IEA GEOTHERMAL

IEA Geothermal
Implementing Agreement

2013 Annual Report
Executive Summary

Executive Summary

Introduction

Renewable power capacity is expanding at its fastest pace to date, but it is still behind global increases in power demand. Currently, only hydropower, onshore wind and solar photovoltaics are keeping pace with renewable energy targets, and the world is off-track in its efforts to keep the average global temperature increase to less than 2 °C by the end of the 21st Century.

Geothermal energy is an important renewable resource for these climate change mitigation efforts. It provides baseload power, is globally extensive, is independent of climate, has sustainable development capabilities, and has a small areal footprint. 25 countries are currently producing electricity from geothermal resources, and about 80 countries are estimated to use geothermal energy for direct applications including heat pumps, space and greenhouse heating, aquaculture, and bathing. While geothermal energy use is increasing worldwide, significant long-term R&D is required to maximise the vast global geothermal potential.

The GIA is an international organisation that aims to promote the sustainable use of geothermal energy globally. It focuses its efforts on optimizing international collaboration, collating and distributing high quality information, supporting the development of geothermal technologies, and communicating geothermal energy's strategic, economic and environmental benefits.

The GIA's work is divided into themes, or *Annexes*, which are subdivided into *Tasks*. There are currently six Annexes, centring on environmental impacts of geothermal energy development, enhanced geothermal systems, advanced geothermal drilling and logging technologies, direct use of geothermal energy, data collection and information, and induced seismicity.

In 2013, the GIA membership comprised 14 countries, the European Commission, two industries and two industry organizations. Their activities included joint R&D projects, development of databases, models, handbooks and best practices, and information exchange via meetings, workshops and networking.

This executive summary forms part of the IEA-GIA 2013 Annual Report, which describes the activities of the GIA, its Annexes and members in 2013, as well as outlining the status of renewable energy in general, and geothermal energy in particular.

The IEA-GIA – An overview

The IEA-GIA was founded in 1997, and began its 4th Term of operation in March 2013. The GIA provides a versatile framework for comprehensive international cooperation in geothermal R&D. The focus is on establishing links between national and industry programmes for exploration, development and utilization of geothermal resources, with emphasis on enhancing effectiveness through connecting geothermal experts in the participating countries and industries.

The general scope of the GIA's activity consists of international scientific collaborative efforts to compile and exchange improved information on worldwide geothermal energy R&D, develop improved technologies for geothermal energy utilization, and improve understanding of the environmental benefits of geothermal energy and the ways to avoid or minimize its environmental impacts. GIA collaboration provides researchers with excellent opportunities for information exchange via meetings, workshops and networking. Members also participate in R&D projects and help in the development of databases, models and handbooks. Participants gain an international perspective on geothermal issues, opportunities and environmentally-appropriate development strategies. New studies and activities are implemented when needs are established.

The GIA's Mission is:

To promote the sustainable utilization of geothermal energy worldwide by optimizing international collaboration to improve technologies, thereby rendering exploitable the vast and widespread global geothermal resources, by facilitating knowledge transfer, by providing high quality information and by widely communicating geothermal energy's strategic, economic and environmental benefits, hence contributing to the mitigation of climate change.

To realize this Mission, seven Strategic Objectives focus the GIA's activities:

- To actively promote effective cooperation on geothermal RD&D, including with industry partnership, through collaborative work programmes, workshops and seminars
- To provide policy makers with information about the newest developments in geothermal energy and highlight its advantages for sustainable development, the environment and economy
- To inform and educate international financial institutions about the value and hurdles specific to geothermal deployment
- To identify and deal with geothermal energy RD&D issues and opportunities, and encourage collaboration to improve/develop cost-effective methods and technologies
- To increase membership in the GIA with particular emphasis on encouraging non-IEA Member countries with significant potential geothermal resources
- To encourage collaboration with other international organizations and appropriate implementing agreements
- To be an unbiased source of reliable, current worldwide information about geothermal energy and increase its dissemination to the IEA family and global decision makers, financiers, researchers and the general public

Activities, called Tasks, are defined and organized in broad topics termed Annexes. Participants must take part in at least one Annex. Annex titles, statuses, leadership and participation are provided in Table 2.2, Chapter 2 of the 2013 IEA-GIA Annual Report. An Executive Committee (ExCo), consisting of one voting member from each Country, the EC and Sponsor (industry, industry organization), supervises the GIA and its decisions are binding on all Members.

