

The IEA Geothermal Implementing Agreement (GIA) – Advancing Into Its Third Term

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ABSTRACT

The Implementing Agreement for a Cooperative Programme on Geothermal Research and Technology (GIA) is now beginning its third 5-year term of operation after having very successfully completed its second. The organization recognizes the major challenges that face our world if a sustainable energy future is to be attained, and has developed its new mission accordingly:

To promote the sustainable utilization of geothermal energy throughout the world by improving existing technologies, by developing new technologies to render usable 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 help fulfill this mission, the GIA has developed new strategic objectives that will *identify and promote policies to stimulate energy technology research, development, demonstration and deployment; enhance development of analytical tools; foster international networking and collaboration; and effectively communicate the key lessons learned.*

The GIA operates by providing a versatile framework for comprehensive international cooperation in geothermal RD&D under the auspices of the International Energy Agency (IEA). It connects national and industry programmes, with the aim of building specific expertise and enhancing effectiveness through establishing direct cooperative links among geothermal experts in participating countries and industries. The GIA's current activities are directed principally toward coordination of country member geothermal programmes and assisting with industry member efforts; though, new activities are also initiated and implemented when needs are demonstrated.

GIA project activities are defined and organized in *Annexes*, and participants must take part in at least one. Currently, participants in the IEA-GIA are working in four broad areas covered by the following Annexes:

- Annex I- Environmental Impacts of Geothermal Energy Development
- Annex III- Enhanced Geothermal Systems (EGS)
- Annex VII- Advanced Geothermal Drilling Techniques
- Annex VIII- Direct Use of Geothermal Energy

Two other topics which are being considered for study and for which draft Annexes have been developed are:

- Annex V- Sustainability of Geothermal Energy Utilization
- Annex VI- Geothermal Power Generation Cycles

As of April 2007, 11 countries: Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, the Republic of Korea, Switzerland and the United States; the European Commission; and three industry Sponsors: Geodynamics Limited, Green Rock Energy Limited and ORMAT Technologies Inc., are members of the GIA.

The IEA-GIA is open for participation to those IEA Member and non-Member Countries, as well as those industries, that are actively working in geothermal energy RD&D. Interested parties should contact the GIA Secretariat at: mongillom@reap.org.nz or visit the GIA website: www.iea-gia.org.

1. INTRODUCTION

This paper summarizes the current status, achievements and future plans of the International Energy Agency (IEA) Geothermal Implementing Agreement (GIA) as it begins its third 5-year term of operation. It also provides a brief description of the structures of the IEA and the GIA. Further details may be found in the GIA 2002-2007 End of Term Report, the GIA Strategic Plan 2007-2012 and the GIA annual reports, all available in the Publications section on GIA website: www.iea-gia.org.

1.1 The IEA and Its Implementing Agreements

The International Energy Agency (IEA) was created in 1974 in response to the 1973-74 oil crisis. It is an autonomous international governmental agency, based in Paris, France, and consists of a cooperative group of 26 Member countries of the Organization for Economic Cooperation and Development (OECD). The Commission of the European Communities also participates. Further information about the IEA and its activities may be found on its website: www.iea.org.

The IEA encourages international collaboration in energy technology through a network of over 40 active Implementing Agreements (IAs), which provide the management structure and legal mechanism for guiding the activities of the IEA's collaborative multilateral programmes. Participants typically include research institutions, utilities and industries. There are two categories of Participants in the IAs: Contracting Parties (representing countries) and Sponsors (industry members). OECD non-Member countries, or entities of OECD non-Member countries, may also participate.

The activities, or tasks, undertaken in the IAs are defined and organized in *annexes*. The annexes specify the R&D task objectives, schedules, funding provisions (if any), and identify the participants and define their obligations. An Executive Committee (ExCo), consisting of individuals from each Contracting Party and Sponsor, coordinates and manages the activities of the IA. An Operating Agent, generally an institution, leads each annex. Funding for IA activities can be of two types: *task-sharing*, whereby the participants allocate specified resources and personnel to conduct a portion of the Annex work at their own expense; or *cost-sharing*, in which participants contribute to a common fund that is used for research, equipment purchase, information processing and exchange, operation of a secretariat, etc.

