Geothermal Implementing Agreement (GIA) - Annual Report 1998

L. Rybach (ETH Zurich/Switzerland; GIA Executive Committee Chairman)

BACKGROUND

The IEA Energy Technology Collaboration Program (ETCP) has already included Implementing Agreements with geothermal objectives in the past, like the MAGES Project ("Man-Made Geothermal Energy Systems"), 1978 - 1980 and "Geothermal Equipment Testing", 1979 - 1981 but there were no such activities in the following years.

In 1995 the IEA Secretariat (Paris) made an effort to revive geothermal activities within the ETCP. At an ad-hoc meeting in May 1995, convened in conjunction with the World Geothermal Congress'95 in Florence, representatives of 14 countries expressed general interest in international collaboration under the IEA ETCP umbrella. An IEA Geothermal Expert Panel was formed, especially to formulate the IA Annexes. In two subsequent meetings in Paris (November 1995, April 1996) the legal text and the technical Annexes of the IEA IMPLEMENTING AGREEMENT FOR A CO-OPERATIVE PROGRAMME ON GEOTHERMAL RESEARCH AND TECHNOLOGY (GIA) were formulated. The IEA Secretariat provided great help in all these activities.

The GIA officially went into effect in March 1997 and is designed to operate for four years.

NATURE AND OBJECTIVES

The GIA represents and important framework for a broad international cooperation in geothermal R & D. It brings together significant national programs and is especially focusing on assembling specific knowhow and on generating synergies by establishing direct links of cooperation between geothermal groups/specialists in the different Participating Countries.

Task/Annexes

Currently there are three active Annexes:

- *Annex I: Environmental Impacts of Geothermal Energy Development* (3 Subtasks)
  The Work Plan of Annex I is designed for 4 years. Operating Agent is the Institute of Geological and Nuclear Sciences, Ltd. (New Zealand); Task Leader is T. Hunt (Wairakei).

- *Annex III: Hot Dry Rocks* (4 Subtasks)
  The Work Plan of Annex III is designed for 4 years. Operating Agent is the New Energy & Industrial Technology Development Organization (NEDO, Japan). Task Leader is M. Kuriyagawa (Tsukuba).

- *Annex IV: Deep Geothermal Resources* (3 Subtasks)
  The Work Plan of Annex IV is designed for 4 years. Operating Agent is NEDO (Japan). Task Leader is K. Kimbara (Tsukuba).

Detailed Annual Reports of these Annexes (including activities in 1998, results, future plans, and references), prepared be the Task Leaders, are given in the **ENCLOSURE.** The 1998 Annex Reports are organized in the following format:

- Introduction
- Work performed in 1998
- Work plan for 1999
- References.

The following Annexes are still in preparation:

- Annex II: Shallow Geothermal Resources
- Annex V: Sustainability of Geothermal Energy Utilization
- Annex VI: Geothermal Power Generation Cycles.

The status of the preparations is different. Whereas Annex V is relatively well developed, Annex VI awaits the participation of Italy which proposed this Annex. Annex II is still waiting for the engagement of countries active in the utilization of shallow resources like the USA (e.g. Geothermal Heat Pump Consortium).

Nature of work

The GIA activities aim primarily at the co-ordination of the ongoing national activities of the Participating Countries. In addition, new activities –as defined in the GIA- are initiated and implemented.

The GIA operates under the task-sharing mode of funding.

Objectives

The GIA defines, under its Article 1 the objectives as ”international collaborative efforts to compile and exchange improved information on geothermal energy research and development worldwide concerning existing and potential technologies and practices, to develop improved technologies for geothermal energy utilization, and to improve the understanding of geothermal energy's benefits and ways to avoid or ameliorate ist environmental drawbacks”.

PARTICIPATION

From the outset of the GIA (March 1997), 5 countries (Japan, New Zealand, Switzerland, United Kingdom, USA) and 1 organization (Commission of the European Communities, CEC) have signed the Agreement; upon unanimous agreement of the ExCo, Greece and Mexico joined in June, Australia in August 1997.

The involvement of the Participants in the different Annexes is shown in Table 1. In this context it must be mentioned that not all Participants are active in all Subtasks of the Annexes in which they participate. The ExCo makes efforts to harmonize this situation. As a result, USA joined in May 1998 also Annex I.

Table 1. Task participants as by December 1998

	Participating country/organization								
	Australia	CEC	Greece	Japan	Mexico	New Zealand	Switzer-land	UK	USA
I: Environmental Impacts			**x**	**x**	**x**	**x**			**x**
III: Hot Dry Rock	**x**	**x**		**x**			**x**	**x**	**x**
IV: Deep Resources				**x**	**x**	**x**			**x**

Member Countries

Negotiations are underway to secure the participation of the Member Countries Italy and Iceland which are prominent in geothermal R & D. The IEA Secretariat is instrumental in these efforts. It is highly probable that these two countries will join the GIA in 1999.

Non-Member Countries

So far, Turkey and the Philippines have shown interest to join the GIA which certainly would add to the GIA, by their substantial geothermal energy development programs. The assistance of the IEA Secretariat is highly needed here also.

ACTIVITIES

Meetings

The ExCo had one Meetings in 1998: on 18 September in Washington D.C., organized by DOE. The list of current ExCo members is attached **(ATTACHMENT I).**

At this Meeting the ExCo elected Prof. L. Rybach (Switzerland) as Chairman, Dr. T. Imanaga as Vice Chairman for 1999. Unfortunately, it has still not been possible so far to find a Secretary for the ExCo. It is expected to find a solution in 1999.

Several Workshops and Conference Sessions have been organized for the individual Annexes. Details about these can be found in the **ENCLOSURE**.

A special presentation of the GIA was given at the International Geothermal Days Azores 1999 on 14 September and at the Geothermal Resources Council 1998 Annual Meeting San Diego on 21 September (see References below). On July 1 the ExCo Chairman gave a presentation about the GIA at the Ministère de la Récherche in Paris.

Costs of Agreement

The GIA operates, as mentioned above, in the task sharing mode. The actual amount of work carried out for the GIA cannot be quantified at this moment. As a general rule it can be assumed that the involvement of the individual countries is somewhere on the order of one to several man-year(s).

It has been agreed at the ExCo meeting in Washington that a common fund (=Cost sharing) will be needed to conduct ExCo business, especially to produce a GIA Brochure (see below) and to establish a GIA homepage. Currently it is under negotiation how to establish the necessary fund.

