International Energy Agency

Implementing Agreement on Geothermal Energy

Strategic Plan 2013-2018

19 July 2012

IEA Geothermal Implementing Agreement

Strategic Plan 2013-2018

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 fourth five-year term, 1March 2013-28 February 2018. It should be considered in association with the IEA-GIA's End-of-3rd Term report (GIA, 2012a).

This Strategic Plan was prepared by Mike Mongillo (IEA-GIA Secretary) and Chris Bromley (IEA-GIA Chair), with contributions from, and under the direction of, the GIA Executive Committee; and it was unanimously accepted by them on 19 July 2012.

19 July 2012

IEA GIA Secretariat
Wairakei Research Centre
GNS Science
Private Bag 2000
Taupo
NEW ZEALAND

Contents

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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, March 2013- February 2018.

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; and in November 2006 the GIA was extended for a third 5-year term, to 28 March 2012. However, in 2011, IEA CERT requested the GIA, among other IAs, to extend the current Term to 28 February 2013, which the GIA ExCo officially approved at the 24th GIA ExCo meeting of 7-8 October 2010.

As of 11 July 2012, the GIA had 20 Members, comprising: 14 countries: Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Norway, the Republic of Korea, Spain, Switzerland, the United Kingdom and the United States; the European Commission; three industry Sponsors: Geodynamics Limited, Green Rock Energy Limited and ORMAT Technologies Inc. and two industry organizations: the Canadian Geothermal Energy Association and the Geothermal Group of the Spanish Renewable Energy Association.

2. Strategic Direction

The GIA 4th Term Vision and Mission endeavour to support the CERT and REWP strategies through significantly extending geothermal power generation and direct heat applications, encouraging development and deployment worldwide. The GIA has revised its Vision for the 4th Term, to more succinctly represent our view, and to align more closely with CERT's Vision, which has changed during the GIA's 3rd Term. GIA's Mission for the new term remains substantially unchanged.

2.1 GIA Vision

As a clean, cost-competitive, renewable energy resource, geothermal energy will contribute significantly to global energy needs and security, by providing baseload electricity and heat for direct use applications in a sustainable manner, and protect the environment.

The following geothermal resource characteristics and development benefits give confidence to this vision:

- Extensive global distribution, available in both developed and developing nations
- Immune from weather effects and independent of season
- Extremely reliable, typically operates as a baseload provider of electricity (capacity factors typically > 90%), though can operate in load-following capacity
- Effective for distributed application in both on and off grid developments, and is especially useful in rural electrification schemes
- Provides continuous source of heat for direct applications
- Demonstrated sustainable operation, with many developments having operated for > 50 years

2.2 GIA Mission

To promote the sustainable utilization of geothermal energy worldwide by optimizing international collaboration to improve technologies, thereby rendering exploitable the vast and widespread global geothermal resources, by facilitating knowledge transfer, by providing high quality information and by widely communicating geothermal energy's strategic, economic and environmental benefits, hence contributing to the mitigation of climate change.

The GIA, which has gained an excellent reputation through its international collaborative efforts under the auspices of the IEA during the past 15 years, and as a recognized international leader in the geothermal community, is well placed to meet this Mission.

2.3 Strategy and Action Plan

The fundamental activities of the GIA are specified in Article 1 of the GIA's IA document (IEA-GIA, 2011) 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 general activities are "in the spirit of" CERT's current Mission: "To maximize energy technologies impact by optimizing international collaborative RD&D and deployment, by initiating timely technology assessment, analysis and scenarios, by engaging non-IEA countries and, crucially, by delivering policy guidance that will make a difference" (CERT, 2007). However, to provide more direct support to CERT's current Mission and its Strategic Objectives (ibid.), and more specific guidance for achieving GIA's 4th Term Mission, the GIA has adopted seven strategic objectives. Six of these are substantially the same as those of the 3rd Term, while one new objective is directed at informing and educating international financial institutions about geothermal development. These objectives are incorporated within four broader topics identified in GIA's previous Strategic Plan along with associated actions.

2.3.1 Stimulate Technology Research, Development & Deployment

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

Active promotion of effective collaboration on geothermal technology RD&D has been an essential activity for the GIA since its initiation, and will remain so. With the significant growth of industry and industry organization membership as Sponsor Members (25% of total GIA Membership as of July 2012) during the 3rd Term, the importance of cooperating with industry, which provides special expertise and views about RD&D is clearly recognized, hence, included within this strategic objective.

GIA's experience during the 3rd Term demonstrates that initiatives like seminars and workshops can be valuable for identifying important issues, extending cooperation, developing policies and disseminating information about geothermal energy, and about the GIA and its activities. An example is the GIA's successful joint workshop with the International Geothermal Association on global geothermal potential and the mitigation of climate change (GIA, 2010). Also, the success that GIA Annexes have achieved through organization and participation in workshops dealing with a wide variety of issues (such as sustainable geothermal utilization, drilling technology, and induced seismicity) are encouragements to continue sponsoring workshops and seminars. These activities provide a means for identifying new programmes, dealing with technical issues, providing objective and accurate information to stakeholders and the public and, through outreach, encouraging new membership.

Defined actions include:

- Review and evaluate RD&D topics for effectiveness and achievement, and initiate new collaborative studies, including with industry, where needs are recognized
- Hold general geothermal and technical workshops and seminars to discuss RD&D and encourage wider collaborative participation.

