IEA
Geothermal Energy
12th Annual Report
2008

Executive Summary

International Energy Agency
Implementing Agreement
for
Cooperation in
Geothermal Research & Technology

December 2009

Contents

To Find Out More

If you are interested in finding out more about the IEA Geothermal Programme, or you wish to join the GIA

Contact the IEA-GIA Secretary

Dr Mike Mongillo
IEA-GIA Secretary
c/o GNS Science
Wairakei Research Centre
Private Bag 2000
Taupo
NEW ZEALAND

Tel: +64-7-378-9774; +64-7-374-8211
Fax: +64-7-374-8199
E-mail: mongillom@reap.org.nz

OR

Visit the IEA-GIA Website

www.iea-gia.org

Cover Photograph: *The AMIS plant for the Hg and H_2S abatement installed at the 20 MW Nuova Gabbro power plant, Italy* (Photo courtesy of Guido Cappetti, ENEL)

Craters of the Moon, or Karapiti, thermal area, Wairakei Geothermal Field, New Zealand. (Photo courtesy of Mike Mongillo)

Introduction

2008 was a very active and successful year for the IEA Geothermal Implementing Agreement (GIA). Of particular note was the 25% growth in membership, with Spain becoming the 12th Country Member; and ORME Jeotermal (Turkey), the Geothermal Group of the Spanish Renewable Energy Association (GG-APPA) and the Canadian Geothermal Energy Association (CanGEA) joining as Sponsor Members, bringing Sponsor membership to 6, and **total GIA membership to 19**. This broad based membership, from Europe, Asia, the Americas and Oceania, is cooperating on a multitude of R&D projects, and sharing experience and information in order to overcome technical and other challenges to advance the sustainable development of geothermal energy worldwide and thereby contribute to the mitigation of climate change.

In 2008, the 12 GIA Member Countries had a combined installed capacity of 6,575 MW_e and generated 38,373 GWh/yr, contributing about 63% of the global geothermal installed capacity and 66% of the geothermal generation. The average national geothermal installed capacity and power generation for GIA Member Countries with non-negligible contributions were 5.8% and 7.1%, respectively; with a "contribution efficiency" of 5.8 GWh/MW_e, by far the highest of all renewables.

This Summary sets the global scene in which the IEA-GIA operates. A review of the current world energy situation is provided, the considerable worldwide geothermal energy potential is discussed and the contribution that geothermal made to the global energy supply in 2008 is described. An overview of the IEA-GIA and a review of the four Annexes' activities and summaries of their accomplishments are presented. Highlights of GIA Members' 2008 activities are provided and the major achievements of the GIA as an organization are described. Finally, the GIA's plans for 2009 and beyond are outlined.

Current World Energy Situation

The global demand for energy has grown nearly every year since 1981, with the 2007 worldwide total primary energy reaching 12,029 Mtoe, or about 504 EJ_{th} (139,900 TWh_{th}); a growth of about 2.5% over 2006 (IEA, 2009a). The electricity generation amounted to 19,771 TWh (*ibid.*). However, as a consequence of the 2008 global financial and economic crisis, the IEA predicts that energy use will actually fall in 2009 (IEA, 2009b). Subsequent recovery will, though, lead to the resumption of the continuing increase in energy demand. Assuming no change in government policies, the IEA's *Reference Scenario* indicates that by 2030, the energy demand will be 40% higher than in 2007, or about 16.8 billion [10^9] toe (Btoe) (706 EJ_{th}) (*ibid.*). About 90% of the increase will result from non-OECD countries, taking their portion of the total primary energy demand to 63%. Fossil fuels will remain the dominant energy supply source, making up 77% of the increase from 2007 to 2030; demand for oil will increase by about 24%, for gas 42% and for coal 53% during this period. Though it seems that the world's fossil fuel resources will be able to meet these needs to 2030, and beyond, this path would likely lead to serious energy security and economic development problems, and catastrophic consequences for climate change.

Urgent, tough action is needed to curb the greenhouse gas (GHG) emissions growth and resulting rise in global temperatures predicted in the *Reference Scenario:* GHG concentration of 1,000 ppm and temperature increase of 6 °C relative to pre-industrial levels, by the end of the century (IEA, 2009b). The IEA has developed two alternative climate-based scenarios to stabilize GHG concentrations at 550 ppm (*550 Policy Scenario*) and 450 ppm CO_2-eq (*450 Policy Scenario*), resulting in a 50% chance of restricting global temperature increases to about 3 °C and 2 °C, respectively (*ibid.*). The CO_2 and total GHG emissions in both of these scenarios are significantly less in 2030 than in the *Reference Scenario*, *vis*. energy-related CO_2 emissions: some 33 Gt for 550 Policy Scenario and 26 Gt for the 450 Policy Scenario; and total GHG emissions: 48 Gt for the 550 Policy Scenario and 39 Gt for the 450 Policy Scenario. However, both of these scenarios require major efficiency gains; CO_2 capture and storage (CCS) deployment; a major decrease in the contribution of fossil fuels, to be replaced by nuclear and renewables; as well as considerable public and private RD&D spending. Awareness of these possible future outcomes provides a strong incentive for expanding the use of clean, renewable energy resources. Providing affordable, reliable and clean energy to meet these needs is an enormous challenge, and geothermal energy can make an important contribution.

Geothermal Energy- a Global Perspective

The main sources for geothermal energy are the heat flow from the earth's core and mantle (~40%), and that generated by the gradual decay of radioactive isotopes in the earth's continental crust (~60%). Together, these result in an average terrestrial heat flow rate of 44 TW_{th} (1,400 EJ/yr), nearly three times the 2007 worldwide total primary energy supply, 504 EJ_{th} (139,900 TWh_{th}) (IEA, 2009a). Though the world's geothermal heat resources are enormous and ubiquitous, their generally *hidden nature* (underground) makes it difficult to accurately determine potentials on a global basis. This uncertainty is accentuated because the technologies used to develop geothermal resources are evolving, extending capabilities and reducing costs, and thereby increasing technical and economic potentials. Therefore, there are considerable uncertainties in estimating the global geothermal resource potentials, and revisions are likely as more information and new technologies become available.

In 2005, Stefansson (2005) estimated the *most likely* worldwide total technical potential for geothermal resources located along tectonic plate boundaries and near volcanic hot spots to be about 6.5 TW_{th} (205 EJ_{th}/yr), about 40% of the 2007 worldwide total annual supply. Of this total, hydrothermal resources capable of development for electricity generation using conventional methods (T > 130 °C) made up about 240 GW_e (6.5 EJ_e/yr, or 65 EJ_{th}/yr), assuming a 10% electrical conversion efficiency. The remaining 4.4 TWh_{th} (140 EJ_{th}/yr), comprise lower temperature resources (T ≤ 130 °C) considered useful mainly for direct heat applications. Incorporating approximations for as yet hidden/unidentified resources increases these estimates by factors of 5-10 (*ibid*.). In addition, with current conversion efficiencies increasing, and now ranging up to 20% (for high temperature [> 180-200 °C] fluids), power generation potentials are increasing.

In addition to the abovementioned hydrothermal resources, there are several other potentially significant geothermal sources capable of power generation and direct heat use, including: 1) the binary generation from the utilization of the hot water discharged from conventional plants (co-generation) and that available from the lower temperature geothermal resources (75 - 130 °C); 2) the cascaded use of hot water discharged from geothermal power stations for direct heat applications; 3) the massive geothermal energy potential available within drilling depths (3-10 km) in the earth's crust using enhanced geothermal systems technology (EGS); 4) the energy resources in the form of super-critical fluids inferred to exist deep (3-5 km) beneath hydrothermal systems; 5) hot water produced from oil and gas wells; 6) hot water present in deep sedimentary basins; 7) off-shore (under-sea) hydrothermal resources located along the submarine rifts and identified by the presence of hydrothermal vents and 8) the ubiquitous shallow geothermal resources utilized by geothermal heat pumps for heating and cooling and available almost anywhere on the earth's surface.