At the end of 2013, there were 19 IEA-GIA Members. These comprised the European Commission, 14 countries (Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Norway, the Republic of Korea, Spain, Switzerland, the United Kingdom and the United States), 2 industries (Green Rock Energy and ORMAT Technologies), and 2 industry organizations (the Canadian Geothermal Energy Association and the Geothermal Group of the Spanish Renewable Energy Association).

The Annexes

In 2013, GIA participants worked on six broad research topics within the Annexes, and contributed to the GIA's geothermal data collection and analysis effort. The Annexes were:

- Annex I- Environmental Impacts of Geothermal Energy Development
- Annex III- Enhanced Geothermal Systems
- Annex VII- Advanced Geothermal Drilling Techniques
- Annex VIII- Direct Use of Geothermal Energy
- Annex X- Data Collection and Information
- Annex XI- Induced Seismicity

The Annexes have started as interest arises; only Annexes I and III have been operating since the original implementing agreement was initiated in 1997. Annex VII began in 2001, while Annex VIII began officially in 2003 and Annexes X and XI were both opened in 2009. All of them continued into

early 2013, and then extended for the entire 4th Term, to 2018. More details regarding the status of the Annexes, including ones completed or yet to start, can be found in Table 2.2 of the 2013 Annual Report.

Some of the GIA's major activities and Annex highlights for 2013 are presented below. Further details can be found in Chapter 2 to Chapter 8 of the 2013 Annual Report.

IEA-GIA ExCo and Annex Meetings in 2013

The IEA-GIA held two Executive Committee (ExCo) Meetings in 2013 (see Chapter 1 of the Annual Report). The 29th ExCo meeting was held in Cuernavaca, Mexico, in April, followed by a two-day fieldtrip to Los Azufres Geothermal field and development. The 30th ExCo meeting was held in Tagaytay, Philippines, in September 2013, followed by an IEA-GIA/EDC international seminar. Both of the ExCo meetings had 15 participants in total. At the meetings, GIA's efforts were discussed and reviewed, and future activities were planned. There were also some changes to the Annex participants and Leaders, and one new ExCo Officer was elected. Progress reports from the Annexes and some Country and Sponsor Members were presented and discussed.

Meetings and Workshops

GIA participants took part in several international meetings and workshops during 2013, including:

- European Geothermal Congress in Pisa, Italy, where GIA had an exhibition booth as well as participants giving talks;
- 3rd European Geothermal Review in Mainz, Germany;
- IEA-GIA/EDC Joint Seminar "Innovative ways to enhance permeability, reduce drilling costs and sustain geothermal production" in Tagaytay, Philippines;
- 10th Asian Geothermal Symposium in Tagaytay, Philippines;
- New Zealand Geothermal Workshops;
- Geothermal Resources Council Annual Meeting in Las Vegas, USA;
- Stanford Geothermal Workshop in Stanford, USA

Annex Activities

Annex I- Environmental Impacts of Geothermal Energy Development – In 2013, Annex I participants contributed a chapter on geothermal resources entitled "Geothermal Energy, Nature, Use, and Expectations" to the book 'Renewable Energy Systems', addressing mitigation of climate change by advocating increased deployment and use of renewable geothermal energy resources. Participants conducted outreach activities on environmental issues with non-member countries, particularly in the Philippines in association with the ExCo and Annex meetings. They also gave presentations at several international conferences on environmental research, improved environmental sustainability strategies and monitoring methods. Invited lectures were presented on geothermal environmental topics at the 3rd European Geothermal Review in Germany. A successful Annex proposal was also funded through the GIA Common Fund proposal scheme to support participation in a special session on modelling sustainable reservoir development at an international conference in Iceland.

Annex III- Enhanced Geothermal Systems – The report "A Global Review of Geothermal Reporting Terminology" (Beardsmore, 2013) was completed and published on the GIA website in February 2013. This study received US$ 10k of GIA funding. As part of Task B (Technology Crossover between Hydrothermal and EGS), work continued on a 'lessons learned' document that was also partially funded by a US$ 10k grant from GIA. There were developments in EGS applications around the world that benefited from experience and collaboration: EGS technologies increased power output of a low-production well at Desert Peak in Nevada, resulting in the first EGS pilot project in the USA to generate commercial electricity; the Habanero Basin demonstration project in Cooper Basin, Australia, generated 1 MW of power for 3 months in 2013; the Pohang EGS project in the Republic of Korea benefited from technical collaboration with other Annex III participants; and a new 24 MW_{th} development in Alsace, France, has used EGS experiences from elsewhere in France.