To provide policy makers with information about the newest developments in geothermal energy and highlight its advantages for sustainable development, the environment and economy

The collection, analysis, improvement, development and dissemination of information on international geothermal technology, research and industry needs, policies, market status, the environment and economy, are essential to stimulating appropriate RD&D. Accordingly, it is extremely important to provide such information, with an emphasis on sustainable development benefits, to policy makers. This revised objective will place stronger emphasis on the provision of key technology information to policy makers, both by direct distribution to them and through the vehicle of the IEA and its developed network. The key methods for the dissemination will continue to be the GIA Annual Reports and other documents, the GIA website, participation at international conferences; and a new venture- a biannual GIA Newsletter. Examples of IEA distribution channels include: GIA contributions to IEA reports, the IEA OPEN Bulletin, and GIA material at IEA events, such as ministerial fairs and meetings. Actions include:

- Provide policy makers with unbiased, reliable and up-to-date information, including national overviews
- Develop geothermal RD&D position and policy papers, emphasizing the advantages/benefits of geothermal energy utilization
- Effectively disseminate information and policy advice to the appropriate audiences

To inform and educate international financial institutions about the value and hurdles specific to geothermal deployment

The issue of financing for geothermal deployment warrants urgent attention. GIA industry members, through their experience in the market place, have identified the important need to directly target financial institutions with information, as well as to educate them, about the value of geothermal energy deployment, and difficulties specific to it. As a result, this new objective has been added for the 4th Term. Activities include:

- Develop and disseminate information (e.g., short 3-4 page brochures for web download and handouts) about geothermal investment and development, incorporating current experience of GIA industry members
- Update geothermal energy development costs
- Hold workshops/seminars specifically for the financial sector to provide unbiased, clear information about geothermal development and associated barriers/risks

2.3.2 Develop and Improve More Cost-effective Methods, Protocols and Tools

To identify and deal with geothermal energy RD&D issues and opportunities, and encourage collaboration to improve/develop cost-effective methods and technologies

The potential for global geothermal electricity generation and direct-heat utilization is vast. Geothermal is, in many ways, a mature technology, however, there are also many barriers that need to be overcome in order to make it more cost-effective and to take advantage of the great opportunities it holds. These barriers can be addressed through targeted RD&D. Conventional drilling and utilization technologies have been successful in developing large hydrothermal systems. However, to realize the vast global potential of heat available almost anywhere, geothermal must become more cost-effective; difficulties associated with financing must be overcome; deeper (> 3 km depth), higher temperature (>350 °C) resources must become accessible; and the vast amounts of heat stored in rock at depths of 4-6 km must be utilized by improved EGS technology. 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 put in place to avoid or mitigate them.

The GIA is currently working on several of these topics, and has, for example, contributed by publishing a protocol for dealing with induced seismicity, a best practices geothermal drilling handbook, and an international journal special issue on sustainable use of geothermal energy. However, further significant effort is warranted, with activities in Annexes I, III, VII, VIII and XI planned to continue into the new term.

- Continue the activities of current Annexes I, III, VII, VIII and XI
- Produce internationally applicable protocols for dealing with identified issues
- Hold Annex workshops/seminars to identify RD&D issues and opportunities; and initiate new efforts (i.e., add new Annexes and Tasks) where the needs and opportunities arise
- Expand deployment opportunities by stressing the benefits of geothermal energy

2.3.3 Encourage and Pursue International Networking and Collaboration

To increase membership in the GIA with particular emphasis on encouraging non-IEA Member countries with significant potential geothermal resources

Currently, about 60% of the global geothermal installed electrical capacity and 60% of global geothermal generation is located within the member countries of the GIA. Member countries also

contribute about 50% of the installed geothermal heat supply, with about 40% of the energy used. To better represent of the global geothermal community, and to more effectively influence decision makers, the GIA aims to increase membership. Recruitment emphasis changes during the 4th Term to non-IEA Member countries with significant geothermal potential/development. However, membership will still be pursued amongst all countries with geothermal interests. Key initiatives will be:

- Identify potential new country members and establish contact with appropriate representatives. Place emphasis on those non-IEA Member countries that have significant potential (e.g., Indonesia, the Philippines, Kenya) plus other countries in Central and South America, Africa, and Central and Eastern Europe (e.g., Turkey)
- Inform prospective new members of GIA activities and the benefits of their participation
- Hold ExCo meetings and associated workshops/seminars in potential member countries
- Invite potential members' representatives to attend ExCo and Annex meetings and GIA-sponsored workshops and seminars held in association with national and international conferences

To encourage collaboration with other international organizations and appropriate implementing agreements

The GIA recognizes the importance of collaborating with other international organizations. This can be of great mutual benefit, while at the same time, extending GIA influence, and promoting geothermal use worldwide. Recent examples include a joint GIA-IGA workshop on global geothermal potential and mitigation of climate change, and close cooperation with the Induced Seismicity Group of the International Partnership for Geothermal Technology [IPGT]. These have demonstrated the value of such collaboration and the GIA plans to continue such efforts. Further cooperation with the IGA is planned, plus new activities with other groups (e.g., Geothermal Resources Council and European Research Area Net [ERA-NET]) through joint meetings, workshops, etc. These collaborations could help identify new issues and design more influential policies on such topics as sustainable use and climate change. Collaboration with the World Energy Council and international renewable energy conference organizers could also be very beneficial for geothermal development and for increasing the awareness of the potential of geothermal energy to the world energy supply.

