For geothermal plants acknowledged as fully innovative, with a non-commercial technology, an **all-inclusive tariff** is granted. The tariff is reduced according to the fluid temperature with a linear formula from US$253/MWh at 151 °C down to US$173/MWh at 235 °C.
- The **standard tariff** has three levels: For plants below 1 MWel it is US$171/MWh, for plants between 1 and 20 MWel it is US$125/MWh, and for other plants the tariff is US$108/MWh.
- For plants with special technologies, an additional **premium** is granted: US$38/MWh for total reinjection (zero emission), US$38/MWh for the first 10 MWel installed in a new area without pre-existing plants and US$19/MWh for plants with over 95 % H2S and mercury abatement.
Japan

After the Great East Japan Earthquake on March 11, 2011, the current Basic Energy Plan was reviewed regarding the promotion of renewable energies. Further development of geothermal energy is expected due to the abundance of geothermal resources in Japan.

• Japan’s feed-in tariff scheme for renewable energy was initiated on July 1, 2012 by the Ministry of Economy, Trade and Industry (METI). METI further reinforced consistent support systems for geothermal resource development from survey to construction by utilizing the know-how and networks of Japan’s Oil, Gas and Metals National Corporation (JOGMEC) which develops fossil fuels, metals, minerals, and other natural resources.
• METI’s budget for the 2012 fiscal year for geothermal energy development was US$188.0 million, including budget for loan guarantees for well drilling. The Ministry of Environment (MOE) separately allocated US$3.1 million in the 2012 budget to support symbiosis of geothermal development and the natural environment.
• In September 2012, functions with respect to Research and Development of geothermal energy as well as the financial supports for the development were transferred from NEDO (New Energy and Industrial Technology Development Organization) to JOGMEC. Some research projects on the ground such as power generation technologies are still conducted by NEDO.
• The Basic Act on Energy Policy became effective on June 14, 2012 and is expected to be revised in every 3 years. The last revision was conducted in 2010. In the act, 10 % of energy produced was expected to be via renewable energy technologies including geothermal energy.

Korea

• The Korean government has set the 3rd New and Renewable Energy Basic Plan which is a subsidiary of the First National Energy Master Plan (2008-2030). According to the plan, the aim is for new and renewable energy to cover 11 % of the total primary energy supply and 7.7 % of the electricity generation by 2030. The target for geothermal energy is 3.8 % of the total new and renewable energy contribution, which means only 0.42 % of the total primary energy. Considering the rapid increase in geothermal heat pump (GHP) installations however, it is expected that geothermal can cover a larger proportion, up to about 1 % of the total primary energy. The main incentives for the rapid increase in GHP installations are the active government subsidy program and a special Act for new and renewable energy.
• The Second National Energy Master Plan will be established by the end of 2013 and the New and Renewable Energy Basic Plan will be updated accordingly.
• There are several subsidy programs - Deployment Subsidy Program, Rural Deployment Program, One Million Green Homes by 2020 Program - by which the government subsidizes 50 % of the total installation costs based on a pre-determined budget. Another powerful subsidy program enacted in 2010 is the Greenhouse Deployment Program for which the central government subsidizes 60 % and local governments cover 20 %, so rural farmers have only to pay 20 % of the GHP installation costs for greenhouses. The annual market for this special program amounted to US$45.2 million in 2012.
• In 2012, the Mandatory Public Renewable Energy Use Act was amended to state that “in all public buildings with an area over 1,000 m², more than 10 % of annual energy uses should be from new and renewable energy sources”. The minimum percentage is to increase annually: 11 % in 2013, 12 % in 2014, and so on. According to the Act, GHP installation plans amounting to a total of 114 MW in 2011 and 120 MW in 2012 were reported, which will be completed two or three years after planning due to construction times.
• There is also a long-term, low-interest loan program for renewable energy deployment.
• There is no electricity generation yet. However, a five-year term EGS pilot plant project was launched at the end of 2010 which is a partly government funded and industry matching RD&D program. The geothermal community in Korea expects 20 MW from one EGS power plant by 2020 and 200 MW (10 sites) by 2030 using EGS technology.
Mexico

Development of all renewable energy sources has been established as a priority by the Federal Government of Mexico. However, as yet, there are no feed-in tariffs or fiscal benefits in effect; a special "postal stamp" transmission tariff is applicable for the case of renewable energy. It is accurate to state that, for the most part, power generation with geothermal energy is considered conventional in Mexico, and thus it is set to compete under the same conditions as fossil fuel, conventional hydropower and nuclear technologies.

![Production well and separator at Los Azufres, Mexico.](image)

New Zealand

- An emissions trading scheme introduced in 2010 has provided some assistance to geothermal projects by reducing the long run marginal cost relative to fossil fuel generators. The start-up flat rate of US$21/t CO₂ has so far been discounted by 50 % to ease financial pressure on the electricity market. “Fugitive” geothermal emissions from industry were included in the scheme. The market carbon price has dropped significantly since 2010, so the incentives for geothermal investment have also reduced.
- A review of the NZ National Policy Statement on Renewable Electricity Generation has confirmed the government target of 90 % renewable electricity by 2025, and 9.5 PJ of new direct use renewable energy (geothermal or biomass) by 2025 relative to 2005. In 2012 total renewable energy for direct heating use was estimated at 66 PJ.

Primary energy supply increased by 3.1 % between 2011 and 2012 and has averaged 1.9 % per annum since 2008, but consumer energy demand has been flat and actually dropped by 0.4 % in 2012.

The biggest consumers are industrial and transport sectors (35 % each), and they have seen the biggest fall in energy demand. In 2012 geothermal contributed 51 % of all renewable primary energy supply.

- In 2012, Waikato, Bay of Plenty and Northland Regional Councils undertook a public review of their Geothermal Policy statements, which provide guidance for the issuance of resource consents for new and renewed geothermal projects.

Norway

In 2008, the Norwegian Parliament adopted the Climate Agreement to increase energy research, development and deployment (RD&D) by US$100 million for CCS and non-fossil based energy systems. Public funding for energy RD&D is among the highest in the world. To develop expertise and promote innovation in targeted energy R&D areas, eight centers for environment-friendly energy research (FME) were established in 2009. Each of the centers receives annual funding of US$1.7–3.4 million for eight years. Geothermal energy was not a prioritized area in 2009 but a new Climate Agreement was approved by the Parliament in 2012 with a specific decision to establish a research center in geothermal energy.

There has been an increase in GSHP particular for larger buildings after a new building code with strict requirements for energy efficiency was introduced in 2007 and revised 2010. These new energy performance requirements are expected to cut the need for energy for heating purposes by around 25 %. The new regulations also specify that, as a main rule, a minimum of 60 % of the energy required for heating and hot water in new and refurbished buildings above 500 m² must be supplied by energy carriers other than electricity and/or fossil fuels. This opens up the possibility that a lot of medium sized GSHP installations will be needed for ubiquitous locations such as school buildings. The building code will be revised in 2015. The target level is the passive house standard or active houses producing energy.

Another new legislation which has contributed to increased interest for GSHPs is the energy labeling scheme. From 2010 this scheme requires buildings to have an energy certificate and an energy consumption label when built, leased or sold. These schemes are assumed to promote increased knowledge and awareness of the energy consumption in buildings.
Spain
The Spanish Renewable Energy Plan (PER) 2011-2020 which considers a number of measures to boost renewable technologies, including geothermal energy, remains in effect.