Of the above non-hydrothermal resources, EGS is the first to have been identified as having an extremely large theoretical potential. Recent estimates indicate that the USA has over 200,000 EJ_{th} extractable heat via EGS techniques, with approximately 100 GW_e of cost-competitive generating capacity developable by 2050, given reasonable R&D investment (MIT, 2006). Estimates of EGS potential for the Rehai and Yangbajing geothermal fields of China (Wan *et al*., 2005) and for regions across India (Chandrasekhar and Chandrasekharam, 2007) also show capacities on the order of 100 GW_e, with further assessments of 35 GW_e for Germany, 12 GW_e for 23% of Switzerland and 13 GW_e for 3 project areas of South Australia (Goldstein, pers. comm., 2008), making a total of ≥ 360 GW_e. A first-order estimate of global EGS theoretical potential of ~ 2 TW_e was obtained by assuming the EGS capacity of 100 GW_e for the US continental area applied to worldwide continental land masses. Though this estimate appears low when compared with the ≥ 360 GW_e limited-area value obtained above, Fridleifsson *et al.* (2008) have indicated that 70 GW_e of EGS could be available by 2050; and considering the challenges facing large-scale EGS deployment (Rybach, pers. comm., 2009) tends to support the lower value. Recent discussions also highlight the continued uncertainties associated with estimating geothermal potentials (Mongillo, in prep.).

Geothermal development for electricity generation and direct use has been in a high-growth phase worldwide for the past few years (Figures ES1 and ES2), and though future prospects look very positive, it is unclear what effect the global financial crisis will have.

Geothermal is a major renewable global energy resource, with a multitude of valuable characteristics, including its: extensive global distribution, environmentally friendly character, independence of season, immunity from weather effects, indigenous nature, contribution to development of diversified power, effectiveness for distributed application, sustainable development capabilities and small areal *foot-print*. Though geothermal usually operates as a baseload provider of electricity with availability and load factors typically well above 90%, it can also operate in a load-following capacity, albeit at lesser efficiency.

Clearly, there is the potential for geothermal resources to make a considerable contribution towards meeting the world's current and future energy needs well into the future, while contributing to reduced future emissions and to the mitigation of climate change. The global geothermal potential is enormous; however, more detailed studies are required to produce confident estimates of its possible contribution.

Status of Global Geothermal Energy in 2008

In 2008, at least 24 countries were producing electricity from geothermal resources, with a total geothermal installed capacity exceeding 10,400 MW_e, based on 2007 data (Bertani, 2007), revised with 2008 GIA Country Member data (Figure ES1, Table ES1). This result is in good agreement with the estimate of 10,587 MW_e expected to be online by 2008/09 based on new power plant that has been commissioned or ordered since 2000 (Bertani, 2008). As stated in the 2007 GIA Annual Report, the worldwide geothermal generation has not been updated since 2005; however, using 2008 GIA data in conjunction with the 2005 information, a minimum estimate of 57,957 GWh/yr is obtained for 2008. The worldwide geothermal installed capacity and power generation figures will be updated for reporting at the World Geothermal Congress 2010. In 2008, the 12 GIA Member Countries contributed about 63% of the global installed geothermal capacity, and 66% of the total geothermal power generated.

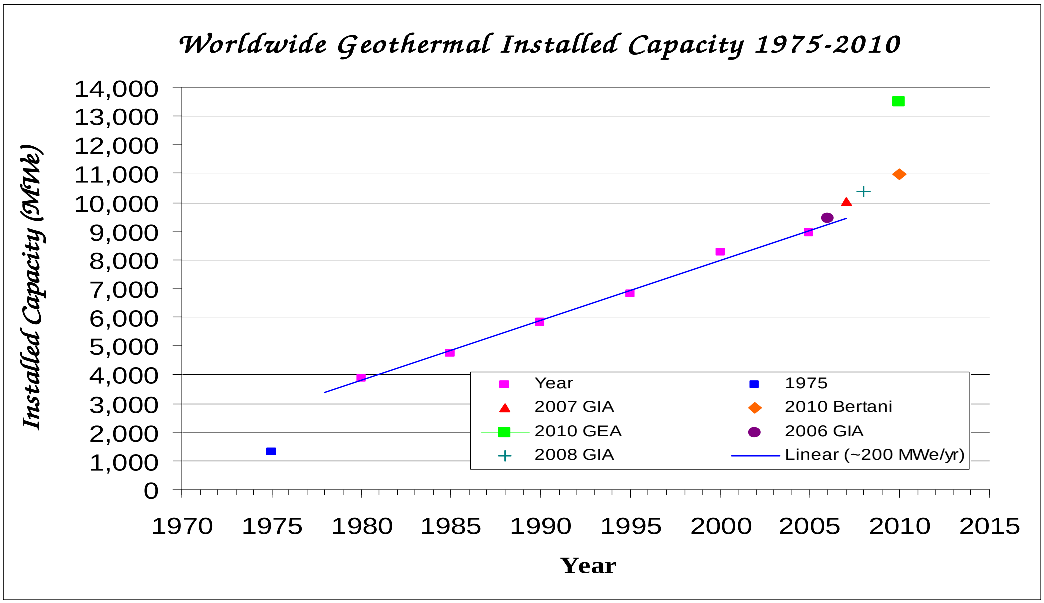

Figure ES1 *Worldwide geothermal installed capacity for the period 1975-2010. The 2006 data [star] includes GIA data for 2006 and data for 16 other countries (Bertani, 2005). The 2007 [triangle] and 2008 [cross] data include 2007 and 2008 GIA data and data for 15 other countries (Bertani, 2007). The trendline was calculated using data for 1980-2005 and has a slope of 200 MW_e/yr; the 2010 estimates are from Bertani (2007) [diamond] and GEA (2007) [square].*

During the period 1980-2005, the worldwide geothermal installed capacity increased by a factor of about 2.3, at a very uniform rate of ~ 200 MW_e/yr (Figure ES1). However, since 2005, an increase in geothermal development has become evident, with a linear trend of about 500 MW_e/yr to 2008, or an average increase of 16.5%/yr. The capacity increase in GIA Member Countries was: 2008 (6,575 MW_e) - 2005 (5,449 MW_e) ~ 1,126 MW_e, or about 20% (6.7%/yr); including data for new GIA Member France in the 2008 total. Table ES1 presents the 2008 data for GIA Member Countries, and 2007 capacity and 2005 generation data for many of the other 15 countries (Bertani, 2007; 2005). Table ES2 illustrates the growth in installed capacity (1995-2008) and generation (1995-2008), with 2006, 2007 and 2008 representing minimum estimates.