As a part of the IEA family, the GIA recognizes the importance of engaging 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 continue to provide the IEA Secretariat with impartial, accurate and up-to-date geothermal information, to assist with their production of reports and policy that correctly represents the role of geothermal energy. The GIA will also consider opportunities to collaborate with other IAs on activities that may utilize the specific capabilities of geothermal technology to help optimize cost-competitive exploitation of alternative forms of renewable energy or hybrid projects (e.g., solar/wind/ocean/geothermal), particularly in challenging settings such as remote or offshore locations. Key initiatives will be:

- Identify appropriate collaboration opportunities at both the ExCo (International Geothermal Association, Geothermal Resources Council, World Energy Council) and Annex levels, and explore joint efforts with other IEA Implementing Agreements
- Continue to provide unbiased, accurate, up-to-date information to the IEA
- Continue to participate in IEA REWP and other sponsored meetings and seminars
- Investigate participation with other research collaboration organizations (e.g., ERA-NET) and with other IEA Implementing Agreements, including those dealing with green house gases, ground source heat pumps, wind, solar, and ocean renewable energy resources

2.3.4 Communicate Key Information

To be an unbiased source of reliable, current worldwide information about geothermal energy and increase its dissemination to the IEA family and global decision makers, financiers, researchers and the general public

There is a clearly defined need to broaden and increase the circulation of impartial, accurate and up-to-date information on geothermal energy resources, technology, R&D 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 produce accurate, quality information in the appropriate format, and also to ensure that it gets to the correct audience. The IEA provides excellent means to achieve both objectives through its online OPEN Bulletin, through its distribution of material from international conference booths, and in its many reports. Other valuable mechanisms include the following: 1) presentation of papers at specific events such as scientific meetings, renewable energy and energy development conferences; 2) the holding of technical workshops and seminars for transfer of information and knowledge; 3) the publication of articles in scientific and trade journals, and in relevant journals for the layman; and 4) the production of information brochures and newsletters for targeted audiences (e.g., appropriate government departments and agencies, and financial institutions), including the public. Relevant actions include:

- Expand development of the GIA website
- Continue to produce and improve the quality of the Annual and Annex X's Trend Report
- Encourage the production of technical reports by the Annexes
- Expand participation at international geothermal and renewable energy conferences, and IEA REWP meetings, workshops and seminars
- Hold more IEA-GIA sponsored workshops and seminars for both technical and general audiences (decision makers, financiers, public)
- Provide the IEA with accurate geothermal energy statistics
- Produce more GIA information material such as policy statements, brochures, IEA OPEN Bulletin articles and contributions to IEA reports and publications
- 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

3. Scope of Activities

The ExCo reviews and assesses the effectiveness and achievements of its RD&D topics regularly, and initiates new studies where needs are recognized. In 2009 (3rd Term), three Annexes were identified as being on track and covering RD&D topics acknowledged as of key importance, both now and for the future. These are: Annex I, environmental effects of development; Annex III, enhancing and creating geothermal systems and extending development away from plate boundaries; and Annex VII, advanced geothermal drilling and logging. Consequently, they were extended for a further four years to 2013. Similarly, in 2011, Annex VIII, the direct use of geothermal energy was extended to 2013. Work began in late 2010 on Annex X, a new effort enhancing GIA's capability in information and data collection and analysis. In 2010, also, the growing international importance of induced seismicity led to the ExCo's decision to increase its efforts in this area by creating Annex XI. The latter two Annexes also continue to 2013 (end of the 3rd Term), with plans to continue the activities of all six Annexes at the start of the GIA's 4th Term.

As of July 2012, the planned scope of work for the 4th Term (March 2013- February 2018) incorporates most of the current activities in all six existing Annexes. Each Annex is, however, undergoing a thorough reassessment of future Task activities, either as a result of changes in Operating Agents or Task Leaders, or as a result of newly identified opportunities and refocusing of priorities. A new objective dealing with the GIA's interaction with international financial institutions is expected to be incorporated within Annex X. Table 1 shows planned activities and participation expected for the 4th Term.

3.1 Action Plan for 4th Term

To realize the GIA's 4th Term Mission and meet its strategic objectives, GIA's effort will continue in the existing six Annexes, with the changes mentioned above. Annex and Task descriptions are provided, and revised activities identified; complete details of current activities are included in the IEA-GIA End-of-Term report.

3.1.1 Annex I- Environmental Impacts of Geothermal Energy Development

Annex I aims to encourage the sustainable development of geothermal energy resources in an economic and environmentally responsible manner; to quantify and balance any adverse and beneficial impacts that geothermal energy development may have on the environment; and to identify ways of avoiding, remedying or mitigating adverse effects. The activities were initially spread over four Tasks: A, B, C and D; but during the 3rd Term, Task D was incorporated into a new Annex XI, and a new Task E was created. Work is planned to continue in the four existing Tasks, with some additional efforts identified below.

Task A: Impacts on Natural Features focuses on documenting impacts on natural geothermal features and devising methods to accurately monitor changes and to avoid or mitigate adverse impacts of development.

- Establish protocols and methods of drilling/producing/injecting deep beneath protected areas with negligible surface impact.

Task B: Discharge and Reinjection Problems investigates methods for avoiding adverse effects of gas emissions on air quality; the effects of toxic chemicals in discharged fluid; and the effects of ground subsidence.

- Mitigate corrosion; document results of subsidence mitigation by injection; investigate biochemical remediation/ treatment of condensates; monitor casing integrity to protect groundwater.

Task C: Methods of Impact Mitigation and Environmental Procedures aims to develop an effective, streamlined environmental analysis process; reducing compliance costs and identifying mitigation options.

- Rank geothermal systems for protection status using appropriate categories and criteria; streamline EIA timeframes by standardising common issues and good practice procedures through programmatic approach; itemize experience and best practice options for cooling, stimulation and make-up water resource issues for EGS projects.