Annex VII- Advanced Geothermal Drilling and Logging Technologies -In 2013, new well data was added to the database that forms the Task A- Compiling Geothermal Well Drilling Cost and Performance Information activity. As Part of Task C– Advanced Drilling and Logging Collaboration, requests for collaboration were discussed and information was exchanged between principal investigators. A proposal supported by the GIA Common Fund provided funding for five international participants at the 47th US Rock Mechanics/Geomechanics Symposium in San Fransicso in June 2013. These participants presented papers in the Session *Geomechanical Challenges associated with Geothermal Drilling, Stimulation and Production*, which was organised by the Annex VII Leader and addressed the comprehensive purpose of the Annex. Eight countries were represented by the 'geothermal' papers in this session.

Annex VIII- Direct Use of Geothermal Energy – This was restructured in 2013, with the creation of four new tasks (A-D), and a fifth (Task E) continuing. Within the framework of Task B- Communication, the GIA Common Fund supported a CanGEA proposal to publish two reports, one on direct use technologies and one a how-to guide for evaluating direct use opportunities. Work began on these reports, with completion planned for 2014. In Tasks C- Guidelines for Geothermal Energy Statistics, and D- Statistics for Geothermal Heat Pump Applications, work began in September 2013, with data collection and comparison. For continuing Task E-, Engineering and Design Configuration Standards, the standards were updated in 2013 and now include documents from five European countries.

Annex X- Data Collection and Information - The second GIA Trend Report, covering 2011, was published in 2013. This report provides key data about geothermal energy uses in GIA member countries and is available as a free download from the GIA website. Data collection and reporting for 2012 was also started in 2013. Two presentations were made about these GIA data collection activities, at the European Geothermal Congress in Italy in June 2013, and at an international workshop on integrating geothermal energy data into IRENA's Global Renewable Energy Atlas.

Annex XI- Induced Seismicity - The induced seismicity (IS) group had in-depth discussions in 2013 about the science and policy issues surrounding IS. They worked on terms and definitions, decided on data formats for seismicity data, started to identify test sites that represent different geological and geothermal conditions and reviewed the USA IS Best Practices document. They were also involved in efforts to modify risk assessment in all countries to be consistent, favoring a physics-based approach. Throughout the year, talks on induced seismicity were given by people from GIA participating countries at various conferences, for example at the Third European Geothermal Review in Germany and at the New Zealand Geothermal Workshop.

Please see Chapter 3 to Chapter 8 of the 2013 IEA-GIA Annual Report for more information.

National Activities

The geothermal programme of each GIA country member provides the basis for cooperative IEA-GIA geothermal activities. These programmes focus on the exploration, development and utilization of geothermal resources. A comprehensive description of the current status of geothermal activities for each of the participating countries and the EC is provided in the 2013 Annual Report (Chapter 9 to Chapter 23) and in standalone country reports available on the GIA website. The status of geothermal use in GIA member countries can be seen in Chapter 1.

Direct Use

All of the GIA member countries used geothermal energy in direct use applications in 2013. In France, Norway, Republic of Korea and Switzerland, in particular, it was the dominant use of geothermal resources. In France, there was a new operation for district heating in 2013, and upgrades and renovations to several existing plants. Ground source heat pumps (GSHP) were used in collective public housing and in office buildings, but had not taken off in individual domestic housing by the end of 2013.

Table 0.1 Geothermal energy use in GIA member countries in 2013

Country	Installed Electricity Capacity (MW)	Contribution to national capacity	Total Direct Heat Used (GWh/year)	Total Net Heat Pump Use (GWh/yr)
Australia	1	<0.001	96	46
Canada	0	0	78	3150
France	17	n.d.	1380	3028
Germany	24	<0.1	870	n.d.
Iceland	663	25	7113	n.d.
Italy	876	1	2269	869
Japan	515	0.2	7250	n.d.
Republic of Korea	0	n.d.	165	463
Mexico	1017	1.6	n.d.	n.d.
New Zealand	1114	11	2375	19
Norway	0	0	2300	n.d.
Switzerland	0	0	233	2199
UK	0	0	12	681

n.d. means no data available. Country chapters of the IEA-GIA Annual Report 2013 contain more detailed information, including installed direct use and heat pump capacities where information is available.