As shown in Table ES1, geothermal energy provides a major contribution to the national capacity and national generation for several countries. For eight countries (including Lihir and San Miguel Islands), the geothermal installed capacity now exceeds 10% of their national capacity, and six obtain 15% or more of their electricity from geothermal. The average contribution to national

Table ES1 *Geothermal power installed capacity and electricity generation for GIA Member Countries in 2008, plus 2007 installed capacity data for 15 other countries (Bertani, 2007) and 2005 generation data for the 15 non-GIA countries (Bertani, 2005).*

Country	Installed Capacity (2008) [MW_e]	Annual Electricity Generated (GIA- 2008) (Others- 2005) [GWh/yr]	% of National Capacity	% of National Energy
Australia*	***0.12***	***2.0***	***Negligible***	***Negligible***
Austria	1.1	3.2	Negligible	Negligible
China (Tibet)	28	95.7	30	30
Costa Rica	163	1,145	8.4	15
El Salvador	204	967	14	24
Ethiopia	7	na	1	n/a
France* ***(Guadeloupe Island)*** ***(Soultz-sous-Forêts)***	 ***15*** ***2.2***	 ***90*** ***0***[#]	 ***~9 (for Island¶)***	 ***~9 (for Island¶)***
Germany*	***6.6***	***18.0***	***Negligible***	***Negligible***
Guatemala	53	212	1.7	3
Iceland*	***575***	***4,000***	***22.3***	***24.5***
Indonesia	992	6,085	2.2	6.7
Italy*	***810.5***	***5,181***	***1.0***	***1.8***
Japan*	***535.26***	***3,064***	***0.2***	***0.3***
Kenya	129	1,088	11.2	19.2
Mexico*	***958***	***7,056***	***1.9***	***~3***
New Zealand*	***632***	***3,962***	***6.0***	***~10.5***
Nicaragua	87	270.7	11.2	9.8
Papua New Guinea (Lihir Island)	56	17	10.9	n/a
Philippines	1,970	9,419	12.7	19.1
Portugal (San Miguel Island)	23	90	25	n/a
Russia	79	85	Negligible	Negligible
Thailand	0.3	1.8	Negligible	Negligible
Turkey	38	105	Negligible	Negligible
USA*	***3,040***	***15,000***	***~0.3***	***0.36***
Total	**10,405**	**57,957**	**9.4****	**11.6****
Total GIA Countries	***6,575***	***38,373***	***5.8*****	***7.1*****

* GIA Member Country (includes Guadeloupe Island); ¶ % from Bertani (2007)
[#] not commissioned in 2008; n/a = not available
** Average values exclude negligible contributions, but include Guadeloupe, Lihir and San Miguel Islands since this is the procedure for World Geothermal Congresses.

installed capacity for GIA Member Countries with *non-negligible* installation/generation was 5.8%, with the corresponding average contribution to national generation being about 7.1%. The corresponding worldwide values were 9.4% and 11.6%, respectively (Table ES1).

The total GIA geothermal generation of 38,373 GWh/yr is equivalent to a savings of about 9.7 Mtoe (using GIA conversion (Mongillo, 2005)) and avoided CO_2 emissions of 31.4 Mt. The equivalent savings for the worldwide total generation of 57,957 GWh/yr is about 14.7 Mtoe and avoided CO_2 emissions of some 47.4 Mt (*ibid.*).

Table ES2 Worldwide installed geothermal capacity (1975-2008) and electricity generation (1995-2008). The generation changes for 2006-2008 only include changes in GIA Member Countries.

Year	1975	1980	1985	1990	1995	2000	2005	2006*	2007	2008
Geothermal Installed Generating Capacity (MW_e)	1,300	3,887	4,764	5,832	6,798	7,974	8,930	9,452	10,026¶	10,405¶
Electricity Generation (GWh/yr)	-	-	-	-	37,744	49,261	53,649	55,209	56,782#	57,957#

* The 2006 values are indicative and consist of 2006 data for 8 GIA Members with corrected USA data, and 2005 data for the other 16 countries with geothermal power (Bertani, 2005)

¶ Includes 2007/2008 updated installed capacity data for 15 countries from Bertani (2007) plus GIA 2007/2008 data

\# The 2007/2008 generation data is from 2005 (Bertani, 2005) with updated 2007/2008 GIA Country data

Table ES3 Installed capacity, electricity generation and contribution efficiency for renewable resources in OECD Countries for 2006 (data from IEA (2008c)) and Wind and GIA Members for 2008.

Resource	Installed Capacity (MW_e)	Generation (GWh)	Contribution Efficiency (GWh/MW_e)
Geothermal			
GIA Members 2008	***6,575***	***38,373****	***5.8****
OECD 2006	5,400	38,100	7.1
Solid Biomass (2006)	22,500	115,900	5.2
Hydro (2006)	344,600	1,286,300	3.7
Wind			
(2006)	63,700	116,200	1.8
(2008)	91,770	194,000	2.1
Tide, Wave, Ocean (2006)	300	550	1.8
Solar PV (2006)	4,100	2,626	0.6

* The new installed capacity for 2008 has not been operational for the whole of 2008; hence, the generation and contribution efficiency are low.

An excellent indicator for determining the contributions that renewable energy resources make is the ratio of the amount of power they provide to the given installed capacity, here called the *contribution efficiency*. This ratio takes into account the amount of time that the renewable generator actually produces power, i.e. the *availability factor*. For geothermal, this can be divided into resource availability (usually sustained by make-up drilling) and plant availability (affected by repairs, maintenance, transmission and load-following constraints). As shown in Table ES3, the contribution efficiencies for the various renewables in the 30 OECD countries in 2007 were: 7.1 GWh/MW_e for geothermal (5.8 for GIA Member Countries in 2008), 5.2 GWh/MW_e for solid biomass, 3.7 GWh/MW_e for hydro, 2.1 GWh/MW_e for wind (data from 2008 IEA Wind Annual Report), 1.8 GWh/MW_e for tide/wave/ocean, and 0.6 GWh/MW_e for solar PV (IEA 2008b). Geothermal's very high availability factor makes it valuable for baseload generation. It should be noted that the *contribution efficiency* for the GIA Countries in 2008 is less than for 2007 because the new installed capacity was not operating for the entire year.

Significant effort is made to collect and report worldwide geothermal direct use statistics every five years for the World Geothermal Congresses (as for electricity generation), and this will next be done in 2010. Therefore, the most current data available is based upon that reported by Lund, *et al.* (2005), and updated using the GIA country data reported in the 2008 Annual Report plus other information for Europe provided by Antics and Sanner (2007).

In 2005, 72 countries were utilizing geothermal energy for direct heat applications, including: geothermal heat pumps (GHPs); space, greenhouse and aquaculture pond heating; agricultural drying; industrial uses; bathing and swimming; cooling; and snow melting (Lund *et. al*, 2005). The total installed capacity at the end of 2008 was estimated to be about 36,023 MW_{th}, by incorporating 2008 GIA updates to the 2007 total of 35,570 MW_{th} (Table ES4, Figure ES2). The total thermal energy usage for 2008 was similarly estimated to be about 329,880 TJ/yr (Table ES4). In 2008, the 12 GIA Member Countries had a total installed thermal power capacity of 21,000 MW_{th} and utilized 155,170 TJ/yr (Table ES6). In 2005, an estimated 1.3 million geothermal heat pumps (GHPs) installed in 33 countries contributed over 54% (15,384 MW_{th}) of direct use installed capacity, with a usage of 87,503 TJ. Estimates for 2007 show continued significant growth in the GHP market; about 1.6 million GHP units installed globally with > 19,000 MW_{th} of capacity and > 105,000 TJ utilization (Mongillo, 2008). Lack of data precludes reasonable heat pump estimates being made for 2008.

