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The GIA Trend Report, a new survey report about geothermal applications and developments with trends in power generation and heat use in IEA-GIA member countries

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ABSTRACT

The Geothermal Trend Report is a new annual publication by the International Energy Agency - Geothermal Implementing Agreement (IEA-GIA), which provides an overview of geothermal energy uses in all 14 GIA member countries. The work for this report is accomplished within Annex X "Data Collection and Information". The first Geothermal Trend Report was published in 2012, showing geothermal applications data for 2010 contributed by GIA country representatives, with trends for heat and power from 2000 on based on an analysis of other publications (e.g. Bertani 2012, Lund et al. 2011).

The Trend Report delivers data on geothermal energy uses on an international scale and helps to point out trends and market developments. The efforts accomplished within Annex X are intended as a contribution to foster information exchange on geothermal energy uses. The following paper provides an overview about the results of the first Trend Report and the future work planned within Annex X.

1. INTRODUCTION

The IEA Geothermal Implementing Agreement (GIA) is a framework for international cooperation in geothermal research and development under the roof of the International Energy Agency (IEA). The work program of the GIA is headed by an Executive Committee with one participant from each of the Country Members and of the Sponsor Members. The cooperative research projects (tasks) undertaken in the GIA are defined and organised in five Annexes.

The main objective of Annex X – "Data Collection and Information" is to collect essential data on geothermal energy uses, trends and developments in the GIA countries, and to publish these data on a yearly basis. All current 14 GIA Country Members, eight of them situated in Europe, are required to support the work within Annex X through their provision of information. The task is managed by the Leibniz Institute for Applied Geophysics (LIAG) in Germany as the responsible Operating Agent.

Annex X was initiated at the end of 2010 with the aim to develop an annual report - the Trend Report - with essential statistical data and additional information on geothermal development in GIA countries. The idea to publish a GIA Geothermal Trend Report developed against the background of a growing demand for periodic data on geothermal energy uses on an international scale.

Basic geothermal applications data are also reported in the GIA Annual Reports (e.g. IEA-GIA 2011). The Annual Reports provide comprehensive information about sponsor activities, work accomplished within the Annexes, and national activities, whereas the new Trend Report focuses on the aspect of geothermal energy uses, with a short overview of projects and developments in the reporting countries. The aim is to provide consistent statistical data and to follow trends in geothermal energy uses.

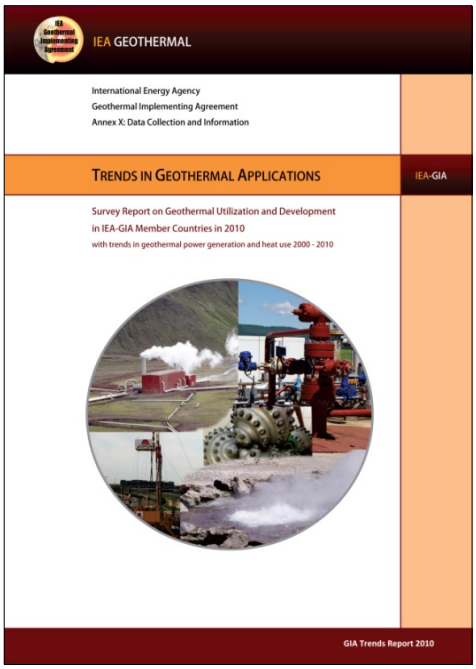

Figure 1: Cover of the GIA Report "Trends in Geothermal Applications - Survey Report on Geothermal Utilization and Developments in IEA-Member Countries in 2010" (http://iea-gia.org).

The first data collection within Annex X started with the development and distribution of a questionnaire in 2011. The spreadsheet covered data on geothermal power generation and heat uses, economic aspects, CO_2 and energy savings by geothermal energy uses, aspects of national policy, support mechanisms, and project highlights.

