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IEA – Hot Dry Rock

Teilnahme am Geothermal Implementing Agreement der IEA (ExCo Vice Chairmanship & Annex III, Hot Dry Rock, Subtask C)

ausgearbeitet durch

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IEA – Hot Dry Rock

Annual Report for 2002 on the Swiss participation in the GIA - the IEA Geothermal Implementing Agreement.

Includes the tasks undertaken by the Chairman of the Executive Committee and progress in Annex III (Hot Dry Rock)

Contributions to this report have been made by the following members of the GIA working party:

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The work reported here has been performed under contract to the Swiss Federal Office for Energy

Summary

From the organisational point of view the year 2002 has seen many changes in the structure of the GIA organisation and activities. Professor Ladislaus Rybach has retired from the Chairmanship of the Executive Committee, a post he has held since 1997. He continues as vice-Chairman.

Work is being undertaken to expand the number of countries participating in the GIA, in particular France, Turkey and the Peoples' Republic of China.

On the technical side, the Swiss team has been able make some progress with the work on three of the themes defined at the start of our participation in the GIA:

- data collection and organisation for specific sites and projects,;
- Collection and organisation of all available literature relating to Hot Dry Rock geothermal energy development;
- definition of data requirements via considerations of a generic HDR project.

Over the past four years the concept of the generic project has been built up. Data requirements for planning a real HDR reservoir and plant continue to be collected and, building on the efforts of 2001 a simple, but practical means of presentation has been developed.

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Participation in the Geothermal Implementing Agreement of the International Energy Agency in the year 2002

1. Contributions of the ExCo vice-chairman to the organisation of the GIA

Prof. Dr. Ladislaus Rybach has decided this year to step down from his post as Chairman of the Executive Committee of the Geothermal Implementing Agreement, having been largely resoonsible for causing the organisation to be created, directing it since its inception in 1997, extending the number of interested participants and the scope of activities and leading it from . He has agreed to remain in the organisation as vice-chairman and to continue to be the Swiss representative in the ExCo. He is now acting in this capacity. His duties during the first part of the year as ExCo Chairman were:

- Production of the GIA Annual Report for 2001. The final version was delivered on 21 March 2002 (see Appendix 1);

- Revision of the GIA End of Term Report on the first five-year term of the GIA. The second version was submitted on 13 Feb 2002. The final revision is still continuing;

- Preparation and Chairing of the 7th ExCo meeting, which was held at the IEA headquarters in Paris on the 7/8 March 2002.

During this meeting Prof. Rybach was formally elected Vice-Chairman and Dr. John Garnish as Chairman. The following duties were defined at this time, and subsequently have been undertaken:

- Study and formally commenting various GIA documents

- Review of applications received for GIA Secretary (in a Task Force: Garnish, Rybach, Schuppers, Krismanndottir, Hashimoto)

- Recommend selection of GIA Secretary for 8th ExCo meeting (same Task Force)

- Solicitation of contributions to GIA Common Fund; distribution of invoices (by the National Renewable Energy Laboratory NREL, Golden/Colorado, USA)

- Co-operative work on the preparation of the GIA strategic plan 2002 (Appendix 2)

- Preparation of GIA input for the CERT Project "Technology Options for Achieving Significant Greenhouse Gas Emissions Reductions from Energy over the Long Term" The latest version of this project description is presented in Appendix 3.

- Consideration of various CERT position papers

- Negotiations for further participants in GIA (France, Turkey)

- Preparations for and participation in the 8th GIA ExCo meeting, which was held on 6th-7th November 2002, at Cuernavaca in Mexico. The draft minutes are included as Appendix 4.

At this meeting Prof. Rybach represented Dr. Garnish as meeting chairman and also presented a brief progress report on Annex III, Subtask C on behalf of R. Hopkirk. This presentation is included as Appendix 5 He was able to participate in the field trip to Los Azufres on Nov. 9 and 10, during which several geothermal power plants, both in operation and under construction were visited. Further tasks have also been undertaken:

- Undertaking various discussions and the first administrative steps for the joining and participation of the Peoples' Republic of China in the GIA;

- Diverse administrative tasks as ExCo Officer.