Dissemination of Results

It is envisaged that the GIA follows the normal way of results dissemination: Publications in scientific/technical journals. Special emphasis is given to Conference Proceedings (see above). It is anticipated that substantial results will be presented at the WORLD GEOTHERMAL CONGRESS 2000 (Japan, 30 May – 10 June 2000).

Further activities

Upon request by the IEA Secretariat the GIA (acting: J. Garnish and L. Rybach) has produced input to the CERT Ministerial Paper (**ATTACHMENT II**).

CO-ORDINATION WITH REWP (IEA Renewable Energy Working Party)

Discussant's report

Upon request by the REWP a GIA Strategic Plan has been devised. This plan, along with the general GIA activities, were reviewed by REWP Discussant H.U. Schärer (Federal Office of Energy, Bern/Switzerland). The report of the Discussant is generally positive; it contains suggestions for revision of the GIA Strategic Plan. The plan has been revised accordingly at the ExCo meeting in Washington (**ATTACHMENT III**).

Key Issues in Developing Renewables

This OECD/IEA publication, issued in 1997, though covering geothermal to some extent, does not present an up-to-date view of the role of geothermal within the renewables. Although it lists geothermal in chapter ”Renewables Today” (also in Table 1); in the Appendix however, which gives summaries of the technologies listed in Table 1, geothermal is missing completely.

Geothermal is the leading ”new” renewable energy source today for electricity generation (cf. **ATTACHMENT II**). At a meeting of the ExCo Chairman at the IEA Headquarters with Dr. Hanns-J. Neef and Dr. Ian Walker on July 2 it was decided that the ExCo should produce a GIA Brochure. This brochure should, besides presenting the GIA activities, put geothermal into the right perspective.

Presently it is under examination how, until when, and by whom this brochure could be prepared and what financial funds would be necessary for its production.

REFERENCES

Rybach, L**.** (1998): The OECD / IEA Geothermal Energy R & D Policy. In: K. Popovski, A.-C. Rodriges (eds.): *Proc. Int. Summer School on Direct Applications of Geothermal Energy, Azores*, 19-27

Rybach, L. (1998): The IEA Geothermal Implementing Agreement – Status and Prospects. *Trans. GRC* Vol. 22, 55-60

ENCLOSURE: Task Reports

IEA GIA Annex I : ENVIRONMENTAL IMPACTS OF GEOTHERMAL ENERGY DEVELOPMENT – 1998 Annual Report
Prepared by Task Leader Dr. T. Hunt (IGNS Wairakei, New Zealand)

1. INTRODUCTION

In the last decade, concern has mounted about the environmental impacts of developing energy resources. Geothermal is generally regarded as a benign energy source, particularly when compared to nuclear, coal and oil; however, but there are some environmental problems associated with its exploitation. Ignoring such problems is, in the long-term, counterproductive to development of an industry because it leads to a loss of confidence by the public, regulatory, and financial sectors. To further the use of geothermal energy, possible environmental effects need to be clearly identified, and countermeasures devised and adopted to avoid or minimise their impact. To assist in this, Task I of the GIA entitled "Environmental Impacts of Geothermal Energy Development" was set up, and is formulated in Annex I of the GIA.

1.1 Goals

- To encourage the sustainable development of geothermal energy resources in an economic and environmentally responsible manner

- To quantify any adverse or beneficial impacts that geothermal energy development may have on the environment

- To identify the ways of avoiding, remedying or mitigating such adverse effects have on the environment.

1.2 Objectives

- To study the effects that existing geothermal developments have had on the environment and determine their cause.
- Identify the most likely and serious adverse effects that geothermal developments can have on the environment.
- Identify the development technologies that have proven to be environmentally sound.
- Publish the results of the studies in international journals and present the results at international forums.
- Improve communications between individuals and organizations in different countries, and between different professional groups involved in geothermal development by involvement in collective presentation of the results in international forums.

It is planned that the Task will operate for at least 4 years, and may continue beyond that time if there is sufficient interest and financial support. However, it should be noted that funding and operation of this Task is not easy because the environmental effects of geothermal developments are a sensitive matter in some countries, both commercially and politically.

1.3 Milestones

- Production of a Special Issue of *Geothermics* journal on Environmental Aspects of Geothermal Developments
- Participation in a Special Session on Environmental Issues at the World Geothermal Congress 2000

Countries formally participating in Annex I, as at 31 December 1998, are:

- Greece
- Japan
- Mexico
- New Zealand
- United States of America

Most environmental problems in geothermal developments occur in high-temperate geothermal systems associated with active volcanism, and so lie outside of IEA countries. Several other countries are therefore informally associated with this Task, including Iceland and the Philippines. Many geothermal researchers in Iceland are keen to participate in this Task of the GIA, but Iceland is not a member of IEA (although a member of OECD). However steps are being taken to try an overcome this problem and it is hoped that Iceland. It is also hoped that Italy and Turkey, both IEA members, will join in the future.

The Operating Agent for Task I is the Institute of Geological & Nuclear Sciences, which is a Crown Research Institute that is owned by the New Zealand Government. The Task Leader is Dr T Hunt.

The Task is sub-divided into three Sub-Tasks:

1. *Sub-Task A: Impacts on natural features*
   (Sub-Task Leader: Dr Michael Sorey, United States Geological Survey (Menlo Park),USA)

Work in this Sub-Task is focussed on documenting the known impacts of geothermal developments on natural geothermal features such as geysers, hot springs and silica terraces. Little of this information has been published either nationally or internationally, and much of that which has been published is not quantitative. The aim of this Sub-Task is to rectify this, and to provide a sound historical and international basis on which to devise methods to avoid or mitigate the impacts of development on such natural geothermal features which generally have significant cultural and economic value.

2. *Sub-Task B: Discharge and reinjection problems*
   (Sub-Task Leader: Dr Trevor Hunt, Institute of Geological & Nuclear Sciences (Wairakei), New Zealand)

Work in this Sub-Task is focussed on identifying and determining methods of overcoming the impacts of geothermal developments on other aspects of the environment, both in and above the ground. This includes the effects of gas emissions from geothermal power plants, effects of toxic chemicals in waste fluid that is discharged both into the ground and into rivers, effects of ground subsidence, and induced earthquakes.

3. *Sub-Task C: Methods of impact mitigation and Environmental Manual*
   (Sub-Task Leader: Dr Susan Goff, Los Alamos National Laboratory, USA).

