International Energy Agency

Geothermal Implementing Agreement

Strategic Plan 2007-2012

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Foreword

This document is the Strategic Plan for the International Energy Agency (IEA) Implementing Agreement for a Cooperative Programme on Geothermal Research and Technology (GIA). Its purpose is to provide direction and focus for the GIA during its third five-year term, 1April 2007 - 31 March 2012.

This Strategic Plan was prepared and edited by Mike Mongillo, IEA GIA Secretary, under the direction of the GIA Executive Committee, and it was unanimously accepted by them on 16 November 2006.

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Cover Photograph: Well Habanero 2 Steam Separator, April 2005, Cooper Basin, Australia. The well is flowing at 12 kg/sec with a wellhead temperature of 160 ^{o}C. During testing in May 2006, the well flowed up to 25 kg/sec with a wellhead temperature of 210 ^{o}C at maximum output. (*Photo by Ralph Weidler of Q-Con GmbH; courtesy of Geodynamics Limited).*

1. Introduction

This document is the Strategic Plan for the International Energy Agency (IEA) Implementing Agreement for a Cooperative Programme on Geothermal Research and Technology (Geothermal Implementing Agreement, GIA). Its purpose is to provide direction and focus for the GIA during the next five years, April 2007- March 2012.

1.1 Background of GIA

The IEA's involvement in geothermal energy began in 1978, with the launching of the "Man-Made Geothermal Energy Systems" Project (MAGES) Implementing Agreement (IA) in the IEA Energy Technology Collaboration Programme (ETCP). One year later, the "Geothermal Equipment Testing" IA began. However, upon the completion of these two 3-year long studies, there was a hiatus in geothermal activities until the IEA Secretariat in Paris initiated an effort to revive them in 1995.

In May 1995, an *ad-hoc* meeting was convened in Florence, Italy, in conjunction with the World Geothermal Congress'95. Representatives of 14 countries expressed general interest in international collaboration under the IEA ETCP umbrella. An IEA Geothermal Expert Panel was formed specifically to prepare the IA Annexes. The legal text and three technical Annexes of the IEA Implementing Agreement for a Cooperative Programme on Geothermal Research and Technology, or Geothermal Implementing Agreement (GIA), were formulated in two subsequent meetings in Paris (November 1995, April 1996) with significant assistance from the IEA Secretariat. The GIA officially went into effect on 7 March 1997, with an initial operating period of five years. In November 2001, the Renewable Energy Working Party (REWP) and the IEA Committee on Energy Research and Technology (CERT) approved the extension of the Agreement for a second 5-year term, to 31 March 2007.

As of 31 October 2006, 10 countries: Australia, 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., were Members of the GIA.

2. The Current Status

2.1 Status of the Geothermal Industry

IEA GIA Member Countries

Today, geothermal energy is used to generate electricity and to provide heat for a large variety of direct-use applications, including: space and district heating; greenhouse and aquaculture pond heating; agricultural drying; industrial process heating; bathing and swimming; and snow melting. In addition, geothermal heat pumps afford an energy efficient, environmentally friendly means for both heating and cooling of homes and buildings, and can be used virtually anywhere in the world.

In 2005, eight IEA GIA Member Countries, or one-third of the total global geothermal generating community, were producing electricity using geothermal energy. They contributed 5,211 MW_e, or about 60%, of the global geothermal installed capacity and 34,523 GWh/year, or about 60% of the worldwide geothermal generation. The six IEA GIA Member Countries with non-negligible geothermal generation provided an average of almost 5% of their total national generation. Geothermal generation by GIA Members amounted to an equivalent savings of over 7 Mtoe and reduced CO_2 emissions by more than 27 Mt.

All ten IEA GIA Member countries were using geothermal energy in direct use applications in 2005, with a total installed capacity well in excess of 4,092 MW_t, or >15% of the worldwide geothermal installed capacity. The thermal energy used was greater than 69,015 TJ/year (25,806 GWh/year), or about 25% of the global total. Direct use displaced the equivalent of approximately 2.5 Mtoe and 6 Mt of CO_2.

Global Community

Geothermal resources are widely distributed, having been identified in over 80 countries worldwide, on every continent, including Oceania. Hot pools and springs have been used 'directly' for bathing, balneology, heating and washing purposes for millennia. Today, geothermal energy is utilized in over 70 countries.

At the start of 2005, 24 countries worldwide were producing electricity from geothermal resources, with a total installed capacity of 8,900 MW_e and electricity generation of 56,800 GWh (Bertani, 2005). Over the past 25 years, geothermal installed capacity has increased by a factor of about 2.3, and at a very steady rate of about 200 MW/year; 11.6%, or about 2.3 %/year, during the past 5 years. Electricity generation has grown by 50% since 1995; 15% in the past 5 years, averaging 3.1 %/year growth (*ibid.*). Geothermal energy provides a major contribution to the national generation of many countries: six countries obtain more than 15% of their electricity from geothermal. In 2005, the average contribution to national installed capacity for the 18 countries with "non-negligible" installation/generation was 8.4%, the corresponding average contribution to national generation being over 9%. The 2005 geothermal generation resulted in a savings of about 14.4 Mtoe and reduced CO_2 emissions of 46.4 Mt.