Table ES4 *Worldwide direct use categories and their development 1995-2005 (from Lund, et al., 2005), with 2007 total and GHP updates from GIA and Antics and Sanner (2007).*

Category	**Capacity (MW_{th})**					**Utilization (TJ/yr)**				
	1995	**2000**	**2005**	**2007**	**2008**	**1995**	**2000**	**2005**	**2007**	**2008**
Geothermal heat pumps	1,854	5,275	15,384	19,010	-	14,617	23,275	87,503	105,000	-
Space heating	2,579	3,263	4,366	-	-	38,230	42,926	55,256	-	-
Greenhouse heating	1,085	1,246	1,404	-	-	15,742	17,864	20,661	-	-
Aquaculture pond heating	1,097	605	616	-	-	13,493	11,733	10,976	-	-
Agricultural drying	67	74	157	-	-	1,124	1,038	2,013	-	-
Industrial uses	544	474	484	-	-	10,120	10,220	10,868	-	-
Bathing and swimming	1,085	3,957	5,401	-	-	15,742	79,546	83,018	-	-
Cooling/snow melting	115	114	371	-	-	1,124	1,063	2,032	-	-
Others	238	137	86	-	-	2,249	3,034	1,045	-	-
Total	**8,664**	**15,145**	**28,269**	**35,570**	**36,023**	**112,441**	**190,699**	**273,372**	**329,270**	**329,880**
Total GIA Countries	**-**	**-**	**-**	***20,547***	**21,000**	**-**	**-**	**-**	***154,560***	***155,170***

Worldwide direct use installed capacity has nearly doubled every 5 years since 1995 and this high growth trend continued through 2007 (Table ES4; Figure ES2). The estimated 2007 direct energy use increased by about 20% since 2005. However, as shown in Table ES4 and Figure ES2, both installed capacity and utilization appear relatively unchanged between 2007 and 2008. The primary cause of this "apparent" halt in growth is a major downward revision in the Japanese data, with the results of a more accurate 2008 survey of hot spring bath use in Japan replacing previous statistical estimates. This resulted in the 2007 estimates of 3,385 MW_{th} installed capacity and 41,518 TJ/yr being reduced by 1,285 MW_{th} and 15,818 TJ/yr, respectively. Iceland also reported a drop of 1,000 TJ/yr in utilization for 2008. The total use of about 329,880 TJ/yr is equivalent to an annual savings of about 11.6 Mtoe in fuel oil and 37.5 Mt in avoided CO_2 emissions (GIA conversions (Mongillo, 2005)).

The IEA-GIA: An Overview

The IEA-GIA was established in 1997, and was in the 2nd year of its 3rd 5-year term (2007-2012) of operation at the end of 2008. The GIA provides a flexible framework for wide-ranging international cooperation in geothermal R&D by bringing together national and industry

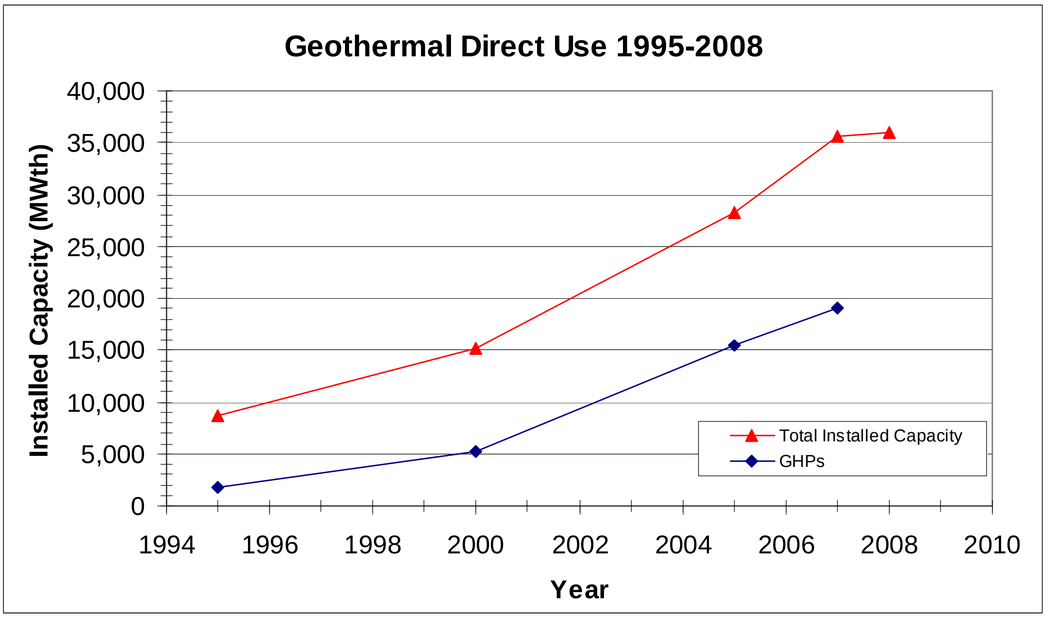

Figure ES2 Total worldwide geothermal direct use installed capacity for the period 1975-2008 (1995-2005 data from Lund, et al. (2005)), with estimates for 2007 and 2008 based on GIA data; and for GHPs for the period 1995-2007 (GIA 2007).

programmes for exploration, development and utilization of geothermal resources, with a focus on enhancing effectiveness through establishing direct cooperative links among geothermal experts in the participating countries and industries. The GIA's general scope of activity consists of international scientific collaborative efforts to: *compile and exchange improved information* on worldwide geothermal energy R&D concerning existing and potential technologies and practices, *develop improved technologies* for geothermal energy utilization, and *improve the understanding of the environmental benefits* of geothermal energy and ways to avoid or minimize its environmental impacts. GIA collaboration provides researchers with opportunities for information exchange via meetings, workshops and networking. Members can also participate in R&D projects and develop databases, models and handbooks. Policy and decision makers can obtain 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 3rd Term **Mission** is:

To promote the sustainable utilization of geothermal energy throughout the world by improving existing technologies and developing new technologies to render exploitable the vast and widespread global geothermal resources, by facilitating the transfer of know-how, by providing high quality information and by widely communicating geothermal energy's strategic, economic and environmental benefits.

To accomplish this Mission, six **Strategic Objectives** were set to target GIA's activities:

- To actively promote effective cooperation on geothermal RD&D through collaborative work programmes, workshops and seminars
- To collect, improve/develop and disseminate geothermal RD&D policy information for IEA Member and non-Member Countries
- To identify geothermal energy RD&D issues and opportunities and improve conventional and develop new geothermal energy technologies and methods to deal with them
- To increase membership in the GIA

- To encourage collaboration with other international organizations and appropriate implementing agreements
- To broaden and increase the dissemination of information on geothermal energy and the GIA's activities and outputs to 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, status, leadership and participation are presented in the 2008 GIA Annual Report (Table 1.2, Chapter 1). An Executive Committee (ExCo) supervises the GIA and its decisions are binding on all Members. The ExCo consists of one voting Member from each Member Country and Sponsor.

Since the GIA's commencement, the Annexes have operated under the *task-sharing* finance mode, whereby participants allocate specified resources and personnel to conduct their portion of the work at their own expense. Total Annex work performed under the auspices of the GIA has been estimated to be well over US$ 310,000/yr, plus several man-years (GIA, 2006a).

In March 2003, the ExCo established a GIA Secretariat to provide it with administrative and other assistance. The Secretariat is funded through *cost-sharing*, with all GIA Members contributing to a Common Fund according to a "share" allocation defined by the ExCo.

At the end of 2008, membership of the IEA-GIA included: the European Commission; 12 countries: Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, the Republic of Korea, Spain, Switzerland and the United States; 4 industry Sponsors: Geodynamics, GreenRock Energy, ORMAT Technologies and ORME Jeotermal; and 2 organization Sponsors: the Canadian Geothermal Energy Association (CanGEA) and the Geothermal Group of the Spanish Renewable Energy Association (GG-APPA).