To provide comparable data in a consistent form, data were requested in form of an Excel sheet with several tables including calculations. The spreadsheet covered the following topics:

- Power generation: installed capacity and power generation, newly installed capacity, and capacity installed in different plant types.
- Direct use: installed capacity and heat produced in different use categories, number, capacity and heat use of geothermal heat pumps.
- CO_2 and energy savings were calculated directly from the reported values for heat use and power generation using the GIA conversion (Mongillo 2005).
- Jobs, costs of geothermal plants, and capital investments in the geothermal market.
- Energy market and national policy: role of geothermal in national energy strategy, funding for geothermal development, market incentives, share of geothermal in the energy mix, electricity price, and feed-in tariffs for geothermal power.
- Geothermal highlights: new projects, research activities and other positive developments in the geothermal sector.
- Health, security and environment (HSE) management: challenges related to the development of geothermal, such as technical problems, and social or political obstacles and their management.

Complementary to the data collection within Annex X, data from additional sources, such as the publications associated with the World Geothermal Congress (e.g. Bertani 2012, Lund et al. 2011, and relevant country updates) and the GIA Annual Reports from 2002 on (IEA-GIA 2003), were compiled and analysed to show trends in geothermal energy uses in GIA countries from the year 2000 on.

Based on the results of the first data collection and publication reviews, the report “Trends in Geothermal Applications - Survey report on geothermal utilization and development in IEA-GIA Member Countries in 2010, with trends in geothermal power generation and heat uses”, in short the Geothermal Trend Report, was published in 2012 (Figure 1).

2. RESULTS

The current 14 GIA countries (Figure 2) contribute a significant amount to the geothermal energy produced worldwide: They account for nearly half of the worldwide geothermal direct uses and contribute about 60 % to the geothermal power generation worldwide.