Switzerland
Switzerland’s energy policy and strategy are framed predominantly by the Energy Act, laws and regulations governing the use of water, the electricity law, laws and regulations governing nuclear energy and protection against radiation, the pipeline law and the CO₂-Act. Geothermal energy is considered a renewable energy and enjoys a principal role for reaching targets with respect to greenhouse gas emission goals, the amount of electricity generated utilizing renewable energy sources, and the amount of heat sold to consumers.
- Building on the energy and CO₂-Act, the framework program “SwissEnergy” was introduced as principal policy instrument designed to (1) reduce CO₂ emissions by 10 % by 2010 versus the 1990 level, in accordance with CO₂ legislation; (2) limit the increase in electricity consumption to a maximum of 5 % compared to the 2000 level; and (3) increase the contribution of renewable energy towards electricity production by 0.5 TWh, and towards heat production by 3.0 TWh.
- In addition, general laws and regulations allow the Swiss Confederation to engage in and support research and development activities (Art. 64 of the Constitution and the Federal Research and Innovation Promotion Act, and specific articles in the Energy Act and related Ordinance and CO₂ Act).
- In the wake of Switzerland’s new energy strategy to 2050, new targets have been proposed in a completely revised Energy Act which has been circulated for consultation in November 2012. A geothermal policy framework has been developed to provide the incentives for industry to grow the contribution of power from geothermal power from zero in 2012 to one TWh by 2035 and about 4.4 TWh in 2050.

United Kingdom
The Government is committed to providing 15 % of the UK’s energy from renewables by 2020.
- In 2009, the UK Renewable Energy Strategy was published. Lead scenario: more than 30 % of electricity and 12 % of heat generated from renewable sources.
- The UK Renewable Energy Roadmap published in 2011 identified deep geothermal as a contributor to renewable electricity and heat. The Renewable Heat Incentive was introduced for non-domestic ground source heat pumps and the Renewable Heat Premium Payment (grant aid) for eligible domestic scale ground source heat pumps.
- The Renewables Obligation (RO) provides an incentive to large scale renewable electricity generation. Electricity suppliers must source a specified and annually increasing proportion of electricity they supply from eligible renewable sources or pay a penalty. Generators sell their ROCs to suppliers or traders which allows them to receive a premium in addition to the wholesale electricity price. If suppliers do not present sufficient ROCs, they have to pay a penalty known as the buy-out price, which was set at £40.71 (US$63.6) in 2012. Geothermal electricity was eligible for 2 ROCs per MWh.
- Feed-in tariffs (FITs) pay a subsidy for small scale electricity generation (< 5MW_e). There is no rate set for geothermal; but for hydro between 2 and 5 MW_e, it is 4.8p/kWh (US$0.07).
- The Renewable Heat Incentive (RHI) was introduced in July 2011 and pays a tariff for renewable heat for non-domestic installations. This includes deep geothermal heat as well as non-domestic ground source heat pumps. The tariff pays 4.7p/kWh (US$0.07) for projects < 100 kW_e and 3.4p/kWh (US$0.05) for projects > 100 kW_e. Domestic scale ground source heat pumps are eligible for a Renewable Heat Premium Payment (RHP) of £1,250 (US$1,960) to help cover the purchase price.
- It was recognized in 2012 that there was an imbalance in the RHI tariff paid to other technologies that has had a negative impact on the number of GSHP installations. In addition there is still no domestic RHI tariff for GSHP. This has been addressed by the Department of Energy and Climate Change. From 1 April 2013 the new non-domestic tariff pays 8.9–10.2p/kWh (US$0.14– 0.16) for all projects for 20 years. A domestic tariff of 18.8p/kWh (US$ 0.29), payable for 7 years, will apply from April 2014. Deep geothermal heat is now eligible for 5p/kWh (US$ 0.08).
The United States energy strategy is characterized by an “All-of-the-Above Approach” given the need to achieve energy independence and to strengthen the Nation’s economy. In 2012, President Obama’s administration remained committed to renewable energy, achieving its 2008 goal to double renewable energy generation (White House, 2012).

The US Department of the Treasury offers incentives designed to reduce the cost of capital for geothermal projects by issuing cash grants and tax credits based on either capital expenditures or production rates. Advanced research, development, and deployment (RD&D) of geothermal technologies are supported by the US Department of Energy, and its programs in the Geothermal Technologies Office (GTO), Building Technologies Office (BTO), and the Loan Programs Office (LPO).

Among other Federal agencies the United States Geological Survey (USGS) has been involved with estimating the location and geothermal resource potential ranging from conventional hydrothermal to EGS and low temperature resources. Lastly, geothermal technologies are also supported through a variety of state-level government initiatives such as renewable portfolio standards and agencies focused on mineral resources.

Given the absence of a national Renewable Portfolio Standard (RPS), many states have passed legislation to implement binding RPS energy targets. For example, Nevada and California, which host approximately 95% of total geothermal installed capacity, have binding targets and are presently reaching interim milestones. A number of other states with significant geothermal potential have implemented RPS targets.

At the federal and state level, a number of policy tools are in place to encourage geothermal development. On the federal level are continuing power generation incentives such as the production tax credit (ITC), Section 1603 cash grants (in lieu of ITC), and Section 1705 loan guarantee program, which has supported qualified renewable energy projects in the United States. On a non-utility scale, residential tax credits are available for geothermal heat pumps (DSIRE, 2012), and state incentive programs exist beyond regulatory efforts that are aimed at offering geothermal providers (electric and non-electric) with property tax exemptions.

Figure 18: Amatitlan Power Station, Guatemala.
6.2 Share of geothermal in the national energy mix

Total primary energy demand and proportion of geothermal energy in GIA countries

Table 16 shows the primary energy demand and the contribution of geothermal energy to the primary energy supply, which is presently negligible (≤ 1%) in the larger industrial nations. From the eleven reporting GIA member nations, geothermal today plays a major role in two, New Zealand and Iceland.

Table 16: Primary energy demand and share of geothermal. na = data not available; * IEA Key Statistics 2013 (reference year 2011); ** 1 Mtoe = 41.868 PJ

<table>
<thead>
<tr>
<th>Country</th>
<th>Total Primary Energy Supply (Mtoe)</th>
<th>Primary Energy Supply in PJ**</th>
<th>% Primary Energy Supplied by Geothermal</th>
<th>% of Power Generation Supplied by Geothermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUS</td>
<td>122.89*</td>
<td>5,145*</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>CAN</td>
<td>251.85*</td>
<td>10,344*</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>CHE</td>
<td>21.07</td>
<td>882</td>
<td>0.9</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>DEU</td>
<td>325.9</td>
<td>13,645</td>
<td>0.1</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>ESP</td>
<td>128.31</td>
<td>5,372</td>
<td>&lt; 0.1</td>
<td>-</td>
</tr>
<tr>
<td>FRA</td>
<td>165.20</td>
<td>6,917</td>
<td>0.2</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>GBR</td>
<td>206.3</td>
<td>8,637</td>
<td>&lt; 0.1</td>
<td>-</td>
</tr>
<tr>
<td>ISL</td>
<td>4.2</td>
<td>175</td>
<td>69.2</td>
<td>29.7</td>
</tr>
<tr>
<td>ITA</td>
<td>167.42*</td>
<td>7,010*</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>JPN</td>
<td>461.47</td>
<td>19,321</td>
<td>0.1</td>
<td>0.12</td>
</tr>
<tr>
<td>KOR</td>
<td>277.6</td>
<td>11,623</td>
<td>0.02</td>
<td>-</td>
</tr>
<tr>
<td>MEX</td>
<td>186.17*</td>
<td>7,795*</td>
<td>na</td>
<td>2.24</td>
</tr>
<tr>
<td>NOR</td>
<td>28.14*</td>
<td>1,178*</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>NZL</td>
<td>20.1</td>
<td>840</td>
<td>19</td>
<td>14</td>
</tr>
<tr>
<td>USA</td>
<td>2,398</td>
<td>100,336</td>
<td>0.41</td>
<td>0.43</td>
</tr>
</tbody>
</table>