As of May 2005, 72 countries were utilizing geothermal energy for direct use applications, including: space, greenhouse and aquaculture pond heating, agricultural

drying, industrial uses, bathing and swimming, cooling and snow melting. The total installed capacity was about 28,270 MW_t, and the thermal energy usage 273,372 TJ/year or 75,940 GWh/year (Lund *et. al*, 2005) (Table ES3). In 2005, over 50% of this total direct use was contributed by geothermal heat pumps. Direct use installed capacity has nearly doubled every 5 years since 1995 and energy use has increased by a factor of almost 2.5 since 1995. The 2005 use is equivalent to an annual savings of about 25.4 Mtoe in fuel oil and a reduced CO_2 emission of about 24 Mt (*ibid*.).

The worldwide use of geothermal resources for both electricity generation and in direct uses in 2005 was equivalent to a total annual savings of about 40 Mtoe with a corresponding estimated reduction in CO_2 emission of over 70 Mt.

2.2 The Market for Geothermal Energy

Global Need and Geothermal Potential

The global demand for energy continues to accelerate, with approximately 25% of the world's population currently having no electricity. In addition, the increasing awareness of global warming issues, the mounting anti-nuclear lobby and requirements of the Kyoto Protocol have led to a growing worldwide desire to use clean and renewable energy sources. Recognition of their potential contribution is also growing within national energy policies. Providing affordable, clean energy to meet the world's rapidly escalating needs is an enormous challenge. With geothermal resources making up two-thirds of the world's technical potential renewable energy base, geothermal can be a very significant part of the solution.

In 2004, the worldwide total primary energy use was estimated to be about 463 EJ/year (IEA, 2006). Current estimates indicate that economic exploitation of geothermal resources could provide about 150 EJ/year for electricity generation and 350 EJ/year for direct uses. Consequently, geothermal has the potential to make a considerable contribution towards meeting the world's current and future energy needs.

Geothermal Benefits

Geothermal energy is an established technology with a long history of use in many countries. It is cost competitive with other energy sources and is among the lowest cost renewable energy resources. It has many benefits, which make it extremely valuable for both electricity generation and direct use:

- Extensive global distribution, makes it accessible to both developed and developing nations
- Environmentally friendly, with very low emission of harmful gases (especially CO_2), few solid or liquid wastes, minor land usage
- Independent of season
- Immune from weather effects, i.e. vagaries of rainfall, wind, sunshine
- Indigenous nature, hence is independent of external supply/demand effects and fluctuations in exchange rates, saves on foreign expenditure, provides a secure energy source
- Increases diversity in energy supply
- Effective for distributed application in both on and off grid developments, and is especially useful in rural electrification schemes

- Extremely reliable, typically operates as a baseload provider of electricity with capacity factors typically well above 90%, though it can also operate in load-following capacity
- Provides employment and industry opportunities

Of interest when considering differences among the various renewable energy resources is a "generation efficiency" that renewable resources can make to power supply, i.e. the ratio of the energy generated to the installed (or operating) capacity, which is 6.4 GWh/MW_e for geothermal [2005], compared to hydro 3.63 GWh/MW_e [2004], solid biomass 5.56 GWh/MW_e [2004], solar PV 0.074 GWh/MW_e [2004] and wind 1.9 GWh/MW_e [2005] (non-geothermal data from IEA (2006)).

Opportunities for Geothermal

The extraordinary increases in the price of oil in 2005 and the very unstable conditions that have persisted and grown in the Middle East during the past several years certainly bode well for worldwide geothermal resources development. The support of renewable energies in the national policies of most of the GIA Member countries and a large number of countries, and the potential for international trading of green certificates also encourage geothermal development.

The situation is looking very positive for future growth of geothermal development within several of the GIA Member countries, especially with several hundred MW_e now under construction or in the planning stages in the USA, Iceland and New Zealand.

Worldwide, there is potential for significant growth in electricity generation well into the future, mainly because many suitable resources have been identified, particularly in the developing countries of South East Asia, Latin America and Africa, where demand for electricity is increasing rapidly. Estimates suggest that geothermal energy could potentially supply 5% of the global electricity by 2020. Future growth in the direct use of geothermal energy is also expected to increase, mainly due to the dramatic rise in the installation of geothermal heat pumps (GHP). Opportunities also exist for other direct uses, particularly in Central and Eastern Europe, however these non-GHP direct heating applications are constrained by distance from the resources. The maximum known distance hot water is piped for direct use is in Iceland, and is 67 km.