2. THE IEA GEOTHERMAL IMPLEMENTING AGREEMENT (GIA)

2.1 Overview

The GIA was established on 7 March 1997, reviving IEA cooperation in geothermal research after a 16-year hiatus. Following a successful first 5-year term, the Renewable Energy Working Party (REWP) and the IEA Committee on Energy Research and Technology (CERT) approved the extension of the GIA for a second 5-year term, to 31 March 2007. In February of this year (2007), the IEA CERT, acting on the recommendation of the IEA REWP, unanimously agreed to extend the GIA's operation for a third 5-year term, taking its activities to 31 March 2012.

The GIA provides a flexible framework for wide-ranging international cooperation in geothermal R & D. It brings together national and industry programmes for exploration, development and utilization of geothermal resources, with a focus on assembling specific expertise and enhancing effectiveness by establishing direct cooperative links among geothermal experts in the participating countries and industries. The GIA's present activities are directed primarily toward the coordination of the ongoing national programmes, with contributions from the Sponsor members.

The GIA's general scope of activity, as specified in its operating document, the IEA Implementing Agreement for a Cooperative Programme on Geothermal Energy Research and Technology, consists of international scientific collaborative efforts to:

- *Compile and exchange improved information* on worldwide geothermal energy research and development concerning existing and potential technologies and practices
- *Develop improved technologies* for geothermal energy utilization
- *Improve the understanding of the environmental benefits* of geothermal energy and ways to avoid or minimize its environmental impacts

The GIA's present activities encompass a range of geothermal topics, from "traditional" uses like power generation and direct use of heat, to new technologies pertinent to enhanced geothermal systems (EGS) and deep resources and the examination of sustainable use strategies. New activities are also pursued when needs are established.

As of April 2007, the European Commission (EC); 11 countries: Australia, France, Germany, Iceland, Italy, Japan,

Mexico, New Zealand, the Republic of Korea, Switzerland and the United States; and 3 industry Sponsors: Geodynamics, Green Rock Energy and ORMAT, were Members (Table 1). Participants take part in those annexes to which they can contribute, hence are not necessarily active in every one.

2.2 Strategy and Objectives

The world's renewable energy resource base has been estimated to be 7,500 EJ/year, two-thirds of which could be provided by geothermal energy (WEA, 2000). The amount of this potential that can be realized is still quite uncertain, with most recent estimates for worldwide geothermal resources located along plate margins ranging up to a total of 1,900 EJ (thermal)/year; about 65 EJ (electrical)/year for electricity generation and 1,400 EJ (thermal)/year for direct use (Stefansson, 2005). These estimates do not include the significant contribution that EGS generation may make, or that from binary generation for temperatures below 130 °C. By comparison, the 2005 installed electrical capacity was 8.9 GW (electrical) [0.3 EJ/year] and installed direct use capacity was 28 GW (thermal) [0.9 EJ/year], and the world total primary energy supply was 463 EJ in 2004 (IEA, 2006a). It is clear that the world's large and ubiquitous geothermal resources are potentially capable of making a very significant contribution towards meeting the accelerating future global energy needs.

The GIA has now begun its third 5-year term of operation, being guided by a new Strategic Plan 2007-2012, which recognizes geothermal's wide-ranging capabilities, including its capacity to assist with meeting the major challenges indicated in the IEA World Energy Outlook 2006 (IEA, 2006b)- to provide adequate and secure energy supplies at affordable prices in a sound environmental manner. The world is now, in the most optimistic case (IEA Alternative Policy Scenario), looking at *reducing the rate of increase* in demand and emissions, which grow by 37% and 30%, respectively, in the period up to 2030 (*ibid!*)