6.3 Funding Instruments

6.3.1 Feed-in tariff and electricity price

Table 17 shows the average electricity prices in GIA countries in 2012, which were highest in Germany, Italy, Japan, and Australia whereas Korea and Mexico had comparatively low energy prices. Few countries reported on the production costs for geothermal power. In high enthalpy regions like New Zealand and Iceland, low generation costs make geothermal competitive with other energy forms. The latter countries did not offer feed-in tariffs for geothermal power, whereas high tariffs were granted in Switzerland, Germany, and France.

Japan introduced a Feed-in tariff on 1 July 2012 which was set to JPY27.3 per kWh (34.22 US cents/kWh) and JPY42.0 per kWh (52.65 US cents/kWh) for the electricity generated by geothermal power plants with installed capacities more or less than 15 MW, respectively.

Table 17: 2012 electricity price, production costs for geothermal power, and feed-in tariffs in selected countries. Data: Annex X country reports 2012 and IEA Key World Statistics 2013 (marked with *); na = data not available.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AUS</td>
<td>25.4</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>CHE</td>
<td>16.83</td>
<td>na</td>
<td>42.21</td>
</tr>
<tr>
<td>DEU</td>
<td>32.9</td>
<td>na</td>
<td>38.0</td>
</tr>
<tr>
<td>ESP</td>
<td>na</td>
<td>na</td>
<td>9.7</td>
</tr>
<tr>
<td>FRA</td>
<td>17.0</td>
<td>na</td>
<td>36.0</td>
</tr>
<tr>
<td>GBR</td>
<td>10.0</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>ISL</td>
<td>na</td>
<td>na</td>
<td>0.0</td>
</tr>
<tr>
<td>ITA</td>
<td>28.8*</td>
<td>na</td>
<td>17.1</td>
</tr>
<tr>
<td>JPN</td>
<td>27.68</td>
<td>na</td>
<td>52.65</td>
</tr>
<tr>
<td>KOR</td>
<td>8.5</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>MEX</td>
<td>9.0*</td>
<td>7.5</td>
<td>na</td>
</tr>
<tr>
<td>NOR</td>
<td>13.6*</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>NZL</td>
<td>14.4</td>
<td>6.5</td>
<td>0.0</td>
</tr>
<tr>
<td>USA</td>
<td>11.44</td>
<td>13.71</td>
<td>na</td>
</tr>
</tbody>
</table>

6.3.2 Governmental expenditure on geothermal RD&D projects

Only a few countries reported on government funding for geothermal RD&D projects, hence the sparse data in Table 18. The support for geothermal projects in these seven countries amounted to over US$ 83 million in 2012, showing a large interest in the research and development of this energy form.


<table>
<thead>
<tr>
<th>Country</th>
<th>Public Support in Million US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE</td>
<td>4.2</td>
</tr>
<tr>
<td>DEU</td>
<td>26.4</td>
</tr>
<tr>
<td>ESP</td>
<td>0.8</td>
</tr>
<tr>
<td>ISL</td>
<td>1.0</td>
</tr>
<tr>
<td>KOR</td>
<td>11.06</td>
</tr>
<tr>
<td>NZL</td>
<td>3.2</td>
</tr>
<tr>
<td>USA</td>
<td>37.00</td>
</tr>
</tbody>
</table>
6.3.3 Market incentives and credit offers
As described below, some countries use market incentives or special credit offers to foster the development of geothermal projects or applications in residential buildings:

- **France:** Due to budget restrictions the tax reduction for individual housing has been reduced in 2012 to now covering 26 % of the investment for heat pumps and geothermal heat exchangers instead of 36 % in 2011. In addition, zero-interest loans and an energy saving certificate scheme are available.

- **Germany:** The market incentive program (MAP) of the German Government promotes renewable energy systems that provide space heating, hot water, cooling and process heat. It has a section for smaller buildings administered by the Federal Office of Economics and Export Control (BAFA), and one for large buildings and commercial uses, the latter being a premium component of the KfW Banking Group renewable energies program. Several geothermal technologies can be supported by the MAP. The MAP backs up the installation of efficient heat pump systems in residential buildings with a maximum of €12,300 (US$15,570) per heat pump. For large heat pump systems over 100 kW a repayment bonus of €80 (US$100) per kW heat capacity is granted with a maximum of €50,000 (US$63,300) for a single system. For heat and power plants using deep geothermal energy, a repayment bonus up to a maximum of €2,000,000 (US$2.5 million) per plant is granted. Well drilling accounts for a large amount of the total projects cost. The repayment bonus for drill costs (only wells over 400 m) amounts to US$540 up to US$1,000 per m TVD depending on the depth of the well. The maximum bonus per well is US$36 million. Furthermore, part of the exploration risk can be covered within a KfW Program.

- **Korea:** The governmental subsidy program "One Million Green Homes by 2020" supports 50 % of the total installation costs based on competition. The project started in 2007 and geothermal heat pumps were included from 2009 on. In 2012, governmental support amounted to US$15.0 million corresponding to 23.22 MWt.

A progressive electricity price system for residential houses in Korea results in very high electricity costs for extensive usage of air-conditioners in summer. From May 2009, GHP became excluded from this price system. Therefore a remarkable increase of GHP installations is expected for residential houses, especially large apartments.

- **Spain:** Geothermal installations in buildings submitted by the ESCOs (Energy Service Companies) are financed within the GEOCTASA Program. In 2012, GEOCTASA authorized 22 companies and approved 10 projects. For these projects, the investment amounted to US$2,155,075 (€1,710,377) and the financing was US$2,093,893 (€1,661,820). In addition, the development of a low-carbon economy is supported through the European Regional Development Fund (ERDF).

- **Switzerland:** Some of the 26 cantonal building programs offer incentives for the installation of ground source heat pumps. The canton of Thurgau has offered a geothermal guarantee for a deep geothermal heat project. The Swiss Confederation offers a geothermal guarantee program for deep geothermal power projects.

- **USA:** Geothermal heat pump projects are eligible for a 30 % tax credit on installed costs for residential customers and a 10 % ITC at the federal level. Various states also offer incentives that promote reduced property taxes and/or tax credits for geothermal heat pump systems.

### 6.3.4 Renewable energy certificates (REC)/ renewable energy credits/green certificates
A REC is a certificate which proves the origin of electricity from a renewable source. The producer receives a certificate for each MWh of green electricity produced. A REC is tradable and can be used within trade and sale of green electricity as a proof of origin. RECs can thus be useful components to promote the production of electricity by renewable energy sources. In Europe, a cross-border electricity tracking and certification system is already established (www.rec.org). However, geothermal energy is not yet included in RECs trading for most countries (Table 19).