Though the capacity of geothermal resources in highly permeable, saturated rock formations is very large, it is limited. However, there is a vast, deep (<5 km) resource of heat present in hot (>150 ºC), low permeability, and/or low fluid content rock available worldwide. But new technology is necessary to economically exploit this resource, and it is known generically as Enhanced Geothermal Systems (EGS). Research programmes have been working on development of EGS since the 1970s, and now an EC project at Soultz-sous-Forêts, in France, is near the point of installing a pilot plant that will demonstrate the efficacy of this technology. Several other EGS research projects are also in progress in Australia, Germany and Switzerland.

Barriers to Geothermal Development

A large fraction of geothermal energy deployment is currently in developed countries, though many of the world's untapped energy resources are located in developing countries. However, barriers such as high initial capital costs, resource risks and drilling limitations pose challenges to their development.

For the more technically mature technologies, such as geothermal, to achieve the desired and possible accelerated growth, the priority remains to become cost-effective in the marketplace. For geothermal, major obstacles include cost and the perception of cost, which result partly from the market's discrimination against capital-intensive technologies and partly from the failure of the market place to take full account of the external costs of competing conventional technologies, e.g. the geothermal 'fuel' (i.e. the hot water/steam) is actually a part of the development cost, and does not have to be purchased following completion of the development. Other barriers are the difficulty of characterizing the geothermal resource prior to making a major financial commitment and the cost of drilling wells.

Other impediments to market penetration arise from a general lack of public awareness and experience with the technologies, and from social and environmental barriers linked to lack of experience with planning, regulation and gaining public acceptance. Like other renewable energy sources, energy from geothermal resources has significant positive environmental benefits; however, deployment can have local impacts (mainly for limited time operations, such as drilling), so projects do not always enjoy universal local support. In addition, investment in geothermal R&D, which is primarily supported by the public sector, has dropped considerably in recent years (IEA, 2006b).

2.3 Geothermal Implementing Agreement Activities

The Executive Committee manages the activities conducted under the GIA agreement, which are directed primarily toward meeting the needs of the member countries and industries. The activities are mainly performed through Annexes to the GIA, and encompass a range of geothermal topics, from 'traditional' uses like power generation and direct use of heat, to new technologies pertinent to EGS, deep resources and advanced drilling. New activities are also initiated and implemented when needs are established. Participants must take part in at least one Annex. Annex work is coordinated by an Operating Agent, with funding to date through task-sharing, in which participants contribute in-kind; though cost-sharing may be considered for some future activities.

The results obtained from the GIA's work consist mainly of published technical papers, presentations at international meetings and workshops, reports, databases, a brochure, and a handbook for EGS development. The GIA Annual Report has become a significant document providing comprehensive information on the work of the ExCo, the Annex research and the activities in the Member Countries. The ExCo Meeting minutes are also substantial and valuable documents that include detailed Annex and Country update reports and presentations from invited observers and guests. In addition, the GIA website provides a large variety of information for Members, non-Members and the public.

Continuing and Recently Completed Annexes

As of October 2006, there were four active annexes. Three of these annexes had their activities extended to 2009, with the fourth currently operating through 2007. None of these annexes have completion dates specified. Most of the activities in one annex were successfully completed, with the remainder of the work redistributed between two other closely related annexes.

Annex I: Environmental Impacts of Geothermal Energy Development The aim of this continuing annex, established in 1997, is 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 four subtasks: 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; and to investigate seismic risk from fluid injection into enhanced geothermal systems.

Annex III: Enhanced Geothermal Systems (EGS) The main objective of this annex, initiated in 1997, 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 subtasks: to review the use of conventional and new geothermal technology to EGS technology; to collect information necessary for decision making, design and the realization of a commercial EGS energy producing plant; to review and evaluate geochemical and modelling techniques for determining reservoir characteristics; and to conduct field studies of EGS reservoir performance.

Annex VII: Advanced Geothermal Drilling Techniques This annex, established in 2001, 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 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.

Annex VIII: Direct Use of Geothermal Energy The aim of this annex, begun in 2003, 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 subtasks: to define and characterize the direct use applications for geothermal energy, with emphasis on defining barriers to widespread application; 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 the closely allied Annexes III and VII. The objective was to address issues necessary for the commercial development of deep geothermal resources at depths greater than 3,000 m, was active during most of the 2nd term. 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.

Information Dissemination Activities

The GIA has continued to emphasize, develop and expand its internal and external information dissemination and exchange this term.

The GIA ExCo Meetings frequently include special presentations on specific Annex-related projects by invited guests, in addition to usual Annex, Country and ExCo business reports, all of which are appended to the meeting minutes for useful reference and distribution. An IEA Secretariat report is always submitted for presentation at GIA ExCo Meetings, and the IEA Desk Officer frequently participates. The GIA has also developed a very good information dissemination relationship with the IEA Secretariat through

participation at IEA seminars and workshops, and via contributions in IEA publications, including the IEA OPEN Bulletin.