Task E: Sustainable Utilization Strategies investigates case histories of reservoir models to see what strategies were successful; assesses long-term reservoir behaviour and identifies sustainable utilization strategies.

- Publish more case studies; investigate permeability changes with time and interference between neighbouring systems; design and test a geothermal sustainability protocol; plan make-up production from deep roots and improve the use of tracers for predictive modelling of long-term reservoir performance.

Table 1. Participants, Contracting Parties, Sponsors and funding for GIA 4th Term (as of July 2012).

			Annex	I	III	VII	VIII	X	XI
Country/Industry	Year Joined	Year Withdrew	Contracting Party/Sponsor	Environmental Impacts of Geothermal Development	Enhanced Geothermal Systems	Advanced Geothermal Drilling Techniques	Direct Use of Geothermal Energy	Data Collection and Information	Induced Seismicity
Australia	1997		Department Manufacturing Innovation Trade Resource and Energy (DMITRE), State Government of South Australia	G	G	G		G	G
Canadian Geothermal Energy Association (CanGEA)	2008		Canadian Geothermal Energy Association (CanGEA)		IO	IO	IO	IO	
European Union (EU)	1997		DG Research and DG-Energy, Belgium		G	G		G	
France	2007		Bureau de recherches géologiques et miniéres (BRGM)		G		G		
Geothermal Group of Spanish Renewable Energy Association (GG-APPA)	2008		Spanish Renewable Energy Association (APPA)		IO		IO	IO	
Germany	2000		Forschungszentrum Jülich GmbH		G			OA, G	G
Geodynamics	2006		Geodynamics Limited, Australia		I			I	
Green Rock Energy	2006		Green Rock Energy Limited, Australia		I			I	
Iceland	2000		Orkustofnun	G, I		G	G	G	
Italy	2000		ENEL Green Power	I	I			I	
Japan	1997		New Energy and Industrial Technology Development Organization (NEDO)	R	R		R	R	
Mexico	1997		Instituto de Investigaciones Electricas (IIE)	G		G		G	
New Zealand	1997		GNS Science	OA, R, I		I	R	R	R
Norway	2010		Norwegian Science Research Council (NFR)		R, I	R, I	R	R	
ORMAT Technologies	2006		ORMAT Technologies, Inc, United States		I			I	
Republic of Korea	2005		Korea Institute of Geoscience and Mineral Resources (KIGAM)		R		R	R	R
Spain	2008		Institute for Diversification and Saving Energy (IDAE)		G		G	G	
Switzerland	1997		Swiss Federal Office of Energy (BFE)	G	G		G	OA, G	G
United Kingdom	1997; 2011	2003	Department of Energy and Climate Change (DECC)		R		R		
USA	1997		United States Department of Energy (US DOE)	N	OA, N	OA, N	U	N	OA, N

G = Government; I = Industry; R = Research Institute (government funded); N = National Laboratory (government funded);
U= University; IO=Industry Organization; OA = Operating Agent

3.1.2 Annex III- Enhanced Geothermal Systems (EGS)

Annex III endeavours to address new and improved technologies to access the huge heat resources present at depth in continental land masses, by engineering heat exchangers in order to allow the extraction of geothermal energy at commercially viable rates. The objective is to generate base load power, supply heat for industrial and domestic applications, and provide environmental benefits. Techniques developed should also help sustain and expand hydrothermal systems through the use of stimulation. The work in Annex III was extensively restructured into four Tasks during the 3rd Term. Task C was discontinued with certain aspects incorporated into Task D. The revised efforts, as described below, are planned to continue in Tasks A, B, and D in the 4th Term. Task E will be discontinued following completion of its remaining revised effort.

Task A: Geothermal Energy Resource, Reserve and Depletion seeks to foster international consistency (through standards) for assessing and reporting geothermal resources and reserves to promote transparency, and confidence.

- Compare existing GIA endorsed EGS protocol with the United Nations code and define the gaps.

Task B: Technology Crossover between Hydrothermal and EGS aims to modify conventional hydrothermal development technology (e.g., horizontal drilling, fracture mapping, and pumping) for EGS applications and vice-versa, with the objective to enhance energy recovery from both high and low permeability systems. Objectives include defining common technology terms, testing and assessment procedures, applicable drilling and high temperature logging tools.

- Develop a "lessons learned" document outlining what worked and what did not work, using information from current US demonstration projects.

Task D: Reservoir Evaluation involves devising standard procedures to stimulate and evaluate EGS reservoirs. Characteristics such as heat transfer area, size of the stimulated volume, total flow impedance, and likely thermal draw down, are necessary for robust commercial valuation. Procedures relate to: well testing models, borehole measurements, water management, numerical methods, micro-seismic data acquisition, and tracer studies. Task C: Data Acquisition and Processing will be discontinued, with certain aspects incorporated into this Task.

- Develop a document that reviews lessons learned from current stimulation efforts.

Task E: Field Study of EGS Reservoir Performance conducts and compares EGS research developments with an emphasis on reservoir-management and reservoir-enhancement technologies. Projects include Soultz (France) and Coso (USA). Work includes tracer tests to: determine heat transfer surface, reservoir rock volume, and identification of preferential flow paths.

- Will endeavour to obtain tracer data from the Soultz-sous-Forêts EGS project for analysis. Results will be incorporated into the Task D document, completing the work of this Task and ending it.