In the United Kingdom, the price for two certificates is US$125; in the Australia, one certificate is traded for US$38.
Table 19: REC programs for geothermal energy. Data: Annex X country reports 2012. Y = yes, N = no; na = data not available

<table>
<thead>
<tr>
<th>Country</th>
<th>REC programs for geothermal?</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUS</td>
<td>Y (38)</td>
</tr>
<tr>
<td>CAN</td>
<td>N</td>
</tr>
<tr>
<td>CHE</td>
<td>Y</td>
</tr>
<tr>
<td>DEU</td>
<td>N</td>
</tr>
<tr>
<td>ESP</td>
<td>N</td>
</tr>
<tr>
<td>FRA</td>
<td>N</td>
</tr>
<tr>
<td>GBR</td>
<td>Y (125/2 cert.)</td>
</tr>
<tr>
<td>ISL</td>
<td>Y</td>
</tr>
<tr>
<td>ITA</td>
<td>na</td>
</tr>
<tr>
<td>JPN</td>
<td>Y</td>
</tr>
<tr>
<td>KOR</td>
<td>N</td>
</tr>
<tr>
<td>MEX</td>
<td>na</td>
</tr>
<tr>
<td>NOR</td>
<td>na</td>
</tr>
<tr>
<td>NZL</td>
<td>N</td>
</tr>
<tr>
<td>USA</td>
<td>Y</td>
</tr>
</tbody>
</table>

6.3.5 Other support/renewable standards

Some countries have installed further support mechanisms for geothermal projects or installations as described below:

- **Australia**: In 2012 the Australian Government created two new funding agencies as part of the Clean Energy Plan:
  1) The Australian Renewable Energy Agency (ARENA) commenced operation in July 2012 and consolidates the management of all new and existing renewable energy funding ($1.7 billion in uncommitted funds, managing $3.2 billion in total) for R&D, demonstration, deployment and early commercialization.
  2) The $10 billion Clean Energy Finance Corporation (CEFC) grants loans and makes equity investments. Returns of these transactions are reinvested in renewables. First contracts are planned to be funded from July 2013.

- **France**: Two risk mitigation schemes have been put into place by public authorities and are funded partly by two public funds, one for deep and one for shallow geothermal heat projects. Both of them cover short (initial flow rate and temperature) and long term risks (sustainability over 20 years).

- **Switzerland**: Advisory programs for consumers and home owners and geothermal guarantee programs are available.

- **Spain**: In 2012, the Spanish R&D national program INNPACTO granted funds in the amount of US$786,461 (€624,176) for the project GREENMAR (Geothermal & Renewable Energy in Modular Architecture System).

- **United States**: The geothermal sector in the United States is supported by several financial mechanisms that support lowering the cost of capital for geothermal projects. (1) The US DOE has provided loan guarantees through the Section 1705 program totaling more than US$360 million. Three power plants brought on line in 2012 benefited from this program. (2) Both the production and investment tax credit policies were continued in 2012, following the eligibility horizon of the Section 1603 Cash Grant program in 2011. Several projects in 2012 continued to benefit from the 1603 program under the safe harbor ruling regarding under construction. The PTC remained at US$0.022 per kWh, over the first ten years of production, and the ITC provided a 30 % credit on capital expenditures in the first year of operation.

6.3.6 Carbon tax/carbon emissions fee

A carbon tax is an instrument for environmental cost internalization. It is an excise tax on the producers of raw fossil fuels based on the relative carbon content of those fuels (United Nations, Glossary of Environment Statistics 1997). Four GIA countries have installed a carbon tax (Table 20).

Table 20: Carbon taxes as stated in the Annex X country reports 2012. Y = yes, N = no; na = data not available

<table>
<thead>
<tr>
<th>Country</th>
<th>Carbon Tax/emission fee?</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUS</td>
<td>Y</td>
</tr>
<tr>
<td>CAN</td>
<td>N</td>
</tr>
<tr>
<td>CHE</td>
<td>Y</td>
</tr>
<tr>
<td>DEU</td>
<td>Y</td>
</tr>
<tr>
<td>ESP</td>
<td>N</td>
</tr>
<tr>
<td>FRA</td>
<td>N</td>
</tr>
<tr>
<td>GBR</td>
<td>N</td>
</tr>
<tr>
<td>ISL</td>
<td>na</td>
</tr>
<tr>
<td>ITA</td>
<td>na</td>
</tr>
<tr>
<td>JPN</td>
<td>N</td>
</tr>
<tr>
<td>KOR</td>
<td>N</td>
</tr>
<tr>
<td>MEX</td>
<td>na</td>
</tr>
<tr>
<td>NOR</td>
<td>na</td>
</tr>
<tr>
<td>NZL</td>
<td>Y</td>
</tr>
<tr>
<td>USA</td>
<td>N</td>
</tr>
</tbody>
</table>
Examples from GIA members show how carbon taxes are calculated and how renewables may benefit from the tax.

**Australia** introduced a carbon tax on 1st July 2012 with a fixed price of AU$23 (US$23.5) per tonne CO₂ equivalent indexed at 2.5 % per annum for three years until July 2015. Then a transition to a free market takes place.

In **Canada** there are some provincial efforts to price carbon. In Alberta there is a CAD$15 a tonne fee on facilities that produce more than 100,000 tonnes of CO₂ equivalent per year. Companies must reduce annual emissions intensity 12 % below a baseline established using 2003-2005 averages for emissions and production. With respect to any emissions that are in excess of this target, companies must pay CAD$15/tonne, buy Alberta-based carbon offsets, or purchase/use emission performance credits generated in previous years or at other facilities.

In **British Columbia** a carbon tax applies to the purchase or use of fuels within the province. Applicable tax rates are based on CAD$30 per tonne of CO₂ equivalent emissions, and fuels with higher carbon content are subject to a higher tax rate.

In **New Zealand**, the carbon tax for industry and power producers is set at NZ$25 (US$20) per tonne CO₂ equivalent (reduced by 50 % since 2010). The alternative is the price on the international carbon market which has dropped to NZ$10 (US$8) per tonne CO₂ equivalent.

In **Switzerland**, the CO₂ incentive tax is a levy on heating fuels (heating oil, natural gas) set at US$38 (CHF36) per tonne of CO₂. The levy depends on meeting CO₂ reduction targets and can go to US$126 (CHF120). Funds are returned to the people (health insurance debate) and Swiss industry (refund on social insurance taxes). One third of revenues (US$316 million per year) are federal matching funds to the cantonal building programs: US$26 million feeds a technology fund for climate protection.
7 Geothermal highlights and HSE management

Australia

• No new developments were constructed in 2012 however one new production well, Habanero 4, was spud and hydraulically stimulated at the Geodynamics’ Innamincka Deeps EGS Project in the Cooper Basin, South Australia.
• On 8 March 2012 the first successful Emerging Renewables Program (ERP) grant of $1.9 million was awarded to National ICT Australia (NICTA) for a $5 million project to provide enhanced data for geothermal exploration.
• The second geothermal-related ERP grant of $1.25 million to the South Australian Centre for Geothermal Energy Research at the University of Adelaide was announced on 17 September 2012. The grant will contribute to a $3.54 million project to better understand and predict the permeability of Hot Sedimentary Aquifers.
• An immediate tax deduction for the exploration of geothermal energy resources came into effect on 1 July 2012. This is intended to ensure that exploration for geothermal receives the same treatment as hydrocarbon energy resources.
• The Victorian Department of Primary Industries awarded $1.6 million to the Education & Demonstration of Direct Geothermal Energy (edDGE) program which is a partnership between the University of Melbourne, Direct Energy Australia and Geotech.
• Standards Australia commenced work on a standard for design & installation of Ground Source Heat Pumps.