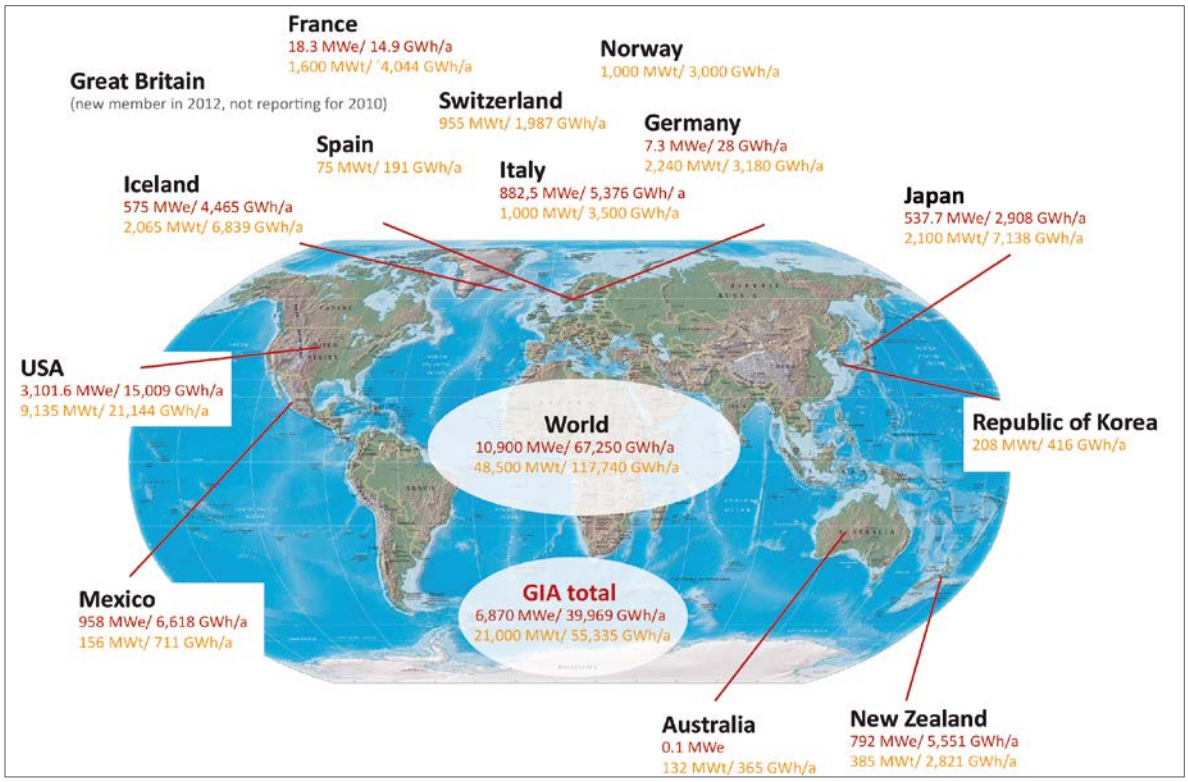

Figure 2: Geothermal electricity (red) and heat (orange) produced in GIA countries and worldwide in 2010. Heat data based on estimated pure geothermal contribution where possible. Data world: Bertani (2012) and Lund et al. (2011), data Norway: Lund et al. (2011), data Japan: GIA Annual Report 2010 (IEA-GIA 2012), all other data: GIA Annex X national reports 2010. Map: The world factbook 2007, CIA (www.cia.gov).

2.1 Geothermal power generation

Data for geothermal power were generally well documented and of good quality. The report shows that nine GIA member countries operate geothermal power plants with a total installed capacity of 6,870 MW_e in 2010 and nearly 7,000 in 2011, and a power generation of 39.9 TWh in 2010 and 41.7 TWh in 2011. This is over 60 % of the geothermal power generation worldwide, which amounted to about 67.2 TWh in 2010 (Bertani 2012).

With about 3,100 MW_e installed capacity and over 15 TWh generated electricity, the USA is by far the biggest producer of geothermal power among the GIA countries, followed by Mexico, Italy, New Zealand, Iceland, and Japan (Figure 3).

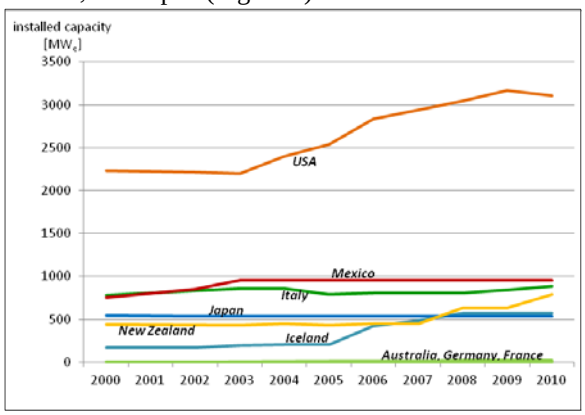

Figure 3: Development of installed capacities for geothermal power generation in selected countries 2000-2010.

In addition to our own data collection, relevant publications were analysed to show trends from 2000 on (e.g. Huttrer 2000, Bertani 2007 and 2012) with respect to data from GIA members and a comparison to the geothermal power production in the world. From 2000 to 2010, the worldwide installed capacity for geothermal power generation has grown from about 8,000 MW_e to 11,000 MW_e. In the same period, the installed capacity in GIA countries increased from nearly 5,000 MW_e in 2000 to 6,870 MW_e in 2010.

Among the non GIA countries, the Philippines with 1,904 MW_e and Indonesia with 1,297 MW_e have the largest share of installed geothermal capacity (Bertani 2012). These two countries account for the major part of the difference between the geothermal capacity worldwide and in GIA countries.

2.2 Direct use of geothermal heat

The data request showed that some countries lack detailed and periodic statistics on geothermal heat uses. Use categories such as bathing/ swimming, greenhouses or district heating are often not clearly defined and the range of geothermal resources of energetic relevance can vary from country to country. Depending on the regional climate and national energy concepts, heat pumps may be used mainly for heating or cooling, and usual capacities and average full load hours can be variable.

In the Annex X questionnaire, heat use data were standardised as far as possible. If no data for the heat produced in various categories was provided, the heat use was calculated automatically from the given capacities using capacity factors for different categories given in Lund et al. (2011). A calculation was also offered for the heat produced by a given number of geothermal heat pumps. For all direct uses it was intended to report the geothermal share of the heat produced in the Trend Report. For heat pumps, the geothermal contribution was calculated according to the EU Directive Renewable Energy.

