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The GIA Trend Report, an Annual Survey Report on Geothermal Applications and Developments

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ABSTRACT

The Geothermal Trend Report, an annual publication by the International Energy Agency - Geothermal Implementing Agreement (IEA-GIA), provides an overview of geothermal energy data in GIA member countries. The work for this report is accomplished within Annex X "Data Collection and Information". The main objective of this annex is to collect data on geothermal energy uses, trends and developments in GIA member countries in a standardized way, and to publish these data in a brief report on a yearly basis.

All GIA member countries are required to support the work on the Trend Report by providing information. Additional data from sources such as the publications associated with the World Geothermal Congress and the GIA Annual Reports have been compiled and analyzed 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 power 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 followed by the second and third issue in 2013 and 2014, respectively.

The Geothermal Trend Report provides a brief overview of data such as installed capacities and produced electricity and heat, as well as relevant political and economic information. The 14 GIA countries contribute a significant amount to the geothermal energy produced worldwide: They account for nearly half of the geothermal direct uses and contribute about 60 % to the geothermal power generation worldwide. The Trend Report also provides CO_2 and fossil fuel savings which are calculated on the basis of the GIA conversion (Mongillo 2005) and efficiency factors given in Lund et al. (2005). Data on costs, investments, and employees proved not to be representative. A policy chapter describes the role of geothermal in national policies and support mechanisms for geothermal. Furthermore, a short overview about geothermal highlights and project developments is given.

Overall, the GIA Trend Report adds substantial information on geothermal energy use on an international scale and helps to point out trends and market developments. It is intended to continue with the data collection and to combine the work of GIA Annex X with international efforts to collect information on a regular basis by collaboration with other organizations and institutions.

The GIA Trend Reports are available on the internet at: http://iea-gia.org/category/publications.

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 organized in six 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 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.

Data collection within Annex X started in 2011. To provide comparable data in a consistent form, data is requested in form of an Excel sheet with several tables including calculations. The spreadsheet covers 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 are 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 analyzed 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 followed by the second issue in 2013 (Fig. 1). Work on the Trend Report for the reporting year 2012 was finished in August 2014.

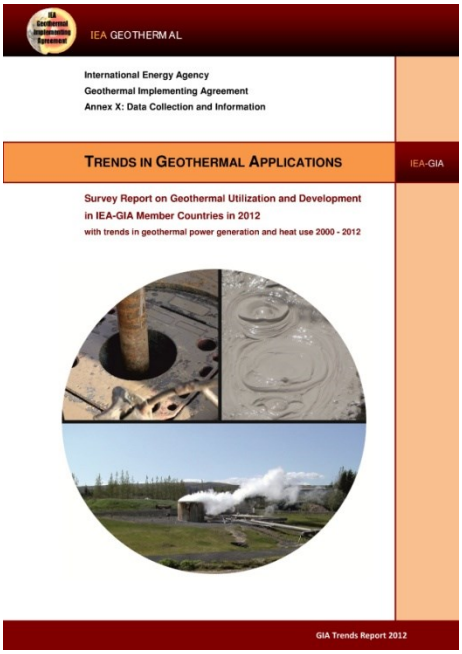

Figure 1: Cover of the GIA Report "Trends in Geothermal Applications – Survey Report on Geothermal Utilization and Development in IEA-GIA Member Countries in 2012" (http://iea-gia.org/category/publications).