Challenges for geothermal developments in Australia: The current challenge for the non-conventional EGS and Hot Sedimentary Aquifer sector in Australia is two-fold: to prove the resource; and to prove the ability of the technologies to generate sustainable amounts of usable electricity at a commercially viable cost. At a broader scale the geothermal sector is having difficulty in accessing capital for their projects in the current financial market.

Canada

• After careful planning since 2008, CanGEA kicked off its efforts towards a National Geothermal Technology Roadmap and Implementation Plan in 2012. Two corporate sponsors were brought on board, two provincial government agencies (from Alberta) and two federal entities participated and the International Geothermal Association provided funding as well for 2012-2013 activities. The entire program’s funding was incomplete at the end of 2012 and fundraising efforts continue via bringing on additional corporate, provincial, federal and international sponsors.
• Work in progress during 2012 was comprised mostly of planning the Technology Roadmap and Implementation Plan, the Canadian Geothermal Projects Overview, the 2013 Annual Report and Projects Portal, the Alberta Favourability Map, Alberta Resource Estimation and Alberta Database efforts.

Challenges for geothermal developments in Canada: A lack of policy on the federal level is extremely crippling to the Canadian geothermal industry (see chapter 6.1 for further details).

Figure 19: Drill rig at Paralana, Australia.
France

- The deep geothermal heat projects realized in 2012 mainly aimed at the rehabilitation of existing geothermal doublets. The Champigny-sur-Marne doublet was transformed into a triplet by drilling a new geothermal production well and using the two existing wells as injection wells with a reduced diameter. The Thiais and Maisons-Alfort 1 & 2 doublets required a casing relining. Moreover, one doublet was realized in the Albian aquifer (650 m depth) for a district heating in Issy-les-Moulineaux, near Paris. The ECOGI EGS project which aims at producing 24 MWth of industrial heat thanks to two deep wells (2,500 m depth) located in Rittershoffen (Alsace) started with the drilling of the first well between September and December 2012.
- Six new applications for exploration permits have been registered in 2012, so that the number of permit applications that are being examined by the ministry for mines amounts to 18. Five exploration permits are currently valid, including the two ones issued in 2011 (Lauterbourg and Wissembourg, Alsace).
- Many new projects are planned for the coming years, mostly for combined heat and power with a focus on the mainland due to a higher feed-in tariff.

Challenges for geothermal developments in France:
The power production of the Bouillante power plant in Guadeloupe, French West Indies (two flash steam units) has been decreased due to a long strike. Additional surface exploration is being performed on the Martinique and Guadeloupe islands. The Interreg project “Caribbean Geothermal” has officially started. This €8.5 million project aims to accelerate geothermal development in the entire Caribbean region. The exploration drilling on Dominica island, funded by the French Agency for development, has been performed and the results are promising. The Guadeloupe and Martinique islands could be supplied with electricity by Dominica using submarine connections.
The Soultz-sous-Forêts EGS pilot plant has to improve its availability (pump failures) and flow rates.
The heat pump market has decreased due to several factors, e.g. economic crisis, decrease of public support, unfavorable thermal regulation of buildings or unclear environmental regulations.
The current French regulation has been designed for deep projects and is not appropriate for small projects using geothermal heat pumps. Unfortunately, the needed modifications have not yet been implemented and will not be put in place before 2013.

Germany

- In 2012, two new sites were developed for electricity generation: Sauerlach (Bavaria) and Insheim (Rhineland-Palatinate) joined the existing sites in Landau, Unterhaching and Bruchsal.
- The funding of on-going projects in the deep geothermal sector increased from around €11.6 million in 2011 to €20.8 million in 2012, due to the sharp rise in new approvals over the previous two years. 37 new projects with a volume of €21.4 million were approved in 2012, on a par with the previous year. This has helped to stabilize research success in the deep geothermal sector. On average, the total of new approvals has doubled since 2004.
- Reliable, efficient submersible pumps are critical to the cost-effective operation of a geothermal power plant. High temperatures and volumetric flows, coupled with aggressive components in deep waters, mean that they are exposed to very different conditions than pumps used for petroleum extraction, for example. Against this
background, Baker Hughes INTEQ GmbH is developing modified underground pumps for use in geothermal drillings in the “Optimised Geothermal Pumps” R&D project. In summer 2012, a high-temperature pump test rig began operation at the Baker Hughes site in Celle, which it is hoped to provide fresh insight into optimum pump design. It is used for high-temperature testing, whereby the motor winding insulation and the pump compensation system are deliberately exposed to temperatures well above 200 °C. The team is also undertaking a comprehensive analysis of all recorded pump failures in geothermal applications, which has already prompted a number of motor modifications.

**Challenges for geothermal developments in Germany:** In 2012, the site development of geothermal reservoirs was generally very positive. In particular, in the Munich area, there are numerous projects for the use of geothermal energy for district heating and partly also for the generation of electricity.

In many systems, problems in plant parts arose due to corrosion and mineral residues, which led to higher maintenance costs and downtime of the power plant. Several shut downs of power plants were caused by residues within devices or failure of heat resistance of special parts like seals.

The seismic events of recent years in connection with the construction and operation of geothermal plants makes public acceptance of this technology sometimes difficult.

The implementation of hydraulic stimulation technology meets with resistance from authorities and populations. In discussion and publications, application of this technology in hydrocarbon production is often not distinguished from use in deep geothermal energy applications.

Despite government of geothermal projects by feed-in tariff, grants, soft loans and insurance, financing of geothermal projects is still classified as high risk investment by banks.

**Iceland**

- Primary energy supply of geothermal increased from 156 PJ to 175 PJ (12 % increase) mainly due to the increase in the electricity generation of geothermal power plants by 8 % from 4.7 TWh to 5.2 TWh. Nine geothermal power plants of total estimated 675 MWe installed capacity are under formal consideration of which 45-170 MWe is predicted to be installed in year 2015-2017.
- The geothermal research cluster GEORG initiated the project Deep Roots of Geothermal Systems (DRG-project) which aims at understanding the relationship of water and magma in the roots of volcanoes and how heat is transferred into geothermal systems to maintain their energy. Furthermore, the design of wells and well heads for high temperatures will be a focus of the project, as will methods for utilizing superheated steam from greater depths. The US$1 million project is financially supported by GEORG, Orkustofnun, Reykjavik Energy, HS Orka, Landsvirkjun and the Iceland Deep Drilling Project (IDDP). The research will be performed by three groups made up of representatives from universities, research institutes, engineering companies and energy companies. The latest technology will be applied in surveying, resistance measurements and seismic measurements, petrology and geochemistry. In addition, new simulation models will be developed. These models will be used to simulate heat transfer and operation of geothermal boreholes for high temperature steam. Training young scientists to work in this field will be an area of heavy focus for this project. This project is to strengthen the ongoing preparation of IDDP-2 in Reykjanes.
- Orkustofnun has the role of a Donor Programme Partner (DPP) for three Renewable Energy Programmes for EEA Grants with a total available budget of about US$29 million (€23 million) for the period 2013-2016 in Hungary (US$11.4/€9 million), Portugal (US$6.3/€5 million) and Romania (US$11.4/€9 million) on the development, execution and supervision of projects supported by the programmes in the field of renewable energy.
- The focus will be on building geothermal heat plants where existing fossil fuel based district heating systems are in place in Hungary and Romania as well as raising awareness on sustainable use of renewable energy in Hungary and supporting higher education in renewable energy in the donor states for Hungarians. As part of the Hungarian Programme eight specialists will be supported to undertake the six months UN University Geothermal Training Programme (UNU-GTP) that Orkustofnun operates. In Portugal the focus of the Programme will be a predefined project for building a 2-3 MW geothermal pilot power plant on the island Terceira, which will be
the first geothermal power plant on that island. Beside reducing carbon emissions by increasing the share of renewable electricity on the islands the Programme will offer specialized courses which will be held in Azores, organized by the UNU-GTP.

