Geothermal Energy

IEA

Annual Report 2010

Executive Summary

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

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Cover Photographs

Well IDDP-1 (Top: Photo courtesy of Jonas Ketilsson, Orkustofnun, Reykjavik, Iceland)
Flash steam plant in the Imperial Valley, Southern California, USA (Bottom: Photo courtesy of US DoE, USA)

Executive Summary

"Manning" the GIA exhibition booth at WGC2010, Bali, Indonesia.
(Photo courtesy of Mike Mongillo)

Introduction

2010 was another very successful year for the IEA Geothermal Implementing Agreement (GIA). Particularly noteworthy was the GIA's participation at the World Geothermal Congress 2010 (WGC2010), held in Bali, Indonesia. The WGCs are premier international geothermal events, held every 5 years. The GIA had a significant and very successful presence, with presentations at technical sessions of 6 papers describing Annex activities on environmental, sustainable utilization, direct use, and advanced drilling and logging topics; and a keynote address describing the GIA's overall efforts: *The International Energy Agency Geothermal Implementing Agreement-International Efforts to Promote Global Sustainable Geothermal Development and Help Mitigate Climate Change* (Mongillo, *et al*., 2010) given as part of a Panel Discussion (see References). In addition, the GIA sponsored an exhibition booth where 20 posters illustrated the organization's Annex and Member geothermal endeavours. Over 100 visitors stopped by for discussions, and several hundred GIA and IEA documents, reports and CD-Roms were distributed.

Also significant in 2010 was the continued expansion of GIA's efforts with the pursuit of special projects deemed valuable for the organization, and the continuation of the GIA proposal programme, which makes available a portion of the GIA Common Fund to support Annex and other GIA activities and amounting to US$ 75 k in 2010. These expanded efforts are possible because of the stable Common Fund support provided by the GIA's relatively high membership (19 Members in 2010) and the comparatively steady cost for operating the GIA Secretariat. Two proposals, each receiving US$ 10 k, were funded in 2010: one to support an Induced Seismicity Workshop in Reykjavik, Iceland, held in October 2010; and the second, a contribution to support the preparation of the IEA Geothermal Roadmap. The ***Geothermics Special Issue* on Sustainable Utilization of Geothermal Energy** was completed and published in December 2010 with the aid of proposal funding provided to the Secretary (2009/2010) to act as a Guest Editor with Guðni Axelsson, Leader of Annex I Task E- Sustainable Utilization Strategies (Geothermics, 2010). The **Special Issue** contains 11 international articles that examine the sustainable utilization of high and low temperature resources for electricity generation and direct heat use for such applications as district heating, industrial processing, geothermal heat pumps, etc. The special projects funded in 2010 included: sponsorship of the WGC2010 exhibition booth and participation of the Secretary, as an official GIA representative, at the IEA Geothermal Roadmap Workshop held in Bandung, Indonesia (Mongillo and Bromley, 2010a).

The GIA's R&D activities were also extended with the addition of new Annex XI- Induced Seismicity, in recognition of the growing importance of seismicity generated in association with the creation and operation of enhanced geothermal systems (EGS). The 2010 Annual Report also includes the first contribution from Annex X- Data Collection and Information, which was opened in late 2009.

The GIA's 2010 membership remained at 19, with the addition of new Country Member, Norway, and the unfortunate loss of Industry Member ORME Jeotermal (Turkey), who withdrew for financial reasons. As of December 2010, membership comprised 13 Country and 5 Sponsor (industry/industry organization) Members, plus the EC. This broad-based membership, from continental Europe, Scandinavia, Asia, the Americas and Oceania, collaborates on a whole host of R&D projects, and shares experience and information in order to overcome technical and other challenges to advance the sustainable development of geothermal energy worldwide and so contribute to the mitigation of climate change.

The GIA's involvement in the production of the Intergovernmental Panel on Climate Change (IPCC) Special Report on Renewable Energy Sources and Climate Change Mitigation continued, with ExCo Members and Secretary participating as Coordinating Lead, Lead and Contributing Authors for the Geothermal Chapter. The final report is expected to be published in mid-2011.

In 2010, the 9 GIA Member Countries with geothermal generation had a combined installed capacity of 6,833 MW_e and total generation of 39,969 GWh/yr, contributing about 63% of the global geothermal installed capacity and 60% of the geothermal power. For GIA Member Countries with non-negligible contributions, the contribution to national geothermal installed capacity and power generation ranged from 1.0-22% and 1.1-27%, respectively; with an average generation per installed capacity of 5.8 GWh/MW_e, by far the highest of all renewables.

This Executive Summary provides an introduction to, and brief summary of, the 2010 GIA Annual Report. It outlines the global scene in which the IEA-GIA operates, describes the current world energy situation, and discusses the extensive worldwide geothermal energy potential and the contribution that geothermal made to the global energy supply in 2010. A synopsis of the IEA-GIA and a review of the six Annexes' activities and summaries of their accomplishments are presented. Highlights of GIA Members' 2010 activities are provided and the major achievements of the GIA as an organization are described. Finally, the GIA's plans for 2011 and beyond are outlined. All references to chapters, sections, etc. here refer to those in the 2010 Annual Report.

Current World Energy Situation

Though the global total demand for energy has grown nearly every year between 1971 and 2008 (Figure ES1), there was a slight (~1%) decrease in the 2009 worldwide total primary energy supply to 12,150 Mtoe (508.7 EJ_{th}) compared to 2008 (12,267 Mtoe, 514 EJ_{th}) and a ~0.6% decrease in electricity generation to 20,055 TWh (IEA, 2010; 2011), probable consequences of the global financial crisis. However, this slight lull was overwhelmed by the extraordinary ~5% increase in primary energy demand in 2010, with associated CO_2 emissions of 30.4 Gt, an increase of 5.3% over 2009 (Birol, 2011). This exceptional annual growth is now raising some concern about the possibility of achieving the global climate change objective of limiting the temperature increases this century to 2 °C above the pre-industrial levels (ibid.). In addition, an unacceptable 20% of the world's population, ~ 1.3 billion, still remain without access to electricity.