In 2010, geothermal heat uses in GIA countries reached a total installed capacity of 26 GW_t, about half of the worldwide capacity of 48.5 GW_t (Lund et al. 2011). Annual heat use amounted to 55.3 TWh (199,200 TJ), which are 47 % of the 117.7 TWh (423,830 TJ) geothermal heat produced worldwide according to Lund et al. (2011).

With an annual heat use of nearly 30,000 GWh (108,000 TJ) in 2010, geothermal heat pumps contributed the major portion of geothermal heat produced in GIA countries. Of the centralised utilizations, space heating and district heating plants made up the largest share of total uses together amounting to over 9,000 GWh. Due to a widespread use of geothermal springs for bathing, Japan was the primary user of geothermal heat with over 7,000 GWh, followed by Iceland with 6,800 GWh and Italy with about 3,000 GWh (Table 1).

Table 1: Direct use of geothermal heat in GIA countries in 2010. Data world, Norway, and Japan from Lund et al. (2011), other data according to Annex X national reports.

Geothermal Heat Use 2010 Installed capacity (MWt) and energy use (GWh, TJ)			
Country	**Installed capacity (total) [MWt]**	**Heat use [GWh/a] (GIA: geothermal contribution)**	**Heat use [TJ/a] (GIA: geothermal contribution)**
AUS	132	365	1,314
CHE	1,366	1,987	7,152
DEU	3,063	3,180	11,449
ESP	92	191	688
FRA	2,016	4,044	14,557
ISL	2,065	6,839	24,621
ITA	1,000	3,500	12,599
JPN	2,099	7,138	25,698
KOR	273	416	1,497
MEX	156	711	2,558
NOR	1,000	3,000	10,800
NZL	385	2,821	10,156
USA	12,564	21,144	76,119
total GIA	**26,212**	**55,336**	**199,207**
World	**48,493**	**117,740**	**423,830**

2.3 CO_2 and fossil fuel savings by geothermal applications

Geothermal energy uses help to reduce the consumption of fossil fuels and to lower greenhouse gas emissions. For a consistent evaluation of avoided CO_2 emissions and fossil fuel savings by geothermal applications, savings were calculated in a standardised way using savings factors given in the GIA conversion (Mongillo 2005) and assuming efficiency factors according to Lund et al. (2005). Fuel savings were estimated based on the values of produced heat and power as given in the spreadsheets. Fossil fuel savings by geothermal power generation in GIA countries in 2010 have thus been estimated to be 10 million tonnes of oil equivalent (toe), and for heat use to be nearly 16 million toe.

Avoided CO_2 emissions were calculated using savings factors given in Lund et al. (2005). CO_2 savings by geothermal power accounted for 7 million t of CO_2 for gas and for over 37 million t of CO_2 if the replaced fuel is coal. For geothermal heat uses in 2010, avoided emissions were estimated with 5 million t of CO_2 for gas or 24 million t CO_2 for the replacement of coal.

2.4 Economic information

Within the work of GIA Annex X "Data collection and information", an attempt was made to supply data about geothermal as an economic factor. However, data on employments, costs for geothermal plants and installations, and capital investments in the geothermal industry were not reported comprehensively and, therefore, not representative in the 2010 report. Yet capital investments in the geothermal sector reported by seven GIA countries amounted to a total investment of over US$ 2.5 billion in 2010, indicating that geothermal is an economic factor of some importance.

2.5 Energy market and policy

This chapter of the Geothermal Trend Report provides a short overview of the role of geothermal in the national policies of selected countries. The report outlines that geothermal often is part of national energy strategies for the development of renewables and thus benefits from subsidy programs and governmental funding for technology development and research.

Several countries offer feed-in tariffs to foster geothermal power developments. High feed-in tariffs for geothermal electricity were reported from Switzerland, France, and Germany, whereas geothermal power was not subsidised in Iceland and New Zealand, where geothermal is competitive with other energy sources due to high enthalpy reservoirs. Furthermore, an overview of governmental expenditure on geothermal R&D projects and about market incentives and other support for geothermal development is given in the report.