The GIA acknowledges the importance of significantly extending the development and deployment of geothermal energy worldwide by reducing costs and overcoming barriers to promote a clean, economic, sustainable and secure energy supply. In the near term, major geothermal power and direct use development is expected to occur in the countries that currently utilize geothermal and are aware of its economic, environmental and social benefits. However, in the longer term, there is great potential for expanded power development in South East Asia, South and Central America and Africa, where major geothermal resources have already been identified and demand for energy is accelerating; and for direct use in Eastern and Central Europe. The GIA also sees the potential for geothermal in distributed application, both on and off grid developments, especially in rural electrification schemes; and to be integrated into power generation systems with those renewable energy sources that are 'variable' by nature, due to their dependence upon sunshine, climate and weather. Such possibilities will require cooperation with other Implementing Agreements.

The GIA realizes that geothermal energy utilization must be promoted on a global scale and sees itself as an organization that should take the lead in supporting and advancing its development. The GIA aims to advance geothermal technology and to produce quality information that can be used to positively influence government and industry decisions and policy on geothermal RD&D.

To meet these challenges, the GIA Strategic Plan 2007-2012 has set its mission:

To promote the sustainable utilization of geothermal energy throughout the world by improving existing technologies, by 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, the following six strategic objectives were designed:

- *To actively promote effective cooperation in 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/develop geothermal energy technologies and methods to deal with them*
- *To increase membership in the GIA*
- *To encourage collaboration with other international organizations and appropriate IEA 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*

2.3 Current GIA Research

At present, GIA participants work in four major research areas specified in four annexes to the GIA, with the activities of each divided into several tasks.

(1) Annex I: Environmental Impacts of Geothermal Energy Development (established in 1997): The aim of this continuing annex is to clearly identify possible environmental effects of geothermal development and devise and adopt methods to avoid or minimize their impact. The main activities of this annex are divided into five tasks: to investigate the impacts of development on natural features; to study the problems associated with discharge and reinjection of geothermal fluids; to examine methods of impact mitigation and produce an environmental manual; to investigate seismic risk from fluid injection into enhanced geothermal systems and to investigate sustainable utilization strategies.

(2) Annex III: Enhanced Geothermal Systems (EGS) (established in 1997): The main objective of this annex is to investigate new and improved technologies that can be used to artificially stimulate a geothermal resource to allow commercial heat extraction. The work is spread over four tasks: to review/modify the use of conventional and develop new geothermal technology for EGS application; to collect information necessary for decision making, design and the realization of a commercial EGS energy producing plant; and to conduct field studies of EGS reservoir performance.

(3) Annex VII: Advanced Geothermal Drilling Techniques (established in 2001): This annex pursues advanced geothermal drilling research and investigates all aspects of well construction with the aim of reducing the costs associated with this essential and expensive part of geothermal exploration, development and utilization. Investigations are conducted in three tasks: the compilation of geothermal well drilling cost and performance information and its storage and maintenance on a database; production of a geothermal drilling best practices handbook; and monitoring and exchange of information on drilling technology development and new applications.

(4) Annex VIII: Direct Use of Geothermal Energy (established in 2003): The aim of this annex is to address all aspects of direct use technology with emphasis on improving implementation, reducing costs and enhancing use. Activities are spread out over five tasks: to define and characterize geothermal resources for direct use applications; to identify and promote opportunities for new and innovative applications; to define and initiate research to remove barriers, to enhance economics and to promote implementation; to test and standardize equipment; and to develop engineering standards.

Annex IV: Deep Geothermal Resources: This annex, which started in 1997, was closed in September 2006 as a result of the successful completion of much of its work, with the remaining unfinished studies transferred to other annexes. The objective was to address issues necessary for the commercial development of deep geothermal resources at depths greater than 3,000 m. This annex was successfully involved with deep geothermal development research in Germany and participated in the Soultz-sous-Forêts project in Alsace, France; revised conceptual models of Mexican geothermal fields and analyzed the effects of their prolonged exploitation; and investigated rigorous simulation of heat and mass transport in high-temperature reservoirs with high non-condensable gases. The major results for the first 5 years of activity were compiled on CD- Rom.