Work in this Sub-Task is focussed on collating methods of how to avoid or mitigate the impacts of geothermal developments. It is intended that a manual will be written which identifies likely environmental impacts for each type of field and field situation, and the best means to avoid or mitigate the impacts so that developers and regulatory authorities can better plan and build geothermal schemes.

Since the last report no changes have been made to internal organisation of the Task, no new participants have joined. but the USA has formally signed the GIA for Task I, and its representative is Marshall Reed of the U.S. Dept. of Energy.

2. WORK PERFORMED IN 1998

2.1 General

A Special Session on Environment was held at the 1998 Geothermal Resources Council Annual Meeting in San Diego, USA, on 21-23 September 1998. The session was attended by several Task members from Japan, New Zealand, and USA. The session included four papers; several other papers on environment were allocated to other sessions. These papers were published in the *Geothermal Resources Council Transactions.* The opportunity was taken to hold discussions between the Sub-Task leaders.

Papers describing preliminary results of experimental studies on silica scaling hydrodynamics were presented at the Workshop on Reservoir Engineering held at Stanford University, USA, in January 1998, and at he 20 th New Zealand Geothermal Workshop, held in Auckland, New Zealand on 11-13 November 1998. These papers were published in the Proceedings of these conferences

Compilation and editing has continued of a Special Issue of ***Geothermics*** journal, on Environmental Aspects of Geothermal Developments, which includes the results of studies undertaken as part of the Task. ***Geothermics*** is an international scientific journal specialising in geothermal topics, and has a very wide distribution among the geothermal industry. Ten papers have been received and are currently undergoing or completed peer review. It is expected that the compilation will be completed early in 1999.

A start has been made by the Operating Agent to establish a website on Internet, which will explain the purposes of the Task, its organisational structure, the projects underway, provide information about the results obtained and the names and addresses of people to contact. The format will be similar to that set up by Task IV.

2.2 Sub-Task 1

Status of projects, by country –

Japan:
Changes to Beppu System project (JP-A1): This project, which reviewed the long–term changes to the Beppu Geothermal System in Japan associated mainly with removal of geothermal fluid for domestic bathing was completed. The results have been incorporated in a paper submitted to the Special Issue of *Geothermics*

Changes to natural thermal features at Kuju project (JP-A2): The project continuing slowly.

Predicting hot spring interference project (JP-A3): Waiting on approval from the funding agency to publish the results of studies in Japan and New Zealand.

Changes to natural thermal features in N.E. Japan project (JP-A4): No report available

New Zealand:
Natural changes to geothermal systems project (NZ-A1): No report, but believed to be progressing.

Biotic processes in sinter development project (NZ-A2): No report, but work is continuing slowly.

Exploitation-induced changes to thermal features project (NZ-A3): The initial goals of this project have been completed. This involved compiling historical (but never published) data on the changes in flow rate, water level, and fluid chemistry of hot springs caused by development of the Wairakei and Ohaaki geothermal power schemes. Several papers have been published describing the results from Wairakei. A further paper, describing the effects of development on a culturally significant hot pool at Ohaaki and steps taken to mitigate these effects, has been submitted to the Special Issue of *Geothermics*. Funding has been obtained for further work, to quantitatively model the data..

Satellite imagery project (NZ-A4): The aim of this project is to develop remote sensing techniques to map changes to natural thermal features caused by power scheme development. This will enable changes to be more easily identified. Funding was delayed, but has recently been approved, and it is planned to begin about mid-1999.

Response to surface features in Rotorua project (NZ-A5): This project involved compiling historical data about the changes to natural thermal features, especially geysers, in the Whakarewarewa Thermal Area resulting from increased drawoff of geothermal fluid for domestic heating and bathing during the 1970-1985. Of special interest was the examination of the results of a ban imposed in 1986 on fluid withdrawal in the vicinity of the thermal area. The analysis showed that the ban was very successful and many, but not all features had begun rejuvenation. The project has now been completed, and two papers have been submitted to the Special Issue of *Geothermics*; one paper describes the effects on the features, the other discusses the economic instruments used to successfully achieve mitigation of the effects.

United States:
Changes to natural thermal features in USA project (US-A1): Changes to the natural thermal features in the Long Valley Geothermal Area, were documented and analysed. The data showed that only a few of the changes were caused by development of the Casa Diablo Geothermal Power Scheme: and that no changes were confined to the immediate area of the scheme. The results were published in the *GRC Transactions*. Further work is planned.

The review of impacts of geothermal development in USA has been delayed, but should be available for WGC2000.

2.3 Sub-Task 2

Status of projects, by country –

Greece:
Environmental impacts of development in Sousaki project (GR-B1): The work proposed in this project has unfortunately been delayed due to funding cuts.

Mexico:
Environmental impacts of development in Mexico project (MX-B1): This is a large multi-disciplinary project which will continue for several years. One paper on the origin of rainwater acidity in and near the Los Azufres geothermal field was submitted for the Special Issue of *Geothermics*

Japan:
Prevention of silica scale project (JP-B1): No report available

New Zealand:
Aquatic environmental effects project (NZ-B1): No report received.

Hydrodynamics of silica scaling project (NZ-B2): This project is underway and a significant amount of theoretical and experimental work involving a ”water tunnel” (liquid equivalent of a wind tunnel) was made. Preliminary results were presented at the 23rd Workshop on Geothermal Reservoir Engineering and the 20th NZ Geothermal Workshop . Further work is planned and funding for this has been gained.

Control of toxic sludges project (NZ-B3): This project failed to gain NZ government research funding in the 1997-98 and was not submitted for the 1998-2000 funding round. The topic may be resubmitted in year 2000.

Causes of exploitation-induced ground movements (NZ-B4): Analysis has been made of the large ground movements (mainly subsidence) that have occurred at the Wairakei and Ohaaki geothermal power schemes. The project, as originally conceived, has been completed and a paper was presented at the Special Session on Environment, held at the 1998 Geothermal Resources Council Annual Meeting. Two further manuscripts have been submitted to the Special Issue of *Geothermics*. Funding has been obtained to extend the work, with regard to examination of the geological aspects of the rocks involved with the subsidence.

2.4 Sub-Task 3

Review of methods of mitigation project (US-C1): Work has not yet started, but will begin when more work in Sub-Tasks 1 and 2 has been done.

Environmental manual project (US-C2): Preliminary discussions have been held to establish who will do this work, and how it will be funded.

3. WORK PLAN FOR 1999

- Complete editing of the Special Issue of *Geothermics* journal on Environmental Aspects of Geothermal Development, and forward it to the publisher (Pergamon).