2.5 Geothermal highlights and challenges in the reporting countries

The final chapter of the Trend Report outlines positive developments in the geothermal sector, such as new projects and research activities or political support and new funding programs.

Apart from geothermal highlights, some countries also reported challenges for geothermal developments, for example technical problems in the French geothermal power plant in Bouillante (Guadeloupe), development constraints due to environmental issues in Iceland, or problems with induced seismicity associated with EGS development in the United States and Germany. Knowledge about challenges for the development of geothermal energy in different regions of the world and how they are managed may improve the ability to solve similar problems in the future.

Among the highlights for geothermal power developments, Mexico reported two new 25 MW_e condensing units in the Los Humeros field. The Iceland Geothermal Drilling Project (IDDP) aimed at the development of hydrothermal systems at superheated conditions. With a fluid temperature of 441 °C the IDDP well is presumably the hottest geothermal well in the world. Interesting project news have been reported from Korea, where an EGS pilot plant is planned. In the USA, geothermal energy capacity has increased by 177 MW_e due to six new plants which came online in 2009. The commissioning of a new plant in Nevada started in 2010, adding another 15 MW_e of geothermal power. Progress in geothermal power generation was also reported from New Zealand with the commissioning of the 140 MW_e Rotokawa flash plant and the 23 MW_e binary plant of Te Huka.

3. CONCLUSIONS

The Work Program undertaken in International Energy Agency - Geothermal Implementing Agreement (IEA-GIA) consists of cooperative research, analysis and information sharing concerning the sustainable development and utilization of geothermal energy. With the Geothermal Trend Report, a new survey report about geothermal applications and developments in the member countries, the GIA wants to contribute to the information exchange on geothermal energy uses on an international scale.

The work is carried out within "Annex X – Data Collection and Information". The main objective of this Annex is to collect essential data on geothermal energy uses, trends and developments in GIA countries and to publish these data in an annual report. All 14 Country Members participate in this Annex through their provision of information.

Work on the first Trend Report, which was published in 2012, started with the development and dissemination of a questionnaire in 2011. Data were requested in a consistent form using an Excel spreadsheet with calculations included, so that values such as CO_2 and fossil fuel savings were evaluated in a standardised way. Furthermore, supplementary information to political support and public funding for geothermal for geothermal and project highlights was requested.

Work on this report was a first important step along the learning curve. As experiences from the first data collection showed, data on geothermal power generation in general was easily accessible and of good quality, whereas reliable statistics on heat uses have not been available in every country and for each use category. In countries where regular statistics on direct uses are not reported on a regular basis, like in Norway or Japan, data for geothermal heat use had to be estimated based on data from older sources.

The automatic calculation of CO_2 and fossil fuel savings from given values for heat and power production proved to be practicable way to show standardised data on the ecologic benefits of geothermal. Information on costs, investments and jobs in the geothermal sector showed not to be representative, here only few numbers from individual countries were available. On the other hand, the authors of the national reports provided detailed information on the role of geothermal energy in national policy, funding instruments for geothermal developments, and project highlights, which was summarized to a short overview about geothermal developments in the reporting countries.

Altogether, the GIA Trend Report adds substantial information on geothermal energy uses on an international scale and helps to point out trends in geothermal energy use and market developments. It is intended to proceed with the effort of data collection and information as part of the GIA´s program of work. Based on the experiences from the first data collections among the GIA countries, future Trend Reports shall be improved continuously.

For the future, there are plans to extend the data collection to non-GIA countries, with emphasis on the remaining leading geothermal nations. Furthermore, it is intended to seek collaboration with other international organisations and institutions with the aim to combine the work of GIA Annex X with other international efforts to collect and share data on geothermal energy uses.

The Report “Trends in Geothermal Applications – Survey Report on Geothermal Utilization and Development in IEA-GIA Member Countries” has 38 pages with 19 tables and 18 figures. It is available for free download on the GIA Homepage (http://iea-gia.org/category/ publications).

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