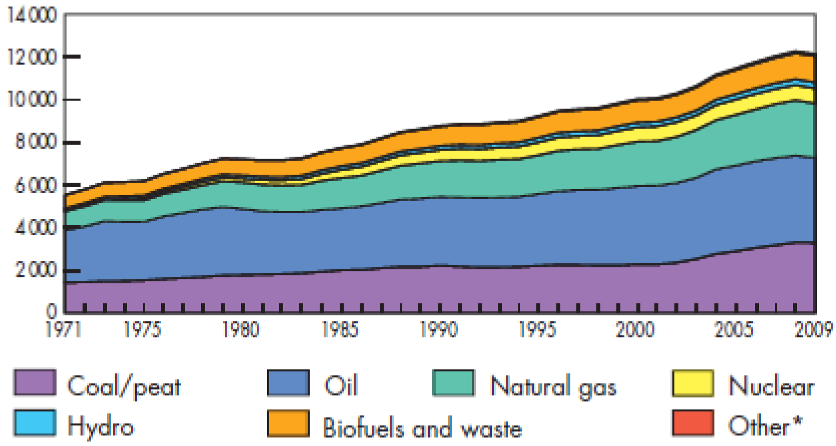

Figure ESI *World total primary energy supply by fuel (in Mtoe) for the period 1971-2009 (IEA, 2011).*

Further challenges arose in 2010, including: the fossil fuel subsidies that promote wasteful consumption increased to about US$ 409 billion; the global energy intensity again worsened as it did in 2009, despite the great efforts many countries are making to increase energy efficiency; and turmoil in the Middle East and North Africa cast doubts about the reliability of global energy supplies. Compounding these issues is the shift of government focus away from energy policy caused by the problems of financial integrity of several countries.

Assuming that recent government policy commitments are implemented in a cautious manner, termed the New Policies Scenario, energy demand grows by 30% between 2010 and 2035 as a consequence of a global population increase of 1.7 billion people and global economy growth of 3.5%/yr. About 90% of the population and energy demand growth occurs in non-OECD countries, with China becoming the largest energy consumer and India, Indonesia, Brazil and the Middle East energy consumption rates growing even faster than in China. Though the demand for all fuels increases, the fossil fuels share decreases from 81% in 2010 to 75% in 2035, however, natural gas does increase its share in the global mix. Renewable energies, mainly hydro and wind, provide about 50% of the new installed power capacity. The outcome of the New Policies Scenario leads to a temperature increase of >3.5 °C, compared to the Current Policies Scenario, which results in a temperature increase of ≥6 °C. Neither of these scenarios is sufficient.

To achieve the 2 °C limit as formulated in the 450 Scenario (450 ppm CO_2 -eq greenhouse gas concentration), 80% of the total energy related CO_2 emissions permissible by 2035 are now "locked-in" by the existing capital stock of power plants, buildings, factories, etc. Furthermore, if no new action is taken by 2017, all of the CO_2 emissions allowed by the 450 Scenario up to 2035 will be generated by the energy related infrastructure then in place. Consequently, only extremely costly "zero-carbon" power plants, factories and other infrastructure could be added between 2017 and 2035 (Birol, 2011).

Therefore, urgent and tough action is required to attain the climate change objective, with global emissions per unit of output needing to be reduced by 65% by 2035 (ibid.). Major energy efficiency improvements are needed, and can contribute 50% of the required energy emissions reductions. The fossil fuel subsidies must be abolished and disincentives, such as sufficient carbon pricing, need to be established to support more low-carbon technologies. Also of great importance is the scale-up and protection of energy sector R&D. Technologies based on renewable and nuclear energies, and carbon capture and storage (CCS) have important and large roles to play, providing 60% of the global electricity production in 2030 in the 450 Scenario. If nothing is done, fossil fuels will still provide 65% of the generation (Birol, 2011).

Awareness of the current global energy situation and possible dire future climate change outcomes are strong incentives for urgent action, particularly for expanding the use of clean, renewable energy resources. Providing affordable, reliable and clean energy to meet future needs while mitigating major climate change 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 2.8 times the 2009 worldwide total primary energy supply, 509 EJ_{th}/yr, (IEA, 2011), which is about 1% less than the 2008 value (514 EJ_{th}/yr). Though the world's geothermal heat resources are enormous and ubiquitous, it is difficult to accurately determine potentials on a global basis due to their generally *hidden* nature (subsurface). This uncertainty is exacerbated 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 expected as more information and new technologies become available.

The most likely worldwide total technical potential for geothermal resources located along tectonic plate boundaries and near volcanic hot spots has been estimated to be about 6.5 TW_{th} (205 EJ_{th}/yr) (Stefansson, 2005), about 40% of the 2009 worldwide total annual supply. Of this total, identified hydrothermal resources capable of development for electricity generation using conventional methods ($T > 130$ °C) amount to some 200 GW_e (5.7 EJ_e/yr, or 57 EJ_{th}/yr), assuming a 10% electrical conversion efficiency. The remaining 4.7 TW_{th} (148 EJ_{th}/yr), comprise lower temperature resources ($T \leq 130$ °C) considered useful mainly for direct heat applications. These estimates may increase by factors of 5-10 if approximations for as yet hidden/unidentified resources are included (ibid.). Power generation potentials are also increasing as a result of technological advances providing conversion efficiencies now ranging up to 20% for high temperature (> 180-200 °C) fluids.

In addition to hydrothermal resources, several other potentially significant geothermal sources capable of power generation and direct heat use exist: 1) binary generation from the use 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 hot rock of 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 beneath hydrothermal systems (3-5 km); 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.

Recent estimates indicate that using current technology hydrothermal resources, available at some 10-15% of the earth's surface and home to ~15% of the world's population, could provide 70-80 GW_e by 2050. In addition, development of other geothermal resources, including: EGS, super-critical fluids, hot water co-produced with oil and gas, hot water from deep sedimentary basins, and off-shore (under-sea) "hydrothermal" resources located along submarine rifts, using "advanced" technologies could deploy another 80 GW_e by 2050, resulting in a total global geothermal power deployment of some 160 GW_e generating 1,260 TWh/yr by 2050. This would provide an estimated 8% of world's electrical power to some 15% of its population and save about 1 Gt of CO_2 emissions (Mongillo and Bromley, 2010b).

Direct use technical potential has recently been assessed at >320 EJ/yr, with a probable deployment of 815 GW_{th} and utilization of 8.35 EJ/yr by 2050 (ibid.).

Geothermal development for electricity generation and direct use has experienced a high growth rate worldwide for the past few years (Figure ES2; Tables ES2 and ES3) and future prospects continue to look very positive.

Geothermal is a significant global renewable energy resource, with many 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 predominantly 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, although at lesser efficiency.

Geothermal resources have the potential to make a considerable contribution towards meeting the world's current and future energy needs well into the future, while contributing to the reduction of emissions and the mitigation of climate change. The global geothermal potential is enormous; however, attaining maximum deployment requires continued R&D.

