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The IEA Geothermal Implementing Agreement - Its Goals, Status, Achievements and Prospects

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ABSTRACT

The International Energy Agency Implementing Agreement for a Cooperative Programme on Geothermal Energy Research and Technology, or Geothermal Implementing Agreement (GIA), provides an important framework for wide-ranging international cooperation in geothermal R&D. The activities of the GIA, which began in March 1997, are directed primarily to the coordination of existing national programmes and focus on assembling specific capabilities and enhancing their effectiveness by establishing direct cooperative links among geothermal experts in the participating countries. The R&D activities are conducted under Annexes to the GIA, of which there are currently five: Environmental Impacts of Geothermal Energy Development, Enhanced Geothermal Systems, Deep Geothermal Resources, Advanced Geothermal Drilling Techniques and Direct Use of Geothermal Energy.

The GIA is now operating in its second 5-year term, which ends in March 2007. The overall goal for this term, defined in the 2002-2007 Strategic Plan, is to support and advance the worldwide use of geothermal energy by seeking to overcome the barriers to its development. To help meet this challenge, the GIA recently expanded its R&D activities by adding a fifth annex, Direct Use of Geothermal Energy; and is preparing to include other new topics, which are now defined as draft annexes. These include: Sustainability of Geothermal Energy Use, Geothermal Power Generation Cycles, and Geothermal Market Acceleration. In addition, efforts are underway to extend official GIA membership and to encourage qualified non-Member participation. As of May 2004, the European Commission (EC) and nine countries: Australia, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Switzerland and the United States, were Members.

A brief review of the IEA and GIA structures is presented; and the goals, status and achievements of the GIA and its future prospects are summarized.

1. INTRODUCTION

This review provides an update and amplification of the papers by Rybach (1998), which introduced the Geothermal Implementing Agreement (GIA) shortly after its formation in March 1997, and Mongillo and Nieva (2003a, 2003b). Refer to these papers and the IEA GIA annual reports (IEA-GIA Webpage) for more details about the IEA, its early involvement with geothermal R&D and the background and extensive work of the GIA. Note that all webpage addresses referred to in this paper are listed in the Reference section.

1.1 The IEA

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 comprising a cooperative group of most of the Member countries of the Organization for Economic Cooperation and Development (OECD).

At present, the IEA is the energy forum for 26 Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also participates in the work of the IEA. The IEA Member countries strive to create conditions in which their energy sectors can promote sustainable economic development for the welfare of their citizens and environment. They recognize the importance of the growing interdependence of the global economic and energy markets, and thus have created a framework for working together to coordinate their energy policies, share energy information and cooperate in the development of rational energy programmes. Significant joint measures include developing alternative energy sources, increasing efficiency of energy use and assisting with the integration of energy and environmental policies. In addition to their many other responsibilities, the IEA encourages international collaboration in energy technology in the areas of: information centres and energy modelling, fossil fuels, renewable energy technologies, energy end-use technologies and fusion power through a large network of Implementing Agreements (IEA Webpage).

1.2 IEA Implementing Agreements

Implementing Agreements (IA) provide the management structure and legal mechanism for guiding the activities of the IEA's collaborative multilateral programmes. They are specific contracts that establish the obligations and rights of the participants and the objectives of the projects. Participants can include government organizations, private organizations formally designated by their governments, international inter-governmental organizations, and others, and typically comprise research institutions, utilities and industrial concerns. There are two categories of Participants in the IA: Contracting Parties and Sponsors. OECD non-Member countries, or entities of OECD non-Member countries, may also participate. There are currently over 40 active IAs covering a wide range of energy technologies. The IA participants benefit from the pooling of skills, knowledge, financial resources and regular scientific interaction, as well as by avoiding costly duplication in their national research programmes.

