



International Energy Agency  
**Geothermal Energy**



**13<sup>th</sup> Annual Report ~ 2009**

***Executive Summary***

**International Efforts to Promote  
Global Sustainable Geothermal Development**

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**Cover Photograph:** *The 24 MW plant in Amatitlan, Guatemala, which survived without damage the eruption of the volcano in May 2010. (Photo courtesy of Lucien Bronicki, Ormat Technologies, Inc.)*

# Executive Summary



*Krafla geothermal power station [operated by Landsvirkjun], NE Iceland.  
(Photo courtesy of Jonas Ketilsson)*

## Introduction

**2009** was another busy and successful year for the IEA Geothermal Implementing Agreement (GIA). Especially noteworthy was the joint *IEA-GIA~IGA Workshop on Geothermal Energy-Global Development Potential and Contribution to Mitigation of Climate Change*, held in Madrid, Spain. This was the GIA's first major meeting with another large and influential international geothermal organization (for more information about the International Geothermal Association see [IGA](#)). The motivation for holding this joint IEA-GIA~IGA workshop grew out of the recognized need to have more accurate information on the global geothermal development potential and its possible contribution to mitigating climate change, the opportunity to contribute such information to the geothermal chapter of the IPCC special report; and the need and desire for both international organizations to join forces, seek a unified position and speak with a single, powerful voice that would be acknowledged. More than 50 attendees, including 40 official participants, from 17 countries participated. Proceedings will be available in early 2010.

Also significant was the GIA ExCo's decision to make available a portion of the GIA Common Fund to support Annex and other GIA activities through a proposal submission and voting procedure. The 70% growth in GIA membership in the past 4 years and the relatively stable cost for operating the GIA Secretariat have resulted in a sizeable annual carry-over that could be tapped for specific efforts that the ExCo deemed worthy. The first successful proposal supports Annex I's

sustainability endeavour by providing US\$ 5 k over a 2-year period for the Secretary to act as a Guest Editor (with Guðni Axelsson, Leader of Task E Sustainable Utilization Strategies) for a *Geothermics Special Issue on Sustainable Utilization of Geothermal Energy*, scheduled for publication in December 2010. This output is based upon the contributions made at an Annex I Sustainability Modelling Workshop held in New Zealand in November 2008.

The GIA's 2009 membership of 19 (25% higher than in 2007) comprised of 12 Country and 6 Sponsor (industry/industry organization) Members, and the EC. This broad based membership, from Europe, Asia, the Americas and Oceania, cooperates on a multitude 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.

In 2009, the 12 GIA Member Countries had a combined installed capacity of 6,735 MW<sub>e</sub> and generated 38,910 GWh/yr, contributing about 64% of the global geothermal installed capacity and 67% of the geothermal generation. The average national geothermal installed capacity and power generation for GIA Member Countries with non-negligible contributions were about 6.0% and 7.7%, respectively; with a "contribution efficiency" of 5.8 GWh/MW<sub>e</sub>, 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 first provided, then the considerable worldwide geothermal energy potential is discussed, and the contribution that geothermal made to the global energy supply in 2009 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' 2009 activities are provided and the major achievements of the GIA as an organization are described. Finally, the GIA's plans for 2010 and beyond are outlined.

## Current World Energy Situation

The global demand for energy has grown nearly every year since 1981, with the 2008 worldwide total primary energy supply reaching 12,267 Mtoe, or about 514 EJ<sub>th</sub> (142,670 TWh<sub>th</sub>); a growth of about 2.0% on 2007 (IEA, 2010). The electricity generation amounted to 20,181 TWh (ibid.). 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<sup>9</sup>] toe (Btoe) (706 EJ<sub>th</sub>) (IEA, 2009b). Approximately 90% of the increase is expected to be from non-OECD countries, or 63% of the total primary energy demand. The dominant energy supply will remain fossil fuels, 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 the world's fossil fuel resources will probably be able to meet these needs to 2030, and beyond, this path will likely lead to serious energy security and economic development problems, and catastrophic climate change consequences.

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<sub>2</sub>-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<sub>2</sub> and total GHG emissions in both of these scenarios are significantly less in 2030 than in the Reference Scenario; however, both scenarios require major efficiency gains; CO<sub>2</sub> 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 is a strong incentive for expanding the use of clean,

renewable energy resources. Providing affordable, reliable and clean energy to meet future 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<sub>th</sub> (1,400 EJ/yr), nearly 2.7 times the 2008 worldwide total primary energy supply, 514 EJ<sub>th</sub> (IEA, 2010). Though the world's geothermal heat resources are enormous and ubiquitous, their generally *hidden* nature (subsurface) makes it difficult to accurately determine potentials on a global basis (GIA, 2009). 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.