- Complete setting up of a website on Internet to inform the general public about the aims of the Task and results obtained.

- Negotiate with convenors of World Geothermal Congress 2000 for a Special Session on Environmental Impacts of Geothermal Energy Development at the Congress, to be held in Japan in June 2000.

- Expand the scope of the studies to include environmental impacts which are not yet covered in the Task, (such as exploitation-induced hydrothermal eruptions), or topics which are as yet poorly covered (such as social, medical and financial aspects of environmental effects).

4. REFERENCES

Papers published as part of Task I

General
Rybach, L. 1998. The IEA Geothermal Implementing Agreement –status and prospects. *GRC Transactions 22*: 55-59

Sub-Task 1
Hunt, T.M., Scott, B.J. 1998. Recovery of natural thermal features after field testing: New Zealand examples. *GRC Transactions 22*: 49-54

Hunt, T.M., Scott, B.J. 1998. Do natural thermal features recover from field testing ?. *Proc. 20th NZ Geothermal Workshop*: 203-208

Sorey, M.L., Farrar, C.D. 1998. Changes in surficial features associated with geothermal development in Long Valley Caldera, California, 1985-1997. *GRC Transactions 22*: 61-64

Sub-Task 2
Allis, R.G., Zhan, X., Clotworthy, A. 1998. Predicting future subsidence at Wairakei field, New Zealand. *GRC Transactions 22*: 43-48

Allis, R.G., Zhan, X., Clotworthy, A. 1998. Predicting future subsidence at Wairakei field, New Zealand. *Proc. 20th NZ Geothermal Workshop*: 133-138

Dunstall, M.G., Brown, K.L. 1998. Silica scaling under controlled hydrodynamic conditions. *Proc. 23rd Workshop on Geothermal Reservoir Engineering.*

Zipfel, H.A., Dunstall, M.G., Brown, K.L. 1998. Investigations of the onset of silica scaling around circular cylinders. *Proc. 20th NZ Geothermal Workshop*: 341-346

IEA GIA Annex III : Hot Dry Rock – 1998 Annual Report
Prepared by Task lader Dr. M. Kuriyagawa (NIRE, Tsukuba, Japan)

1. INTRODUCTION

The objective of Hot Dry Rock Task may address HDR geothermal technologies as well as any other new and improved technologies which can be used to artificially simulate a geothermal resource to enable commercial heat extraction.
Since last IEA GIA Executive Committee meeting in 1997 in New Zealand, Subtask B has newly started. Lynn MacLarty from Princeton Economic Research, Inc (PERI) is a leader of Subtask B. Leader of Subtask D changed from Isao Matsunaga, National Institute for Resources and Environment (NIRE) to Tsutomu Yamaguchi, NIRE.

Countries and organization participating in Annex III are as follows:

- Australia
- CEC
- Japan
- Switzerland
- UK
- USA

The following four Subtasks have now been carrying out under this Annex.

(1) Subtask A: Hot Dry Rock Economic Model
(Subtask Leader: H. Herzog, MIT, USA)

This project has two major thrusts. First is to upgrade MIT's existing HDR economic model in three ways -- review and revise databases, make the model accessible to a larger user base by upgrading to Windows and rewriting input/output capabilities, and add new capabilities to the model as required by task 2. Task 2 is to use the model to run case studies. The exact studies will be determined through discussions with DOE, industry, and our collaborators in the IEA Implementing Agreement.
This is a three year project. Year 1 has focussed on upgrading the model. In year 2, the focus will shift to the case studies.

(2) Subtask B: Application of Technology of Conventional to Hot Dry Rock Technology
(Subtask Leader: Lynn McLarty, Princeton Economic Research, Inc, USA)

The U.S. Department of Energy□s approach to this Subtask is to focus some of its research efforts on developing technology that is applicable to both hydrothermal resources (in the near term) and HDR resources (in the longer term). In other words, the approach is to focus efforts initially at the more permeable end of the spectrum - in lower permeability areas in or adjacent to commercial hydrothermal fields. The term □dual-use□has been coined to describe this approach because the technology to be developed will be used not only to salvage dry or marginal wells and improve production and injection at commercial hydrothermal fields but also to develop heat resources that are not associated with commercial hydrothermal resources. DOE is using the term Enhanced Geothermal Systems (EGS) to refer to the use of advanced technology to exploit heat reservoirs that have insufficient permeability and/or fluid for economic development with current commercial technology.

(3) Subtask C: Data Acquisition and Processing
(Subtask Leader: R. Hopkirk, Polydynamics Engineering, Switzerland)

The overall aim of this Subtask is to provide a framework for the construction of a commercial HDR plant including project planning, availability of special tools and services and an overview of data, data analyses and experiences (in the way of lists of reports and publications with their abstracts) gained at the major HDR projects world wide.

(4) Subtask D: Reservoir Evaluation

(Subtask Leader ; Tsutomu Yamaguchi, NIRE, Japan)

The final objectives of this Subtask is to understand how much, how fast and how long geothermal energy can be extracted from a HDR reservoir system. This Subtask will make clear what kind of methods, techniques and tools are effective for reservoir evaluation, and finally will establish the evaluation method which can be applied to develop a new HDR site.

2. WORK PERFORMED IN 1998

2.1 2nd HDR Task meeting

Date: September 27, 1998
Place: Strasbourg, France
Attendants:

ABE Hiroyuki, Tohoky Univ., Japan
BARBIER Enrico, C.N.R. Insti Per le Recerche Geothermiche, Italy
BARIA Roy, SOCOMINE, France
BAUMGARTNER Jorg, SOCOMINE, France
CAPPETTI Guido, ENEL, Italy
DUCHANE David, LANL, USA
ENTINGH Donald, PERI, USA
GERARD Andrew, SOCOMINE, France
GARNISH John, EC-DGXII, Belgium
HERZOG Howard, MIT, USA
HOPKIRK Robert, Polydynamics, Switzerland
KITSOU Olga, MIT, USA
KURIYAGAWA Michio, NIRE, Japan
RYBACH Ladislaus, ETH Zurich, Switzerland
SQUARCI Paolo, C.N.R. Istituto per le Ricerche Geothermiche, Italy
TENMA Norio, NEDO, Japan
YAMAGUCHI Tsutomu, NIRE, Japan

Major items discussed:

* Report of the results of 3rd Executive Committee which was held in September 1998 in Washington D.C.
* Introduction of attende.
* Work plan of the four Subtasks.
* Schedule

2.2 Activities of HDR Task Subcommittee in Japan

HDR Task Subcommittee in Japan which is operated by NEDO were two times in this year; on May 27 and July 1. The discussions were made how to support the activities of Subtasks A, B and C, and how to promote Subtask D.