The projects, or tasks, undertaken in IAs are defined and organized in annexes to the IA. The annexes specify the R&D task objectives, schedules, funding provisions, and identify the participants and define their obligations. An Executive Committee (ExCo), consisting of one Member and one Alternate from each Participant (i.e. Contracting Party or Sponsor), coordinates and manages the activities of the IA and is also responsible for disseminating results and reporting annually to the IEA. Each annex is coordinated and administered by an Operating Agent (generally an institution), which is usually designated by the participating country and confirmed by the ExCo. New task annexes can be added to an IA project as it progresses if the ExCo determines that new specific issues should be examined collaboratively. 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*. (Rybach, 1998). Often a combination of these funding mechanisms is used to finance IA operations.

2. THE IEA GEOTHERMAL IMPLEMENTING AGREEMENT (GIA)

2.1 Overview

The GIA officially went into effect on 7 March 1997, reviving IEA cooperation in geothermal research after a 16-year hiatus. The Agreement was designed to operate for an initial period of five years. However, in late 2001, the GIA was extended for a second 5-year term, to 31 March 2007, with the approval of the Renewable Energy Working Party (REWP) and the IEA Committee on Energy Research and Technology (CERT).

The GIA provides an important and flexible framework for wide-ranging international cooperation in geothermal R & D, which seeks especially to overcome barriers to the development of geothermal energy utilization. It brings together important national programmes for exploration, development and utilization of geothermal resources, with the focus on assembling specific expertise and enhancing effectiveness by establishing direct cooperative links among geothermal experts in the participating countries.

The GIA's present activities are directed primarily toward the coordination of the ongoing national programmes of the participants, and 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. New activities are also initiated and implemented when needs are established. The GIA is available on the web (IEA-GIA Webpage).

As of May 2004, the European Commission (EC) and nine countries: Australia, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Switzerland and the United States were Members. The present involvement of these 10 Members in the GIA programme is shown in Table 1. Participants take part in those annexes to which they can contribute, hence are not necessarily active in every one

2.2 The Strategic Plans and Objectives

The GIA's first Strategic Plan, produced at its formation in 1997, identified the organization's goal as: *to encourage and support the worldwide use of geothermal energy*. To attain this goal, objectives were specified that included conducting international 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 methods to avoid or ameliorate its environmental drawbacks.

These efforts kept the GIA well on track during its initial years. However, as the first term drew to a close, it became clear that the environment in which the GIA operated had evolved since 1997, and would continue to do so.

Consequently, a new strategic plan was designed and implemented to guide the organization through its 2002-2007 term. The Strategic Plan reflects the actions underway, and those being considered, by the GIA in response to market, management and government policy dynamics, as well as technological advances. It also recognizes the challenges presented by the IEA World Energy Outlook 2002 forecasted growth of 4% per annum in global geothermal electricity production for the 2000-2010 period (WEO, 2002), the desire to increase worldwide geothermal direct use, and the growing acceptance and consequences of the Kyoto Protocol.

Geothermal energy must become cost-effective in the marketplace and overcome the difficulty of characterizing the resource prior to major financial commitment and the discrimination against its capital-intensive nature. Barriers to market penetration arising from a general lack of public awareness and experience with the technologies, and the environmental and social barriers linked to the lack of experience with planning, regulation and gaining public acceptance must also be overcome. Geothermal energy has significant positive environmental benefits on the global scale; however, local impacts must be clearly identified and dealt with in an open manner. To meet these challenges, the GIA Strategic Plan 2002-2007 was designed with the specific mission for the second term as being: *to advance and support the use of geothermal energy on a worldwide scale by overcoming barriers to its development*. To do this, the original GIA objectives were augmented with additional ones specifically focused to:

- *Expand R&D collaboration*: Geothermal technology development is progressing and new areas of collaboration are required. Table 1 contains a summary of current collaborative efforts under the GIA. The Executive Committee (ExCo) will consider and implement new subtasks and annexes where additional collaboration could be useful.
- *Increase the number of participants*
- *Increase outreach to non-Member countries with large geothermal energy potential*: The electricity markets in many countries were opened to competition in the 1990s. As energy markets deregulate, they are driven more by market forces and less by government programmes and intervention. New regions are opening up as international energy markets expand and the GIA will embrace this opportunity and explore ways to accelerate development of the world's

geothermal resources through invited participation in its programmes.