**Challenges for geothermal developments in Iceland:**

Development constraints are mostly due to environmental issues and low electricity prices in Iceland, though geothermal energy was looked upon more positively than hydropower in a recent national review. Local issues do place constraints on drilling sites and access to them. As well, the visual impact of geothermal power plants is becoming increasingly important. Another development constraint is the governmental subsidies to communities where there is no access to geothermal energy for space heating. The subsidies, although effective for regional development, can decrease interest in search for geothermal resources.

**Italy**

- In the year 2012 the electricity demand in Italy reached 342.4 billion kWh, with a domestic contribution of 87.4 %, while a significant portion of 12.6 % was imported. As regards the 299 TWh of domestic electricity generation, 72.7 % comes from fossil fuels, 14.7 % from hydro and 12.6 % from geothermal, biomass, wind and solar. Even if the contribution of geothermal electricity generation is only 1.9 % of the whole Italian generation, it covers about 33 % of the electricity needs in Tuscany, giving a substantial contribution to the green energy generation.

- According to the Ministerial Decree issued on July 2012, starting from January 1st 2013 new power plants with a capacity exceeding 1MW, will no longer be granted with “Green Certificates” but with an “Incentive Fee” similar to an all-inclusive fee decreased by zonal price of energy to which additional premiums can be added. The value of the net kWh generated from new or recent geothermal power plants awarded with “Green Certificates” is about €0.143 per kWh, while with a new “Incentive Fee” will be €0.099 per kWh (less than 20 MW installed capacity) or €0.085 per kWh (more than 20 MW installed capacity).

- Over the last five years thanks to the Green Certificates it has been possible to get a development of the geothermal source. Now with the new decree the income from the energy sale will be reduced. This significant incentive reduction is likely to penalize investments in new exploration and in fields characterized by a lower productivity per well.

**Challenges for geothermal developments in Italy**

A deep exploration program including 3D seismic surveys and eleven 3,000 to 4,000 m deep exploratory wells was completed in the Larderello-Travale/Radicondoli area with positive results, but the strong interaction occurring between geothermal activities and territory, taking into account that we operate in Tuscany, has placed serious hindrance to the development of new projects.

In the shallow and most depleted areas of the geothermal field, different strategies for the optimization of resource management have been put in place (reinjection, chemical stimulation) to increase steam production and reduce natural decline.

Aiming at the retrieval of a constructive and mutually beneficial relation with the territory, Enel Green Power has set going a number of initiatives with the intent of achieving a reduction of environmental drawbacks and an increase of acceptability. New design solutions have been envisaged to reduce the noise and visual impact of drilling pads, gathering systems and power plants.

An innovative plant for the abatement of mercury and hydrogen sulfide (called AMIS) was designed by Enel and 26 abatement plants were installed and are now in operation.

On the basis of the programs already in progress, an increase of 85.3 MW of installed capacity for the period 2010-2015 can be regarded as a reasonable target.

**Japan**

- Several private companies, which do not have experience in developing underground resources, are interested in developing geothermal energies. To combine these companies, the Japan Geothermal Association was established in December 2012, with the aim of
  1) Undertaking research and study in geothermal power generation,
  2) Providing recommendations and petitions to the government and related organizations,
  3) Fostering information exchange among members on the geothermal power generation, and
  4) Producing media releases and promoting understanding of geothermal power generation.
**Challenges for geothermal developments in Japan:**
Some hot spring owners are interested in geothermal power production using small generators of a capacity less than 1,000 kW, as the number of visitors decreased after the disaster on March 11, 2011 and as the Japanese feed-in tariff initiated in 2012 presents a good price for selling the electricity. Turbine makers release new binary power generators with capacities such as 20 kW, 50 kW, 70 kW, and so on.

**Korea**
- In September 2012, drilling of the first well for the Korean EGS pilot plant project started in the Pohang area. Target depth of drilling is between 4.5 and 5 km with an expected subsurface temperature of 180 °C. The first well went down to 2.25 km in December and will be re-entered in May 2013. The installation of a micro-seismicity monitoring network around the EGS drilling site, including nine stations equipped with three-component borehole accelerometers, has been completed and is currently under operation. Eight observatories are located along circles with a radius of three and five kilometers centered on the drilling site with depths of borehole probes of 120-130 m. Another probe is situated at the drilling site at a depth of 180 m. All individual observatories are connected to an internet network through high speed optical LAN to handle high frequency data in real time.

**Challenges for geothermal developments in Korea:**
Although the Korean pilot project for geothermal power generation started at the end of 2010 and targets the construction of a 1 MWe plant by the end of 2014, Korea has not yet defined a legal frame or supportive measures for geothermal power generation. In the 2012 Renewable Portfolio Standards (RPS) initiated by the Korean government, geothermal power generation is not yet included because reference data for costs do not exist. This lack of a legal framework is a major barrier to activation of industry participation in the geothermal business. The geothermal community in Korea expects that geothermal power generation will be included in the RPS in 2013; however the price of Renewable Energy Certificates (RECs) for geothermal electricity is not yet fixed. Geothermal law is expected to be set up as a part of the Mining law by 2014.

![Figure 21: MakBan Geothermal power plant, Philippines.](image-url)
Mexico

- International bidding for construction and installation of a new 50 MWₑ condensing (flash) unit in the Los Azufres geothermal field was conducted by the CFE. The contract was awarded to a joint venture headed by Mitsubishi Heavy Industries, who started the construction activities in 2013.
- At the Los Humeros geothermal field, a new 25 MWₑ condensing (flash) unit was completed by the end of 2012 and started to operate in January 2013. With this unit, the installed capacity in this field reaches 65 MWₑ. Another unit of the same type and capacity was almost finished and expected to be commissioned in 2013.