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<sub>th</sub> (205 EJ<sub>th</sub>/yr) (Stefansson, 2005), about 40% of the 2008 worldwide total annual supply. Of this total, hydrothermal resources capable of development for electricity generation using conventional methods ( $T > 130$  °C) amount to some 240 GW<sub>e</sub> (6.5 EJ<sub>e</sub>/yr, or 65 EJ<sub>th</sub>/yr), assuming a 10% electrical conversion efficiency. The remaining 4.4 TW<sub>th</sub> (140 EJ<sub>th</sub>/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 (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 using EGS techniques, in the USA alone, approximately 100 GW<sub>e</sub> of cost-competitive generating capacity is developable by 2050, given reasonable R&D investment (MIT, 2006). Incorporating preliminary estimates of EGS potential for two geothermal fields in China (Wan et al., 2005); parts of India (Chandrasekhar and Chandrasekharam, 2007), Switzerland, South Australia, and much of Germany, a total of  $\geq 360$  GW<sub>e</sub> is obtained. A first-order estimate of global EGS theoretical potential of  $\sim 2$  TW<sub>e</sub> was obtained by assuming the EGS capacity of 100 GW<sub>e</sub> for the US continental area applied to worldwide continental land masses. Fridleifsson et al. (2008) and discussions at the IEA-GIA~IGA Workshop (GIA, 2010) suggest that  $\sim 100$  GW<sub>e</sub> of EGS could be deployed globally by 2050. Recent discussions also highlight the continued uncertainties associated with estimating geothermal potentials (*ibid.*).

Geothermal development for electricity generation and direct use have experienced a high-growth rate worldwide for the past few years (Figure ESI and Table ES4), and future prospects are looking very positive.

Geothermal is a key renewable global 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.

Clearly, 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 reduced future emissions and to the mitigation of climate change. The global geothermal potential is enormous; however, more detailed studies are needed to produce confident estimates of its possible contribution.

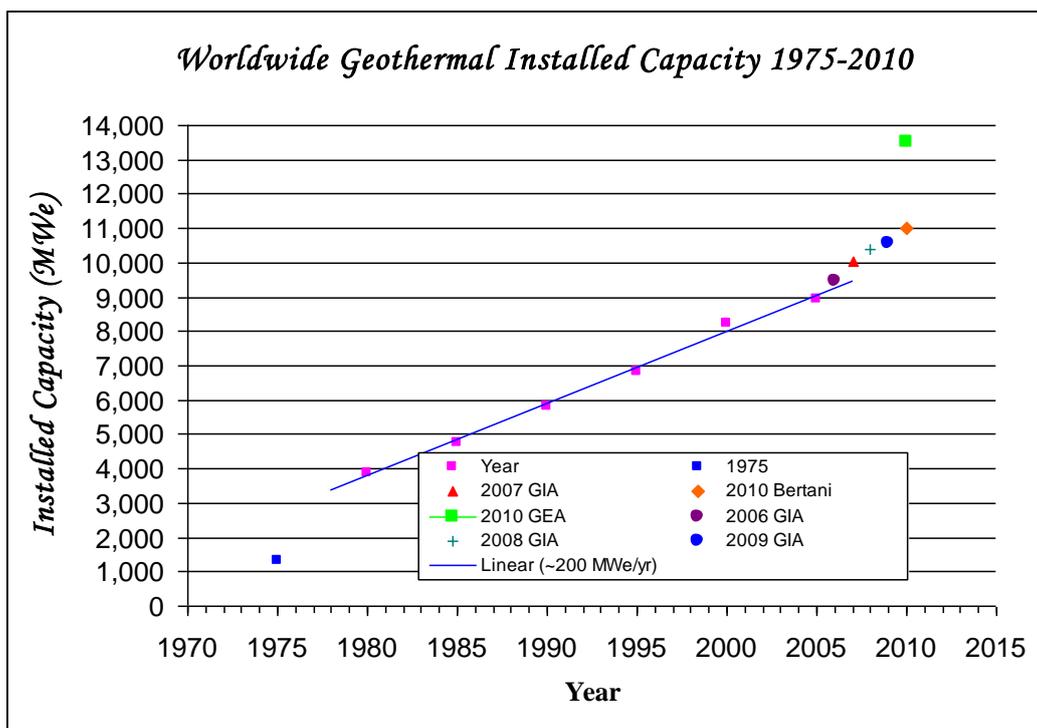
## Status of Global Geothermal Energy in 2009

In 2009, at least 24 countries were producing electricity from geothermal resources, with a total geothermal installed capacity exceeding 10,565 MW<sub>e</sub>, based on 2007 data (Bertani, 2007), revised with 2009 GIA Country Member data (Figure ESI, Table ESI). As stated in the 2007 GIA Annual Report, the worldwide geothermal generation has not been comprehensively updated since 2005; however, using 2009 GIA data in conjunction with the 2005 information, a minimum estimate of 58,494 GWh/yr is obtained for 2009. The worldwide geothermal installed capacity and power generation figures will be updated for reporting at the World Geothermal Congress 2010. In 2009, the 12 GIA Member Countries contributed about 64% of the global installed geothermal capacity, and 67% of the total geothermal power generated.