Status of Global Geothermal Energy in 2010

In 2010, worldwide geothermal data was comprehensively updated for reporting at the World Geothermal Congress 2010, held on 25-29 April 2010, in Bali, Indonesia (Bertani, 2010). Twenty-four countries were producing electricity from geothermal resources, with a total geothermal installed capacity exceeding 10,892 MW_e, with electricity generation of 66,184.1 GWh, based on 2010 data (Bertani, 2010), updated with 2010 GIA Country Member data (Figure ES2, Table ES1). In 2010, the 9 GIA Member Countries having geothermal generation contributed about 63% of the global installed geothermal capacity, and 60% of the total geothermal power generated.

During the period 1950 to 1970 the worldwide geothermal installed capacity growth rate was quite small, then began to accelerate following the energy crisis of the early 1970s, increasing by a factor of >6.5 between 1970 and 1985. Between 1985 and 2005, the worldwide geothermal installed capacity increased by a factor of about 2.3, at a very uniform rate of ~210 MW_e/yr (Figure ES2). However, between 2005 and 2010, the rate of increase grew significantly, with a linear trend of about 386 MW_e/yr to the end of 2010; nearly double that of the previous 5 year period. The capacity increase in GIA Member Countries was: 2010 (6,833 MW_e) – 2005 (5,449 MW_e) = 1,284 MW_e, or about 20% (4%/yr). Table ES1 presents the 2010 data for GIA Member Countries and the other 15 countries with geothermal power generation (Bertani, 2010). Table ES2 illustrates the growth in installed capacity (1950-2010) and generation (1995-2010), with 2006, 2007, 2008 and 2009 representing minimum estimates.

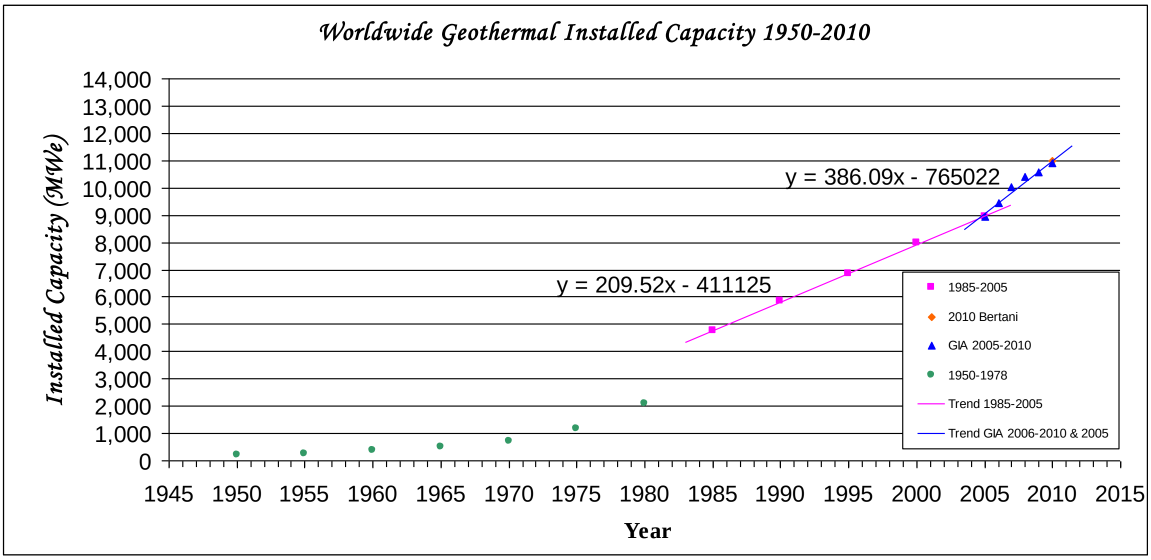

Figure ES2 *Worldwide geothermal installed capacity for the period 1950-2010. The 2006-2010 data [blue triangles] includes GIA data for 2006-2010 and data for the other countries from Bertani (2005; 2007, 2010), and has a trendline slope of 386 MW_e/yr. Data for 1950-2005 is from Bertani (2010), with the 1985-2005 data [magenta squares] having a trendline slope of 210 MW_e/yr. Data for 1950 to 1980 [green stars] is from Bertani (2010).*

As shown in Table ES1, geothermal energy provides a major contribution to the national capacity and national generation for several countries. For seven countries (including Lihir and San Miguel Islands), the geothermal installed capacity now exceeds 10% of national capacity, and five of these obtain 15-75% of their electricity from geothermal. In 2010, the contribution to national installed capacity for GIA Member Countries with *non-negligible* installation/generation ranged from 1.7-22.3%, with a corresponding range in contribution to national generation of 2.7-27%.

The total GIA geothermal generation of 39,969.3 GWh/yr is equivalent to a savings of about 10.1 Mtoe (using GIA conversion (Mongillo, 2005)) and avoided CO_2 emissions of 32.78 Mt. The equivalent savings for the worldwide total generation of 66,184.1 GWh/yr is about 16.8 Mtoe and avoided CO_2 emissions of some 54.1 Mt (*ibid.*).

A good indicator of the contribution a renewable energy resource makes is the ratio of the power they generate to the installed capacity, which for the GIA Countries in 2010 was 5.85 GWh/yr/MW_e, with the global average being 6.03 GWh/yr/MW_e. This quantity takes into account the amount of time that the generator actually produces power, i.e., the *availability factor*. For geothermal, this incorporates the resource availability (usually sustained by make-up drilling), plant availability (affected by repairs and maintenance), and transmission or load-following constraints. Geothermal's very high availability factors make it possible to operate at high capacity factors, which for new installations are above 90%, making geothermal valuable for baseload generation.

Table ES1 *Geothermal power installed capacity and electricity generation for GIA Member Countries and the 15 non-GIA countries (Bertani, 2010).*