2.3 Progress of Each Subtask

2.3.1 Subtask A: Hot Dry Rock Economic Model

Task to Update Model

Reviewed and updated all cost correlations and cost indices.
Updated code to be on an extensive basis (i.e., user specifies size of plant) as opposed to an intensive basis (i.e., all calculations done on a per MW basis)
Ported code to Windows from DOS
Rewrote all input/output to use forms and graphics under windows (as opposed to text input and output).
Task to Perform Case Studies - Had meetings with the following three groups, reviewed data they submitted, and discussed case studies of interest to them:

On February 10, 1998, we had a visit from Drs. Hori and Kaieda of CRIEPI in Japan (in charge of the Ogachi HDR test site).
On March 18, 1998, Howard Herzog visited Michio Kuriyagawa and several colleagues at NIRE (National Institute for Resources and the Environment) in Tsukuba, Japan (in charge of the Hijiori test site).
On April 8, 1998, we had a visit from Martyn Howells and Yoram Shoham of Shell International to discuss our HDR economic model.
September 18, 1998, Howard Herzog attended the IEA executive committee
meeting in Washington.
September 28-30, Howard Herzog and Olga Kitsou attended the HDR Forum in Strasbourg, France.
We are currently conducting a case study based on data from Australia concerning their proposed HDR test site.

2.3.2 Subtask B: Application of Technology of Conventional Geothermal Energy to Hot Dry Rock Technology

To date, the DOE R&D management contractor team conducted a "mini" workshop (half day) at the U.S. DOE annual Geothermal R&D Program Review, in Berkeley, California on April 2, 1998. This was titled "Workshop on Dual-Use Technologies for Hydrothermal and Advanced Geothermal Reservoirs." About 50 people participated in the workshop, and about 30 participated in breakout groups on "Evaluation," "Stimulation," and "Siting Considerations." A number of important concepts surfaced, including:
a) On evaluation and stimulation, much important RD&D is conducted within the DOE Environmental Management program to ameliorate aspects of nuclear wastes, and within enhanced oil recovery programs,
b) Much of the Enhanced Geothermal Systems field work should initially be conducted at the margins of producing hydrothermal reservoirs to take advantage of the existing operational infrastructure and wells in marginal formations. As importantly, the participants seemed generally quite excited at being involved in helping to set new directions for the EGS program.
The R&D management contractor team conducted a preliminary investigation of the appropriate sites in the Southwestern U.S. for dual-use field R&D projects. This was done in conjunction with the U.S. Geological Survey, and the results were presented at the 4th International HDR Forum in Strasbourg France in September, 1998.

2.3.3 Subtask C: Data Acquisition and Processing

a) The continuation of those of some activities started in 1997, but not yet finished. This means:

- production of an English-language handbook for the project index database and for the data archiving technique.
  Status: completed and distributed. Awaiting suggestions for improvement.

- continuation of the setting up of archives and index databases for Soultz and Rosemanowes together with the respective project teams and including the Swiss contribution to the European HDR effort.
  Status: continuing the work of archiving of data and of reports for Soultz; still with the cooperation of CSMA trying to obtain extra credit from EU to archive Rosemanowes data and build up the data Index system.

- instruction and guidance of the other project teams worldwide to achieve a status of auto-capability.
  Status: waiting for reactions and requests.

- collection of information on services, tools and techniques suitable for use during the design and construction of an HDR power plant.
  Status: Data on more than 160 suppliers of borehole-related services worldwide have been collected so far.

b) Software selection for database on tools, equipment and services for use in the generic project development and construction plan and initialization of the design of this new database.
Status: Provisionally this database has been implemented using the Microsoft EXCEL spreadsheet program. We shall distribute periodically updated lists for comment and await suggestions for extending and improving this database.

c) Seeking methods of linking this database with the project planning tool.
Status: Last year (1997) it was possible to start the planning of a generic project on the bases of past experience and of current experience with the Swiss Deep Heat Mining Project. We find we are entering a stage requiring

much site-specific input without this apparently advancing the project. This activity will be pushed back by several months before progress can be made.

2.3.4 Subtask D: Reservoir Evaluation

a) Subtask meetings were held twice in May 27 and July 1. In these meetings, it was decided that the questionnaires would be conducted using Internet web for the convenience in replying the questionnaires.

b) The categories of the questionnaires is grouped into five categories as follows;
1. Numerical simulation
2. Geology
3. Tracer
   3.1 Field tracer experiment
   3.2 Laboratory (Basic) tracer experiment
4. Geochemistry
   4.1 Fluid chemistry
   4.2 Gas chemistry
5. Measurement techniques
   5.1 Microseismic monitoring
   5.2 Seismic logging
   5.3 Well logging

c) The contents of the questionnaires had been discussed within Subtask D, and a preliminary version of the questionnaires was temporary placed at a working homepage.

d) The preliminary version of the questionnaires was introduced both at the IEA 3rd. EX-Co meeting in Washington DC on September 18, and at the subtask leader meeting in Strasbourg on September 27 to ask comments and/or opinions from the attendants.

e) The original questionnaires are now under reexamination. Next meeting of HDR Task Subcommittee in Japan is scheduled on January 5, 1999 at NEDO. The questionnaires that are opening to the general public will be finalized at the meeting.

3. WORK PLAN FOR 1999

We may have next task meeting in Strasbourg before or after next Executive Committee which will be held in Paris next November.
The following is the work plan for each Subtask.

3.1 Subtask A

Quality control new version of model and make a Beta Test version available to any interested party.
Write documentation for model.

Add new capabilities as needed to perform case studies.

Perform Case Studies. During discussions with Michio Kuriyagawa, we identified one series of case studies was to use our model to analyze the economics associated with the four main HDR test sites (Soultz, Fenton Hill, Ogachi, and Hijiori). Additional case studies will be identified and performed. Some case studies may require the model to be enhanced (see above). The list of potential case studies is quite long and varied. We will complete the Australian case study. Switzerland team will commence the exchange and the mutual comparison of programs, together with the results of analyses of agreed and standardized data sets.