- *Evaluate market stimulation mechanisms*: In the ExCo's efforts to expand geothermal heat and power markets in both OECD and non-OECD countries, research actions are clearly important and indeed essential, but they are not in themselves sufficient to open up markets. Market stimulation is also needed to create an expanded market for geothermal energy.

- *Improve dissemination of information about geothermal energy*: The ExCo has recognized its role in promoting the use of geothermal energy, but more emphasis is needed on the open distribution of high quality and attractive information products.

- *Leverage limited R&D funding*: The R&D budgets of many of the participants have been declining, and the need for cost-shared collaboration is increasing. An affiliation with the IEA brings added value to activities rather than funding. The IEA's reputation for technical competence and broad unbiased excellence can be leveraged to obtain support from industry and other multilateral organizations and financial institutions.

2.3 The GIA Annexes

GIA participants presently work on five research tasks that are specified by five annexes to the GIA, with the activities of each divided into several subtasks. The operating agents, task leaders, participants and status of activity are presented in Table 1. Three of these annexes were part of the original GIA:

(1) Annex I: Environmental Impacts of Geothermal Energy Development: In order to expand the use of geothermal energy, it is necessary to clearly identify possible environmental effects and devise and adopt methods to avoid or minimize their impact. The main activities of this annex are divided into three subtasks: to investigate the impacts of development on natural features; to study the problems associated with discharge and reinjection of geothermal fluids; and to examine methods of impact mitigation and produce an environmental manual.

(2) Annex III: Enhanced Geothermal Systems (formerly Hot Dry Rock): This annex investigates new and improved technologies that can be used to artificially stimulate a geothermal resource to allow commercial heat extraction. The work currently being conducted is spread over three subtasks: to review the use of conventional and new geothermal technology to enhanced geothermal system (EGS) technology; to collect information necessary for decision making, design and the realization of a commercial EGS energy producing plant; and to review and evaluate geochemical and modelling techniques for determining reservoir characteristics.

(3) Annex IV: Deep Geothermal Resources: Issues associated with the commercial development of deep geothermal resources at depths greater than 3,000 m are addressed by this annex. The activities are pursued in three subtasks: research on exploration technologies and reservoir engineering for deep, hot reservoirs; investigation into drilling and logging techniques; and exchange of information and establishment of a database on fluid chemistry, material properties and corrosion issues, together with field-testing.

The work in this annex is closely related to that in Annex III (EGS) because enhanced geothermal systems studies are being pursued in several regions where the desired high temperatures are reached at much greater depths (>4,000 m) than in the "normal" high-temperature geothermal fields. Consequently, some of the projects over-lap, with related activities being conducted in both annexes.

The fourth annex was established in 2001:

(4) Annex VII: Advanced Geothermal Drilling Techniques: 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. The investigation extends over three subtasks: 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.

The fifth annex became active in September 2003:

(5) Annex VIII: Direct Use of Geothermal Energy: Geothermal energy can be used directly as heat for many applications such as building and district heating, industrial process heating, commercial uses such as greenhouse heating and temperature control of water for fish farming, bathing and swimming; through geothermal heat pumps to provide heating, cooling and domestic hot water; and for many other purposes. Many applications are well developed and economically viable, while implementation problems and unfavourable economics challenge others. This annex will address all aspects of the technology with emphasis on improving implementation, reducing costs and enhancing use.

Funding for Annexes I, III, IV and VII is of the *task-sharing* mode, with that for Annex VIII intended to be both *task-sharing* and *cost-sharing*.