The results and material produced from the Annex work are produced as reports and papers published in scientific and technical journals; and presented at conferences, meetings and workshops. Some of the data and results are also made available as databases and manuals available on CD-Rom. There is also a wide range of promotional and less technical material produced by the ExCo and GIA Secretariat for the public, and government and financial institutions available, including: non-technical PowerPoint presentations, colour posters and reports. Significant redesign of the GIA Annual Report was begun with the 2002 report, and now includes a Member Country report section and a country synopsis chapter. The GIA's first colour brochure describing geothermal energy, the GIA and its activities was produced at the start of 2005.

The GIA established a new website (http://www.iea-gia.org/) at the end of 2004, which provides public access to much of the GIA's promotional material, as well as to some less technical information including the GIA annual reports. The site has links to Participants' sites and other important geothermal sites as well as a link to the IEA website (http://www.iea.org/), which also includes information about the GIA and its activities. There is also a Member's Area, password protected, which provides efficient information exchange among the GIA Members and Participants, and includes access to ExCo Meeting Minutes, documents for review and other information.

3. Vision, Mission and Benefits

3.1 Vision Statement

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.

3.2 Mission Statement

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.

The GIA vision and mission endeavour to support the CERT's vision and mission through 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.

3.3 Benefits of GIA Activities

The main beneficiaries of the GIA's activities are the research, government, industry and academic sectors, at both technical and policy levels. In addition there are benefits to society that arise from the acceptable development of geothermal resources in an environmentally appropriate manner. More specifically, the benefits of GIA's activities include:

- **Increases R&D capabilities** beyond that of a single country or groups by combining national and industry efforts
- **Provides appropriate focus for R&D**, hence avoids duplication and unproductive research
- **Improves R&D cost effectiveness** by sharing research costs and technical resources
- **Provides wider and easier access to key information**, research results and technical capabilities
- **Provides impartial information and analysis** to help guide national policies and programmes
- **Provides an international overview** of current issues, ongoing research and the need for future research
- **Contributes to the development of national energy policies**
- **Develops technical standards and methodologies**
- **Develops skills and knowledge** required to meeting future technical challenges
- **Minimizes environmental effects** of development

4. Programme Strengths, Limitations and Opportunities

In its efforts to foster global development of geothermal energy, the GIA must define its capabilities in order to take advantage of its strengths, and to identify and pursue major opportunities.

4.1 Programme Strengths

The GIA's current broad membership provides many of the programme's strengths. GIA membership consists of government departments or their agents (national laboratories, research institutes and a university) responsible for national R&D programmes and industry. The GIA's fundamental strengths are:

- **Broad international membership** that includes many of the major geothermal-using countries as well as industries involved at the forefront of geothermal development and extends capabilities beyond that of a single country or group
- **Access to leading technical R&D teams, programmes and research institutes**
- **Proven ability to conduct significant collaborative and innovative R&D**
- **Recognized credibility, objectivity and neutrality** as a consequence of its being a part of the IEA
- **Knowledge of and easy access to key information** including major public sector programmes in geothermal energy
- **Strong technical base for GIA outreach** is provided by the R&D activities of its members
- **Ready access to the IEA** Secretariat and other implementing agreements
- **Ability to join in cooperative efforts with other international organizations**
- **Activities are pertinent** to environmentally friendly and sustainable energy national policies

The GIA is well placed to provide information on geothermal resources and geothermal RD&D as a consequence of its international membership and resources, its government and industry connections, and its membership in the IEA, who themselves have strong ties to governments and international organizations.

4.2 Programme and Market Limitations

The GIA's current major programme limitations include:

- Limited staff and financial resources
- Lack of marketing experience
- Lack of understanding by governments and industry of the benefits of geothermal energy utilization and the added-value of collaboration within the GIA
- Limited industry participation in the GIA's planning and activities
- Lack of access and interaction with financial and political decision makers
- Limited time of ExCo Members to focus on GIA activities

The GIA's current market limitations include:

- Low and stable price for conventional energy
- Lack of political support
- Cost and the market's perception of cost
- High initial costs and/or technical risks
- Failure of marketplace to fully account for external cost of competing conventional technologies
- Lack of experience on the part of decision makers and end-users

4.3 Opportunities

The ExCo recognizes the potential for expanding its capabilities and influence, and for advancing global geothermal development, through increasing its membership. There are significant opportunities for doing so with the large number of non-GIA member countries with significant geothermal resources and those rapidly growing economies of South East Asia, Central and South America, Africa, and Eastern and Central Europe with identified geothermal resources. The GIA will actively pursue these potential members.

The opportunity for increasing the GIA's expertise and scope of activities has also recently grown with the IEA's introduction of Implementing Agreement Sponsor Membership. Sponsors are any company or organization, within or outside of the OECD group, and they can be Members of the ExCo and participate in the Annexes. In the past year, three companies have joined the GIA as Sponsors; a move that is hoped will encourage further company participation. The new expertise thus gained may increase the GIA's scope for market related activities. Sponsor participation should also make it easier to identify and respond to the commercial sector's RD&D needs. However, care will have to be taken in order for the GIA to maintain, and be seen to maintain, its objectivity and independence from the commercial sector. In addition, it will be necessary to avoid supporting projects that affect the competitive position of individual companies, especially since there is a requirement that all European Community Government funded R&D does so.