Collaborative Activities

The Annexes

In 2008, GIA participants worked on four broad research topics, specified in the following Annexes:

- 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

Annexes I and III have been operating since the original implementing agreement was initiated in 1997, and have continued programmes into the current term. In September 2006, Annexes I, III and VII were extended by the ExCo for a further 4 years, to 2009. Annex VIII, which officially started in 2003, completed its first term of operation in 2007, and was unanimously continued by the ExCo for another 4 years to 2011. Four other Annexes have been drafted since the start of the organization, with II- Shallow Geothermal Resources and IX- Geothermal Market Acceleration subsequently closed. The possibility remains for draft Annexes V- Sustainability of Geothermal Energy Utilization and VI- Geothermal Power Generation Cycles to be initiated if sufficient interest arises. The status of the Annexes is presented in the 2008 GIA Annual Report (Table 1.2, Chapter 1).

A brief discussion of some of the GIA's activities and major highlights for the Annexes active in 2008 is presented below. Details are available in Chapter 1 and in the Annex Reports included in Chapters 2-5 of the 2008 GIA Annual Report.

IEA-GIA Annex Meetings 2008

The four GIA Annexes held technical meetings in association with the two 2008 ExCo Meetings in Paris, France (April 2008), and Busan, Korea (October 2008). Each Annex meeting is typically 2-3 hours long and provides the opportunity for detailed discussions of current and planned activities. Important issues that have arisen during the year, e.g. induced seismicity, are also examined.

IEA-GIA Annex I International Geothermal Sustainability Workshop

Task E- Sustainable Utilization Strategies of Annex I (Environmental Impacts of Geothermal Energy Development) co-sponsored, with GNS Science and Contact Energy, an international Sustainability Modelling Workshop dealing with reservoir modelling issues associated with long-term sustainability on 10 November 2008, in Taupo New Zealand. This workshop, which was held in association with the 50th Anniversary of the Wairakei Geothermal Power Station, attracted over 40 participants from 6 countries. The 20 presentations made at the workshop are available on the GIA website (Sustainability Workshop) and plans are proceeding to use these as the basis for a ***Geothermics*** Special Issue on Sustainable Geothermal Utilization to be published in 2010.

Renewable Energy 2008 International Conference, Busan

The GIA had a significant presence at the international Renewable Energy 2008 (RE 2008) conference held in Busan, Korea, on 13-17 October 2008. The GIA sponsored an exhibition booth promoting geothermal energy and the IEA-GIA's activities through the display of several posters (covering geothermal energy; and general GIA, Annex, Country and Sponsor activities) and continuously running PowerPoint presentations. Many GIA documents and CD-Roms were distributed (see photos below). GIA participants were also on hand to talk to visitors. In addition, several papers by GIA participants were presented at the conference, including a general one about the IEA-GIA, its activities and geothermal energy: *Geothermal Energy- IEA-GIA's Efforts Towards Accelerating Development of this Global, Under-Utilized Renewable Resource* (Bromley, et al., 2008).

(photo courtesy Mike Mongillo)

(photo courtesy Adrian Larking)

GIA Participation in IEA Activities

In 2008, the GIA continued its active participation in IEA workshops and meetings, and by providing information and comments on IEA reports.

An IEA-GIA paper reviewing induced seismicity associated with the development and operation of enhanced geothermal systems, entitled: *Geothermal Energy from Fractured Reservoirs- Dealing with Induced Seismicity* (Bromley and Mongillo, 2008) was published in the IEA Open Bulletin #48, February 2008. The GIA also provided information and comments on the geothermal section of the **IEA Energy Technology Perspectives 2008 Report** and participated in the **IEA-RETD Climate Change, Security of Supply and Soaring Energy Prices- the Role of Renewables in Global Energy Models Workshop- Copenhagen** (Denmark) with representation by Guðni Axelsson (Annex I Task E Leader). On 30 September-1 October 2008, the GIA Secretary, Mike Mongillo, participated in the **IEA Network of Expertise in Energy Technology (NEET) Workshop** held in Moscow, Russia, with a presentation: *The IEA Geothermal Implementing Agreement (GIA) Accelerating Sustainable Development of Geothermal Energy Through International Cooperation*.

Use of Geothermal Energy and the Environment

Energy utilization causes a variety of environmental impacts which can be of concern on the global scale. Though geothermal is a relatively benign renewable energy source, with important advantages over fossil fuels, e.g. significantly less carbon emissions, there are some environmental effects associated with its use that require attention. Annex I- Environmental Impacts of Geothermal Energy Development encourages the sustainable development of geothermal resources in an economic and environmentally responsible manner, while identifying and quantifying possible adverse and beneficial environmental impacts, and determining ways to avoid, remedy or minimize the adverse ones, while encouraging the beneficial.

Geothermal development may affect natural surface features like hot springs. Strategies to mitigate, recover or enhance such thermal features using targeted injection and strategic production were improved; and policies to aid regulators to monitor and manage effects on thermal features were refined. Results were presented at the RE 2008 Busan conference and at workshops in the USA and New Zealand.

The disposal of waste fluids and the small quantities of chemicals (e.g. arsenic) and gases (H_2S and CO_2) contained in them is an important issue; and optimum injection strategies for dealing with them were further investigated. Subsidence may arise from production in some geothermal areas; detailed investigations into its causes were conducted for two fields, with methods for improving predictive tools using coupled reservoir and subsidence models developed.

International collaboration continued to help advance understanding of induced seismicity mechanisms and a final version of the induced seismicity protocol was produced (Majer, et al., 2008). Reservoir modelling issues relating to long-term sustainable geothermal utilization were considered at a very successful international workshop on 10 November 2008, at Taupo, New Zealand. The Annex also contributed a poster for the GIA exhibition booth at RE 2008 Busan.

Accessing Geothermal Resources Using Enhancement Techniques

Huge heat resources consisting of high temperature, water-poor rock are available within current drilling depths (>3 km) almost anywhere on earth. To utilize the enormous amount of geothermal energy in this hot rock, Annex III- Enhanced Geothermal Systems (EGS) is investigating the development of new and improved technologies to artificially stimulate these resources (e.g. hydraulically fracture the rock) to enable commercial heat extraction for electricity production and, in some cases, co-generation of heat for direct use applications. These techniques can also be used to help sustain and enhance energy production at existing conventional hydrothermal developments through increasing permeability and via reinjection. The successful development of EGS is presently one of the major challenges facing the international geothermal community.

Revision and restructuring continued in several of the Annex's activities, including those related to economic modelling; data acquisition and processing; and reservoir evaluation and field studies. Discussion continues on how conventional technologies like horizontal drilling, fracture detection and mapping and pumping can be modified for EGS applications; and the US DoE continues to fund such investigations, with several results presented at the 2008 GRC meeting and 2008 Stanford Geothermal Workshop.

The EGS plant at Soultz-sous-Forêts, France, was opened by a representative of the French Government in mid-2008; however, the plant will be "officially" commissioned when the feed-in tariff value is confirmed.

Reducing Geothermal Drilling Costs

One of the most expensive and essential parts of geothermal exploration, development and utilization is the drilling of wells; with subsequent logging and completion also expensive. Reducing well drilling, logging and completion costs can bring major benefits, since these can amount to up to about 50% of the capital cost of a geothermal power project. Annex VII- Advanced Geothermal Drilling Technology, is working to identify, develop and promote ways to reduce the costs of drilling, logging and completing geothermal wells.