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<sub>e</sub>/yr (Figure ESI). However, since 2005, an increase in geothermal development has become evident, with a linear trend of about 420 MW<sub>e</sub>/yr to 2009. The capacity increase in GIA Member Countries was: 2009 (6,735 MW<sub>e</sub>) - 2005 (5,449 MW<sub>e</sub>) ~ 1,286 MW<sub>e</sub>, or about 24% (6%/yr). Table ESI presents the 2009 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 (1995-2009) and generation (1995-2009), with 2006, 2007, 2008 and 2009 representing minimum estimates.

As shown in Table ESI, 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 15-30% of their electricity from geothermal. The average contribution to national installed capacity for GIA Member Countries with *non-negligible* installation/generation was about 6%, with the corresponding average contribution to national generation being about 7.7%. The corresponding worldwide values were 9.4% and 12.2%, respectively (Table ESI).

The total GIA geothermal generation of 38,910 GWh/yr is equivalent to a savings of about 9.8 Mtoe (using GIA conversion (Mongillo, 2005)) and avoided CO<sub>2</sub> emissions of 31.8 Mt. The equivalent savings for the worldwide total generation of 58,494 GWh/yr is about 14.8 Mtoe and avoided CO<sub>2</sub> emissions of some 47.8 Mt (*ibid.*).



**Figure ESI** 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], 2008 [cross] and 2009 [blue dot] data include 2007, 2008 and 2009 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<sub>e</sub>/yr; the 2010 estimates are from Bertani (2007) [diamond] and GEA (2007) [green square].

A good indicator of 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), plant availability (affected by repairs and maintenance), and transmission or 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<sub>e</sub> for geothermal (5.8 for GIA Member Countries in 2009), 5.2 GWh/MW<sub>e</sub> for solid biomass, 3.7 GWh/MW<sub>e</sub> for hydro, 1.9 GWh/MW<sub>e</sub> for wind (data from 2009 IEA Wind Annual Report), 1.8 GWh/MW<sub>e</sub> for tide/wave/ocean, and 0.6 GWh/MW<sub>e</sub> 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 2009 is a lower value 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 2009 Annual Report plus other information for Europe provided by Antics and Sanner (2007).

**Table ESI** Geothermal power installed capacity and electricity generation for GIA Member Countries in 2009, 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 (2009) [MW <sub>e</sub> ]	Annual Electricity Generated (GIA- 2009) (Others- 2005) [GWh/yr]	% of National Capacity	% of National Energy
<i>Australia*</i>	<i>0.12</i>	<i>1.9</i>	<i>Negligible</i>	<i>Negligible</i>
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
<i>France*</i> <i>(Guadeloupe Island)</i> <i>(Soutz-sous-Forêts)</i>	<i>15</i> <i>2.2</i>	<i>89</i> <i>0<sup>#</sup></i>	<i>~9 (for Island*)</i>	<i>~9 (for Island*)</i>
<i>Germany*</i>	<i>6.6</i>	<i>19.0</i>	<i>Negligible</i>	<i>Negligible</i>
Guatemala	53	212	1.7	3
<i>Iceland*</i>	<i>575</i>	<i>4,553</i>	<i>22.3</i>	<i>27.0</i>
Indonesia	992	6,085	2.2	6.7
<i>Italy*</i>	<i>842.5</i>	<i>5,200</i>	<i>1.0</i>	<i>1.6</i>
<i>Japan*</i>	<i>535.26</i>	<i>2,765</i>	<i>&lt;0.2</i>	<i>&lt;1.1</i>
Kenya	129	1,088	11.2	19.2
<i>Mexico*</i>	<i>958</i>	<i>6,740</i>	<i>1.9</i>	<i>2.9</i>
<i>New Zealand*</i>	<i>632</i>	<i>4,542</i>	<i>7.0</i>	<i>11.4</i>
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
<i>USA*</i>	<i>3,168</i>	<i>15,000</i>	<i>0.31</i>	<i>0.38</i>
<b>Total</b>	<b>10,565</b>	<b>58,494</b>	<b>9.4**</b>	<b>12.2**</b>
<b>Total GIA Countries</b>	<b>6,735</b>	<b>38,910</b>	<b>&lt;6.0**</b>	<b>&lt;7.7**</b>

\* GIA Member Country (includes Guadeloupe Island); † % from Bertani (2007)

# Not operating in 2009; 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

**Table ES2** Worldwide installed geothermal capacity (1975-2009) and electricity generation (1995-2009). The generation changes for 2006-2009 only include changes in GIA Member Countries.