Country	Installed Capacity (2010) [MW_e]	Annual Electricity Generated (2010) [GWh/yr]	% of National Capacity	% of National Energy
Australia*	***0.12***	***0.7***	***Negligible***	***Negligible***
Austria	1.1	3.8	Negligible	Negligible
China (Tibet)	24	150	-	-
Costa Rica	166	1,131	-	13
El Salvador	204	1,422	-	25
Ethiopia	7.3	10	-	-
France* ***(Guadeloupe Island)*** ***(Soultz-sous-Forêts)***	***15.8*** ***2.5*** ***(Total: 18.3)***	***14.9*** ***-***	***-*** ***-***	***8 (Guadeloupe)******
Germany*	***7.5***	***27.7***	***Negligible***	***Negligible***
Guatemala	52	289	-	-
Iceland*	***575***	***4,465***	***22.3***	***27.0***
Indonesia	1,197	9,600	-	-
Italy*	***842.5***	***5,376***	***1.0***	***1.6 (25% for Tuscany)***
Japan*	***537.71***	***2,908***	***0.2***	***1.1***
Kenya	167	1,430	-	-
Mexico*	***958***	***6,618***	***1.7***	***2.7***
New Zealand*	***792***	***5,550***	***8.0***	***13.0***
Nicaragua	88	310	-	-
Papua New Guinea (Lihir Island)	56	450	-	75% (Lihir)
Philippines	1,904	10,311	12	17
Portugal (San Miguel Island)	29	175	-	40 (San Miguel)
Russia	82	441	Negligible	Negligible
Thailand	0.3	2	Negligible	Negligible
Turkey	82	490	Negligible	Negligible
USA*	***3,101.6***	***15,009***	Negligible	***0.38***
Total GIA Countries	***6,832.73***	***39,969.3***	**-**	**-**
Total- Global***	**10,892.4**	**66,184.1**	**-**	**-**

* GIA Member Country, data from 2010 Country Reports
** Average values exclude negligible contributions, but include Guadeloupe, Lihir and San Miguel Islands since this is The procedure for World Geothermal Congresses
*** Data for non-GIA countries from Bertani (2010)

In 2010, 78 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.*, 2010). The total worldwide installed capacity for 2010 was about 50,583 MW_{th}, with a total thermal energy usage of about 438,071 TJ/yr (Table ES3) (ibid.). In 2010, the 13 GIA Member Countries had a total installed thermal power capacity of approximately 24,107 MW_{th} and utilized about 183,312 TJ/yr (Table ES3). It is estimated that in 2010, some 2.9 million GHP units were installed worldwide (ibid.).

Table ES2 *Worldwide installed geothermal capacity (1950-2010) and electricity generation (1995-2010). The generation for 2006-2010 include GIA Member Country data.*

Year	1950*	1955*	1960*	1965*	1970*	1975	1980	1985	1990	1995	2000	2005	2006#	2007#	2008#	2009#	2010♦
Geothermal Installed Generating Capacity (MW_e)	200	270	386	520	720	1,180	2,110	4,764	5,834	6,833	7,972	8,933	9,452	10,026¢	10,405¢	10,565¢	10,892
Electricity Generation (GWh/yr)	-	-	-	-	-	-	-	-	-	38,035	49,261	53,649	55,209	56,782	57,957	58,494	66,184

¢ Includes 2007 installed capacity data for 15 countries from Bertani (2007) with updates for GIA countries for 2007, 2008 and 2009

Generation data is: 2005 from Bertani (2005); other from Bertani (2010) with updates for GIA countries for 2006, 2007, 2008, 2009 and 2010 (from this 2010 annual report)

Table ES3 *Worldwide direct use categories and their development 1995-2010 (from Lund et al., 2010), with 2007 updates from Antics and Sanner (2007) and 2007, 2008, 2009 and 2010 updates for GIA Country Members.*

Category	Installed Capacity (MW_{th})							Utilization (TJ/yr)						
	1995	2000	2005	2007	2008	2009*	2010¥	1995	2000	2005	2007	2008	2009*	2010¥
Geothermal heat pumps	1,854	5,275	15,384	19,010	-	-	35,236	14,617	23,275	87,503	105,000	-	-	214,782
Space heating	2,579	3,263	4,366	-	-	-	5,391	38,230	42,926	55,256	-	-	-	62,984
Greenhouse heating	1,085	1,246	1,404	-	-	-	1,544	15,742	17,864	20,661	-	-	-	23,264
Aquaculture pond heating	1,097	605	616	-	-	-	653	13,493	11,733	10,976	-	-	-	11,521
Agricultural drying	67	74	157	-	-	-	127	1,124	1,038	2,013	-	-	-	1,662
Industrial uses	544	474	484	-	-	-	533	10,120	10,220	10,868	-	-	-	11,746
Bathing and swimming	1,085	3,957	5,401	-	-	-	6,689	15,742	79,546	83,018	-	-	-	109,032
Cooling/snow melting	115	114	371	-	-	-	368	1,124	1,063	2,032	-	-	-	2,126
Others	238	137	86	-	-	-	41	2,249	3,034	1,045	-	-	-	956
Total GIA Countries	**-**	**-**	**-**	***20,547***	**21,000**	**>21,927**	**24,107****	**-**	**-**	**-**	***154,560***	***155,170***	**>173,745**	**183,312****
Worldwide Total	**8,664**	**15,145**	**28,269**	**35,570**	**36,023**	**>36,950**	**50,583**	**112,441**	**190,699**	**273,372**	**329,270**	**329,880**	**>348,455**	**438,071**

* Estimates indicating "greater than" result from lack of 2009 data from some GIA Country Members

** GIA data from 2010 GIA Country Reports

¥ Data from Lund *et al.*, 2010

Worldwide direct use installed capacity has increased by about 80% every 5 years between 1995 and 2010 (Table ES3), with a compound growth rate of about 12%/yr between 2005 and 2010. Direct energy use increased by about 60% since 2005, or a compound rate of about 10%/yr (Lund *et al.*, 2010). The total use of about 438,071 TJ/yr is equivalent to an annual savings of about 15.4 Mtoe/yr in fuel oil and 49.8 Mt/yr in avoided CO_2 emissions (GIA conversions, Mongillo (2005)). Direct use in GIA Member Countries, 183,312 TJ/yr in 2010, was equivalent to a savings of 6.4 Mtoe/yr and avoided CO_2 emissions of about 20.8 Mt/yr.

The IEA-GIA- an Overview

The IEA-GIA was founded in 1997, and was in the 4th year of its 3rd Term of operation at the end of 2010. At the request of the IEA, the GIA agreed in 2010 to extend the 3rd Term by one year, taking it to 28 February 2013. The GIA provides a versatile framework for wide-ranging international cooperation in geothermal R&D by connecting national and industry programmes for exploration, development and utilization of geothermal resources, with emphasis on enhancing effectiveness through establishing direct cooperative links among 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 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 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, and thereby contribute to the mitigation of climate change.

To realize this Mission, six Strategic Objectives focus the 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 provided in 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 (industry/industry organization).

Since the GIA's initiation, 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 efforts conducted under the auspices of the GIA have been estimated to be in excess of US$ 300,000/yr, plus several man-years time (GIA, 2006).