3.2 Subtask B

Work is proposed to further investigate U.S. sites as possible locations for dual-use field R&D projects. This will include the development of a more comprehensive list of sites, and an evaluation of available data on those sites.
DOE is planning to solicit proposals for EGS field and lab work in 1999. The nature of this work will depend on the proposals submitted.

3.3 Subtask C

Integration of changes into the Index Database Applications and provision of support for the project-oriented users in the documentation of their projects.

Further development of the database / list of HDR / HWR publications. We shall be asking for contributions and distributing the library list in the course of the year.

Conversion of the currently available list of service providers and suppliers to a database and distribution of the first version for trial and comment.

Extending the generic project plan, started in 1997 but with progress temporarily delayed during the early part of 1998, whilst awaiting completion of more of the Swiss internal Deep Heat Mining project's current phase. The DHM project serves as a model for this aspect of the work.

3.4 Subtask D

The Internet questionnaires for reservoir evaluation will be open to the public on NEDO server after asking and reflecting comments on the questionnaires of the core member of HDR task in the world. The internet address will be announced by E-mail to the core members of HDR task and attendants of the 4th. International HDR forum in Strasbourg, etc. The answer to the questionnaires will be summarized in a table-format, and will be compiled and reviewed to establish the methodology in developing a new HDR site. Cooperation with the NIRE team in the study of the questionnaire on methods and techniques during the reservoir evaluation phase is foreseen. We will intensively contact with Switzerland team, as their program to support Subtask D will start at the beginning of 1999.

4. REFERENCES

The followings which are directly related to the activities of this Annex were presented at the International Conference – 4th HDR Forum which was held in Strasbourg, France on September 28 to 30, 1998.

M. Kuriyagawa (Japan): IEA Overview (Overall activities of Annex III)

R. Hopkirk and T. Megel (Switzerland): Data collection, archiving and indexing (Activities of Subtask C)

IEA GIA Annex IV : Deep Geothermal Resources – 1998 Annual Report
Prepared by Task lader Dr. K. Kimbara (GSJ, Tsukuba, Japan)

1. INTRODUCTION

The objective of this task is to address the issues necessary for the commercial development of Deep Geothermal Resources which prevail at depths of approximately 3,000 meters. The task consists of three Subtasks:

Subtask A: Exploration Technology and Reservoir Engineering
Subtask B: Drilling and Logging Technologies
Subtask C: Material Evaluation Programme

The Task officially went into effect on March 10, 1997, when New Zealand and Japan signed the Agreement at the 1st Executive Committee (ExCo) Meeting. Australia, Mexico and USA were approved to join the Task at the 2nd ExCo meeting on November 10, 1997, and Italy was approved to participate in GIA at the 3rd ExCo meeting on September 19, 1998.

The Task of Deep Geothermal Resources was planned as a four-year international collaboration program with the participants of five countries; Australia, Japan, New Zealand, Mexico and USA. Japan is taking the lead in developing the entire work program, and NEDO is undertaking the role of the Operating Agent (OA). The Subtask leaders develop the details of their yearly work plans, and OA presents annually the revised work programs at the ExCo Meeting.

Based on the task sharing way, OA organizes meetings, workshops and field trips to promote the work programs including information exchange through Internet among the participants. The final results will be presented at the World Geothermal Congress 2000 (WGC2000) to be held in Japan in the year 2000, and the research papers will be submitted to special volumes of international scientific journals over the next year.

2. WORK PERFORMED IN 1998

2.1 Opening the web site

OA opened a web site (http://www.ieageo.or.jp) for the Task in April 1998, and the instruction manuals were distributed to the participants.

The web site has several pages, "Whats new," "Log in, Link," "Member" and "Info Database." "What‘s new" and "Link" are open to the public. "Log in" (BBS for discussion) and some parts of "Member" and "Info Database" are open to the participants only. The password to access to the restricted pages was given to each task participants by OA.

Country reports provided by the participants and progress reports of NEDO projects are available on this web site. Database of Subtask B is also available on the web site.

2.2 IEA-related technical session

OA organized a technical session, "IEA Deep Geothermal Resources," at the 20th New Zealand Geothermal Workshop which was held in the University of Auckland, New Zealand on November 12. More than fourteen papers were presented at the session from Japan, New Zealand and Mexico.

2.3 IEA-related field trip

OA conducted a field trip to the geothermal fields, Wairakei, Rotokawa, Mokai, Ohakuri, Ohaaki, Waiotapu and White Island, to investigate the present status of deep geothermal resources in New Zealand. The trip was carried out from November 14 to 16 just after the New Zealand Geothermal Workshop. The trip was guided by colleagues of New Zealand, and fifteen geothermal experts participated from six countries; Indonesia, Italy, Japan, New Zealand, Mexico and USA.

2.4 Progress of Each Subtask

2.4.1 Subtask A: Exploration Technology and Reservoir Engineering
(Subtask leader: H. Muraoka, GSJ, Japan)

a) Making a conceptual model and a reservoir model
The work plan for this year was to make a conceptual model or a reservoir model for a given geothermal field in each participating country. This objective was successfully performed by the parties from New Zealand, Italy and Japan. Papers related to the modeling of deep geothermal resources were presented at a special session of the New Zealand Geothermal Workshop in November 1998. In addition, a party from Mexico presented the expert software system for the assessment and the management of deep geothermal reservoir systems in the session.

b) Collecting information on deep geothermal wells
This Subtask group also continued effort to collect information on deep geothermal wells in the world not only through the bibliography but also through the Task Excursions to the deep geothermal fields, including Taupo in New Zealand. The Subtask group started to construct a small spread sheet type database for the deep geothermal wells in the world in 1998. This database contains only simple information such as location, depth, productivity and maximum temperature, considering the availability of the data.

2.4.2 Subtask B: Drilling and Logging Technology
(Subtask leader: H. Kobayashi, NIRE, Japan)

Following works were performed in 1998 to carry out the collaborative researches on drilling and logging technologies which are necessary to develop deep geothermal resources.

a) Collection of papers related to geothermal drilling and well logging
Collecting the papers related to geothermal drilling and well logging was continued, and the data were stored in the database of the DGR web site. The time distributions for drilling wells in several fields of Japan, the Philippines and USA were compared. Job classification formats were different depending on the fields, therefore, it might be necessary to make a standard format for easy understanding and utilization of data.

b) Human network
Three members joined in this Subtask in 1998. There are 13 members from 6 countries in this human network; Australia (1), Italy (2), Japan (4), Mexico (1), the Philippines (1) and USA (4).

c) Exchanging the progress reports and status reports
Progress reports and status reports of 5 proposed programs were mutually exchanged among the members. Karasawa (NIRE) tested newly developed PDC (polycrystalline diamond compact) bits against granite rock samples in the laboratory. The bit-life of about 40-50 m for Sori granite was achieved with bits of 142.88 mm (5-1/2") and 66 mm in diameter.
Wada and Bessho (NEDO) reported several field tests results on the developed bit, mud, cement, and so on.
Rowley (Pajarito Ent.) reported the status of their proposal for getting fund of the program.
Wada and Bessho (NEDO) revealed that PTS logging tool and C sampler were field tested with sufficient temperature reliability.
Iglesias (IIE) is still making efforts to get funding on "Borehole Logging Based on Optical Fiber Technology".