2.4 Membership Benefits

The main beneficiaries of membership in the GIA are the research, government, industry and academic sectors, at both technical and policy levels.

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

More specifically, membership within the GIA provides the following benefits:

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

- Provides appropriate focus for R&D, hence avoids duplication and unproductive research

- Provides opportunities for research networking

- Develops skills and knowledge required to meet future technical challenges
- 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
- Makes accessible a strong technical base provided by R&D activities in the participating countries
- 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
- Provides the opportunity to draw upon expertise and efforts of our sponsoring organization, the OECD/IEA
- Helps build a common understanding of the technical basis for various geothermal issues
- Investigates barriers to development
- Helps develop technical standards and methodologies
- Contributes to the development of energy policies
- Opportunities to join in cooperative efforts with the United Nations Environment Programme (UNEP), the Global Environmental Fund (GEF) and other project financing agencies

2.5 Structure of the GIA and Membership Obligations

Members of the GIA participate in one or more tasks described by the annexes. They coordinate their activities with other task participants in order to avoid duplication and enjoy mutual benefits from existing resources and expertise. They also cooperate in coordinating the annex work and endeavour, on the basis of an appropriate sharing of burdens and benefits, to encourage cooperation among other participants with the objective of advancing the state of understanding of all participants. Each annex is binding only upon its Operating Agent and the participants therein, and does not affect the rights or obligations of other Members.

Supervisory control of the GIA is vested in the Executive Committee (ExCo) and decisions made by the ExCo are binding on the Members. The ExCo consists of one voting Member from each Member country. 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 expected to attend. The ExCo manages all administrative activities resulting from or affecting the GIA. During ExCo meetings the Members report on national programmes, exchange information and results of work conducted in the annexes, and consider ongoing or arising issues.

The ExCo provides a comprehensive annual report describing its annex and national activities to the IEA (IEA-GIA Webpage) each year. In turn, the ExCo can rely upon the IEA Secretariat in Paris to provide it with assistance in its operation when necessary, especially in legal and administrative matters.

Members cover the travel expenses for their representatives to attend meetings and workshops. Travel costs are minimized by conducting business by mail and e-mail whenever possible. To the extent practicable, meetings are scheduled to coincide with other events to minimize travel costs. Each participant bears all the costs they incur in carrying out their task activities, including reporting and travel expenses. Unless otherwise specified, the cost of publishing annex reports and summary assessments is borne by the Operating Agent.

The GIA ExCo has a Secretary based in New Zealand who provides secretarial, administrative and other services as required for the organization under a contractual arrangement.

2.6 GIA Financial Structure and Costs

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 that is administered by a Custodian, presently the National Renewable Energy Laboratory (NREL, USA).

Monetary contributions to support the common fund are made by Members through an apportionment system based upon the assignment of shares according to IEA guidelines. Table 2 shows the share apportionment based on current membership. The ExCo has set the current cost per common fund share at US$ 2,500/year.

Table 2: Share distribution among the GIA Members as of September 2004.

Australia	2	Japan	4
European Commission	4	Mexico	1
Germany	4	New Zealand	1
Iceland	1	Switzerland	2
Italy	2	United States	4
Total = 25 shares			

With the addition of new Members, or the withdrawal of current Members, the total number of shares will change, and may affect each Member's contribution. The contributions are made annually on a calendar-year basis.

Other common funds may be established as required to meet the needs of new annexes, with costs shared among the participants of the relevant annexes in accordance with the shares established by the IEA and set out in Table 2.

3. GIA ACHIEVEMENTS 1999-2004

3.1 General

The GIA clearly recognizes as one of its major objectives the importance of disseminating the information and results of work conducted in its programmes. An indication of its success is the over 175 publications produced during the 1999-2003 period. Many of these were presented at major international forums, including the World Geothermal Congress (WGC) 2000, International Geothermal Congress Reykjavik 2003, GRC Annual Meetings and annual NZ Geothermal Workshops, where large international

participation provided opportunities for widespread exchange and interaction. A comprehensive reference list is not included here due to space limitations, but may be found in the IEA-GIA Annual Reports (IEA-GIA Webpage).