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 2010, there were 19 IEA-GIA Members: the European Commission; 13 countries: Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Norway, the Republic of Korea, Spain, Switzerland and the United States; 3 industry Sponsors: Geodynamics, Green Rock Energy and ORMAT Technologies; 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 2010, GIA participants worked on five broad research topics, and contributed to a geothermal data collection and analysis effort, 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
- Annex X- Data Collection and Information
- Annex XI- Induced Seismicity

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 October 2009, Annexes I, III and VII were extended by the ExCo for a further 4 years, to 2013. 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. Annexes X and XI were both opened in October 2009, with their activities begun in 2010. 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 Table 1.2, Chapter 1 of the 2010 Annual Report.

A few of the GIA's major activities and Annex highlights for the 2010-Year are presented below. Details are available in Chapter 1 and in the Annex Reports included in Chapters 2-7 of the 2010 Report.

IEA-GIA ExCo and Annex Meetings in 2010

The IEA-GIA ExCo held its 23rd ExCo Meeting in Bali, Indonesia, in late April 2010 in association with the World Geothermal Congress 2010, the premier international geothermal event held every 5 years, and at which the GIA had significant presence. The 24th ExCo Meeting was held in Reykjavik, Iceland, in early October 2010 as part of the Reykjavik Geothermal Week, which allowed participation at the international workshop on induced seismicity. Attendance was at its usually high level (27) for the Reykjavik meeting; however, the Bali Meeting participation was lower than expected (21), due to European flight cancellations caused by a volcanic eruption in Iceland. These meetings are briefly described in Chapter 1 of the Annual Report.

The four fully operational GIA Annexes I, III, VII and VIII held technical meetings in association with the 23rd and 24th ExCo Meetings. Each Annex meeting is typically ~2 hours long and provides the opportunity to discuss and assess current and planned activities. Important issues related to Annex activities that have arisen during the year, e.g., induced seismicity and sustainability, are also examined. The status of Annex operations, including activities, achievements, challenges, etc., is also reported at the ExCo meetings.

Participation at the World Geothermal Congress 2010, Bali, Indonesia

World Geothermal Congresses (WGCs) are premiere events for the international geothermal community, and are held every 5 years. The GIA had a significant and very successful presence at the WGC 2010, held in Bali, Indonesia, in April 2010. Several technical papers produced from Annex efforts were presented and a keynote address by Mongillo, Bromley and Rybach: *The IEA Geothermal Implementing Agreement- International Efforts to Promote Global Sustainable Geothermal Development and Help Mitigate Climate Change* was made as an introduction to a major panel discussion (Papers). In addition, a very successful exhibition booth was sponsored which attracted over 100 visitors for discussions and dissemination of a multitude of GIA and IEA documents and information (see photo at beginning of this document).

Geothermal Resources Council Annual Meeting 2010, Sacramento, California, USA

The GIA participated at the 2010 Annual Meeting of the GRC held in Sacramento, California, USA, in October 2010. A paper describing the GIA's international efforts to promote global sustainable geothermal development and help mitigate climate change was presented by GIA-Chair, Chris Bromley. A brief review of the GIA and its activities, achievements, future directions and prospects was presented in light of the current global energy situation and estimated global geothermal potential.

Publication of Proceedings of Joint IEA-GIA~IGA Workshop

The ***Proceedings of the Joint IEA-GIA~IGA Workshop Geothermal Energy- Its Global Development Potential and Contribution to Mitigation of Climate Change*** was published in March 2010 as a reference source for the expert presentations made and to document the associated panel and general discussions at the Workshop held in Madrid, Spain, on 5-6 May 2009 (Proceedings).

GIA Participation on IPCC Renewable Energy Report

Several GIA participants played key roles in the preparation of the geothermal chapter of the IPCC Special Report on Renewable Energy Sources (SRREN) by acting as Coordinating, Lead and Contributing Authors. This extremely important document will be published in 2011.

Continuation of GIA Proposal Initiative for Supplementary Activities

The mechanism for funding proposals from the GIA Common Fund for approved supplementary activities related to ExCo initiatives or Annex Task activities continued in 2010. A proposal for US$ 10 k supporting participation at the Induced Seismicity Workshop held in Reykjavik, Iceland, was funded; and one for US$ 10 k to support the ***IEA Energy Technology Roadmap for Geothermal Energy*** was paid. In addition, the GIA Secretary's Annex I effort as a Guest Editor (with Guðni Axelsson) supported from a US$ 5 k proposal funded during 2009-2010, was concluded with the publication of the ***Geothermics Special Issue*** **on Sustainable Utilization of Geothermal Energy** in December 2010.

GIA Participation in IEA Activities

In 2010, the GIA continued a high level of participation with the IEA through its participation at several workshops, including three IEA Geothermal Roadmap Workshops; by contributing information and comment on IEA reports such as the ***IEA Renewable Energies in Cities***, ***Energy Technology Initiatives*** and ***Energy Technologies Perspectives*** reports; and by working closely with the IEA to complete the ***IEA Renewable Energy Essentials: Geothermal*** brochure. The article: *Geothermal's Rising Fortunes* (Mongillo and Bromley, 2010b) was also provided for the IEA OPEN Bulletin (June 2010).

Use of Geothermal Energy and the Environment (Annex I)

Geothermal is a renewable energy source, has major benefits relative to fossil fuels with respect to global carbon dioxide emissions, and accordingly has significant potential for reducing global warming effects. Its use is mostly environmentally benign. However, there are some local environmental problems associated with geothermal utilization. To further the use of geothermal energy, it is important to identify possible adverse and beneficial environmental effects, and devise and adopt measures to avoid or minimize adverse impacts, while encouraging the benefits.

Annex I- Environmental Impacts of Geothermal Energy Development activities aim to encourage the sustainable development of geothermal energy resources in an economic and environmentally responsible manner; to quantify and balance any adverse and beneficial impacts that geothermal energy development may have on the environment, and to identify ways of avoiding, remedying or mitigating adverse effects.

The sustainable use of geothermal resources is recognized internationally as an important goal, and Annex I achieved significant success in its promotion in 2010 with the completion of the ***Geothermics Special Issue*** **on Sustainable Utilization of Geothermal Energy** (volume 39, No. 4, December 2010) as well as through the several papers and presentations its participants made on improved environmental sustainability strategies and monitoring methods at the World Geothermal Congress 2010 (Bali, Indonesia) and several other workshops and conferences.

In addition, several Annex I participants continued their efforts in the preparation of the geothermal chapter for the IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, which is to be published in 2011; conducted outreach activities with presentations on environmental issues in GIA non-member countries Chile and Indonesia; contributed to an international two-day geothermal induced seismicity workshop held in Reykjavik, Iceland; and took part in collaborative technical meetings at Bali and Reykjavik on the development of improved methods for monitoring, avoiding and mitigating environmental effects, including subsidence, induced seismicity and gas and heat emissions.