The status of all the GIA annexes, including those that have been drafted, completed or are currently active, is provided in Table 2. Funding for Annexes I, III, VII and VIII is of the *task-sharing* mode, though some future activities in Annex VIII may require *cost-sharing*.

2.4 GIA Membership Benefits

Membership in the GIA benefits the research, government, industry and academic sectors, at both technical and policy levels.

GIA collaboration provides researchers with the opportunities for joint R&D cooperation and information exchange on recent R&D developments via meetings, workshops and networking. Members can participate together on R&D projects and to develop databases, models and handbooks. Policy and decision makers can obtain an international perspective on geothermal issues, opportunities and development. In addition, there are benefits to society that arise from environmentally appropriate development of geothermal resources.

More specifically, GIA membership provides the following benefits:

- *Increases R&D capabilities* beyond that of single a country/group by combining the efforts of several nations and industry

- *Provides appropriate focus for R&D*, hence avoids duplication and unproductive research
- *Develops skills and knowledge*
- *Improves R&D cost effectiveness* by sharing research costs and technical resources
- *Provides wider and easier access to key information*, research results and technological capabilities
- *Provides impartial information and analysis* to help guide national policies and programmes
- *Provides the opportunity to review current issues*, ongoing research and the need for future research
- *Helps build a common understanding* of the technical basis for various geothermal issues
- *Investigates barriers* to implementation
- *Helps develop technical standards and methodologies*
- *Contributes to the development of energy policies*

2.5 Structure, Management and Costs of the GIA

Members of the GIA participate in one or more tasks within the annexes. Each annex is binding only upon its Operating Agent and the participants therein, and does not affect the rights or obligations of other Members.

The GIA is supervised by an Executive Committee (ExCo) and its decisions are binding on all Members. The ExCo consists of one voting Member from each Member Country and Sponsor. An Alternate may serve on the ExCo if the designated Member is unable to do so. The ExCo meets twice a year and Members and/or their Alternates are strongly encouraged to attend. Members cover the travel expenses for their representatives to attend meetings and workshops.

The GIA ExCo has a Secretariat, currently based in New Zealand, which provides secretarial, administrative and other services as required for the organization.

The operational expenses for the GIA Secretariat, including the Secretary's salary, and other common costs of the ExCo, are met from an ExCo common fund. Monetary contributions to support the common fund are made by Members through a share apportionment system. The current cost per common fund share is US\$ 3,500/year.

3. GIA 2ND TERM SUCCESSES AND ACHIEVEMENTS

The ExCo and the Annexes have been very active during the GIA's second term, and particularly successful in the pursuit of its 2002-2007 mission (GIA, 2003). A few examples that demonstrate the range of GIA activities, its successes and its most significant achievements are presented here. More details can be found in the Publications section on the GIA website: www.iea-gia.org/publications.asp.

An important indicator of the GIA's success this term has been its growth in membership, with the Republic of Korea, France and the first three industry Members, Geodynamics, Green Rock Energy and ORMAT Technologies joining.

The GIA ExCo and Annexes have also been very successful in their information dissemination efforts as illustrated by their over 150 publications and wide-ranging participation at major international forums, including: the International Geothermal Congress Reykjavik 2003, GRC Annual Meetings and New Zealand Geothermal Workshops, which provided opportunities for widespread exchange and interaction. The GIA's participation at the World Geothermal Congress 2005 was particularly successful, with the presentation of over 40 papers and posters by GIA Members, and sponsorship of an exhibition booth that attracted wide attention. The GIA has increased its participation in IEA renewable energy workshops and seminars and its contributions to IEA publications (e.g. OPEN Bulletin #35), thus raising the profile of geothermal energy on a worldwide scale as well as within the IEA and among the other renewable energy technologies.

A new comprehensive GIA website was also developed and went on-line in December 2004. It now provides a very important additional, and easily accessible, means for information dissemination and expands availability to GIA and non-GIA members, as well as the public.