2 RESULTS

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

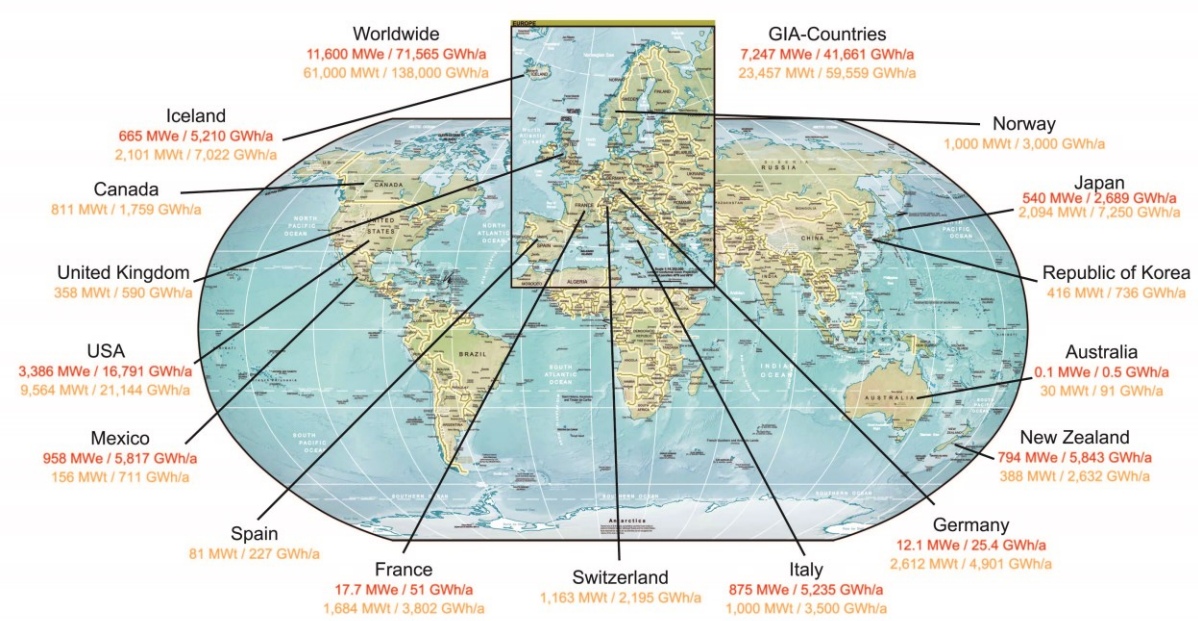

Figure 2: Installed capacity and annual production of power (red) and heat (orange) in GIA countries (GIA Annex X national reports 2012, Lund et al. 2011 and GEA 2013) and worldwide in 2012. Heat data based on estimated pure geothermal contribution where possible. Worldwide data estimation based on numbers in Bertani (2012) and Lund et al. (2011) plus an annual increase (see text). Map: The World Factbook (CIA 2013).

2.1 Geothermal power generation

Data for geothermal power are 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, nearly 7,000 MW_e in 2011 and about 7,250 MW_e in 2012. The power generation amounted to 39.9 TWh in 2010 and about 41.7 TWh in 2011 and 2012. This is about 60 % of the geothermal power generation worldwide, which amounted to about 67.2 TWh in 2010 (Bertani 2012) and 71.5 TWh in 2012 (estimated on basis of a compound annual growth rate (CAGR) of 3.2% and the numbers given in Bertani 2012).

With about 3,380 MW_e installed capacity and over 16.7 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 2).

In addition to the GIA data collection, relevant publications were analyzed 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 1,197 MW_e have the largest share in installed geothermal capacity, but also El Salvador, Kenya and Turkey contribute a considerable amount to the worldwide installed capacity (204 MW_e, 202 MW_e and 91 MW_e, respectively; Bertani 2012).

These countries account for the major part of the difference between the geothermal capacity worldwide and in GIA countries: about 95 % of the worldwide installed electric capacity and annual power production is covered by these five countries together with the GIA member countries (Fig. 3).

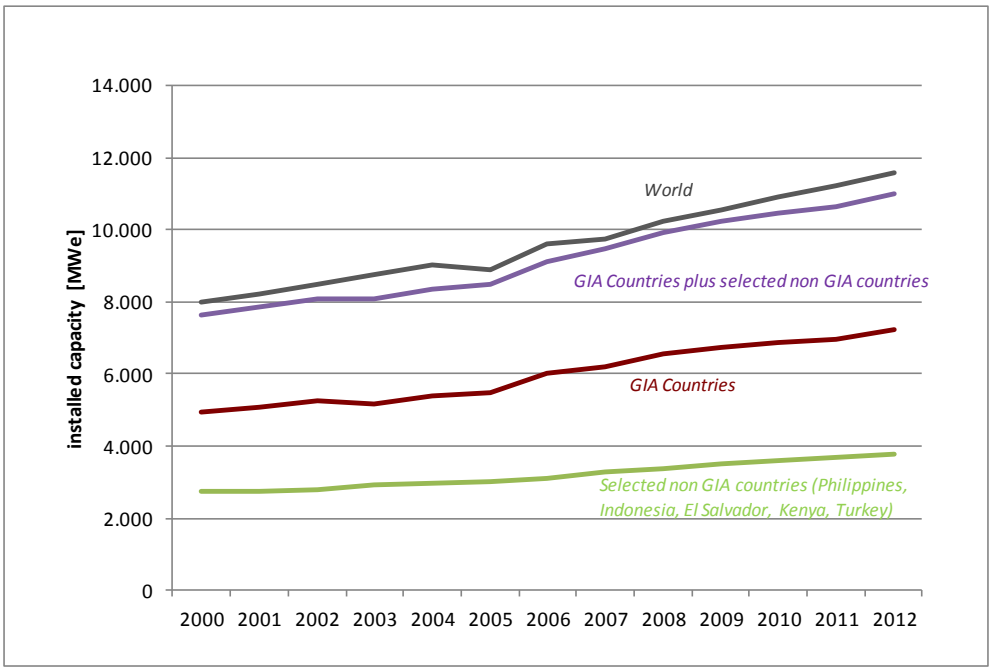

Figure 3: Development of installed capacities for geothermal power generation in the GIA Countries, selected non GIA countries and worldwide 2000-2012 (Huttrer 2000, Bertani 2007, 2012, GIA Annual Reports, GIA Annex X national reports, Parlaktuna et al. 2013).