In late 2001, the decision was made to extend the GIA for a second 5-year term, to 31 March 2007. Annexes I, III and IV were continued into the new term, and Annexes VII and VIII were subsequently added to the programme, extending the GIA's range of geothermal activities.

In 2002, the ExCo decided to increase the scope of its activities as described in the 2002-2007 Strategic Plan (see above). This necessitated the establishment of a dedicated Secretariat, which officially began operations on 14 March 2003. The Secretariat is the first GIA activity financed by *cost-sharing*, operating through a GIA common fund.

In 2003, the GIA presented papers at the Budapest Forum (Mongillo and Nieva, 2003a) and GRC 2003 Annual Meeting in October 2003 (Mongillo and Nieva, 2003b). GIA promotional material was also distributed, with the assistance of the IEA, at the international Conference for Renewable Energies held in Bonn, Germany, on 1-4 June 2004.

The new, more comprehensive GIA website (IEA-GIA Webpage) also went on-line in June 2004, updating and expanding the amount and kind of information base available to both Members and non-Members.

Several papers relating to work conducted in the GIA programmes are also being presented at this World Geothermal Congress (WGC 2005 Antalya, Turkey, 24-29 April 2005).

3.2 Annex I: Environmental Impacts of Geothermal Energy Development This is a Subsection

Significant amounts of information have been compiled, documented and interpreted on the impacts of geothermal development on the natural features of many fields around the world. Improved techniques have been developed for the monitoring of heat flux and carbon dioxide in areas of steaming ground; and subsidence modelling has been improved, providing a more reliable basis for future prediction and possible mitigation, remediation and avoidance strategies. A better understanding of processes for reducing hydrogen sulphide and mercury emissions, and removing arsenic from wastewater, has also been achieved. Dissemination of results has been very successful through participation at workshops and seminars in Iceland, Japan, New Zealand, the Philippines and the United States.

There was significant participation by the GIA in the WGC 2000, in Japan, with major Annex I contributions in two IEA special sessions on geothermal environmental issues and a Plenary Session on international scientific collaboration programmes developed and held. A special issue of *Geothermics* on "Environmental Aspects of Geothermal Development" (Hunt, 2000) was produced in 2000 and a second is currently in preparation. Geothermal environmental short courses have also been held at Auckland University (New Zealand) to provide specialized training in environmental management of geothermal projects.

3.2 Annex III: Enhanced Geothermal Systems (formerly Hot Dry Rock)

Annex III research results have been actively circulated. The development of high temperature logging instrumentation, and the collection and assessment of information relating to the application of geophysical methods for fracture mapping have been published; and there was major participation at the WGC 2000.

A significant contribution was made with the completion of the EGS Economic Model in 2001. It allows the user to define the geothermal resources and specify the engineering and financial characteristics of a proposed project to determine the resulting economics and to optimize the plant configuration. Extensive applications at Fenton Hill (USA), Soultz-sous-Forêts (Alsace, France), and a site at Hunter Valley (Australia) have demonstrated the usefulness of the model. The model operates on a PC in the Windows environment and is freely available on the web (MIT Webpage).

In 2003, a new down-hole motor was successfully tested for drilling a highly deviated well at the Geysers geothermal field. The use of shear-wave splitting as a fracture characterization tool was further developed and will be applied in conjunction with the future Coso geothermal field massive hydraulic fracture test. Development of new methods for interpreting tracer tests to estimate fluid flow paths and velocities and temperature flow in fractured geothermal reservoirs continued with the goal of producing a simple set of tools for test interpretation in single- and two-phase, fractured geothermal reservoirs. Work was begun on the design and production of the first version of the Project Management Decisional Assistant (PMDA) for helping guide work through the various development stages of EGS projects. Drilling, acoustic emission, hydraulic fracturing and modelling/simulation data were compiled for the "Overall Compilation and Review of Hijiori HDR Experiments" as part of the EGS reservoir evaluation project.