Year	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009
<b>Geothermal Installed Generating Capacity (MW<sub>e</sub>)</b>	1,300	3,887	4,764	5,832	6,798	7,974	8,930	9,452	10,026 <sup>¶</sup>	10,405 <sup>¶</sup>	10,565 <sup>¶</sup>
<b>Electricity Generation (GWh/yr)</b>	-	-	-	-	37,744	49,261	53,649	55,209 <sup>#</sup>	56,782 <sup>#</sup>	57,957 <sup>#</sup>	58,494 <sup>#</sup>

<sup>¶</sup> Includes 2007 installed capacity data for 15 countries from Bertani (2007) with updates for GIA countries for 2007, 2008 and 2009

<sup>#</sup> Generation data is from 2005 (Bertani, 2005) with updates for GIA countries for 2006, 2007, 2008 and 2009

**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 for 2009.

Resource	Installed Capacity (MW <sub>e</sub> )	Generation (GWh)	Contribution Efficiency (GWh/MW <sub>e</sub> )
<b>Geothermal</b>			
<i>GIA Members 2009</i>	<b>6,735</b>	<b>38,910*</b>	<b>5.8*</b>
OECD 2006	5,400	38,100	7.1
<b>Solid Biomass (2006)</b>	22,500	115,900	5.2
<b>Hydro (2006)</b>	344,600	1,286,300	3.7
<b>Wind (2009)**</b>	111,000	207,000	1.9
<b>Tide, Wave, Ocean (2006)</b>	300	550	1.8
<b>Solar PV (2006)</b>	4,100	2,626	0.6

\* The new installed capacity for 2009 has not been operational for the whole of the 2009 year; hence, the generation and contribution efficiency are low

\*\* IEA Wind Annual Report (2009)

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 2009 was estimated to be about 36,950 MW<sub>th</sub>, by incorporating 2009 GIA updates with the data of Lund *et al.* (2005) and Antics and Sanner (2007) (Table ES4). The total thermal energy usage for 2009 was similarly estimated to be about 348,455 TJ/yr (Table ES4). In 2009, the 12 GIA Member Countries had a total installed thermal power capacity of approximately 21,927 MW<sub>th</sub> and utilized 173,745 TJ/yr (Table ES6). It is estimated that some 2 million GHP units are installed globally. Lack of data precludes reasonable heat pump estimates being made for 2009.

Worldwide direct use installed capacity has nearly doubled every 5 years between 1995 and 2005, and this high growth trend continued through 2007 (Table ES4). The estimated 2007 direct energy use increased by about 20% since 2005. However, as shown in Table ES4, both installed capacity and utilization appear to have increased only slightly (4% and 6%, respectively) between 2007 and 2009. The total use of about 348,455 TJ/yr is equivalent to an annual savings of about 12.3 Mtoe in fuel oil and 39.6 Mt in avoided CO<sub>2</sub> emissions (GIA conversions (Mongillo, 2005)).

**Table ES4** Worldwide direct use categories and their development 1995-2005 (from Lund, et al., 2005), with 2007 updates from Antics and Sanner (2007) and 2007, 2008 and 2009 updates for GIA Country Members.

Category	Capacity (MW <sub>e</sub> )						Utilization (TJ/yr)					
	1995	2000	2005	2007	2008	2009*	1995	2000	2005	2007	2008	2009*
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	-	-	-
<b>Total</b>	<b>8,664</b>	<b>15,145</b>	<b>28,269</b>	<b>35,570</b>	<b>36,023</b>	<b>&gt;36,950</b>	<b>112,441</b>	<b>190,699</b>	<b>273,372</b>	<b>329,270</b>	<b>329,880</b>	<b>&gt;348,455</b>
<i>Total GIA Countries</i>	-	-	-	<i>20,547</i>	<i>21,000</i>	<i>&gt;21,927</i>	-	-	-	<i>154,560</i>	<i>155,170</i>	<i>&gt;173,745</i>

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

## The IEA-GIA- an Overview

The IEA-GIA, founded in 1997, was in the 3rd year of its 3rd 5-year term (2007-2012) of operation at the end of 2009. The GIA provides a flexible framework for wide-ranging international cooperation in geothermal R&D by bringing together national and industry 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 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 this 2009 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 (industry/industry organization).

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 2009, there were 19 IEA-GIA Members: 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 Jeothermal; 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 2009, 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
- Annex X- Data for Geothermal Applications (new)

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. Annex X is a new Annex initiated in October 2009. 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 I of this 2009 GIA Annual Report.

A brief discussion of some of the GIA's activities and major highlights for the Annexes active in 2009 is presented below. Details are available in Chapter I and in the Annex Reports included in Chapters 2-5 of this 2009 GIA Annual Report.