New Zealand

- All NZ geothermal power plants, except Ohaaki, were operating at full load throughout the year.
- Geothermal is a major contributor of renewable energy to the NZ electricity supply: 14 % compared to 53 % hydro, 5 % wind and 1 % bio-energy.
- In 2012, a total of 14 deep geothermal wells were drilled including make-up wells and wells for development expansion and exploration.
- Exploration continues with a new deep well drilled at Taheke by Contact Energy, interests in expanding the Ngawha geothermal field and possible projects at Tikitere, Rotoma-Tikorangi, Tauhara and Reporoa remaining “on the drawing board”.
- Construction of the Ngatamariki 82 MW binary power plant is continued with a planned completion by mid 2013.
- Construction also continues at the Wairakei Geothermal Field: the Te Mihi 166 MW double flash power plant will upgrade and replace 45 MW of retiring 50 year old turbines. In addition, Contact Energy commissioned a unique sulphur bioreactor, a bio-remediation facility to reduce dissolved hydrogen sulphide from Wairakei condensate-cooling water discharge.
- The Wairakei Terraces upgraded a tourist facility by installing a large hot spa pool bathing facility next to the existing artificial silica terraces, using separated water from the nearby injection pipeline.
- Surplus steam and brine supplied by NTGA (when not needed for Kawerau Mill direct use applications) is used more effective due to completed construction and commenced commissioning of a new 25 MW binary power plant at Kawerau (“TOPP1”) by NST.
- Preparations for resource consent hearings were undertake in order to increase geothermal fluid production rate at Kawerau (NTGA 45 kt/day, MRP 20 kt/day, Te Ahi O Maui 15 kt/day) and to continue production of Ohaaki (40 kt/day).

Challenges for geothermal developments in NZ:

Flat growth in electricity and industrial heat demand has postponed new project plans for investment in the next 3 to 5 years. There may still be niche projects identified by land owners or other investors, but these may be of limited size.

The 90 % by 2025 renewable target may have little impact with respect to commercial market decisions, because it is just a target and comes with no incentives or penalties.

As noted in 2011, CO₂ equivalent “fugitive” gas emissions from industrial-size geothermal power and heat projects in New Zealand are still subject to an emissions tax (the initial US$21 cost per tonne fixed rate was remitted by 50 % during 2012, while the market price dropped). Emission rates are usually assessed and then assumed constant, rather than measured. A challenge is to provide a financial incentive to developers to adjust well bore discharges to minimize total emissions. Another challenge would be recognition of the natural origin of the gas flux.

Resource availability remained a challenge at Ohaaki, where total net generation in 2012 was about 350 GWh (~40 % of original installed capacity). Long term projections recognize the reduced sustainable take from this resource, whilst using conventional technology.

Land access remains the single biggest hurdle to new developments and can take many years to arrange. Regulatory constraints also remain a significant challenge for developers. Streamlining the consenting process has reduced some compliance costs by providing an alternative faster route for large renewable energy projects.

Growth in geothermal has recently averaged 20 % per annum, but once baseload capacity exceeds demand or the 90 % target has been reached, further growth could be restricted.

New growth opportunities beyond 2020 might include electric vehicle conversions (complete conversion would need 1 GWₑ of new baseload generation), export through HVDC cables to Australia (perhaps 1 GWe) or energy intensive industry growth.
But, without any significant subsidies, these would be subject to normal market drivers and constraints.

Norway
An interesting initiative launched in 2012 for Ny Ålesund, Svalbard. Svalbard is an archipelago in the Arctic Ocean, located north of mainland Europe. The Svalbard Treaty of 1920 established full Norwegian sovereignty over Svalbard. Ny Ålesund is a remote settlement on the west coast of Spitsbergen, the main island of Svalbard. Funding is being sought for investigations relating to the replacement of fossil fuel with geothermal energy for this settlement, where research of the arctic environment is a main activity. There are lots of uncertainties regarding the geothermal potential and the geology in this region, but hot springs exist in an area north of Ny Ålesund.

Spain
- The use of shallow geothermal for heating, ventilation, and air conditioning (HVAC) and domestic hot water (DHW) has undergone relative expansion in Spain over several years due to the former success of the construction industry. The share of this technology in the market is growing, although the current crisis in the construction sector in Spain affects its development. However, the possibility of using the same system for heating and cooling, high performance, progressive reduction of technology costs and upward trend of prices for fossil energy sources, make this technology more and more attractive in Spain.
- Regarding R&D, in 2012 the Spanish Geothermal Technology Platform GEOPLAT agreed to create an entity dedicated to promote the official geothermal energy training in Spain, according to standard parameters issued by the European geothermal training Committee, which has been established in Brussels. Through GEOPLAT official geothermal energy training with European recognition will be certified, promoting the safe and reliable evolution of the Spanish geothermal sector.

Challenges for geothermal developments in Spain:
The transposition of the Energy Performance of Buildings Directive (EPBD), approved 2010, and its articles have to be implemented into updated versions of the Spanish Thermal Installations on Building Regulations (RITE) and the Spanish Technical Building Code (CTE). During 2012 the Spanish geothermal sector worked on proposals for the draft Royal Decree amending certain articles and RITE technical instructions and updating the Basic Document DB HE “Energy Saving” of CTE. These proposals, submitted to the Ministry, focused on the key role of geothermal energy in improving energy efficiency in buildings and the need to adapt RITE and CTE to the integration of geothermal energy in the building elements and of geothermal systems in building. Explicit consideration of this renewable technology, prioritizing its use in building with other renewable technologies, and its installation in public buildings will certainly contribute to making this technology better known and used in Spain.

In 2012, the development of geothermal energy for electricity production – or deep geothermal – in Spain was significantly complicated.
- On 28 January 2012, the Spanish Government approved Royal Decree-Law 1/2012, which temporarily suspends pre-allocation of remuneration procedures and removes economic incentives for new production of electricity from cogeneration, renewables and waste. The law is not retroactive, i.e., does not affect facilities already in place, already authorized to premiums nor facilities already listed in the records of earmarking.
- On the other hand, the adoption of Law 15/2012 of fiscal sustainability measures for energy sustainability in December 2012 imposes a tax of 7% on the production and supply of electricity in the Spanish electricity market.
These measures hold back the impulse that relevant Spanish energy companies had taken to develop projects in Spain. There used to be over 50 geothermal exploration/research permits that represented a commitment of US$10 million. Many of these activities are now on standby.

Switzerland
A number of draft policy proposals have been published for consultation which should result in market improvements for developing geothermal energy resources.

The city utility of St Gallen (Sankt Galler Stadtwerke) has been awarded a geothermal guarantee of up to US$25.4 million (CHF24.1 million). The award will take effect if the utility fails to encounter suitable geothermal reserves for power and to some extent heat production.

Challenges for geothermal development in Switzerland:
Switzerland’s plans to realize
geothermal power projects face major obstacles mostly due to complex stakeholder interactions that result from the novelty of such projects. Switzerland’s risk guarantee scheme is evolving; two projects have been awarded guarantee schemes that offset the failure cost due to the high probability of not finding a resource. Cantonal regulations are highly relevant for geothermal project planning. Since the enacting of laws, acts and ordinances in the course of applications for exploration licenses and concessions involves a set procedure, progress in project development is relatively slow. Switzerland’s subsurface is more or less unregulated. Recently however, endeavors to include the subsurface in cantonal and federal spatial planning procedures are of increasing importance.

United Kingdom

• By the end of 2012 there were 37 accredited ground source heat pump installations receiving the Renewable Heat Incentive with a combined installed capacity of 1.0 MWth. Eligible heat generated since July 2011 was 853 MWh.
• 1,251 ground source heat pump installations received the Renewable Heat Premium Payment between August 2011 and November 2012.
• Two major initiatives are proceeding for direct use. 1) GT Energy Ltd. announced in July 2012 that it was working with a major utility to develop a geothermal heat project in the city of Manchester. In December 2012 the Manchester project received its Ground Investigation Consent (GIC) from the Environment Agency (EA) which was followed by the granting of a 24 year water abstraction license in January.
2) Cluff Geothermal Ltd. is proposing to drill at Shiremore, located to the north of Newcastle upon Tyne in the northeast of England. The heat would supply a new office and housing development.