The potential for the GIA to cooperate/collaborate with other international organizations such as the International Geothermal Association, the United Nations and industry associations also exists, and should be pursued.

The main resources of the GIA are the time of the individuals who participate on the ExCo and in the Annexes, both funded by home organizations, and the GIA membership Common Fund fees. The possibility of accessing further government resources should be considered, but this is a time consuming and complex procedure, and currently may not warrant the effort.

The time available by the ExCo Members to conduct ongoing activities is obviously limited, thus restricting their direct participation. However, the efforts of the ExCo have been greatly extended through the employment of a Secretary, whose salary is paid from the GIA common fund. The opportunity to further utilize the GIA Secretary should be taken in order to expand GIA and ExCo activities and raise its profile by holding seminars and workshops, and by producing more materials for dissemination.

Other, more general opportunities also exist for the GIA and for geothermal energy utilization, such as taking advantage of the growing importance of, and demand for, low greenhouse gas producing and sustainable energy sources; the increasing cost of fuel oil and the CO_2 tax as a result of the Kyoto Protocol.

5. Strategic Objectives and Action

The fundamental activities of the GIA are specified in Article 1 of the Implementing Agreement (IEA GIA, 2006) and consist of international scientific collaborative efforts to:

- Compile and exchange information on geothermal energy research and development worldwide 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 ameliorate environmental impacts
- Coordinate activities with other IEA Implementing Agreements as well as with those of other competent bodies

These activities are consistent with the CERT's Mission "...to support the IEA's mission and goals by promoting the development and deployment of clean and advanced energy technologies through international networking, co-operation, collaboration, analysis and policy advice" (CERT, 2002); and the GIA sees them as continuing to provide good direction through its 3rd term (2007-2012).

In addition to the above fundamental activities, the GIA has also developed a set of strategic objectives aimed at providing more specific guidance towards achieving its 2007-2012 Mission: ***to promote the sustainable utilization of geothermal energy throughout the world***.

In its April 2002 strategic plan, the IEA CERT set out four strategic objectives to help it attain its vision and mission. This plan outlined the general direction expected from the various working parties, including the REWP, and the IAs reporting to them. The ExCo has designed its strategic objectives around those of the CERT, and the relationships between them are provided in Table 1 below.

5.1 Stimulate Technology Research, Development & Deployment

To actively promote effective cooperation on geothermal RD&D through collaborative work programmes, workshops and seminars

The active promotion of effective collaboration on geothermal technology RD&D has been an essential activity for the GIA since its initiation, and will continue as such.

The ExCo continues to review and assess its RD&D topics for effectiveness and achievement on a regular basis, and initiates new studies where needs are recognized. During the past year, all but one of the Annexes was identified as being on track and covering several of the RD&D topics identified as of key importance for the future: environmental effects of development (Annex I), enhancing and creating geothermal systems and extending development away from plate boundaries (Annex III), advanced geothermal drilling (Annex VII) and direct uses of geothermal energy (Annex VIII).

Table 5.1 CERT and GIA Strategic Objectives

CERT Objectives	GIA Objectives
1. To better identify and promote effective and innovative policies that ***stimulate energy technology research, development, demonstration and deployment.***	• 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
2. To more clearly define and analyze energy technology issues and opportunities, and to enhance ***development of analytical tools*** that inform and support policy and programme development in 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
3. To more vigorously foster ***international networking and collaboration*** in energy technology research, development, demonstration and deployment.	• To increase membership in the GIA • To encourage collaboration with other international organizations and appropriate implementing agreements
4. To more effectively ***communicate the key lessons learned*** through CERT's activities to IEA Member-country governments and agencies, the research community and other interested parties.	• 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

Consequently, Annexes I- Environmental Impacts of Geothermal Development, III- Enhanced Geothermal Systems (EGS) and VII- Advanced Geothermal Drilling Techniques were extended for a further four years, to 2009. Annex VIII- Direct Use of Geothermal Energy, has only recently begun its work and is poised to make important contributions. Though Annex IV's RD&D topic, deep geothermal resources, is of major importance to future geothermal energy development and use, its effectiveness had been slowly declining due to both completion of some aspects of its work, and the slow migration of other activities to the closely allied Annexes III and VII. It was recognized that the remainder of Annex IV's activities were still of importance; consequently, these were shifted to Annexes III and VII, and the Annex was closed.

Other key RD&D topics have also been identified and include the sustainable use of geothermal energy and geothermal power generation cycles. The ExCo is currently reviewing the draft Annexes that cover these topics.

The need to have greater direct input from the commercial sector was recently helped with the IEA's addition of IA Sponsor Membership. Subsequently, three Sponsors have joined the GIA, extending expertise and broadening its collaboration.