3.1.3 Annex VII- Advanced Geothermal Drilling and Logging Technologies

The goal of Annex VII is to promote ways and means to reduce the cost of geothermal drilling through developing an understanding of drilling and logging needs, elucidating best practices, and sharing methods to advance the state of the art. Drilling is an expensive part of geothermal development because of the high temperatures and formation types encountered. Activities address aspects of geothermal well construction and logging and include developing a detailed understanding of worldwide geothermal drilling costs, compiling a directory of geothermal drilling practices and how they vary across the globe, and developing improved drilling and logging technologies. The three Tasks are planned to continue into the 4th Term, with some minor revision.

Task A: Compile Geothermal Well Drilling Cost and Performance Information is a database task to help identify key cost components that might be reduced by new technology or by different drilling

practices. Drilling depth-time data allows performance to be estimated where cost information is confidential.

- Continue to grow the well cost data base and its use in developing and further enhancement of the evolving well cost model, with release of the model to the general community.

Task B: Identification and Publication of "Best Practices" for Geothermal Drilling identifies and catalogues the technologies that have been most successful for drilling, logging and completing geothermal wells. Production of a Handbook of drilling practices covers: design criteria, cost avoidance, problem diagnosis avoidance and remediation, well testing, geophysical logging, and wellbore preservation.

- Since publication of the handbook, activities will be directed to the organization of a drilling workshop based on the guiding premises reported in the handbook.

Task C: Advanced Drilling and Logging Collaboration aims to monitor and exchange information on drilling and logging technology development and new applications. Participants identify and develop activities and projects for collaboration, e.g., opportunities to field-test new technology in a collaborating country.

- Continue the current mode of communication through presentations and discussions of cutting edge technologies, while endeavouring to successfully facilitate collaborative tests.

3.1.4 Annex VIII- Direct Use of Geothermal Energy

Direct use of geothermal fluid has increased significantly and is now used for many different applications that require heat, such as buildings/towns, greenhouses, crop drying, fish farming, snow melting, bathing/spa, and industrial processes such as paper manufacturing, timber curing and milk drying. In addition, the use of geothermal heat pumps for heating and/or cooling of buildings and other facilities, such as greenhouses, has become one of the most important applications of geothermal direct use. Annex VIII aims to promote and expand the direct use of geothermal energy worldwide. The anticipated outcomes are improvements in systems and equipment, reduction in the cost of delivered heating and/or cooling, and an increase in the number of direct use applications.

The major work of Annex VIII has been performed in six Tasks during the 3rd Term; however, significant reorganization is currently underway because of recent changes in Task and Operating Agent leadership. As of July 2012, three Task Leaders (for A, C and E) wish to continue the Annex work, as does the ExCo. Efforts are currently underway to appoint an Operating Agent for this important effort. The ExCo is confident the Annex will continue into the 4th Term with Tasks A, C and E as follows.

Task A- Resource Characterization aims to define the available geothermal resources in participating countries. Chemical, temperature and flow data are collected and evaluated. Information is disseminated through presentations at Annex meetings, and in conference papers and journal publications.

- Publish an Atlas of World Hydrothermal Systems

Task B- Cost and Performance Database focuses on collecting, analyzing and disseminating the characteristic cost and performance data for installations, with emphasis on establishing a baseline and then validating the improvements from innovative components and better designs. Collect and compile information regarding Tasks B and C.

- Postponed until a new Leader is found.

Task C- Barrier and Opportunity Identification uses the information obtained in Tasks A and B to define the barriers which must be overcome to gain widespread use of geothermal heat. The research

activities necessary to take advantage of these opportunities will be defined, reported and, where possible, initiated.

- Extend data and information collection to include "bad" examples and deep geothermal systems.

Task D- Equipment Performance Validation aims to define and test critical and innovative equipment; such as submersible and line shaft pumps, compact heat exchangers, down-hole heat exchangers, non-metallic piping, and heat pumps, to characterize performance for various applications and for various geothermal brines.

- Postponed until a new Leader is found.

Task E- Design Configuration and Engineering Standards develops and characterizes standardized designs for various applications, with the goal of minimizing the engineering costs related to various applications.

- Produce a comprehensive list of references for standards, guidelines, best practices, etc.

Task F- Publication and Geographic Presentation on the Web seeks to define a suitable form to present data on direct use of geothermal water geographically on the web. Tests have been performed to present geothermal direct use data in files which can be opened on the web using Google Earth.

- Postponed until a new Leader is found.

3.1.5 Annex X- Data Collection and Information

The goal of Annex X is to collect essential data on geothermal energy uses, trends and developments in member countries and to publish these data in an annual report in hardcopy form and on the GIA website for wide public distribution. This report will stand with the Annual Report as a significant GIA information dissemination source, providing a brief overview of data trends such as installed capacities and produced electricity and heat, as well as relevant political and economic information. All Country members (14 as of July 2012) are required to participate in this Annex, and all Sponsor members support this effort by providing supplementary material. A new effort related to interacting more directly with financial institutions will be pursued in the 4th Term.

- There are plans to extend the current data collection to include non-GIA member and non-IEA Member countries, with emphasis on the remaining leading geothermal nations (where reliable data can be obtained): Kenya, the Philippines, Indonesia, Turkey, China, El Salvador, Nicaragua, and Russia.
- To inform and educate international financial institutions about the value and hurdles specific to geothermal deployment

3.1.6 Annex XI- Induced Seismicity

The goal of Annex XI, initiated in late-2010, is to determine the steps required to make EGS/fluid injection a safe, useful and economic technology that is publically acceptable. Specific objectives are to reduce the uncertainty associated with both technical and public acceptability issues in order to facilitate and to accelerate the development of geothermal energy by: developing accepted risk assessment protocols; identifying areas of research collaboration; and identifying key roadblocks.