Challenges for geothermal developments in the United Kingdom: The Renewable Heat Incentive (RHI) tariff for non-domestic GSHP was set too low, resulting in ground source heat losing out to other technologies such as biomass boilers. Recognizing this anomaly, the government was then slow to consult to raise the tariff creating uncertainty and further loss of market share for the GSHP industry. The domestic RHI was delayed until 2014.

USA

• New project development in 2012 included the addition of seven power plants with an additional installed capacity of more than 150 MW, which averages more than 20 MW per plant. These plants are located in 3 states – Nevada, Oregon, and California – and are dominated by binary systems. Most notable in this collection are the Florida Canyon Mine project and the John L. Featherstone project. Florida Canyon is a comparatively small project in design and output, but is unique in its use of ElectraTherm modular binary technology, the remote location, and the lower temperature requirements to produce economically viable power. John L. Featherstone (previously called Hudson Ranch I) is a 49 MW power project in the Salton Sea region of California and is operating in conjunction with advanced R&D methods of mineral extraction, specifically lithium. The extraction project is administered by Simbol. The other five plants, which began operations in 2012 are McGinness Hills, Dixie Valley, Neal Hot Springs (first utility scale plant in Oregon), Tuscarora, and San Emidio.
• Advanced research and development efforts in the U.S. led to several notable accomplishments in 2012. At the Geysers, the first EGS Demonstration project was brought online for testing. Simbol Materials developed a method for extracting rare earth mineral from geothermal brine and is proving this process at the Salton Sea in California. Enel Green Power established the first hybrid geothermal plant by adding on solar PV generating capabilities. The U.S. Department of Energy’s Geothermal Technologies Office, in conjunction with the National Renewable Energy Laboratory, produced the Regulatory Roadmap as a measure of understanding the regulatory nature of geothermal resources and development in eight western U.S. states. Additional information based R&D was developed through NREL’s OpenEI database, as a public source of geothermal and renewable energy information, and the National Geothermal Database System (NGDS), which aims at collecting, and confirming, sources of geological data from across the nation to better understand the nature of sub-surface technologies. In a similar measure, the Geothermal Technologies Office has also begun developing play fairway mapping and analysis to better understand the location probabilities of resource beneath the surface.
• Low temperature has also been advanced in 2012 with the deployment of co-produced power in oil and gas plays, and the relocation of the binary ORC unit from RMOTC. EGS development moved forward with continued progress at AltaRock’s Newberry site, which received a finding of “no significant impact” by both the Bureau of Land Management (BLM) and the Department of Energy regarding environmental reviews and NEPA (National Environmental Protection Act). Baker Hughes’ televiewer development was successful and the company has begun comparative testing against existingwellbore characterization tools, which is expected to significantly improve methods for understanding the sub-surface and its resources. Researchers at Lawrence Berkeley National Laboratory (LBNL) and Lawrence Livermore National Laboratory (LLNL) embarked upon an innovative collaboration focused on addressing issues of fracture sustainability designed to determine “ideal site characteristics and the best techniques for EGS hydro-sheeting”. Lastly, “Addressing Induced Seismicity” was published by the Geothermal Technologies Office, while NREL released a geothermal version of its JEDI (Jobs and Economic Development Impact) Model to the public with additional geothermal analysis.

Challenges for geothermal developments in the USA: The U.S. geothermal industry discussed a number of challenges throughout 2012. Early in the year, at the Geothermal Energy Association’s Finance Forum, a primary discussion was focused on issues related to siting and transmission, an obvious result of the lack of control developers face in locating and then identifying suitable resources for development. Industry risk was also a topic for debate early on, with the question raised as how best to address this by utilizing the markets. Both insurance schemes and feed-in-tariffs were recognized as potential options.

• In the state of Hawaii public support improved as stakeholder views had come a significant way since initial development of geothermal on the islands in the early 1990’s. Although public perception remains a barrier to development in Hawaii, the warming attitude in 2012 may be a move forward to future project development.

• As financial market continued to recover amidst the 2008 crisis, it was reported by Forbes magazine that renewable energy IPO markets, including geothermal, were comparatively weak and lacked investor interest. This posed a direct challenge to several developers wishing to enter these financing markets to generate additional funds for project development. With the cooler than normal attitude toward potential IPOs continued growth was directly challenged.

• Political leaders who support the geothermal sector in the U.S. also noted continued difficulties in advancing policy agendas focused on renewable energy. Senator Bingham noted this political gridlock as the core obstacle in an address to the International Geothermal community in May 2012.

• Lastly, the forecast reduction of long-term output at Nevada Geothermal Power’s Blue Mountain project brought the developer under public and political scrutiny as concern was raised regarding the company’s ability to service debt directly secured by the U.S. DOE Section 1705 Loan Guarantee Program. Brian Fairbanks, CEO of Nevada Geothermal Power, confronted these concerns directly by assuring members of the U.S. Congress thatthere was no risk of default. Although outside the geothermal sector, the prior failure of solar developer Solyndra made public security and financing a highly scrutinized issue in 2012.
8 References


References and data sources as given in Annex X Country Reports 2012

References for the country data in the reporting period are specifically given in the Annex X questionnaire by the person in charge for each reporting country. Country data are based on official numbers, publications, or personal communication with persons from official bodies and institutions. The contributing authors and their references for data sources stated the national reports are listed below.

**Australia**
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**France**
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3. Chiffres clés des énergies renouvelables, Édition 2013, France SOeS.
6. Miscellaneous information received from Géothermie Bouillante and EEIG EMC.

**Germany**
Authors National Report: Josef Weber (Leibniz Institute for Applied Geophysics, Hannover), Lothar Wissing (Forschungszentrum Jülich, Project Management)

3. Bundesverband Geothermie GtV-BV: http://www.geothermie.de/
4. www.erdwaermepumpe.de (costs for GSHP).


Iceland
Author National Report: Jónas Ketilsson (Orkustofnun, Reykjavik)
1 Orkustofnun, Energy Statistics 2013 (accessible on the website www.os.is).

Italy
Authors National Report: Ruggero Bertani, Paolo Romagnoli (ENEL Green Power, Pisa)
1 Terna - Statistical data (Electricity production, primary energy need, feed in tariff, GC value).
2 Authority for the control of the Energy & Gas market (Average retail price).
3 UGI Italian geothermal association (data regarding direct uses of geothermal energy).
4 Internal evaluation, related to plants of large size (production costs, number of people employed, total investments, cost of the projects).

Japan
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2 Strategic Research Agenda - GEOPLAT. www.geoplat.org/setup/upload/modules_docs/content_cont_URI_1266.pdf
3 APPA, documentation Geothermal Department (Low and High Enthalpy).

Switzerland
Author National Report: Gunter Siddiqi (Swiss Federal Office of Energy BFE)
1 Heat Pump Association of Switzerland FWS. http://www.fws.ch/statistiken.html#statistik-2012 (last accessed on 15 Sep 2013).

United Kingdom
Author National Report: Jonathan Busby (British Geologic Survey, London)
1 www.decc.gov.uk (pers comm)
5 Renewable energy statistics, https://restats.decc.gov.uk

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