The GIA has recognized that initiatives like seminars and workshops could be valuable for identifying important issues, extending cooperation, developing policies and disseminating information about the GIA, its activities and geothermal energy in general. The success that Annex I has had through its organization and participation in four workshops that dealt with the technical aspects of induced seismicity and development of related policy issues is an encouragement to pursue workshops and seminars as means for determining the value of new programmes as well as for dealing with technical issues and providing accurate and objective information to the public.

To collect, improve/develop and disseminate geothermal energy RD&D policy information for IEA Member and non-Member countries

The collection, analysis, improvement, development and dissemination of information on geothermal technology, R&D needs, policies and markets are essential to stimulating RD&D. The GIA sees the addition of financial schemes that favour geothermal investment and risk-sharing schemes as other topics to be considered and promoted. The key method for the dissemination of this information by the GIA has been through the production of its annual report and other documents like the GIA brochure, and by participation at international conferences. There is also scope for expanding these activities through use of the GIA website. In addition, the IEA has assisted through its publication of documents that the GIA has contributed to and through its distribution of GIA material at IEA events; and there is good potential for continuing and expanding these activities.

5.2 Develop Analytical Tools

To identify geothermal energy RD&D issues and opportunities and improve conventional and develop new geothermal energy technologies and methods to deal with them

There is vast potential for geothermal resources to be developed worldwide, for both electricity generation and direct use. Though geothermal is, in many ways, a mature technology, there are many RD&D issues that must be surmounted in order to take advantage of the great opportunities it holds. Conventional drilling and utilization technologies have been successful in the past. However, for geothermal's worldwide potential to be realized, it must become more cost-effective; difficulties associated with financing must be overcome; deeper (> 3 km depth), higher temperature (>350 C) resources and the vast amounts of heat available in dry rock at depths of 4-5 km must become accessible to extend the base of exploitable geothermal resources for electricity generation throughout the world. Direct use of geothermal resources is growing rapidly, and can contribute to important energy savings worldwide, but issues related to implementation, cost reduction and enhancing use must be addressed. Though geothermal has significant positive environmental benefits, possible impacts from development must be understood, clearly identified and mechanisms in place to avoid or mitigate them. The GIA is currently working on several of these topics, and though gains have been made, further significant effort is warranted, with efforts in Annexes I, III, VII and VIII planned to continue into the new term. The issue of financing for geothermal development warrants investigation, and the expertise recently gained with the GIA's new industry members could initiate such a study. Similarly, studies of sustainable use of geothermal energy and of geothermal power cycles merit inquiry.

5.3 Foster International Networking and Collaboration

To increase membership in the GIA

The Member Countries of the GIA currently have 59% of the global geothermal installed electrical capacity and contribute about 61% of the total generation; they also have about 15% of the installed thermal power, with the energy used about 25% of the worldwide total. To become more representative of the global geothermal community and to

develop more influence among the decision makers, the GIA aims to increase membership with emphasis on those countries with significant geothermal development (electrical and direct use), good RD&D infrastructure and potential. In addition, it will encourage further industry membership and participation for the guidance they can provide on the relevance of the activities for developers and users of geothermal energy, for the financial expertise they can provide, and for the help they can provide in the development of the large, important markets in non-Member Countries.

To encourage collaboration with other international organizations and appropriate implementing agreements

The GIA recognizes the importance of collaborating with other international organizations and believes it could be of great mutual benefit, while also extending its influence, raising geothermal's profile and promoting its use worldwide. Coordination with geothermal organizations such as the International Geothermal Association, the Geothermal Resources Council and the Geothermal Energy Association through joint meetings, workshops, etc. and could help with the identification of new issues and design of more influential policies pertaining to sustainable use and climate change. Collaboration with the World Bank, the World Energy Council, and international renewable energy conference organizers could also be very beneficial for the development of financial schemes supportive of geothermal development and to increase the awareness of the contributions that geothermal energy can make to the world energy supply. Consideration of such cooperation would require an understanding of their activities and ensuring that they have the correct perception of geothermal energy (capabilities, status, markets, benefits, etc.).

As a part of the IEA, the GIA sees important opportunities to engage in a wider range of collaborative energy activities and issues through expanding its already excellent interaction with the IEA Secretariat, and possibly through cooperative activities with other renewable energy implementing agreements. The GIA will endeavour to provide the IEA Secretariat with accurate and up-to-date geothermal information to assist them with the production of reports and policy that 'correctly' represent geothermal energy. The possibility of collaborating with other IAs on activities that could utilize geothermal's capabilities to help them optimize exploitation of other alternative forms of energy could also be considered. The GIA has long realized the importance of proper marketing in helping break down barriers to geothermal development, so participation with the Implementing Agreement for Renewable Energy Technology Deployment could also be of mutual benefit.