Annex XI has been developed to work in cooperation with the International Partnership for Geothermal Technology (IPGT) Induced Seismicity Working Group, whose members, the United States, Australia, Iceland, Switzerland and New Zealand, are also members of the IEA-GIA. Participants work in two Tasks. At present, there are plans to expand the scope of activities in this Annex beyond Tasks A and B and to develop even closer cooperation with IPGT.

Task A: Mitigating the Effects of Induced Seismicity aims to: i) develop a set of risk mitigation strategies and best practices to help stakeholders in all phases of a project; ii) create a functioning website for the Annex; and iii) identify what should be communicated at each stage of a project.

Task B: Using Induced Seismicity for Optimizing Production from Geothermal Reservoirs seeks to: i) identify terms and definitions based on significant published reports and create a glossary; ii) evaluate centralized data access and availability and develop a common understanding of an open data policy; and iii) establish the conditions by which a site can be defined as a global "demonstration" site, meeting a threshold of data quality, quantity and availability, and adherence to protocols.

- It has been proposed that several geothermal test sites be set up where a variety of geologic environments can be tested for induced seismicity effects at field-scale.

3.2 Working Arrangement and Fees

Members of the GIA are required to participate in one or more Tasks described by the Annexes to the implementing agreement. Management of the GIA is vested in the Executive Committee (ExCo), which meets twice a year. A Secretariat, currently based in New Zealand, is managed by a Secretary whose duties are specified in Article 5 of the GIA IA document, and include provision of secretarial, administrative and other services as required for the organization.

The GIA's operation is supported by a combination of cost sharing, task sharing and knowledge sharing. Members cover the travel expenses for their participants to attend meetings and workshops, and each participant bears all the costs incurred in conducting its Annex/Task activities, including reporting and travel expenses. The GIA's Annex activities, in general, are implemented under the task-sharing mode. However, with the GIA's substantially increased scope of work during the 2nd Term, a paid Secretary was hired through a contracted Secretariat. The Chair and Secretary prepare an annual work plan and associated annual budget for the calendar year, which are submitted for approval by the ExCo. The expenses associated with the operation of the GIA Secretariat and annual work plan, including the Secretary's salary, and other common costs of the ExCo are met from a Common Fund to which all GIA members contribute. As of July 2012, there are no changes foreseen in the working arrangement or current fee structure.

The GIA is financially secure with the Common Fund having had significant surplus for the past several years. As a consequence, in April 2009, the ExCo established a mechanism to fund ExCo approved supplementary activities. Proposals may be submitted requesting funding from the Common Fund for ExCo initiatives and Annex efforts to stimulate more joint activity by participants, and create more tangible products. This effort will continue into the 4th Term.

4. Contractual and Management Requirements

The ExCo consists of one voting Member from each Member Country and Sponsor, with an Alternate appointed who 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. As a result of a recent ExCo decision, members who miss three consecutive ExCo meetings will be sent an ExCo letter expressing concern.

The ExCo Chair and Vice-Chairs are elected by the ExCo for a minimum term of one year. At the end of 2011, the ExCo increased the number of Vice-Chairpersons from two to three in order to assist with the growing workload.

ExCo discussion during the 3rd Term, and as part of the GIA's request for extension, has expressed generally high levels of satisfaction with the existing management operation, especially the support provided by IEA-GIA Secretariat.

The GIA Annual Report is the organization's premier document. Since 2002, it has been compiled and edited by the Secretary, with significant support from the Chair, and there are currently no plans to change this. As a result of Annex X initiating production of the annual ***Trends in Geothermal Applications*** report in 2012, the issue of revising the scope of the Annual Report has arisen. To avoid duplication, some rationalization has been suggested. The issue of "late publication" of the GIA Annual Report due to delayed provision of verified data has also been discussed. This issue also affects the timing of the Annex X trends document. One solution may be to include "estimated data" for countries when verified data is not available. All GIA Annual Reports are provided in the public area of the GIA website, with the Executive Summary of the report published in hardcopy as a more convenient sized document for distribution.

5. Contribution to Technology Evolution/Progress

Current plans are to maintain the GIA's present level of emphasis on technological progress through the involvement of its industry and private sector delegates, and through participation by national energy agencies and national laboratories. Additionally, further participation through peer reviews of national geothermal technology programmes, and further coordination of national laboratory efforts, should contribute to technology evolution and progress. For example, US participants from DOE/Sandia National Laboratories, and Norwegian participants from Statoil AB/Institute for Energy Technology (IFE), are undertaking research and technology development into high-temperature downhole tools, advanced drilling methods and tracer technology.

EGS has great potential for global deployment, so development of methods, protocols and best practices for stimulating increased permeability will result in significant technology progress. Such technology will also be pertinent to hydrothermal system development. Through increased direct participation of GIA's active industry members, supported by GIA's national laboratory participants, government energy and regulatory agencies, technology issues will be efficiently identified and rapidly addressed.