### **IEA-GIA ExCo and Annex Meetings in 2009**

In 2009, the IEA-GIA ExCo held its 21<sup>st</sup> ExCo Meeting in Madrid, Spain and its 22<sup>nd</sup> in Reno, USA. Attendance remained at its usually high level, with ~30 participants at each meeting. Brief reviews of these meetings are presented in Chapter I of this 2009 Annual Report.

The four GIA Annexes held technical meetings in association with the 22<sup>nd</sup> ExCo Meeting held in Reno, USA, in October 2009. The GIA's 2-day joint IEA-GIA~IGA Workshop held in May 2009 in conjunction with the Madrid, Spain, ExCo meeting precluded the holding of associated Annex meetings. The Annex meetings are typically ~2 hours long and provide the opportunity for detailed discussions and assessments of current and planned activities. Important issues related to annex activities that have arisen during the year, e.g. induced seismicity, sustainability, etc. are also examined. Annex reports describing the status of activities, achievements, challenges, etc. are also presented at both of the annual ExCo meetings.

### **Joint IEA-GIA~IGA Workshop on Global Geothermal Potential and Climate Change**

The workshop *Geothermal Energy- Its Global Development Potential and Contribution to Mitigation of Climate Change*, held in Madrid, Spain, on 5-6 May 2009, was organized jointly by the IEA-GIA and the International Geothermal Association (IGA), and hosted by IEA-GIA Members: The Institute for Diversification and Saving Energy (IDAE), Spain, with assistance from the Geothermal Group of the Spanish Renewable Energy Association (GG-APPA). The motivation for holding this workshop was the recognized need to have more accurate information on the global geothermal development potential and its possible contribution to mitigating climate change, the opportunity to provide such information to the geothermal chapter of the IPCC special report; and the desire for both major international organizations to work together to contribute. This effort proved very worthwhile, allowing over 50 participants from 17 countries to meet, debate and provide information and data that led to valuable insight into how geothermal might contribute to future energy needs and impact on CO<sub>2</sub> emissions. Results will certainly be used in the preparation of the geothermal chapter of the IPCC Special Report on renewable energy and its contribution to the mitigation of climate change. Presentations are available on the IEA-GIA website ([Presentations](#)) and proceedings will be produced and published on both the GIA and IGA websites.

### **Geothermal Resources Council (GRC) Annual Meeting 2009, Reno, USA**

The GIA participated at the 33<sup>rd</sup> Annual Meeting of the GRC (theme: Geothermal 2009: "Making Renewable Energy Hot!") in Reno, Nevada, USA, in conjunction with the 22<sup>nd</sup> ExCo Meeting. The GRC Meetings are significant annual international geothermal events, and GIA paper: *IEA-GIA International Geothermal Cooperation: Going from Strength to Strength* (Mongillo, Bromley and Rybach, 2009a) was presented by GIA-Chair, Chris Bromley. A brief review of the IEA, and the GIA and its activities, achievements, future directions and prospects were presented in light of the current global energy situation.

### **Launch of GIA Proposal Initiative**

At the 21<sup>st</sup> ExCo Meeting, the GIA ExCo unanimously approved a proposal by Chair Chris Bromley that a mechanism for providing funding for approved supplementary activities related to

ExCo initiatives or Annex Task activities carried out by IEA-GIA participants be provided from the IEA-GIA Common Fund. The objective of this proposal is to stimulate more joint activity by participants, and create more tangible products to help fulfil the geothermal educational, outreach, and research objectives of the IEA-GIA, particularly those activities that would otherwise be stifled by lack of funding from any other source. Procedures for determining the budget available each year, describing proposal format and assessment, and typical level of proposal funding were described. The ExCo also unanimously agreed to fund the first proposal submitted in this initiative (see below).

## Two Successful GIA Proposals in 2009

- *Geothermics* Special Issue on Sustainable Utilization of Geothermal Energy
- IEA Energy Technology Roadmap “Geothermal Energy”

The first successful proposal (see above) submitted for ExCo approval provided US\$ 5 k over a 2-year period for the GIA Secretary to act as a Guest Editor, with Guðni Axelsson (Leader of Task E Sustainable Utilization Strategies), for a ***Geothermics* Special Issue on Sustainable Utilization of Geothermal Energy**, scheduled for publication in December 2010. This effort will complete a significant public output from the 2008 Annex I Task E international Sustainability Modelling Workshop held in Taupo, New Zealand, in association with the 50<sup>th</sup> Anniversary of the Wairakei Geothermal Power Station.

The second successful proposal in 2009 was for a contribution of US\$ 10 k towards the creation of an IEA Geothermal Roadmap, if the IEA Energy Technology division agrees to produce it. Unfunded time from GIA participants to assist with the formulation of the Roadmap would also be required. The IEA initiated the Geothermal Roadmap process in early 2010.