GIA research activities have grown during the second term, with the addition of important new investigations into induced seismicity associated with EGS reservoir development and energy extraction (Annex I); field studies of EGS reservoir development and performance (Annex III); and the commencement of the new Annex VIII, which examines many aspects of geothermal energy direct use. In March 2007, a new task related to the investigation of sustainable utilization strategies was added to Annex I.

Among some of the more important specific recent achievements of the Annexes themselves are:

- *Annex I* published a special environmental issue of *Geothermics* journal; convened three international workshops on geothermal induced seismicity; produced a white paper on Induced Seismicity Associated with Enhanced Geothermal Systems and a draft protocol for dealing with induced seismicity
- *Annex III* completed development of a suite of software interpretational tools for hydrothermal and EGS systems and a high-temperature (= 275 °C) acoustic televiewer; produced an English-language review of circulation and heat extraction and monitoring of the Hijiori EGS on CD-Rom; and compiled the experience of most of the major EGS research and development projects on a "Project Management Decision Assistant" handbook (PMDA) which is currently available and widely distributed
- *Annex IV* was especially involved with deep geothermal developments in Germany and participated in the Soultz-sous-Forêts project in Alsace, France; revised conceptual models of Mexican geothermal fields and analyzed the effects of their prolonged exploitation; and investigated rigorous simulation of heat and mass transport in high-temperature reservoirs with high non-condensable gases
- *Annex VII* is well on the way to producing a *Handbook of Best Practices for Geothermal Drilling*; and has collaborated with Japan on the use of a newly developed downhole high-temperature gauge

- *Annex VIII* recently began operations and has collected a significant quantity of temperature and chemistry data for geothermal features in several countries and produced its first publication (Muraoka, *et al.*, 2006)

4. FUTURE DIRECTIONS- BEGINNING THE 3RD TERM

The GIA began its third term of operation in April 2007 with great confidence, guided by its new strategic plan for 2007-2012. Its organizational vision is clear:

For the Geothermal Implementing Agreement to become a multinational forum with sufficient governmental and industrial strength to positively influence the design of Participants' RD&D plans, to optimize Participants' returns on RD&D investment by coordinating joint projects and sharing information, and to effectively support and complement IEA's efforts to promote geothermal as a clean, economic, renewable energy resource which will contribute significantly to global energy needs and security, and at the same time protect the environment.

The GIA's 2007-2012 mission and objectives, as discussed above, are aimed at making this vision a reality.

In addition to continuing its work in Annexes I, III, VII and VIII, the GIA is presently considering expanding its range of activities to include investigations into the sustainable utilization of geothermal energy (draft Annex V) and studies of the performance, environmental impact and economics of the geothermal power cycles to establish guidelines for best selection (draft Annex VI). The breaking down of barriers to geothermal development continues to be an extremely important issue, and the expertise of the GIA's new country and industry members will help address it. Options are always open for new collaborative activities to be added to the programme and new proposals are encouraged.

The GIA also recognizes the importance of increasing membership to help advance worldwide geothermal energy use. To this end, the GIA plans to more actively pursue its outreach programme to both non-GIA Members and non-IEA countries, especially those with major geothermal resources and developments. Options to encourage potential Members to join include inviting them to attend ExCo Meetings and seminars.

The GIA plans to continue to build upon its already excellent cooperation with the IEA, which provides important opportunities for international exposure and communication.

Information dissemination and communication will remain major activities for the GIA and there are plans to continue and emphasize their development through its website, the production of brochures and reports, by holding seminars.

5. CONCLUSIONS

It is clear that the global energy demand will continue to accelerate in the coming decades. The world's vast and ubiquitous geothermal resources can play an important role in helping meet this demand by providing secure, clean and affordable energy, both for electricity generation and direct use. However, to do so, it is essential to improve and develop new technologies and promote the benefits of sustainable geothermal utilization.

The GIA has already achieved a great deal towards helping meet the global energy challenges during its first two terms. It is also clear that a significant amount of work remains. The GIA can continue to make major contributions and is confident its activities in the current third term will continue to provide the means for very successful extensive international cooperation in geothermal R&D. At present, the EC, 11 Member countries from Europe, Asia, the Americas and Oceania, and 3 geothermal industries are collaborating to help make geothermal energy the major energy resource of the future.