6. Contribution to Technology Deployment/Market Facilitation

The GIA has plans to increase its effort in technology/market facilitation in several ways. Firstly, it plans to hold more IEA-GIA seminars and workshops in association with its ExCo meetings on both general topics for educational purposes and on technical topics that examine deployment issues. An example of the former is: "What is geothermal energy and what are the environmental benefits of utilization, such as contribution to mitigation of climate change?" An example of the latter might be "Mitigation of effects of development on natural features, sustainable use, subsidence and induced seismicity." Plans include increasing the benefits of these seminars/workshops by holding them in potential member countries with important geothermal resources and high energy demand (e.g., Indonesia, the Philippines, Kenya, Russia, India, Central/South America) in association with renewable energy conferences, as well as technical meetings. Plans to increase GIA's participation in the IEA technology network (e.g., meetings and workshops), as well as increase contributions to the IEA OPEN Bulletin should also help direct important geothermal information to policy makers. GIA's increased efforts in development of methods, protocols and best practices, mentioned above, would also contribute to increased technology deployment.

A major new effort for the 4th Term that will directly target deployment and market facilitation is to inform and educate international financial institutions about the value and hurdles specific to geothermal deployment. This activity grows from GIA's current 25% industry membership with appropriate knowledge and experience in deployment and market facilitation. To help support this initiative, the GIA will actively seek to increase its Sponsor membership.

7. Policy Relevance

The results of the recent IEA Technology Roadmap on Geothermal Power and Heat and the Intergovernmental Panel on Climate Change (IPCC) report show that geothermal energy can make a valuable contribution towards meeting the global energy demand while mitigating climate change. Of significant importance is that geothermal power provides sustainable, baseload power with >90% load factor for new installations. In addition, geothermal can provide large amounts of process heat for direct applications such as timber drying and building heating and cooling (GIA, 2012b). However, in order to realize geothermal's potential deployment, the GIA recognizes the importance of gaining the attention of policy-makers. Consequently, the GIA plans to increase its policy related efforts during the 4th Term.

Annex X (Data Collection and Information) now collects current geothermal data and information on an annual basis. This increases GIA's ability to better, and more quickly, provide the IEA Secretariat with impartial, up-to-date, geothermal data and information. The Annex's new annual trend report extends GIA's information dissemination capability; and it, together with the GIA's Annual Report and executive summary, will provide policy-makers with performance, cost, and national policy information. Examples of policies include: feed-in tariffs, renewable portfolio standards, and loan guarantees. GIA members will thus be able to modify and create better policies and establish R&D priorities. GIA also plans to better target its information. Increased efforts will be made to more accurately identify the most appropriate policy makers in government offices or ministries, and within industries and financial organizations, who can significantly influence policy. In addition, a portion of GIA's planned seminars will be aimed at policy-makers.

The new GIA website, planned to go active before mid-August 2012, is designed to provide easier access to impartial, current geothermal data and information, Annex results, and other important news; thus providing policy makers and the IEA better access to GIA and geothermal material.

8. Contribution to Environmental Protection

Annex I- Environmental Impacts of Geothermal Development has been active since the GIA's founding (1997), and has achieved a significant number of productive outputs. Its activities will continue to investigate development impacts on natural features, fluid discharge and reinjection issues, and how to mitigate them, plus investigation and identification of sustainable utilization strategies.

The following example illustrates a contribution the GIA makes to environmental enhancement through collaborative sharing of ideas. Conventional geothermal power plants frequently dispose of the separated hot water remaining after steam production (mainly by reinjection back into the ground) at temperatures >150 °C. Some power developments (combined heat and power) also incorporate the use of this hot water for direct heat applications such as for district heating (Iceland); paper manufacture, timber drying and milk powder production (New Zealand). In addition, the availability of binary plants that generate power from hot water (with temperatures as low as 73 °C, depending upon geographic location), allows many stations to generate power using the separated water (e.g., 15 MWe at Wairakei, New Zealand). These applications increase generation, without increasing fluid production, hence reduce the need for new power developments and their associated environmental effects. The GIA encourages and supports this combined heat and power, and waste heat recovery, through its publications. Significant support and input comes from a GIA member, Ormat Technologies, who is a manufacturer of binary plants for geothermal waste heat recovery.

A further environmental consideration in any renewable energy project is minimizing the land use footprint that such a project occupies. The photo below shows the footprint of a single-shaft 140 MW_e turbine station (installed in 2010 at Nga Awa Purua, Rotokawa, New Zealand). A typical footprint size for a 100 MW_e flash-pant geothermal station is about 0.13 km^2, or 160 m^2/GWh/yr. With drilling

pads and pipelines included, the footprint increase to about 0.7 km^2, but this is often multi-use (farmable) land. Such footprints are amongst the smallest of all renewables. In the 4th Term, the GIA will continue to research and publish such studies.

Figure 1. Nga Awa Purua (Rotokawa) 140 MW_e power plant, the world's largest triple flash single geothermal turbine (commissioned April 2010). (Photo courtesy of Sumitomo Corporation)

9. Contribution to Information Dissemination

Information dissemination is one of the GIA's highest priorities and most significant activities, and plans are to continue this emphasis with increased effort.

The GIA endeavours to maintain an excellent communications and information dissemination relationship with the IEA. Closer coordination between the work of the GIA Secretariat and activities within the new Annex X, should assist GIA to more easily contribute information and material (e.g., posters, presentations, reports) to support promotional efforts of the IEA Secretariat. The GIA recognizes the many benefits of information dissemination through the IEA OPEN Technology Bulletin, and plans to contribute more to it. In addition, the GIA would like to increase its direct participation in IEA meetings, workshops, etc., where this is useful.

GIA will develop better targeted information dissemination to government officers and ministries, and to industry representatives, through increased effort of the GIA Secretariat, with assistance from Annex X. Participation at RE and general energy meetings, and at geothermal workshops, including the World Geothermal Congress 2015, is planned.