2.4.3 Subtask C: Material Evaluation Programme
(Subtask leader: N.Sanada, TNIRI, Japan)

a) Databases of fluid chemistry
Chemistry data were compiled from published papers to develop databases of deep and acidic geothermal wells.

b) Compile references
It was continued to compile references related to chemistries, materials performance experienced in geothermal activities from the literature which were published in these ten years. Over 160 papers were listed up from "Geothermics," "GRC Transaction," "Geochemical Journal," "Proceedings," "Journal of the Japan Geothermal Energy Association (in Japanese)," "Resource Geology (in Japanese)," etc. The databases will be available through the WWW system soon.

c) Corrosion model
Corrosion models were developed for downhole well conditions including; the effect of fluid velocity on erosion, corrosion chemistry and mineral corrosion product phase stability. These models help to predict materials performance requirements and corrosion control needs. Materials performance results were also modelled for acid wells in Japan, acidic wellhead applications in the USA and acidic volcanic hot spring environments in New Zealand. The materials performance results will be incorporated into the developing database for materials guidelines for utilisation of deep geothermal well fluids.

d) Information exchange through visits to the Philippine organizations
In order to exchange information on the materials and chemistries, Japan and New Zealand participants visited the organizations of the Philippines such as PNOC-EDC, NPC, etc. in March 1998. Some organizations have been interested in the Subtask.

4. WORK PLAN FOR 1999

4.1 General

The year 1999 is to accelerate the task-collaboration work, and every effort will be made in order to promote the Task activities toward its final goal.

OA is conceiving a plan about an IEA-related technical meeting as well as a field trip in either Italy or the Philippines. A mini-workshop might be held in Italy in cooperation with ENEL or IIRG subject to their consent and participation in the Task. Holding a technical-oriented meeting will be also possible in Tongonan in the Philippines under the support from PNOC.

4.2 Subtask A

a) Make a general model
An objective for 1999 is basically to make a comparative study among the individual models presented for a given geothermal field in each participating country. The individual models may contain local as well as general factors. General factors will be extracted and then a general model will be constructed. Based on the general model, economical evaluation for deep geothermal resources will be given, and strategy and recommendation for deep geothermal development will be given as a concluding remark for this Subtask.

b) Continue collecting information on deep geothermal wells
By now, this Subtask group did the excursions to Cerro Prieto in Mexico, The Geysers and Salton Sea in USA, and Taupo in New Zealand, so that the rest of the major deep geothermal fields to investigate could be Japan, the Philippines and Italy. WGC2000 is the best opportunity for an excursion to Japan, so that an excursion to the Philippines or Italy should be considered in the year 1999 for the comparative study as well as the database construction.

4.3 Subtask B

Proposed work plans will be as follows:
a) Continue to collect and store data on geothermal drilling and well logging.
b) Analyze and evaluate drilling and logging technologies. Several items will be nominated for evaluation such as the distribution of the time and the cost for drilling well, drilling practices and problems, and well completion time in various locations.
c) Make preliminary reports of 5 proposed programs related to drilling and well logging.

4.4 Subtask C
a) Develop databases of deep and acidic fluid chemistries from published papers.
b) Develop corrosion models for materials in inflows and in deep and acidic fluids.
c) Continue to compile references of the literature concerned with chemistries and materials performance.
d) Preparation of guidelines for materials selection for utilisation of deep geothermal well fluids.
e) Establish a human network of interested individuals having a common aim of Development of Utilisation Technologies for Deep Geothermal Systems.

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b) Paper presented at the PNOC-EDC Annual Meeting

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Zurich, 21 January 1998

L. Rybach,
ExCo Chairman

ATTACHMENT I

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ATTACHMENT II

Input of the GIA for the CERT Ministerial Paper, prepared by J. Garnish & L. Rybach (November 1998)

IEA Implementing Agreement on Geothermal Energy Research and Technology

1. Brief description of the technologies

The overall agreement currently provides for task-sharing collaboration on four aspects of geothermal technology: Environmental Impacts (Annex I); Shallow Geothermal Resources (Annex II); Hot Dry Rock (Annex III); and Deep Geothermal Resources (Annex IV). All are concerned with aspects of the production and use of underground heat as a sustainable, non-polluting form of energy. Annex II has not yet become active.

Geothermal resources are already in widespread though limited use worldwide, with some 7 GWe of installed power-generating capacity and 8-10 GWt of direct heating applications. Electrical power is generated from underground steam or hot water, with typical unit plant sizes of 10-50 MWe, and – being firm power – is normally fed directly to the electrical transmission and distribution system. Heat is obtained from lower temperature resources and used predominantly for space heating or agribusiness. Worldwide, geothermal developments are the third largest sustainable energy source (after biomass and hydro). The advantage that geothermal derives from being a firm energy source is illustrated in the following table :

Table 1: Electricity generation from "new" renewable sources
(after Fridleifsson 1998)

Power plant type	Installed capacity **(MW)**	%	Production **(GWh/year)**	%
Geothermal	7 049	52.0	42 053	79.6
Wind	6 050	44.7	9 933	18.8
Solar (PV)	175	1.3	229	0.4
Tidal	264	2.0	602	1.2
Total	13 538	100	52 817	100

Compiled from WEC Survey of Energy Resources (WEC 1998)

Annex I of the Implementing Agreement is concerned with amelioration of potential impacts arising from the presently-established technologies, Annexes III and IV are more concerned with medium- and longer-term potential.

1. Technologies available today

Geothermal technology contributes to meeting the Kyoto commitments through the replacement of fossil fuels by an energy source which need not (under best practice conditions) emit any greenhouse gases at all. (Note that displacement of fossil fuels contributes in two ways: direct elimination of CO_2 through reduced combustion of fossil fuels, and reduced leakage of CH_4 through reduced demand on the supply chain). It is estimated that in 1997 geothermal resources displaced 780 000 TJ of conventional energy, saving some 60 Mt CO_2.