## Preparations for the World Geothermal Congress 2010, Bali, Indonesia

The World Geothermal Congress, held every 5 years, is the premiere international geothermal event, and the next one will be on 25-30 April 2010, in Bali, Indonesia. Well over 1,000 official participants present papers, posters, sponsor exhibition booths, hold seminars, etc. The GIA will have significant involvement, with several papers accepted for presentation from the Annexes plus a general one which has been chosen as a keynote address (*IEA Geothermal Implementing Agreement- International Efforts to Promote Global Sustainable Geothermal Development and Help Mitigate Climate Change* by Mongillo, Bromley and Rybach (2010)). The GIA will also have an exhibition booth, at which general GIA activities and those of the Annexes, and Country and Sponsor Members will be presented by posters and handout documents and reports. A range of IEA material will also be displayed and distributed.

## GIA Participation in IEA Activities

In 2009, the GIA continued its active participation in IEA workshops and meetings, and by providing information and comments on IEA reports.

The GIA provided information and comments on the geothermal content of the *IEA Cities, Towns & Renewable Energy- Yes in My Front Yard* book, and also contributed material for the GIA portion of the *IEA Energy Technology Initiatives* book (2010). In addition, a draft version of the *IEA Renewable Energy Essentials: Geothermal* brochure was completed.

## Use of Geothermal Energy and the Environment (Annex I)

Energy utilization may cause 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.

The sustainable utilization of geothermal resources is globally an important goal. Case histories and modelling of long term reservoir behaviour are being undertaken to identify optimum future development strategies. Results on improved environmental sustainability strategies and monitoring methods were presented at several international meetings, including the 2009 New Zealand Geothermal Workshop, the 2009 Stanford Geothermal Reservoir Workshop and the 2009 GRC Annual Meeting. Major interest in sustainability issues led to the commencement of a special issue of *Geothermics* journal on this topic.

Annex I participants are taking part in the preparation of a geothermal chapter for the IPCC renewable energy report for the mitigation of climate change.

Annex I participants also took part in discussions at the joint IEA-GIA~IGA "Geothermal Energy- Its Global Development Potential and Contribution to the Mitigation of Climate Change Workshop held in Madrid, Spain, in May 2009.

### **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. 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. The current lack of developing and operating EGS projects around the world has slowed the efforts of this Annex. However, increased EGS effort in the USA, Australia and Germany should begin to provide data in the near future. The adverse publicity arising from the issue of induced seismicity has also slowed progress. Good news is that the EGS plant at Soultz-sous-Forêts, France, is expected to begin operation once the feed-in tariff value is confirmed.

### **Reducing Geothermal Drilling Costs (Annex VII)**

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 and Logging Technology, is working to identify, develop and promote ways to reduce the costs of drilling, logging and completing geothermal wells.

Collection of information for the geothermal well drilling cost and performance database continues and development of a well cost calculator based on this information is expected in the near future. An update on geothermal well costs was presented at the GRC 2009 Annual Meeting and a paper describing the Annex's activities has been accepted for presentation at the World Geothermal Congress in 2010.

Preparation of a “best practices” handbook for geothermal drilling is proceeding and plans are to complete a full draft of the handbook in 2010.

## **Direct Use of Geothermal Heat (Annex VIII)**

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 a meeting, in association with the 22<sup>nd</sup> ExCo Meeting, Reno, USA, in October 2009. Significant new information has been obtained and compiled from a revised questionnaire on barriers and opportunities for direct use and analysis has begun. Efforts continue in the development of a method to present direct use data on the web using Goggle Earth.

A resource characterization paper presented at the RE2008 Busan, Korea, will be published in *Current Applied Physics*, and several papers were prepared and accepted for presentation at the WGC 2010.

## **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 2009, 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 2009, the 12 GIA Member Countries with geothermal generation had an installed capacity of about 6,735 MWe, or about 64% of the total global geothermal capacity of 10,565 MWe; and generated 38,910 GWh/yr, or about 67% of the total geothermal generation of 58,494 GWh/yr (Tables ESI and ES5). The United States was by far the largest producer, generating about 15,000 GWh/yr, with Mexico second with 6,740 GWh/yr and Italy third with 5,200 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 6.0%. 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 ES5** Total geothermal installed capacity, electricity generation and direct use in GIA Member Countries in 2009.

Country	Electrical Installed Capacity (MW)	Annual Energy Generated (GWh/yr)	% of National Capacity	% of National Energy	Installed Thermal Power (MW <sub>th</sub> )	Annual Energy Used (TJ/yr)
GIA Member Countries	6,735	38,910	<6.0*	7.7*	>21,927	>173,745
Worldwide Total**	10,565	58,494	9.4	12.2	>36,950	>348,455
GIA % of Worldwide Total	64	67	-	-	59	50

\* Average % of 7 GIA Member Countries with non-negligible 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 2009, with a total installed capacity of >21,927 MW<sub>th</sub> and total thermal energy used >173,745 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. The three largest users of geothermal heat by far were the USA (56,552 TJ/yr), Japan (25,698 TJ/yr), and Iceland (25,400 TJ/yr). However, the non-high enthalpy geothermal countries, France (12,929 TJ/yr), Germany (17,890 TJ/yr) and Switzerland (7,744 TJ/yr) also had very high utilization, mainly due to the large and growing geothermal heat pump usage.