Due to the significantly reduced US DoE geothermal budget in 2008, limited funding continued for the Annex Leader, and this severely restricted efforts in the Annex. However, there was still come activity, which mainly consisted of contributing to the 2008 GIA Annual Report, providing revised Annex descriptions for the developing GIA document, reporting to the ExCo and the holding an Annex meeting at the 19th ExCo Meeting (Paris, France). A poster was also provided for the GIA RE 2008 Busan exhibition booth.

Direct Use of Geothermal Heat

Geothermal heat and water have been used directly for bathing, cooking and therapeutic purposes for thousands of years. There are many applications for direct use today, including: building and district heating; industrial process heating; greenhouse heating; crop drying, temperature control for fish farming, bathing and swimming; and snow melting. In fact, the application of geothermal heat pumps allows heat from the earth's shallowest depths (< 100 m depth) to be used almost anywhere on earth for heating and cooling homes and buildings. Geothermal direct use has grown significantly, almost doubling every 5 years since 1995, and its scope for continued expansion remains great.

Though many direct use applications are now well developed and economically viable, implementation difficulties and unfavourable economics still provide major challenges. Annex VIII- Direct Use of Geothermal Resources, addresses all facets of direct use technology, with emphasis on improving implementation, reducing costs and expanding use.

Annex VIII held two meetings during 2008, in association with the two ExCo Meetings (Paris, France and Busan, Korea), at which reports were also made. The Annex contributed papers to the RE 2008 Busan and a poster for the GIA exhibition booth.

Results from the evaluation of temperature and chemical data from geothermal manifestations in Korea, Iceland, Japan and the US, showing that differences in rock types are related to geological environments was published at the RE 2008 Busan conference (Muraoka et al., 2008). The questionnaire for obtaining cost and performance information for direct use of geothermal energy was revised and more widely distributed than the first one. GIS-type methods to present and access direct use data are being investigated, with successful tests using Google Earth demonstrated and further development continuing.

National Activities

The geothermal programmes of the GIA Country Members provide the basis for the cooperative IEA 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 2008 GIA Annual Report (Chapters 6-18).

In 2008, Contracting Parties from 12 countries and the European Commission (EC) participated in the IEA-GIA. The Member Countries were: Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, the Republic of Korea, Spain, Switzerland and the United States.

Contributions of GIA Members to Power Generation and Direct Use

In 2008, the 9 GIA Member Countries with geothermal generation had an installed capacity of about 6,575 MW_e, or about 63% of the total global geothermal capacity of 10,405 MW_e; and generated 38,373 GWh/yr, or about 66% of the total geothermal generation of 57,957 GWh/yr (Tables ES1 and ES5). The United States was by far the largest producer, generating about 15,000 GWh/yr, with Mexico second with 7,056 GWh/yr and Italy third with 5,181 GWh/yr. The percent of national installed capacity provided by geothermal in the 7 IEA-GIA Member Countries with non-negligible power development ranged from 0.2% for Japan to 22.3% for Iceland, with an average of about 5.8%. The contribution of geothermal to national generation in Member Countries ranged from 0.3% for Japan to 24.5% for Iceland, with an average of 7.1%.

Table ES5 *Total geothermal installed capacity, electricity generation and direct use in GIA Member Countries in 2008.*

Country	Electrical Installed Capacity (MW)	Annual Energy Generated (GWh/yr)	% of National Capacity	% of National Energy	Installed Thermal Power (MW_{th})	Annual Energy Used (TJ/yr)
GIA Member Countries	6,575	38,373	5.8*	7.1*	21,000	155,170
Worldwide Total**	10,405	57,957	9.4	11.6	36,023	329,880
GIA % of Worldwide Total	63	66	-	-	58	47

* Average % of 7 GIA Member Countries with non-negliglble generation, including Guadeloupe Island (France).

** For sources of worldwide total data see Tables ES 1 and ES4? above.

All 12 GIA Member Countries utilized geothermal in direct applications in 2008, with a total installed capacity of about 21,000 MW_{th} and total thermal energy used approximately 155,170 TJ/yr (Table ES6). In a few cases, the data presented are from 2005 (Lund, *et al.*, 2005) or Antics and Sanner (2007), or has been estimated based on indicative rates of growth. Relative to 2007, there was significant growth in installed capacity for France, Iceland, Korea, Switzerland and the USA; and in the utilization for France, Germany, Korea, Switzerland and the USA. There was a significant decrease in Japan's installed capacity and utilization due to a "readjustment" that was made for the contribution from hot springs use. The three largest users of geothermal heat by far were the USA (46,831 TJ/yr), Japan (25,700 TJ/yr), and Iceland (25,000 TJ/yr). However, the non-high enthalpy geothermal countries, Germany (9,100 TJ/yr) and Switzerland (7,660 TJ/yr) also had very high utilization, mainly due to the large and growing geothermal heat pump usage.

In 2008, the GIA Member Countries were estimated to have saved the equivalent of approximately 16.1 Mtoe and avoided CO_2 emissions of about 45.8 Mt, assuming total fuel oil replacement (GIA conversions (Mongillo, 2005)) (Table ES6). The differences between the equivalent fuel oil savings reported by the GIA and the IEA values presented for geothermal electricity generation are mainly due to the use of the GIA relation (*ibid.*): 1 GWh = 253.4 toe, rather than that of the IEA: of 1 GWh = 860 toe. Some of the GIA Members have also taken into account the fuel source mix used in their countries.

Table ES6 Geothermal direct use in GIA Member Countries in 2008.

Country	Installed Thermal Power (MW_{th})	Annual Energy Used (TJ/yr)
Australia	130	3,672
France installed thermal capacity heat pumps	 307 1,300	 5,440 10,470
Germany near surface deep geothermal	 [952]	 8,500 600
Iceland	(1,844)	25,000
Italy	[650]	8,000
Japan	2,100	25,700
Mexico	156	(1,932)
New Zealand	(308)	10,000
Republic of Korea	149	1,365
Spain	6.0	na
Switzerland	1,057	7,660
USA	12,037	46,831
Total for GIA[1]	**21,000**	**155,170**

[1] Total excludes the EC; ( ) = from Lund, *et al*. (2005); na = not available
[ ] = from Antics and Sanner (2007)

Table ES6 Equivalent fuel oil savings and avoided CO_2 emissions in 2008.

Country	Equivalent Fuel Oil Savings (Mtoe) §			Avoided CO_2 Emissions (Mt)¥		
	Electricity Generation	Direct Use	Total	Electricity Generation	Direct Use	Total
Australia	negligible	0.09	0.09	negligible	0.44	0.44
France	0.03	0.13	0.16	0.07	0.40[1]	0.47[1]
Germany	negligible	0.32	0.32§	negligible	1.0	1.0
Iceland	1.01	0.88	1.89	3.44	1.20	4.64
Italy	1.31	0.28	1.59	4.23	0.91	5.14
Japan*	0.78	0.90	1.68	2.50	2.92	5.42
Mexico	1.79	0.07	1.86	5.76	0.22	5.98
New Zealand	1.00	0.35	1.35	3.19	1.10	4.29
Republic of Korea	0	0.07	0.07	0	0.16	0.16
Spain	0	na	na	0	na	na
Switzerland	0	0.18	0.18	0	0.58	0.58
USA	3.67	3.19	6.86	12.3	5.32	17.6
Total for GIA[2]	**9.59 [33.0]✱**	**6.46 [7.42]✱**	**16.1 [40.4]✱**	**31.5**	**14.25**	**45.8**

* Year to March 2008; [1] Excluding geothermal heat pumps;
§ Where values are not provided, GIA conversions (Mongillo, 2005) are used: for electricity generation: 1 GWh = 253.4 toe, assuming oil thermal power plants; conversion for direct use assuming oil thermal power plants: 1 TJ = 35.2 toe
¥ Where values are not provided, GIA conversions used (*ibid*.): for electricity generation: 1 GWh = 817 tonnes CO_2; for direct use: 1 TJ = 113.6 tonnes CO_2; na = not available;
✱ Totals using IEA conversion (1 GWh = 860 toe; 1 TJ ~ 47.8 toe)

Sponsor Activities

At the end of 2008, the GIA had 6 Sponsor Members, 4 from industry: Geodynamics Limited and Green Rock Energy Limited, from Australia; Ormat Technologies, Inc. from the USA and ORME Jeotermal from Turkey; and 2 organizations: the Canadian Geothermal Energy Association (CanGEA) and the Geothermal Group of the Spanish Renewable Energy Association (GG-APPA).