5.4 Communicate Key Lessons Learned

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

There is a definite need to broaden and increase the circulation of impartial and accurate information on geothermal energy technology and issues pertaining to its deployment. The GIA will endeavour to improve its effectiveness and influence, and raise its profile and that of geothermal energy, by further developing its information products and dissemination efforts. It is important to both produce accurate, quality information in the appropriate format and to ensure that it gets to the correct audience. The IEA provides excellent means to do both through its online OPEN Bulletin, through its distribution of

material from international conference booths, and in its many reports. Other valuable mechanisms include the presentation of papers at specific events such as scientific meetings, renewable energy and energy development conferences; the holding of technical workshops and seminars for transfer of know-how; the publication of articles in trade journals and relevant journals for the layman; and the production of information brochures and newsletters for the public. It will also be important to target information to the appropriate government departments and agencies, and financial institutions.

5.5 Action Plan for 2007-2012

The GIA ExCo has developed and agreed upon the set of objectives described above and which support those of the IEA CERT. The following Plan of Action sets out, in a general way, the actions which the ExCo will pursue in support of its Mission: ***to promote the sustainable utilization of geothermal energy throughout the world***. In conducting these activities, the ExCo will take into account both administrative and technical factors, as well as policy guidance from the IEA.

Objective 1 *To actively promote effective cooperation on geothermal RD&D through collaborative work programmes, workshops and seminars*

Actions:

- Review and evaluate RD&D topics for effectiveness and achievement, and initiate new collaborative studies where needs are recognized
- Hold technical workshops and seminars to discuss RD&D and encourage new participation
- Work with industry to help make contacts and develop the large and important markets in non-Member countries

Objective 2 *To collect, improve/develop and disseminate geothermal energy RD&D policy information for IEA Member and non-Member countries*

Actions:

- Provide national policy overviews
- Develop geothermal RD&D position and policy papers
- Develop and promote financial policies/schemes that will support/favour geothermal investment and development
- Effectively disseminate all of the above to the appropriate audiences

Objective 3 *To identify geothermal energy RD&D issues and opportunities and improve conventional and develop new geothermal energy technologies and methods to deal with them*

Actions:

- Continue the activities of current Annexes I, III, VII and VIII
- Hold Annex meetings to identify RD&D issues and opportunities

- Expand research topics (i.e. add new Annexes and Subtasks) where the needs and opportunities arise, e.g. sustainability of geothermal energy utilization (draft Annex V), geothermal power generation cycles (draft Annex VI), and financing geothermal development
- Update geothermal energy development costs
- Expand opportunities by stressing the benefits of geothermal energy

Objective 4 *To increase membership in the GIA*

Actions:

- Identify potential new Members (countries and industry) and establish contact with appropriate representatives. Place emphasis on those countries that have significant RD&D and potential (e.g. Indonesia, the Philippines, countries in Central and South America, Africa, and Central and Eastern Europe).
- Inform perspective new Members of GIA activities and on the benefits of their participation
- Invite potential Members to attend ExCo and Annex Meetings and possibly IEA GIA sponsored workshops and seminars held in association with national and international conferences

Objective 5 *To encourage collaboration with other international organizations and appropriate implementing agreements*

Actions:

- Identify appropriate collaboration opportunities at both the ExCo (International Geothermal Association, Geothermal Resources Council, Geothermal Energy Association, World Bank, World Energy Council) and Annex (other IEA Implementing Agreements) levels and explore joint efforts
- Continue to provide up-to-date information to the IEA
- Continue to participate in IEA sponsored REWP meetings and seminars
- Consider establishing a 'Trade Association Committee' to work with the major geothermal trade associations to maximize the synergy between their interests and the GIA programme's activities
- Investigate participation with the Implementing Agreement for Renewable Energy Technology Deployment

Objective 6 *To broaden and increase the dissemination of information on the GIA's activities and outputs and on geothermal energy to decision makers, financiers, researchers and the general public*

Actions:

- Expand development of the GIA website
- Continue to produce and improve the quality of the annual report
- Encourage the production of technical reports by the Annexes
- Expand participation at international geothermal and renewable energy conferences, and IEA REWP meetings and seminars

- Consider holding IEA GIA sponsored workshops and seminars for both technical and general audiences (decision makers, financiers, public)
- Provide the IEA with good geothermal energy statistics
- Produce more GIA information material such as policy statements, brochures, IEA OPEN Bulletin articles and contributions to IEA reports and publications
- Investigate starting a Public Awareness and Education Annex as an ExCo initiative
- Target information circulation to appropriate government departments and agencies, and financial institutions
- Expand the transfer of geothermal know-how through technical visits, workshops, seminars and exchange of personnel

6. Programme Management

6.1 Organization

Members of the GIA participate in one or more tasks described by the Annexes to the implementing agreement. Members designate an Operating Agent for each task in the relevant Annex. Each Annex is binding only upon its Operating Agent and the participants therein, and does not affect the rights or obligations of other Members.