Plans are to increase number and frequency of GIA general and Annex technical seminars/workshops, especially in association with ExCo meetings planned for potential new members (e.g., Hungary, Turkey, Kenya, the Philippines, Russia), with emphasis on non-IEA Member countries; and in conjunction with international energy and RE conferences. Efforts will be made to gear seminars and workshops to specific audiences, e.g., policy-makers within government energy ministries, financial institutions and industry.

The Annex X geothermal data and information trend report will continue to be produced annually, with plans to expand the content to include non-GIA Member countries (where reliable data can be obtained). The new biannual newsletters will provide quicker, topical information dissemination.

Several GIA participants currently present invited lectures, some as part of official course work, at universities, with geothermal energy teaching courses and graduate programmes. A new initiative of the GIA will be to contact such universities in advance, to provide links between them and appropriately qualified speakers, as and when opportunities arise.

The new GIA website, planned to go on-line in August 2012, will be more user-friendly, provide more up-to-date information in a clearer manner, and allow site visitors to easily contact the GIA with questions and comments.

10. Outreach to IEA non-Member Countries

The GIA has had two non-IEA Member country (NMCs) signatories, Iceland and Mexico, for several years. The GIA has maintained a continuous effort to expand membership by inviting countries with important geothermal resources/development, including those from NMCs, to send representatives as Observers and Invited Guests to participate at ExCo and Annex Meetings, and at international GIA workshops. China, Indonesia, the Philippines, Poland, Russia, India, Turkey, and recently, Kenya and Malaysia are among the invitees, with the first four having participated at two or more ExCo and Annex meetings and GIA international workshops. These efforts will continue, and be expanded in the 4th Term by plans to hold more ExCo meetings and associated Annex meetings and workshops/seminars in prospective member countries.

The GIA also participated in the IEA NEET Workshops in Moscow, Russia, and Beijing, China, and received good follow-up support from the IEA Secretariat in the pursuit of Russia and China, but without success. Clear stumbling-blocks to gaining membership from most of the abovementioned countries have been identified: 1) identification of the appropriate person or government ministry to approach, 2) the "lack of funds" required to contribute to the GIA Common Fund. Since the international financial situation is quite difficult at present, and will probably remain so for some time, the prospect for gaining new members from the above group of countries could be limited. The ExCo is, however, considering possible solutions, such as inviting certain countries to participate as Observers, without voting rights, or giving them "limited" rights with a partial contribution for 1-2 years; and some current members "sponsoring" new members by paying part/all of their Common Fund fees for a specific amount of time (e.g., 1-2 years). IEA's assistance with gaining new members will also be sought.

11. Added Value

The GIA is recognized as a major international geothermal forum for national R&D groups to combine their efforts with those of industry. Such a combination increases capabilities well beyond those of the individual countries and organizations. Global geothermal deployment grew steadily during the 1985 to 2005 period, at which point it began to accelerate. Such growth continues today and looks to be continuing well into the future. To support this increasing growth, it is necessary for the GIA to build on its achievements to date. The GIA plans to undertake more actively in the following: stimulate technology RD&D; develop and improve more cost-effective methods, protocols and tools; encourage and pursue international networking and collaboration; and communicate key information. Examples of planned efforts for providing increased added value follow.

GIA will continue to provide impartial, accurate and up-to-date information to governments on geothermal energy potential, availability, costs, benefits and current support policies (e.g., feed-in

tariffs). This will help governments in their decision-making regarding energy policies, including their energy R&D funding priorities. These efforts will be supported through: 1) the new initiative of holding GIA ExCo and Annex meetings and associated seminars/workshops in countries with important geothermal resources, with emphasis on non-IEA Member countries; and 2) better targeted information dissemination, with more resources provided by Annex X (Data Collection and Information). Where appropriate, efforts will also be targeted at large corporations, energy companies, investors, and financial institutions with interests in renewable energy development.

Country membership in the GIA represents about 60% of the global geothermal installed power capacity and generation; and for direct heat use, about 50% of the total installed capacity and 40% of the total utilization (including geothermal heat pumps). The GIA recognizes that having a membership that represents a significant portion of total global resource development will provide the organization with added experience and expertise, and increase collaborative R&D; hence, benefit the technology and more strongly promote global sustainable geothermal development. The GIA has made concerted efforts to join countries with significant geothermal resources and/or development. Non-IEA Member countries Indonesia, the Philippines, Russia and China have been pursued, as well as several other countries. Further emphasis will be placed on gaining new membership, especially of non-IEA Member countries, by holding ExCo and Annex meetings and associated seminars and workshops in those countries and by increasing information dissemination to them.

Geothermal provides sustainable baseload power, however, there are opportunities for hybrid operations with variable renewables such as wind and solar. In addition, there are recognized overlaps in technology development for carbon sequestration (greenhouse gas injection). The GIA will endeavour to make contact with the relevant IAs to investigate possible joint activities.

The GIA will continue to provide appropriate focus for R&D that helps avoid duplication and unproductive research by identifying and collaborating on issues of critical importance, e.g., induced seismicity, sustainable geothermal development, and geothermal drilling and logging techniques. By developing standards and methodologies, protocols and best practices handbooks, and by reducing costs, the GIA will be able to add value to R&D programmes.

Growth in geothermal development globally has led to a shortage of geothermal experts, scientists and engineers; hence, expanded education and training are needed. The GIA members and their associates collectively represent a large source of expertise and knowledge, and the GIA has used this to contribute to education through its participants taking part in seminars and workshops, and as guest speakers and invited lecturers at technical schools, universities and research laboratories. There are plans to expand some of these activities in the 4th Term.

12. References

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