**Table ES6** Geothermal direct use in GIA Member Countries in 2009.

Country	Installed Thermal Power (MW <sub>th</sub> )	Annual Energy Used (TJ/yr)
Australia	132	3,746
France	1,345	12,929
Germany	> 2,000	17,890
Iceland	1,607	25,400
Italy	[650]	10,000
Japan	1,686	25,698
Mexico	156	(1,932)
New Zealand	364	10,000
Republic of Korea	229	1,854
Spain	90	na
Switzerland	1,057	7,744
USA	12,611	56,552
<b>Total for GIA<sup>1</sup></b>	<b>&gt; 21,927</b>	<b>&gt; 173,745</b>

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

## Sponsor Activities

At the end of 2009, 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 Jeothermal from Turkey; and 2 industry 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 most advanced geothermal energy developer 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 3.6-4.0 km below surface into hot ( $T \sim 280$  °C at 5 km) fractured granite in the Cooper and Eromanga Basins in South Australia.

Well Savina I was drilled into an over pressured fracture in granite at a depth of 3,700 m. Tests showed that this was similar to the overpressure at the Habanero field 19 km east. Unfortunately, the overpressure resulted in the drill string becoming stuck and the well had to be plugged.

Another setback occurred when Habanero 3 production well failed, probably due to hydrogen embrittlement of the very shallow part of the casing, and had to be cemented. This resulted in activities on the pilot plant being deferred and a delay of further activities at Jolokia and Savina sites.

However, several important successes were had in 2009. In March 2009, Geodynamics announced that "proof-of-concept" had been attained after demonstrating its ability to extract heat from hydraulically stimulated hot fractured rock to generate power. This major achievement marked the completion of Stage I of the Company's business plan. In addition, the Innamincka 1 MW Pilot Plant was completed as was the power line between it and Innamincka.

Geodynamics also received further significant funding with a A\$ 90 M from the Australian Government's Renewable Energy Demonstration Program which provides 30% of the funds needed for drilling 6 wells, a 25 MW power plant and its connection to the wells. Another A\$ 17 M in grants were received for development of Geodynamics' Hunter Valley geothermal project in New South Wales, which provides for drilling of 2 wells and construction of a power station.

### 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 abroad.

Over the near term Green Rock plans to develop two commercial demonstration geothermal projects in sedimentary aquifers, a direct use one in Australia and a combined electricity-direct use one Hungary. The chief challenges for both types of geothermal resources proving sufficient reservoir permeability to deliver commercial energy at the surface for 20 years.

Green Rock has the first geothermal exploration permit in Western Australia, and the Company's first project is a commercial demonstration designed to utilize 80-100 °C water from sedimentary aquifers at 2,500-3,000 m depth, to air condition the University of Western Australia in Perth using geothermal powered absorption chillers. Success will lead to the larger scale deployment throughout metropolitan Perth.

In Hungary, Central European Geothermal Energy (CEGE), a joint venture of Green Rock and MOL, plan to test the production of geothermal water ( $T \sim 140$  °C) from an existing petroleum well for electricity and direct use. Success could lead to Hungary's first commercial geothermal power generation.

Green Rock also has a project that aims to generate electricity from geothermal water obtained from hot sediments in the north Perth Basin and an EGS project located at the site of a major market, the Olympic Dam mine, where successful mini-hydro fracture stimulation has been demonstrated, and further work awaits funding via a “farm-in”, before beginning deep drilling, stimulation and flow testing for prove-of-concept.

### **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 538 MW<sub>e</sub> of geothermal and RE generation in the USA, Nicaragua, Kenya and Guatemala, including 367 MW<sub>e</sub> of geothermal in the USA, and has deployed about 70% of all geothermal capacity in the US since 2000. In 2008 and 2009, Ormat added about 240 MW<sub>e</sub> of gross geothermal capacity worldwide, with 120-130 MW<sub>e</sub> under construction and 138 MW<sub>e</sub> in various stages of development. Ormat has over 1,000 employees. It also has its own in-house drilling company, GeoDrill, with four rigs (capacity ~ 5,500 m) and over 100 staff.

Ormat is involved in the largest effort undertaken by a single company in the past 20 years, to categorize, map, sample and drill US greenfield prospects. Also, a joint project with the US DoE has 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 provided a 3.2 MW<sub>e</sub> ORC power plant at Landau, Germany, which has been operating for over a year.