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 standardized 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 2012, geothermal heat uses in GIA countries reached a total installed capacity of 28.6 GW_t (geothermal contribution: 23.5 GW_t), about half of the estimated worldwide capacity of about 60 GW_t (estimation based on 48.5 GW_t in 2010 and an annual increase of 11.4 %; Lund et al. 2011). Annual heat use amounted to 59.6 TWh (214.411 TJ), which is 43 % of the estimated 140 TWh (504.000 TJ) geothermal heat produced worldwide (estimation based on 117.7 TWh in 2010 and an annual increase of 9.2 %; Lund et al. 2011).

With an annual heat use of over 34,000 GWh (123,234 TJ) in 2012, geothermal heat pumps contributed the major portion of geothermal heat produced in GIA countries. Of the centralized utilizations, space heating and district heating plants made up the largest share of total uses together amounting to about 8,200 GWh (Fig. 4). Due to a widespread use of geothermal springs for bathing, Japan was the primary user of geothermal heat with 7,250 GWh, followed by Iceland with 7,000 GWh and Italy with about 3,000 GWh.

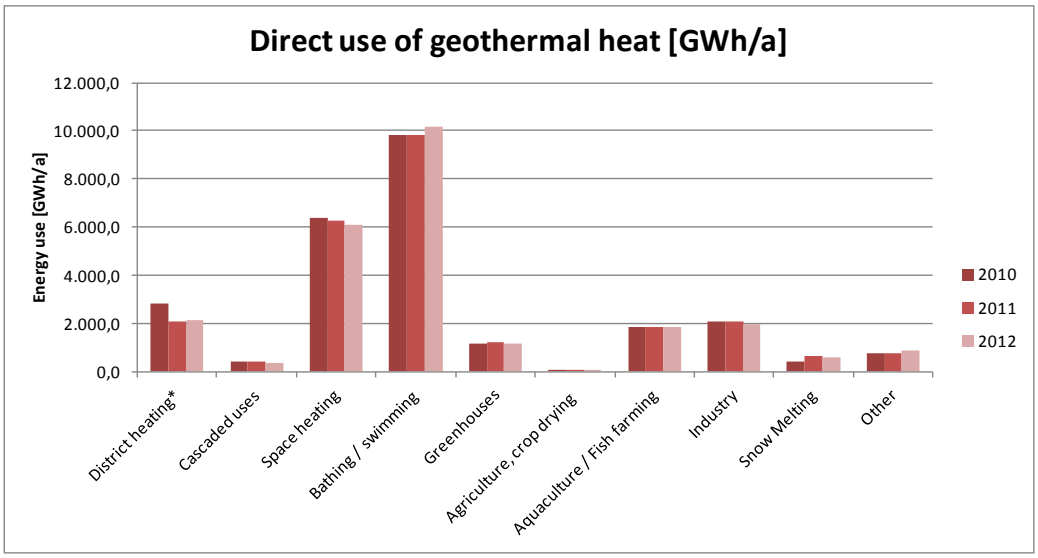

Figure 4: Development of annual direct energy use of geothermal heat in GIA countries for different categories (other than heat pumps) 2010-2012 (Data: Annex X national reports).

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 standardized 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 2012 have thus been estimated to be 10.5 million tons of oil equivalent (toe), and for heat use to be about 7.5 million toe.

Avoided CO_2 emissions were calculated using savings factors given in Lund et al. (2005). Replacement of gas and coal by geothermal power leads to CO_2 savings of 8 and nearly 40 million t of CO_2, respectively. Geothermal heat uses helped to avoid CO_2 emissions of over 5.7 million tons in the case of substituting gas and over 28.4 million tons for the replacement of coal in 2012.

2.4 Economic information

Within the work of GIA Annex X "Data Collection and Information", an attempt was made to gather data on geothermal energy 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. Yet capital investments in the geothermal sector reported by eight GIA countries amounted to a total investment between US$ 2.5 and 3.8 billion for the years 2010 to 2012, 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 like France, Germany, Japan and Switzerland offer feed-in tariffs to foster geothermal power developments, whereas geothermal power is not subsidized 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.

2.6 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, but also deals with challenges coming along with the construction and operation of geothermal facilities.

Among the highlights in 2012 for developing geothermal energies, the establishment of the Japan Geothermal Association, the construction and commissioning of new geothermal power plants in several GIA member countries, and the funding of research and development projects have to be mentioned.

Apart from geothermal highlights, some countries also reported obstacles for geothermal developments, for example development constraints due to environmental issues in Iceland, loss of acceptance in the population due to induced seismicity in Germany but also deferral of investments for new developments on the part of companies due to uncertainties regarding funding or feed-in tariffs in several countries. 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.

3. CONCLUSIONS

The Work Program undertaken in the 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 survey report on 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 for the year 2010, which was published in 2012, started with the development and dissemination of a questionnaire in 2011. Data was 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 standardized way. Furthermore, supplementary information to political support and public funding for geothermal and project highlights was requested.

Experiences from the first data collections show that data on geothermal power generation in general is 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 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 a practicable way to show standardized 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 organizations 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 Reports "Trends in Geothermal Applications – Survey Report on Geothermal Utilization and Development in IEA-GIA Member Countries" are available for free download on the GIA Homepage (http://iea-gia.org/category/publications).

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