The GIA invites those national organizations, industry and other groups who are able to contribute to join us. Membership is open to both IEA Member and non-Member countries. Interested parties should contact the IEA-GIA Secretary at: mongillom@reap.org.nz and/or visit the IEA GIA website at: www.iea-gia.org for further information. Membership is formalized through the IEA Secretariat, which has been instrumental in assisting with the growth of the GIA.

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The IEA Geothermal Implementing Agreement (GIA), also known as the Implementing Agreement for a Cooperative Programme on Geothermal Energy Research and Technology, functions within a framework created by the International Energy Agency (IEA). Views, findings and publications of IEA GIA do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.

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Table 1. Contracting Party and Sponsor Membership in the IEA Implementing Agreement for a Co-operative Programme on Geothermal Research and Technology as of April 2007.

Country	Starting Date of GIA Membership	Current Contracting Party
Australia	August 1997	Primary Industries and Resources SA (PIRSA)
European Commission	March 1997	Commission of the European Communities
France	February 2007	BRGM
Germany	July 1997	Forschungszentrum Jülich GmbH(F-J)
Iceland	December 2000	Orkustofnun (The National Energy Authority)
Italy	May 2000	ERGA Spa (ENEL Group)
Japan	March 1997	New Energy and Industrial Technology Development Organization (NEDO)
Mexico*	July 1997	Instituto de Investigaciones Eléctricas (IIE)
New Zealand	March 1997	GNS Science
Republic of Korea	September 2005	Korea Institute of Geoscience and Mineral Resources (KIGAM)
Switzerland	March 1997	Swiss Federal Office of Energy
United States of America	March 1997	US Department of Energy (US DOE)
Industry Home Country		Sponsor
Australia	June 2006	Geodynamics Limited
Australia	June 2006	Green Rock Energy Limited
United States of America	March 2006	ORMAT Technologies Inc.

* Non-IEA Member Country participant

Table 2. List of GIA Annex titles, operating agents, annex leaders, affiliations & contact e-mail addresses, participating countries and operating status as of April 2007.

Annex Number	Annex Title Operating Agent (OA) Annex Leader (AL); Affiliation; Contact E-mail Participants	Status
I	Environmental Impacts of Geothermal Development OA: GNS Science (GNS), New Zealand AL: Chris Bromley; GNS, New Zealand; c.bromley@gns.cri.nz Participants: EC, Iceland, Italy, Japan, Mexico, New Zealand, USA	Active since 1997, Continuing through 2009
II	Shallow Geothermal Resources	Closed
III	Enhanced Geothermal Systems (EGS) OA: Geodynamics Limited, Australia AL: Roy Baria; MIL-TECH UK Ltd, England; roybaria@onetel.com Participants: Australia, EC, Geodynamics, Germany, GreenRock Energy, Italy, Japan, ORMAT, Switzerland, USA	Active since 1997, Continuing through 2009
IV	Deep Geothermal Resources	Closed 2006
V	Sustainability of Geothermal Energy Utilization	Draft
VI	Geothermal Power Generation Cycles	Draft
VII	Advanced Geothermal Drilling Techniques OA: Sandia National Laboratories, United States AL: Stephen Bauer; Sandia National Laboratories, USA; sjbauer@sandia.gov Participants: EC, Geodynamics, Green Rock Energy, Iceland, Mexico, New Zealand, ORMAT, USA	Active since 2001, Continuing through 2009
VIII	Direct Use of Geothermal Energy OA: Federation of Icelandic Energy and Waterworks, Iceland AL: Einar Gunnlaugsson, Reykjavik Energy, Iceland; einar.gunnlaugsson@or.is Participants: Iceland, Japan, New Zealand, Republic of Korea, Switzerland, USA	Active since 2003, Continuing through 2007
IX	Geothermal Market Acceleration	Closed