Management control of the GIA is vested in the Executive Committee (ExCo). Decisions made by the ExCo are binding on the 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. 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 under Annexes, and consider ongoing and arising issues.

The ExCo elects a Chairperson for a minimum term of one year. Two Vice-Chairpersons are also elected by the ExCo to assist the Chairperson, one responsible for technology and the other for policy.

6.2 Secretary

The GIA ExCo has a Secretariat, currently based in New Zealand, and managed by a Secretary. The Secretary's basic duties are defined in Article 5 of the Implementing Agreement, and include provision of secretarial, administrative and other services as required for the organization:

- Make and distribute agendas, minutes and other documents
- Prepare decisions and recommendations
- Assist the officers in carrying out their responsibilities
- Assist the committee in overall coordination of the work in the Annexes
- Prepare the annual budget for planned activities
- Prepare the Annual Report
- Undertake such other activities as may be required by the ExCo

The operational expenses for the GIA Secretary, 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.

6.3 Standing Committees

The GIA ExCo has established a Planning Committee consisting of the Chairperson, the two Vice-Chairpersons and the Secretary to deal with future issues related to GIA policy

and plans. The ExCo may also elect to appoint other standing committees as the needs arise.

6.4 Budgets and Costs

The GIA's annex activities, in general, are implemented under the task-sharing mode. However, because the GIA's scope of work broadened significantly during the 2nd Term, a paid Secretary was hired. With this move, the ExCo recognized that other cost-sharing activities might also be accepted, with decisions to be made on a case-by-case basis.

Contracting Parties and Sponsors cover the travel expenses for their members to attend meetings and workshops. Each Participant bears all the costs it incurs in conducting its Task activities, including reporting and travel expenses. The costs for publishing annex reports and summary assessments are borne by the Operating Agent, unless otherwise specified.

The expenses for the operation of the GIA Secretariat, including the Secretary's salary, and other common costs of the ExCo are met from a Secretariat Common Fund, administered by the Custodian, presently the National Renewable Energy Laboratory (NREL) based in the USA. The Secretary prepares an annual work plan and associated annual budget for the calendar year, which are submitted for approval by the ExCo. Only the Chairperson may authorize expenditures not in accordance with the approved budget, and the ExCo must be notified at once of any exceptions to the approved budget. See Appendix I for the Common fund share apportionment.

Other common funds may be established as required to meet the needs of new annexes. The costs will be shared among the Participants or the relevant annex in accordance with the shares established by the ExCo. The designated Operating Agent will serve as the Custodian of the annex common fund. Issues of finance and budgeting will be decided based upon Article 7 of the GIA.

6.5 Term

This Strategic Plan, in the present form or as subsequently modified by the ExCo, will remain in effect for the term of GIA: 1 April 2007 – 31 March 2012.

7. Strategy and Performance Review

This Strategic Plan is a guiding reference document and not a fixed course of action. The objective of an annual review is to assess the current strategy and determine if changes are required to account for any alterations in the Implementing Agreement or changes in the field of geothermal energy.

7.1 Annual Review

The Strategic Plan will be reviewed every year to assess the current relevance of the objectives and related actions taking into consideration any changes on key issues. The review can take the form of an appendix to this Plan and include:

- A brief discussion of new important issues that need to be considered
- A brief review of the relevance of the strategic objectives and explanation of any changes in them or their priorities
- Production of a revised action plan
- Conclusions providing a general assessment (for both the ExCo and Annexes) of work progress against that planned, a list of major achievements, and comment on the general effectiveness of the plan

It is suggested that the annual strategy review and associated action plan be considered at the spring ExCo meeting, with an interim review of progress and final approval at the autumn ExCo meeting.

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IEA (2006) IEA Renewables Information 2006. Paris, France, 238 p.

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

Strategic Plan of the IEA R&D Wind 2003-2008.

Strategic Plan for the IEA Solar Heating & Cooling Programme 2004-2008.

Appendix I

As discussed in Section 6.4 above, the expenses and other common costs of the ExCo are met from a Common Fund. Monetary contributions to support the Common Fund are made by Members through a share apportionment system determined by the ExCo. Sponsors from Member Countries are assessed half the number of shares of their Member Country. Based on membership at October 2006, the apportionment for the GIA is:

Common Fund Membership and Shares

Australia	2	New Zealand	1
European Commission	4	Republic of Korea	2
Germany	4	Switzerland	2
Iceland	1	United States	4
Italy	2	Geodynamics	1
Japan	4	Green Rock Energy	1
Mexico	1	ORMAT	2
Total = 31 shares			

The ExCo has set the cost per Common Fund share at US$ 3,500/year for 2006.

With the addition of new members, or the withdrawal of current members, the total number of shares will increase or decrease, and may affect each member's contribution. Contributions are made annually on a calendar year basis. The number of shares assigned to new members is determined by the ExCo acting in unanimity. The Custodian, who administers the Common Fund, provides periodic accounting reports to the ExCo.