Similarly in the Republic of Korea, GSHPs had a strong presence in office buildings, with a new government office building completed in 2013 that has 38% of its heating and cooling provided by GSHPs (38 MW_{th}). Geothermal was still a very minor energy source and hampered by a lack of legal framework or government support, but it was growing.

GSHPs also dominated geothermal use in Norway and Switzerland, with strong and growing markets. In Norway, about 5000 new GSHPS are installed per year, although air/air heat pumps were still about ten times more numerous. In Switzerland, a total of some 90,000 ground source heat pump systems were deployed by the end of 2013, with an annual growth rate of about 12%.

Power Generation

Five of the GIA member countries have well-established electricity production from high-temperature, conventional geothermal resources. These are Iceland, Italy, Japan, Mexico and New Zealand.

In Iceland, in 2013, a further nine geothermal power plants were under formal consideration. These would provide ~675 MWe installed capacity. In Italy, a new small binary unit was completed at Mount Amiata in 2013. Larderello continued its sustainable electricity production after more than 100 years of exploitation. The first geothermal-biomass power plant in the world also successfully operated in Italy.

In Japan, the electricity production from geothermal resources dropped slightly, from an installed capacity of 540 MW to 515 MW, because of a decrease in steam at Mori Power Plant. However, a new binary demonstration plant was operational and owners and local governments applied for subsidies to investigate future opportunities for small geothermal power plants.

In Mexico, a new 25 MWe condensing flash unit began operating in Los Humeros geothermal field in 2013. A 50 MWe flash power unit was also being developed in Los Azufres. For the first time, private investors carried out their own exploration and drilling in 2013.

In New Zealand, 13 deep geothermal wells were drilled for make-up, development and exploration. The 82 MWe Ngatamariki geothermal power plant was completed, and won Best Power Project at the World GeoPower Markets Awards 2013. The hottest well to date at Wairakei was drilled (272 °C at 1170m, sufficient for 25 MWe) and a 25 MW binary plant was commissioned at Kawerau. A fourth deep well was drilled and tested at Taheke, but flat electricity demand has stalled any further

development in New Zealand. A new wireline borehole descaling technique (broaching) was also successfully introduced in 2013.

Several other countries had developments with geothermal electricity production in 2013. In Australia, the 1 MWe Habanero Pilot Plant had a successful 160 day trial. In France, a well was stimulated as part of an EGS project. Exploration for high-temperature geothermal resources was carried out in the French overseas regions of Martinique and Guadeloupe.

In Germany, four locations with installed electrical capacity were operational in 2013, with five others under construction. A 4.8 MW organic Rankine cycle power plant was also installed. Iceland was a partner in a renewable energy program to build a 2-3 MW geothermal power plant in Portugal. In Switzerland, drilling and testing of a first well was carried out for a combined heat and power project in St. Gallen and two deep geothermal projects were initiated in northern Switzerland.

Research into EGS was a focus in Australia, Germany, Norway, Switzerland and Japan in 2013.

Policy, organisation and environmental efforts

The national governments continued to play significant roles in geothermal development in 2013. For example, government subsidies or underwriting in case of failure were offered in France, Germany, Italy, Japan, Korea, Switzerland and the UK to potentially encourage use of geothermal resources.

Legislation was in place to control and aid geothermal development in most countries, except for Korea and for deep geothermal development in Switzerland. In Italy, a recent law opened the possibility for new players to apply for a lease for geothermal exploration.

Funding from governments, and in some countries from industry, aided research in almost all GIA countries. In Japan, budgets for R&D were reinstated in 2013, after more than 10 years of no support for high-temperature geothermal energy.

Some organisational changes were implemented in 2013 in regards to geothermal science. In Australia, the Australian Renewable Energy Agency was created to look into the potential of non-conventional geothermal energy resources, and Germany was involved in a project to improve collaboration between European authorities and ministries in regards to R&D. The Fukushima Renewable Energy Institute, AIST, was established in Japan including a geothermal energy team and a shallow geothermal team to develop innovative new technologies.