In 2009, Ormat’s revenues were US\$ 415 M, an increase of 20% over 2008.

### **ORME Jeothermal, Inc.**

ORME Jeothermal, 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 under review.

## **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 had 27 members at the end of 2009, including geothermal developers, equipment manufacturers and utilities, and firms specializing in consulting, engineering, construction, financial and legal aspects of geothermal energy. The Canadian and international CanGEA members are currently involved in 76 projects worldwide, with 1,470 MW<sub>e</sub> under development and ~2,000 MW<sub>e</sub> of operating power plants.

CanGEA was proactive in instituting the Geothermal Code for Public Reporting to enhance investor confidence and provide requirements for reporting exploration results, and geothermal resources and reserves.

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

The Geothermal Group of the Spanish Renewable Energy Association (GG-APPA) 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 with 11 company members and a low enthalpy one with 18 members.

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.

Work continues in 2009 to complete the new 2011-2020 Spanish Renewable Energy Plan (PER) and the new National Renewable Energy Action Plan (PANER), the latter required by the EU for each of its members. GG-APPA is working to influence the Government to include geothermal objectives in both, which are to be published in 2010. The APPA Low Enthalpy Geothermal Department bases its efforts on analyses of the problems hindering development of low enthalpy use, including: barriers to exploiting resources; and economic, technical and regulatory barriers. The APPA High Enthalpy Geothermal Department has appointed two companies to study the status of geothermal resources in Spain and investigate support mechanisms to stimulate the Spanish geothermal industry in order to make considerable contribution to Spain's climate goals by 2020; the report is to be published in 2010.

In addition, the Spanish Geothermal Technology Platform (GEOPLAT), which aims to identify and develop sustainable strategies for the promotion and marketing of geothermal energy in Spain, was officially launched in May 2009.

## **Plans for 2010 and Beyond**

The end of 2009 sees the GIA nearly half-way through its 3<sup>rd</sup> Term, having made good progress towards meeting its Mission and Strategic Objectives. The GIA has held ExCo meetings in Spain and the USA; held a joint GIA-IGA international workshop on global geothermal potential and contribution to the mitigation of climate change in Madrid, Spain; participated at the international 2009 GRC Annual Meeting conference in the USA; prepared several papers describing its activities and outputs for the World Geothermal Congress 2010; provided up-to-date geothermal information to several IEA publications; instituted a funding programme for assisting GIA activities; and initiated the publication of a special issue of the international geothermal journal *Geothermics* on the topic of sustainable geothermal use.

The GIA anticipates continued growth in its efforts and its membership in 2010, and onwards. The GIA has committed to participate at the important World Geothermal Congress in 2010 by submitting several papers and sponsoring an exhibition booth. The Proceedings of the joint international GIA-IGA (International Geothermal Association) Workshop mentioned above will be published; and significant effort will be made to complete a Special Issue of *Geothermics* on Sustainable Geothermal Utilization in December 2010. The GIA will continue its strong support of the IEA by providing current geothermal data/information, contributing to their publications, including providing an article for the IEA OPEN Bulletin (distribution of >12,000 subscribers) and completion of the *IEA Technology Essentials: Geothermal* brochure. Assuming the strong financial position of the GIA continues, the substantial balance of the Common Fund 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. In addition, the GIA will continue to pursue new membership in order to extend its base and expand its expertise.

The global financial and economic crisis that began at the end of 2008 is still a concern to the geothermal community, though there is some optimism buoyed by a continuing growth in global geothermal development that became evident in 2007. US President Obama's commitment to the development of renewable energy is also still providing a very positive influence in the geothermal sphere. 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.

## 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. (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.
- Chandrasekhar, V. and Chandrasekhar, 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: <http://www.iea.org/Textbase/npsum/WEO2008SUM.pdf>).
- 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 (2009b) World Energy Outlook 2009- Fact Sheets. OECD/IEA, Paris, France.
- IEA (2010) IEA Key World Energy Statistics 2010. OECD/IEA, Paris, France.
- IEA Wind (2010) IEA Wind Energy Annual Report 2009. (available on: [www.ieawind.org](http://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.
- MIT (2006) The Future of Geothermal Energy- Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21<sup>st</sup> Century. MIT Press, Boston, USA.

- Mongillo, M.A., Bromley, C.J. and Rybach, L. (2009a) IEA-GIA International Geothermal Cooperation: Going from Strength to Strength. GRC Trans. , 8 p.
- Mongillo, M.A., Bromley, C.J. and Rybach, L. (2010.) IEA Geothermal Implementing Agreement- International Efforts to Promote Global Sustainable Geothermal Development and Help Mitigate Climate Change. World Geothermal Congress 2010.
- Mongillo, M.A. (2005) Savings factors for geothermal energy utilization. IEA Geothermal Implementing Agreement document, January 2005. (document available at: [Savings Factors.pdf](#))
- 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.

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