Excellent progress continued in 2003 on the major European EGS Project at Soultz-sous-Forêts, with successful hydraulic stimulation of a 3-km^3 volume around the 5,000 m deep injection and production wells; and drilling of the second production well began. France, Germany, Italy and Switzerland, with technical support from Japan and the USA, are expecting to produce 6 MW of electricity from this project by 2005 (Soultz Webpage). Further significant EGS success has been had by an Australian GIA participant, who became the worlds first publicly listed company concerned solely with EGS energy, with its successful public offering on the Australian Stock Exchange in 2002. Venture capital amounting to several million Australian dollars was raised in 2002 with additional funding of A$5 M awarded by the Government. Further significant venture capital was raised in 2003. The first well in this Australian Cooper Basin project, was successfully completed to >4,300 m depth and had very successful hydraulic stimulation results.

Many of the 2003 results from Annex III were presented at international workshops and conferences in the USA and Mexico.

3.3 Annex IV: Deep Geothermal Resources

A special session on deep geothermal resources was organized for the WGC 2000, at which results for the general modelling and strategy for development of deep geothermal resources were presented.

Important databases pertaining to the drilling and logging of deep geothermal wells, techniques for the exploration of deep geothermal resources and the characterization of their reservoirs, and of references related to materials performance in aggressive geothermal chemical environments have been created and are available on CD-ROM. Much of this information has also been published.

Corrosion models, which include the effects of fluid chemistry, phase stability and fluid velocity, have been developed for down-hole and wellhead environments under flow conditions and used to identify corrosion control options.

As stated above, the first deep geothermal well to be drilled in Australia was successfully completed in 2003 as part of the Cooper Basin EGS project. Encouraging results were obtained with the encounter of systems of fractures and joints at depths >4,000 m and temperatures in excess of 250 °C reached. As part of the European EGS Soultz project, a third well was successfully drilled to ~5,000 m in 2003 and very successful hydraulic tests performed. In addition, the first well was drilled at the German deep geothermal project in Bad Urach to about 4,200 m. Subsequent stimulation tests created a deep reservoir at 3,300-4,200 m depth where temperatures of about 170 °C were attained.

In 2003, the conceptual models of several Mexican geothermal fields with deep reservoirs were updated and a new computer code for the rigorous simulation of heat and mass transport in high temperature reservoirs, including effects of high non-condensable gas, was developed and successfully tested.

Several of the annex participants presented results at a geothermal conference in Iceland and several reports and six scientific papers were published.

3.4 Annex VII: Advanced Geothermal Drilling Techniques

The working group for this annex held meetings in March and November 2002, March and September 2003, and March 2004, to refine the subtask objectives and define the specific task activities. Finger and Hoover (2003) have described the role of this annex in advanced geothermal drilling.

The format for the presentation of well cost/performance data was defined and the first group of well-cost data sets was placed into the database. Agreement was reached on the outline for the high-temperature part of *Geothermal Drilling Best Practices Handbook.* Preliminary discussions for collaborative testing at Cerro Prieto, Mexico, were also held.

3.5 Annex VIII: Direct Use of Geothermal Resources

The Direct Use of Geothermal Energy annex is the most recent annex to be initiated by the GIA. It officially commenced operations on 19 September 2003, and work in the annex is expected to begin in late 2004.