Accessing Geothermal Resources Using Enhancement Techniques (Annex III)

Huge heat resources consisting of high temperature, water-poor rock are available within current drilling depths (>3 km) almost anywhere on earth. Annex III- Enhanced Geothermal Systems (EGS) has been designed to investigate new and improved technologies (e.g., hydraulic fracturing) via international collaboration to develop engineered heat exchangers at depth to enable commercial heat extraction for electricity production and, in some cases, co-generation of heat for direct use applications. These technologies 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. Reduced funding from various participants in 2010 resulted in major efforts in the Annex being directed at revising its activities.

Reducing Geothermal Drilling and Logging Costs (Annex VII)

Drilling is an essential and expensive part of geothermal exploration, development, and utilization. Drilling, logging, and completing geothermal wells are expensive because of the high temperatures and hard, fractured formations encountered. The consequences of reducing cost are often impressive, because drilling and well completion can account for more than half of the capital cost for a geothermal power project. Consequently, Annex VII- Advanced Drilling and Logging

Technology aims to promote ways and means to reduce the cost of geothermal drilling through an integrated effort which involves developing an understanding of geothermal drilling and logging needs, elucidating best practices, and fostering an environment and mechanisms to share methods and means to advance the state of the art. More specifically, Annex VII is: developing a detailed understanding of worldwide geothermal drilling costs, 2) compiling a directory of geothermal drilling practices and how they vary globally and 3) developing improved drilling and logging technologies.

Data and information collection for the geothermal well drilling cost and performance database continued and a basic version of the well cost calculator based on this information was developed, with verification and further development continuing. A paper describing the Annex's activities and status (Bauer *et al.*, 2010) was presented at the WGC 2010, Bali, Indonesia.

Most significant of the Annex outputs for 2010 was the completion and publication of the ***Handbook of Best Practices for Geothermal Drilling*** (Finger and Blankenship, 2010), available on the GIA website (Handbook).

Direct Use of Geothermal Heat (Annex VIII)

Geothermal water has been used for centuries for various applications. In earlier times, only the hot geothermal water present in surface springs was used, mainly for bathing, cooking and for therapeutic purposes. In recent decades, direct use of geothermal water has grown, and today, direct use of geothermal energy is possible everywhere. Now, geothermal water is used for many applications that require heat, such as: heating buildings individually, or whole towns via district heating schemes; raising plants in greenhouses; drying crops; heating water at fish farms; snow melting; bathing and for therapeutic purposes; and for several industrial processes. Geothermal direct use has grown significantly during the past 15 years, almost doubling every 5 years since 1995, and its scope for continued expansion remains great.

Many direct use applications are now well developed and economically viable; however, 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.

Three Annex VIII papers were presented at the WGC 2010, Bali, Indonesia, covering the general efforts and status of the Annex (Gunnlaugsson, 2010), the developing international database of hydrothermal chemistry (Muraoka *et al.*, 2010) and barrier and opportunity identification in geothermal direct use (Song *et al.*, 2010).

In addition, work has begun on equipment performance validation and information collection on standardized designs for various applications and development of engineering standards for designs, equipment and controls. Efforts are advancing in the presentation of direct use data on the web using Goggle Earth, with minimum required data defined.

Geothermal Data and Information (Annex X)

The value of collecting, analyzing and publishing geothermal use data and information is well recognized. At the end of 2010, new Annex X- Geothermal Data and Information, initiated its activities. It aims to collect essential data on geothermal energy uses, trends and developments in GIA countries and to publish these data in a yearly report. This report shall provide a brief overview of the geothermal energy data, such as installed capacities, produced electricity and heat, supplemented by political and economic information relevant to the development of geothermal energy in GIA member countries. There are plans to extend this data collection to include non-GIA Member Countries, if reliable data can be obtained.

In 2010, the organization and operation of Annex X were defined, with the structure, objectives, programme of work and desired form of results defined. The first compilation and analyses of data and information, and the annual trend report are planned for publication in 2011.

Induced Seismicity (Annex XI)

A seismic event, e.g., is an earthquake that is induced by manmade activities such as fluid injection, reservoir impoundment, mining, and other activities. In terms of EGS, an induced event would occur during the EGS operations of either fluid injection and/or withdrawal.

Although induced seismicity had been a Task pursued in Annex I for the past several years, the growth in its global importance, especially for EGS development, led the GIA ExCo to shift the Task activity to new Annex XI- Induced Seismicity. Annex XI encourages international cooperation to determine the steps needed to be taken to make EGS/fluid injection a safe and economic technology that is accepted by the public and useful to the industry. This includes not only steps to allow acceptance of EGS technology by the public, regulators and policy makers, but also allows induced seismicity to become a useful tool to optimize EGS applications.

In 2010, the objectives of the Annex were designed and are: to develop accepted approaches for addressing technical and public acceptance issues that industry can use as a guide, develop a methodology to assess risk, identify areas of collaboration/cooperation and identify key roadblocks and areas of technology development and research in order to reduce uncertainty associated with acceptability issues to facilitate and accelerate geothermal energy development.

Plans for 2011 include sorting out the integration and coordination of Annex XI's induced seismicity efforts with those of the International Partnership on Geothermal Technology (IPGT) and defining and distributing the activities among the participants of the two organizations.

National Activities

The geothermal programmes of the GIA Country Members provide the basis for the 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 2010 Annual Report (Chapters 8-21).

In 2010, Contracting Parties from 13 countries and the European Commission (EC) participated in the IEA-GIA. The Member Countries were: Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Norway, the Republic of Korea, Spain, Switzerland and the United States.

Contributions of GIA Members to Power Generation and Direct Use

In 2010, the 9 GIA Member Countries with geothermal generation had a combined installed capacity of about 6,834 MW_e, or about 63% of the total global geothermal capacity of 10,892 MW_e; and generated 39,969 GWh/yr, or about 60% of the total geothermal generation of 66,184 GWh/yr (Tables ES1 and ES4). The United States was by far the largest producer, generating about 15,000 GWh/yr, with Mexico second with 6,618 GWh/yr and Italy third with 5,376 GWh/yr. The percent of national installed capacity contributed by geothermal in the 5 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 6.6%. The contribution of geothermal to national generation in Member Countries ranged from 0.38% for the USA to 27.0% for Iceland, with an average of 7.7%.