Industry Sponsors

Geodynamics Limited

Geodynamics is Australia's largest geothermal company and specifically focuses on the economic extraction of heat from hot rocks using enhanced geothermal systems (EGS) technology. In particular, its efforts are concentrating on drilling to depths of 3.6-4 km below surface into hot (T ~ 230 °C) fractured granite in the Cooper Basin area of northern South Australia.

Several flow tests involving wells Habanero 1 (Hb1) and Hb3 were performed in March and April 2008, with stimulation of Hb3 in mid-April. This was followed with the first closed-loop circulation between Hb3 and Hb1 achieved on 1 August, and a successful 6-week closed-loop circulation and tracer test that ended in February 2009. Stable flow rates of about 20 kg/s with surface temperatures of 212 °C have been achieved. Construction of a 1 MW power station began in mid-2008, and was virtually complete in March 2009. In late September, well Jolokia 1 was successfully completed to a depth of 4,911 m at a site 10 km west of the Habanero reservoir; with results demonstrating that the over-pressure that existed at Habanero extended to Jolokia. In mid-October, drilling commenced at the Savina site, 10 km west of Jolokia; where drilling of Savina 1 identified the over-pressured fracture at about 3,700 m depth- indicating that it extended 20 km from the Habanero site. An extensive microseismic monitoring network consisting of 18 permanent stations and covering an area of 160 km^2 has been installed and now extends over the Habanero-Jolokia-Sabina area. Geodynamics also plans to purchase another heavy-duty rig (US$ 38.3 M) with a capacity to drill to 6,000 m.

There has been further significant investment in Geodynamics in 2008, with the Sentient Group and Sunsuper Pty Ltd, and Tata Power agreeing to become cornerstone investors. In addition, in June, AUS$ 33.5 M was raised from a share purchase plan; in July, Origin committed a further AUS$ 9.6 M; and in November, Geodynamics received a NSW Government award of AUS$ 10 M for development of the Hunter Valley Geothermal Project.

Green Rock Energy Limited

Green Rock Energy Limited is a public company listed on the Australian Securities Exchange whose purpose is to evaluate and develop geothermal resources in Australia and abroad.

Over the next three years Green Rock is focussing on developing two commercial demonstration projects in sedimentary aquifers in each of Australia and Hungary, and one engineered geothermal system (EGS) project in thermally anomalous granite at Olympic Dam in South Australia. All three projects are located at markets, and can be commercialised quickly, given success with drilling and flow testing.

The chief challenges for both types of geothermal resources relate to: drilling to depths with sufficient temperatures for the end uses (2,000-5,000 m), finding or engineering sustainable permeability at reasonable cost, and proving the capacity of the geothermal reservoir to deliver enough energy at the surface to justify the investment.

Green Rock's Olympic Dam project, located at the site of a major market, the Olympic Dam mine, has demonstrated successful mini-hydro fracture stimulation, and is now seeking funding, via a "farm-in", before commencing deep drilling, stimulation and flow testing to prove commercial viability.

In August 2008, Green Rock, MOL (Hungary) and Enex (Iceland) formed Central European Geothermal Energy (CEGE) to pursue a demonstration project to produce electricity from geothermal water at depths of about 3,000 m. CEGE was acquired by MOL (50%) and Green Rock (50%) in January 2009. CEGE's aim is to use hot geothermal water produced from existing petroleum wells to generate electricity using ORC plants. CEGE is also considering investments in direct heat projects in Hungary.

Ormat Technologies, Inc.

Ormat Technologies, Inc., based in the USA, is a leading vertically integrated company engaged in the geothermal and recovered energy (i.e. from "waste heat") power business. Ormat has over 40 years experience with ORC and 25 years of its applications to geothermal development. Ormat explores, develops, designs, builds, owns and operates clean, environmentally friendly geothermal and recovered energy-based power plants. In addition, the company also designs, manufactures and sells power units and other power generating equipment for geothermal and recovered energy (RE) based electricity generation for third parties.

Ormat owns and operates 515 MW_e of geothermal and RE generation in 6 countries, including 350 MW_e of geothermal in the USA, and has deployed about 70% of all geothermal capacity in the US since 2000. In 2008 and early 2009, Ormat added about 187 MW_e of gross geothermal capacity worldwide, and signed US$ 230 M in contracts with third parties for power plants in Nevada, New Zealand Turkey and Costa Rica. The company has over 1,000 employees. It also has its own in-house drilling company, GeoDrill, with four rigs (capacity ~ 5,500 m) and over 90 staff.

In a joint project with the US DoE in 2008, Ormat validated the feasibility of using its proven ORC technology to commercially generate electricity using hot water produced during oil and gas field production, the first project of its type to provide on-site fuel-free power. Ormat is also involved in EGS projects at Desert Peak and Brady in the USA, and at Landau, Germany.

In 2008, Ormat's revenues were US$ 345 M, an increase of 16.5% over 2007, with 2009 revenues expected to increase by 9-15% over 2008.

ORME Jeotermal, Inc.

ORME Jeotermal, a geothermal engineering, industry and trade company based in Turkey, became an industry Sponsor Member in July 2008. ORME was founded in 1984 and became a joint-stock company in 1987.

ORME's scope of work includes: geothermal field studies; drilling, well testing, reservoir determination; feasibility, design and engineering; geothermal electricity production; district heating, greenhouse heating, and cooling systems; complete design of thermal tourist facilities; installation of geothermal district heating systems; and finance, investment and management of geothermal projects.

ORME's participation in GIA activities is currently being reviewed.

Organization Sponsors

Canadian Geothermal Energy Association (CanGEA)

The Canadian Geothermal Energy Association (CanGEA) became an organization Sponsor Member of the GIA in October 2008. CanGEA is a non-profit association that promotes the development and use of sustainable geothermal energy in Canada. Their focus is on moderate to high temperature resources (> 70 °C) for power generation.

CanGEA, working together with the British Columbia (BC) Provincial Government, produced a comprehensive white paper on best practices policy for Canadian geothermal energy development.

Reported activities in Canada include: a Geothermal Task Force was established by the BC Provincial Government to update current geothermal regulations in anticipation of a geothermal lease sale. Testing at Meager Creek hydrothermal project, located in BC and owned by Western GeoPower Corporation, verified Canada's first potentially commercial geothermal reservoir for electricity production.

Geothermal Group- Spanish Renewable Energy Association (GG-APPA)

The Geothermal Group of the Spanish Renewable Energy Association (GG-APPA) became a GIA Sponsor Member in October 2008. It represents its geothermal members' interests in politics, civil society and the media and participates in the development of Spanish energy and environmental policy. GG-APPA currently has a high enthalpy geothermal department and is proceeding to setup a low enthalpy one.