Currently, the growth rate of geothermal development is low (1-3% per year), principally because of competition from cheap fossil fuels (especially natural gas). However, the industry has the ability to expand rapidly when conditions are favourable (growth rates of installed electrical capacity exceeded 18% per year in the wake of the first oil shock). Any initiatives aimed at ”levelling the playing field” between competing fuels (e.g. accounting for environmental externalities) could reasonably be expected to lift growth rates to >10% within 3-4 years.

Although geothermal resources adequate for direct heat applications are widely available and could be applied wherever a market exists (though economic considerations usually dictate that the market must be located within a few kilometres of the source), geothermal resources suitable for power generation with current technologies are much more restricted geographically. For this reason, it has been estimated that the upper limit for geothermal generating capacity would be about four times the current level (25-30 GWe), unless new types of resources can be developed. Annexes III and IV are addressing this issue.

A further use of geothermal heat is through Ground Source Heat Pumps. These fall under the IEA's Heat Pump IA rather than the Geothermal IA, but are mentioned here for completeness. The technology of these applications, drawing on ubiquitous low temperature heat from depths (typically) of only 50-200m, is well-established and commercial. Many hundreds of thousands of domestic scale commercial units are now in operation in USA and Europe, providing both heating and cooling. The energy supplied by these units is additional to that mentioned above for conventional sources. Although the heat pumps require electricity input (often derived from fossil fuels), net CO_2 emissions are reduced by 40-70%. The capital cost per tonne of CO_2 avoided is lower than that of low energy light bulbs. This market is expected to grow at more than 10% per year.

2. Near-term technologies and technology improvements

Within the timescale of the Kyoto commitments (2010), it is unlikely that R&D by itself will have a major impact on accelerating the installation of geothermal systems. As noted above, the constraints are essentially economic and institutional. However, Annex I is addressing existing environmental impacts (which can, in principle, be almost zero) and evaluating the best methods of minimizing any adverse effects. It is also addressing one of the principal existing barriers to increased uptake – lack of awareness of geothermal technologies on the part of decision makers and the general public.

Some countries, however, such as Italy, Iceland and USA, are already beginning to apply HDR technologies in the poorly-productive margins of conventional geothermal fields. This approach offers the potential of increasing the output of existing developments at a modest marginal cost, though it is too early to assess the impact of such applications A doubling of potential output would seem to be a realistic guess.

3. Technologies for the longer term

The centre-piece of longer-term geothermal R&D is known variously as "Hot Dry Rock" (HDR), "Hot Wet Rock" or (most recently) "Enhanced Geothermal Systems". Most commonly, all such work is still included in the term "HDR", explicitly addressed by Annex III.

HDR is aimed at developing technologies for extracting heat from rocks that do not naturally possess an adequate supply of circulating water. If the R&D is successful, this opens up the prospect of an extremely large energy source, available to virtually every country in the world and capable of supplying heat adequate for power generation. Though the technology has yet to be proven, good progress has been made in recent years and several countries or organizations are planning to build and operate pilot plants within the next decade. If successful, the impact from this new technology would make itself felt in the second quarter of the next century. It could realistically supply ca. 15% of electricity needs in most countries.

Work directed towards HDR pilot plant development is already underway, notably in Japan, Europe (as an integrated project within an overall European Commission programme, and as a separate but associated Swiss project) and Australia, while USA is redirecting its efforts towards the shorter-term goal of enhancing conventional geothermal systems by the use of HDR-type technology.

Co-ordination of all these activities is ensured by the task- and information-sharing agreement under Annex III.

4. Additional questions

a. *Barriers to uptake*

For conventional geothermal developments, and for ground source heat pumps, the barriers to further uptake are essentially non-technical and are unlikely to be amenable to R&D. The principal barriers are:

- Competition from low-priced fossil fuels; pricing that accounted for environmental issues would redress this balance.
- General lack of awareness of the technology, among decision makers and the public.
- Legislative uncertainty; relatively few countries have specific legislation establishing the rights, ownership and obligations of geothermal resources. This can inhibit the commercial financing of projects.

At present, HDR technology is still in the R&D phase. Once the technological issues have been resolved, it will then be faced with same non-technical barriers as for conventional resources.

Generally speaking, all geothermal technologies can be integrated comparatively simply with existing infra-structures (electricity distribution systems, domestic or industrial heating systems) but large scale heating applications depend on the proximity of the resource to the heating network. Increased uptake of district heating and/or CHP would expand this market.

b. *Principal players*

Almost all power generation from geothermal sources is carried out by large utility organizations (many of which are state-owned). Uptake by the private sector is occurring as state-owned power companies are decentralized. The extent of uptake is again controlled by the non-technical factors listed earlier.

Direct heating uses are almost entirely in the private sector, though national governments play a role in some cases through (e.g.) insurance / risk-sharing schemes.

International organizations play a role in several areas:

- IEA co-ordinates information exchange and task sharing;
- UN provides technical and financial support for new developments in developing countries;
- European Commission supports research and demonstration within the European Union and other countries associated with its programmes.

Collaboration between these organizations is, in general, good – although it is dependent on the fact that the geothermal community is comparatively small and hence personal contacts are well-developed. Further action is probably unnecessary, unless it is to formalize these contacts and avoid the dependence on individuals.

c. *Prospects for GHG reductions in developing countries*

Many of the developing countries (esp. central America and SE Asia) have good potential for development of conventional geothermal resources for power generation, thereby directly avoiding CO_2 emissions. Few have significant heating needs but, as they develop a need for cooling technologies (initially in industry and later on a domestic scale), virtually all of this could be met by geothermal or ground source heat pump technologies. All of these are available today.

In the longer term, successful development of HDR technology would be of equal benefit to developing countries as to developed countries.

ATTACHMENT III

GIA Strategic Plan

- **Implementation of work programmes of the individual Tasks**

- **Development of a communication plan to disseminate information about geothermal energy utilization, especially by preparing a GIA Brochure**

- **Examination of the role of utilities towards geothermal energy (electricity production as well as consumption, e.g. by heat pumps) in market opening, especially in Europe**

- **Organization, on a regular basis, of GIA Workshops (by Tasks) and of more general GIA Sessions (“work in progress / results achieved”) at international geothermal conferences**

- **Definition of longer term R & D needs of geothermal technology.**