Environmental issues were a factor in geothermal development and/or research in several GIA countries. Almost all countries have renewable energy targets which geothermal is helping them to try and reach. However, visual impacts of geothermal power plants are becoming issues for Iceland and Italy, noise is causing some concern in Germany and Italy, induced seismicity is a focus of research in Germany, Switzerland and the USA, conservation of natural areas is being discussed in Iceland, and subsidence concerns formed part of the consent process in New Zealand. Some of these issues are already being addressed, for example with a biomass remediation facility to reduce dissolved H_2S from Wairakei water discharge, which won New Zealand's energy project of the year in 2013, and with Enel Green Power's successful installation of abatement systems to reduce H_2S odour emissions from power plants in Italy.

Sponsor Activities

The GIA had four sponsor members in 2013, from industry and organisations that represent industry.

The Geothermal Department of the Spanish Renewable Energy Agency (APPA) represents members' interests in politics, civil society and the media. In 2013, they were involved in legislative measures that were introduced in Spain that both favour and detract from geothermal energy use. Two regulations were introduced that were seen as potential obstacles to developing geothermal power generation, relating to the sale of electricity and to energy sector reform. In contrast, a new legislative

package sought to stimulate the deployment of renewable energies through several new measures, for example introducing grant programs for conversion to renewable heat, and certifying energy efficient buildings. A new government programme also promoted energy efficient buildings and the use of renewable energy in residential buildings, which should have a favourable impact on the use of renewable energies in the Spanish residence and hotel sectors. In addition, geothermal energy was recognised as a scientific/technical and industrial priority of the State Plans of Scientific and Technical Investigation, and of Innovation, for the first time in 2013.

In Canada, CanGEA is an organisation that represents Canadian and international companies that believe in the opportunity for geothermal development in Canada, for high temperature and direct uses (GSHPs are represented elsewhere). At present, the government is minimally involved in geothermal energy. In 2013, CanGEA continued to work on their National Geothermal Technology Roadmap and Implementation Plan and completed numerous aspects of it. In addition, they updated two publications: 'Geothermal Power and Direct Use of Heat Supply Chain'; and 'Sector Profile (An Assessment of the Geothermal Energy Sector in Canada – Now and in the Future)'. They also completed the Geothermal Favourability Map of Alberta and began work on one for British Columbia. This data forms part of a Canadian National Geothermal Database, which a web portal was set up for in 2013.

Green Rock Energy Ltd is an Australian geothermal company. In 2013, they focussed their efforts on two sedimentary geothermal projects, in the north Perth Basin in Western Australia, and in Hungary. For the Perth project, substantial funding was won in 2013 from the Commonwealth Government's Emerging Renewables Program to drill two deep wells in 2014. A joint venture agreement was also signed with a petroleum exploration and production company for them to operate the wells and provide the balance of funds. Exploration focussed on scientific studies to locate naturally fractured reservoirs in areas of high heat flow near existing power transmission lines. In Hungary, Green Rock submitted a bid for the grant of a concession area through the joint venture company Central European Geothermal Energy (CEGE). CEGE had been waiting for around three years for the right to apply for a geothermal energy concession, to generate electricity to be sold to nearby power grids.

Ormat is an international geothermal company with about 45% of its employees based in the USA. They carry out exploration, development, designing and building, as well as owning and operating geothermal power plants. They also design, manufacture and sell power units and other power generating equipment. In 2013, Ormat successfully completed nine power plants worldwide with approximately 270 MW of gross generating capacity. Of these, three were owned by Ormat; two in Kenya and one in USA. The remainder were in New Zealand and the USA, with the Ngatamariki plant in New Zealand becoming the largest single-site binary geothermal power plant in the world. In addition, Ormat completed the refurbishment of Mammoth G-1 in California. 2013 was a financially successful year where new projects were completed, existing plants were enhanced and considerable progress was made in production, development and exploration activities. Ormat was also engaged in the largest effort undertaken by a single company within the last 25 years to categorize, map, sample and drill greenfield prospects in the USA, as well as undertaking R&D in drilling technologies, exploration and EGS.

Plans for 2014 and beyond

The GIA's request for extension for a 4th Term was granted in February 2013, taking its efforts into 2014 and beyond. Members will continue to work on the six Annex research themes and will also start a new theme, Annex XII – Deep Roots of Geothermal Systems. Annex participants will continue to work on R&D projects, international collaboration and collecting and disseminating information, as well as funding networking events and proposals relevant to their work. Individual country and sponsor members will carry on working towards a variety of geothermal goals as outlined in their chapters of the annual report, including new geothermal exploration and production, improved policies relating to geothermal energy, enhanced international collaboration and developing tools and techniques.

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