Though there are significant geothermal resources in Spain, they presently have low penetration in the energy balance. Studies show several favourable areas with potential for high temperature volcanic convective hydrothermal, conductive sedimentary and EGS systems for electricity generation. A significant number of medium/low temperature resources have also been identified across Spain and will be useful for direct heat applications, including district heating (Barcelona and Madrid); and geothermal heat pumps are applicable everywhere.

In 2008, more than 50 geothermal exploration and investigation licenses covering 7,500 km^2 were applied for in Spain and over 10 M€ was committed for exploration by companies over the next 3 years. The first district heating production is expected in 2011 and the first power generation in 2013 A feasibility study for a Madrid geothermal district heating scheme was conducted; and GG-APPA collaborated with the European Geothermal Energy Council (EGEC) to develop and prepare a research agenda for geothermal energy strategy for 2008-2030 and a geothermal regulation framework for Europe.

In addition, the high and low enthalpy departments of APPA manage the Secretariat of the recently initiated Spanish Geothermal Technology Platform (GEOPLAT), which aims to identify and develop sustainable strategies for the promotion and marketing of geothermal energy in Spain.

Plans for 2009 and Beyond

The end of 2008 sees the GIA nearly 2 years into its 3rd Term; having made significant progress towards meeting its Mission and Strategic Objectives. The GIA has participated at large international workshops/conferences in Korea, Russia and Denmark, co-sponsored an international workshop in New Zealand, contributed up-to-date geothermal information to several IEA reports, and membership has grown by 25%, with new Country Member Spain, and three new Sponsor Members: CanGEA, GG-APPA and ORME Jeothermal.

The GIA anticipates continued growth in its efforts and its membership in 2009, and onwards. The GIA already has plans to participate at the 2009 Geothermal Resources Council Meeting and at the very important World Geothermal Congress in 2010. There are commitments to hold a joint international GIA-IGA (International Geothermal Association) Workshop in Madrid, Spain, dealing with global geothermal development potential and its possible contribution to the mitigation of climate change; and arrangements have been made to produce a Special Issue of ***Geothermics*** on Sustainable Geothermal Utilization based upon the presentations made at the 2008 Workshop. The GIA will continue its strong support of the IEA by providing current geothermal data/information, contributing to their publications and by participating in IEA workshops. The ExCo is considering the possibility of using a part of the GIA Common Fund to support one-off Annex related activities to help advance joint Member projects and assist with the publication of Annex reports. In addition, the GIA will continue to pursue new membership in order to extend its base and expand its expertise.

Though there is some concern caused by the financial and economic crisis that appeared so suddenly during the later part of 2008, there is still optimism within the geothermal community, buoyed by a continuing growth in global geothermal development that became evident in 2007, and strengthened in November, with the election of US President (Elect) Obama, who strongly supports the development of renewable energy. It is clear that geothermal energy can make a substantial contribution towards meeting the future global energy needs, and the GIA sees the organization and its activities continuing and growing into the future in order to help ensure that geothermal provides its maximum sustainable contribution.

References

Antics, M. and Sanner, B. (2007) Status of geothermal energy use and resources in Europe. *Proc. European Geothermal Congress 2007*, Unterhaching, Germany, 30 May- 1 June 2007, 8 p.

Bertani, R. (2008) Geothermal power plants commissioned in the third millennium. *IGA News*, No.72, 5-10.

Bertani, R. (2007) World geothermal generation in 2007. *Proc. European Geothermal Congress 2007*, Unterhaching, Germany, 30 May- 1 June 2007. 11 p.

Bertani, R. (2005) Worldwide geothermal generation 2001-2005: state of the art. *Proc. World Geothermal Congress 2005*, Antalya, Turkey, 24-29 April 2005.

Bromley, C.J. and Mongillo, M.A. (2008) Geothermal energy from fractured reservoirs: dealing with induced seismicity. IEA *OPEN energy technology bulletin,* **48,** 7p. (available at: Fractured reservoirs and induced seismicity).

Bromley, C.J., Mongillo, M.A., Rybach, L., Jelacic, A. and Song, Y. (2008) Geothermal energy- IEA-GIA's efforts towards accelerating development of this global, under-utilized renewable resource. *RE 2008 Busan, Korea; CD-Rom*, 4p.

Chandrasekhar, V. and Chandrasekharam, D. (2007) Enhanced geothermal resources: Indian scenario. GRC Transactions, 31, 271-273.

Fridleifsson, I.B., Bertani, R., Huenges, E. Lund, J., Rangnarsson, A. and Rybach, L. (2008) The possible role and contribution of geothermal energy to the mitigation of climate change. *Proceedings IPCC Climatic Scoping Meeting Lübeck,36p* (available on IEA-GIA website: IPCC Geothermal 2008).

GIA (2007) 2007 GIA Annual Report (available at: http://www.iea-gia.org/publications.asp).

IEA (2008a) Energy Technology Perspectives 2008- Scearios & Strategies to 2050. OECD/IEA, Paris, France (for information see IEA website: ETP 2008).

IEA (2008b) World Energy Outlook 2008. OECD/IEA, Paris, France (Summary available on IEA website: http://www.iea.org/Textbase/npsum/WEO2008SUM.pdf).

IEA (2008c) IEA Renewables Information 2008. Paris, France, 238 p.

IEA (2009a) IEA Key World Energy Statistics 2009. OECD/IEA, Paris, France.

IEA (2009b) World Energy Outlook 2009- Fact Sheets. OECD/IEA, Paris, France.

IEA-GIA Annex I (2008) Presentations from IEA-GIA Sustainability Modelling Workshop, Taupo, New Zealand, 10 November 2008 (available on IEA-GIA website: geothermal sustainability).

IEA Wind (2009) IEA Wind Energy Annual Report 2008, July 2009. (available on: www.ieawind.org)

Lund, J.W., Freeston, D.H. and Boyd, T.L. (2005) Direct application of geothermal energy: 2005 worldwide review. *Geothermics*, vol. 34, 690-727.

Majer, E., Baria, R. and Stark, M. (2008) Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems (final version), 8p. (available on IEA-GIA website at: Induced Seismicity Protocol).

MIT (2006) The Future of Geothermal Energy- Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century. MIT Press, Boston, USA.

Mongillo, M.A. (2008) Accelerating sustainable development of geothermal energy through international cooperation. IEA Networks of Expertise in Energy Technology (NEET) Moscow, Russia, 30 September-1 October 2008 (available on IEA website: IEA-GIA NEET Moscow)

Mongillo, M.A. (2005) Savings factors for geothermal energy utilization. IEA Geothermal Implementing Agreement document, January 2005. (document available at: Savings Factors.pdf)

Muraoka, H., Gunnlaugsson, E., Song, Y., Lund, J., Bromley, C.J. and Rybach, L. (2008) Host rock controls to thermal water chemistry induced from the global comparison. *RE 2008 Busan, Korea; CD-Rom*, 3p.

Stefansson, V. (2005) World geothermal assessment. Proceedings World Geothermal Congress 2005, Antalya, Turkey, 24-29 April 2005, 6p.

Wan, Z., Zhao, Y. and Kang, J. (2005) Forecast and evaluation of hot dry rock geothermal resource in China. Renewable Energy, 30, 1831-1846.

Author and Contact

Mike Mongillo
IEA-GIA Secretary
GNS Science
Wairakei Research Centre
Box 2000
Taupo 3352
New Zealand
mongillom@reap.org.nz