Table ES4 *Total geothermal installed capacity, electricity generation and direct use in GIA Member Countries in 2010.*

Country	Electrical Installed Capacity (MW)	Annual Energy Generated (GWh/yr)	% of National Capacity (Range)	% of National Energy (Range)	Installed Thermal Power (MW_{th})	Annual Energy Used (TJ/yr)
GIA Member Countries	6,834	39,969	0.2-22.3	1.1-27	24,107	183,312
Worldwide Total**	10,892	66,184	-	-	50,583	438,071
GIA % of Worldwide Total	63	60	-	-	48	42

** For sources of worldwide total data see Tables ES1 and ES3 above.

All 13 GIA Member Countries utilized geothermal in direct applications in 2010, with a total installed capacity of 24,107 MW_{th} and total thermal energy used amounting to 183,312 TJ/yr (Table ES5). In the case of Norway, the data presented are from Lund, *et al.* (2010). The three largest users of geothermal heat by far were the USA (55,645 TJ/yr), Japan (25,698 TJ/yr), and Iceland (24,621 TJ/yr). However, the non-high enthalpy geothermal countries, France (14,558 TJ/yr), Germany (16,026 TJ/yr), Norway (10,800 TJ/yr and Switzerland (7,152 TJ/yr) also had very high utilization, mainly due to the large and growing geothermal heat pump usage.

Sponsor Activities

At the end of 2010, the GIA had 5 Sponsor Members, 3 from industry: Geodynamics Limited and Green Rock Energy Limited from Australia; and Ormat Technologies, Inc. from the USA; and 2 industry organizations: the Canadian Geothermal Energy Association (CanGEA) and the Geothermal Group of the Spanish Renewable Energy Association (GG-APPA).

Table ES5 *Geothermal direct use in GIA Member Countries in 2010.*

Country	Installed Thermal Power (MW_{th})	Annual Energy Used (TJ/yr)
Australia	129.0	1,314.3
France	1,598.5	14,557.5
Germany	1,897.4	16,025.9
Iceland	2,002.9	24,621.4
Italy	1,000	12,599.6
Japan	2,099.5	25,697.9
Mexico	156	2,558.2
New Zealand	385.0	10,155.6
Norway*	1,000	10,800.0
Republic of Korea	268.1	1,496.8
Spain	52.5	687.6
Switzerland	954.6	7,151.8
USA	12,563.8	55,645.1
Total for GIA[1]	**24,107**	**183,312**

* Data from Lund *et al.*, 2011

[1] Total excludes the EC

Industry Sponsors

Geodynamics Limited

Geodynamics Limited, Australia's most advanced geothermal energy developer, is a public company limited by shares, incorporated and domiciled in Australia, and was listed on the Australian Securities Exchange on September 2002. Geodynamics specifically focuses on the economic extraction of heat from hot rocks using enhanced geothermal systems (EGS) technology. While the Company holds geothermal exploration licences in South Australia, New South Wales and Queensland, the majority of efforts are currently focused on extracting heat from its geothermal tenements near Innamincka in South Australia, where high heat production granite buried 3.6-4 km beneath the Cooper and Eromanga Basins approaches temperatures of 280 °C at 5 km depth.

During 2010, Geodynamics carried out a major stimulation of well Jolokia 1, located about 10 km west of its Habanero project. The stimulation followed an exhaustive re-design of the Jolokia 1 completion following the Habanero 3 casing failure in 2009. Although temperature and stress conditions were as expected, the stimulation was less successful than predicted, due to only steeply dipping fractures being activated. It was concluded that optimally oriented, shallowly dipping fractures were not available in the 4,325-4,911 (TD) m depth interval stimulated.

The current plan is to return to Habanero and drill new well Habanero 4 near Habanero 3 and commission a 1 MW_e power station using the Habanero 4-Habanero 1 loop.

Green Rock Energy Limited

Green Rock Energy Limited is a public company listed on the Australian Securities Exchange whose focus is on developing geothermal energy in Australia and in Europe.

The Company plans to develop two commercial scale power projects using geothermal fluid obtained from hot sedimentary aquifers. One project is in Hungary and the other in the north Perth Basin in Western Australia. There is evidence from previous petroleum wells at both projects that suitable temperatures can be obtained at reasonable target depths. During 2010, the Company's activities for both projects have been directed to proving there is reservoir capacity and geothermal fluid flow potential to sustain commercial scale power projects.

In 2010, difficulties with obtaining funding for direct use projects in Australia, led Green Rock to shift focus to electricity production from deep sedimentary aquifers in the northern Perth Basin where high heat flows are known to exist. Green Rock holds seven Permits (known as the Mid-West Geothermal Project) occupying 2,094 km^2 in the north Perth Basin where there is good geological resource potential for power generation. There are 39 petroleum wells in the Permits where the temperature in sediments is estimated to be over 150 °C at depths less than 3,500 m, sufficient to generate electricity commercially, provided that sufficient geothermal water recovery flow rates can be achieved.

Joint venture company CEGE (Central European Geothermal Energy), owned by Green Rock (50%) and MOL (50%), the latter with a market capitalisation of over US$ 10 billion, aims to generate electricity for distribution and sale in Hungary. In 2010, after obtaining very positive results from evaluation of a former MOL petroleum well that intersected hot geothermal water, CEGE purchased the well and is now pursuing rights and approvals to proceed with drilling a second well in 2012.

Green Rock is also searching for funding via a "farm-in" before it begins deep drilling, fracture stimulation and flow testing for its Olympic Dam EGS project in South Australia. Participation in an R&D development of a surface heat probe continued with field testing.

Ormat Technologies, Inc.

Ormat Technologies, 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 (RE)-based power plants. In addition, the company also designs, manufactures and sells power units and other power generating equipment for geothermal and RE-based electricity generation (REG) for third parties.

As of December 2010, Ormat owned and operated ~500 MW_e of geothermal and ~53 MW_e REG in the United States, Nicaragua, Kenya and Guatemala. In total, Ormat has built approximately 1,370 MW_e of geothermal, REG and solar installations worldwide, in 24 countries. Geothermal represents over 90% of the total installation. In the U.S, Ormat has deployed approximately 70% of the geothermal capacity installed since 2000. Ormat has grown to a team of 1,150 employees worldwide, with approximately 500 in the United States. It also has its own in-house drilling company, GeoDrill, with six rigs capable of drilling to 5,500 m and over 100 staff.

In 2009 and 2010, Ormat added approximately 110 MW_e of gross geothermal capacity and 45 MW_e of gross REG capacity worldwide. In 2010, Ormat acquired the remaining 50% of the Mammoth complex, in California, where the company plans to repower, optimize and expand the facility. As of mid-2011, Ormat has 160-165 MW_e under construction and another 87 MW_e in various phases of development.