4. FUTURE DIRECTIONS

The GIA has actively advanced into its second 5-year term guided by a new Strategic Plan. The studies in several of the active annexes are being revised, reorganized and extended. As examples, planning is proceeding for new work to begin in Annex I on induced seismicity and in Annex III, new work is being proposed on field experiments on enhanced geothermal systems. The programme is also expanding through the addition of completely new areas of cooperative research, e.g. Annex VIII: Direct Use of Geothermal Energy commenced activities in September 2003, and preparation is well advanced on Annex V: Sustainability of Geothermal Energy Utilization and Annex VI: Geothermal Power Generation Cycles. The tasks associated with Annex IX: Geothermal Market Acceleration, are recognized as very important, and are being developed in association with the IEA's own market acceleration annex. Options are also open for new collaborative activities to be added to the programme under new subtasks and annexes, and new proposals are encouraged.

The GIA recognizes the importance of expanding its membership to help achieve its goal of supporting and advancing worldwide geothermal energy use. Therefore, the GIA extends an invitation to national organizations, universities, multilateral organizations, international inter-governmental organizations and industry to seriously consider joining. Membership is open to both IEA Member and non-Member countries. Interested parties should contact the IEA-GIA Secretariat (IEA-GIASec@gns.cri.nz) for information on joining. Membership is formalized through the IEA Secretariat, which has been instrumental in assisting with the growth of the GIA.

The GIA website (IEA-GIA Webpage) also provides contact information and easy access to its major documents including: the Implementing Agreement, annex descriptions, strategic plan, GIA membership details and annual reports. The site also provides a major resource for the dissemination of the programme's results.

5. CONCLUSIONS

As global energy demand accelerates in the coming decades, especially in the rapidly growing developing countries, more effort must be directed at increasing the contribution of sustainable energy systems. Geothermal energy can play a significant role, especially with its vast untapped worldwide potential. However, to do so, it is essential to overcome market and technical barriers.

The GIA programme, now well into its second 5-year term, provides a mechanism for the extensive international cooperation in geothermal R&D necessary to overcome these barriers and advance the use of geothermal energy worldwide. At present, the EC and nine Member countries from Europe, Asia, the Americas and Oceania are collaborating to help meet the challenge. Considerable effort is needed, and the GIA extends an invitation to those national organizations, universities, industry and other groups who are able to contribute to join us.

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Table 1. List of GIA Annex titles, operating agents, task leaders and contact e-mail addresses, participating countries and operating status.

Annex Number	Title Operating Agent (OA) Task Leader (TL); Affiliation; Contact E-mail Participants	Status
I	Environmental Impacts of Geothermal Development OA: Institute of Geological and Nuclear Sciences Limited (IGNS), New Zealand TL: Chris Bromley; IGNS, New Zealand; c.bromley@gns.cri.nz Participants: Iceland, Italy, Japan, Mexico, New Zealand, USA	Active, Continuing through 2005
II	Shallow Geothermal Resources	Closed
III	Enhanced Geothermal Systems OA: New Energy & Industrial Technology Development Organization (NEDO), Japan TL: I. Matsunaga; AIST, Japan; matsunaga-isao@aist.go.jp Participants: Australia, EC, Germany, Italy, Japan, Switzerland, USA	Active, Continuing through 2005
IV	Deep Geothermal Resources OA: Forschungszentrum Jülich (F-J), Germany TL: Dieter Rathjen; F-J, Germany; d.rathjen@fz-juelich.de Participants: Australia, Germany, Italy, Mexico, New Zealand, USA	Active, Continuing through 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 TL: Jack Wise; Sandia National Laboratories, USA; jlwise@sandia.gov Participants: EC, Iceland, Japan, Mexico, New Zealand, USA	Active, Continuing through 2005
VIII	Direct Use of Geothermal Energy OA: The Federation of Icelandic Energy and Waterworks, Iceland TL: Einar Gunnlaugsson; The Federation of Icelandic Energy and Waterworks, Iceland; einar.gunnlaugsson@or.is Participants: Iceland, New Zealand, Switzerland, USA	Active, Continuing through 2007
IX	Geothermal Market Acceleration	Draft