Ormat is engaged in the largest effort undertaken by a single company, within the last 20 years, to categorize, map, sample and drill US greenfield prospects. Ormat has various leases and concessions for geothermal resources of approximately 355,000 acres in 32 sites located in Alaska, California, Nevada, Hawaii, Oregon, Idaho and Utah in the United States, and in Chile, Guatemala and New Zealand.

Ormat is involved in several R&D projects, including EGS (with US DoE at Brady's Hot Springs and Desert Peak, Nevada), innovative exploration and drilling technology (with US DoE in Hawaii, Oregon and California; and in Alaska), and co-production with oil wells (with US DoE at the Rocky Mountain Oil Test Center).

In 2010, Ormat's total revenues were US$ 373 M, with a 15% increase in the company's electricity segment, which totalled US$ 292 M; total generation increased about 14% to 3.8 million MWh.

Organization Sponsors

Canadian Geothermal Energy Association

The Canadian Geothermal Energy Association (CanGEA), an industry organization Sponsor Member of the GIA, 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 had grown to 42 members at the end of 2010, including geothermal developers, equipment manufacturers, utilities, and firms specializing in consulting, engineering, construction, financial and legal aspects of geothermal energy. CanGEA's geothermal producers represent ~ C$ 1 billion in market capitalization on the Toronto and Venture Stock Exchange and more than 2,000 MW_e of installed geothermal capacity worldwide. CanGEA members currently represent active projects in all parts of the world, with more than 1,500 MW_e under development.

Though Canada currently has no domestic geothermal power production, CanGEA was proactive in instituting the Geothermal Code for Public Reporting to increase investor confidence and provide requirements for reporting exploration results, and geothermal resources and reserves in a transparent and consistent manner.

With the vast experience of CanGEA members and the right incentives, investment in the development of Canada's large geothermal resources for power generation (an estimated near-term potential of 5,000 MW_e of conventional resources) can be achieved.

In direct use applications, heat pumps are being steadily embraced, with about 50,000 residential and 5,000 commercial systems currently installed. Federal and local subsidies are encouraging this growth, which is about 13%/yr, with recent rates as high as 50%/yr.

Recently, three geothermal projects have received government funding for pilot demonstration and research initiatives: 1) the Ft. Liard, NWT, community-based geothermal project to demonstrate use of geothermal to generate electricity and heat, and thereby reduce the entire community's demand for fossil fuel and energy costs (Federal C$10-20 M); 2) the Yellowknife, NWT, Con Mine project to provide heat from the abandoned Con Gold Mine to the city of Yellowknife (Federal: C$ 10-20 M), and 3) the Swan Hills, Alberta, project to investigate the use of geothermal energy from deep oil and gas wells in the Canadian Foothills to produce electricity (Provincial: C$ 2.6 M). In addition, there is also an initiative to examine the potential for providing power and/or heat from the surrounding natural hot springs and reservoirs for the community of Whitehorse, Yukon Territory, with testing of remote sensing techniques to locate geothermal resource sites forming part of this effort.

Geothermal Department- Spanish Renewable Energy Association

The Geothermal Department of the Spanish Renewable Energy Association represents the geothermal members' interests in politics, civil society and the media and participates in the development of Spanish energy and environmental policy. APPA itself represents more than 500 producers, businesses and other associations in the Spanish renewable energy sector, with the Geothermal Department comprising 9 company members in the high enthalpy geothermal section and 18 members in the low enthalpy one.

Though there are significant geothermal resources in Spain, there are a number of barriers that hinder both low and high enthalpy geothermal energy deployment. 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. Currently, there is about 150 MW_{th} of installed capacity for geothermal heat pumps, small compared to the estimated geothermal resource potential for Spain.

In 2010, the Spanish geothermal industry made significant achievements in getting geothermal energy included as an alternative among other renewables: the inclusion of geothermal energy in the National Action Plan for Renewable Energy (NREAP) 2011-2020; the addition, for the first time, of a geothermal chapter in the new Spanish Renewable Energy Plan (PER) 2011-2020; establishment of a series of measures in the PER 2011-2020 to boost geothermal as an emerging technology; probable inclusion of geothermal in the Law on Energy Efficiency and Renewable Energy to achieve objectives of the European Directive on promotion of the use of renewable sources; and geothermal's probable inclusion in CALENER, software for qualifying energy efficiency in buildings. In addition, major efforts are being made by Government and other agencies to train and inform professionals in the heating/cooling trade; and grants that help reduce the cost of this technology are encouraging its integration into buildings.

In 2010, the Institute for Diversification and Saving of Energy (IDEA) initiated the GEOTCASA program for financing geothermal projects through energy companies, thus promoting the design of quality offers adapted to the needs of potential users. Also, as the result of geothermal power generation being identified as 100% dispatchable, more than 50 permits for investigating geothermal electricity generation have been obtained by entrepreneurs.

In 2010, design and environmental investigations were conducted as part of the first geothermal drilling on Tenerife, Canary Islands; with drilling expected to start in 2012. The Madrid geothermal district heating network project is also now ready to proceed, waiting only for the necessary funding.

The Spanish Geothermal Technology Platform (GEOPLAT) continues to play an important role in both Spain and in the European geothermal scene.

Plans for 2011 and Beyond

The GIA expects to extend its efforts and will continue to pursue new membership in 2011, and onwards. The GIA has committed to work with the IPGT to coordinate induced seismicity activities and plans to participate in the US DoE Geothermal Technologies Program peer review. The GIA will continue its strong support of the IEA by assisting the IEA Geothermal Roadmap project through review of draft versions and participation in workshops, providing current geothermal data/information, contributing to their publications, and by taking part in the REWP/REDT meeting and 59th REWP meeting to present the GIA Mid-term report. The strong financial position of the GIA at the end of 2010 will allow continued funding of successful proposals to support special GIA efforts and Annex related activities to increase/enhance the organization's outputs and its international status.

The global financial and economic crisis that began at the end of 2008 remains a concern to the international geothermal community, especially the geothermal industry, though the continuing growth in geothermal development in some countries provides some optimism. Geothermal energy can make a considerable contribution to providing sustainable renewable energy for future global energy needs, and the GIA sees its activities continuing and growing to make this a reality.

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Appendix A Participants at the 23rd IEA-GIA Executive Committee Meeting, Bali, Indonesia, 23 April 2010

Appendix B Participants at the 24th IEA-GIA Executive Committee Meeting, Reykjavik, Iceland, 8 October 2010

Appendix C IEA-GIA Executive Committee as of December 2010

IEA Geothermal Implementing Agreement Executive Committee

Country / Name	Delegate	Organization / address	e-mail / tel / Fax	Alternate	Address, etc. (where different)
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