The 9th GIA ExCo meeting has been scheduled for 13th-14th March 2003 at IEA Headquarters in Paris.

2. Activities in the framework of Annex III, Subtask C

2.1 Tasks and targets

The overall aim of this Subtask is to provide an information framework for the project planning and construction of the first commercial HDR plants. The resulting information collection will be assembled to create a Project Management Decision Assistant (PMDA). The concept includes documenting the availability of special tools and services and assembling 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 worldwide since the early 1970's.

Four activity domains have been envisaged from the start:

1. Generalising and improving the data indexing, archiving and presentation system developed over the four previous years. This has been largely funded by the Swiss participation in the European Hot Dry Rock Geothermal project. In 2001 a first usable version of the indexing, data archiving and literature archiving complex for the European project at Soultz-sous-Forets, Alsace was completed and issued. The Data Index concept has been well received internationally and the application distributed to several interested organisations
2. The first trial version of an index of suppliers of services and equipment was produced as an Excel application in 2000. No work could be done on this subject in 2001.

3. An HDR-specific literature index, containing well over 2000 entries with keywords under 11 separate headings, was also not further developed in 2001. It is proposed to convert the root version , created and assembled in an EndNote library, to a user-friendly, generally accessible document form.

4. To formulate an HDR Project Management Decision Assistant, a generic project was conceived. Over the past four years, using direct experience derived from past and present R & D work throughout the World, a concept has emerged and data requirements for the initial phases of a project have been collected. In 2001 a formalised data structure could finally be shown. This has served as a base for creating a user-friendly and accessible document to fulfil the same requirements as as the literature collection above.

2.2 Assembling Data relevant to the plant site

2.2.1 General remarks

The data necessary for and arising from the selection and design of a surface site (or sites) requires most careful consideration, since the site is used for different purposes during each phase of the project. In 2001 work on surface installations concentrated on the preparation of (a) a list of the main technical characteristics of a basic HDR power plant, and (b) an inventory of surface equipment and installations required during construction and during operation.

Although we attempt in setting up the virtual project to include conditions and requirements as general as possible we are often forced to use local experience as examples (Basel, Geneva).

The inventory of surface equipment and infrastructure requirements has been continued and refined using data from literature and from the Deep Heat Mining project in Basel. The inventory includes area requirements for buildings, equipment, transport surfaces and storage areas. A first result is that the area needed during construction is larger than the area required for the installation of the surface equipment. In other words, part of the space required during the drilling phase can be used for other purposes once the plant is operating.

2.2.2 System parameters

The studies on the energy system include a compilation of basic parameters for a basic EGS plant with a reservoir accessed by one injection and two extraction holes drilled to approximately 5000 to 6000 meters. These values are used as input data for the comparison of various types of power plants. Preliminary studies so far include considerations of power plants for providing electrical power only, combined heat and power, and heat only. Besides purely geothermal power plants also combined systems with gas turbine topping cycle and ORC bottoming cycle are being studied.

In the following table 2.2-1 the design point values of the main parameters are listed. For most of these values at the present state-of-the-art there iexists a substantial uncertainty until the EGS system has been built and a stable water circulation has been achieved. This uncertainty is a main reason for the economic risk currently associated with EGS projects in the introductory phase of the technology. In the future, the uncertainty will be reduced as experience with experimental, pilot and commercial EGS systems is built up on varying types of site worldwide.

2.2.3 Energy utilization parameters

EGS power plants are of particular interest for the combined production of heat and power. Since even a "small" EGS system as described in 2.2.2 provides a heat production of several 10's of Megawatts the availability of heat consumers is essential. In regions of moderate and cold climates many cities have extensive district heating systems (DHS), which could absorb some tens or hundreds of MW of thermal power. In some places such as Iceland, DHS are already powered by geothermal heat. Elsewhere, most of the energy is provided by fossil fuels.

The quantity of heat that can be absorbed by a DHS depends upon the following main criteria:

- Heat demand characteristics (power duration curve)
- Availability of existing sources of heat (incineration plants, industrial waste heat, cogeneration plants)
- Heat injection and return temperatures

Since the EGS provides base load power, it is important that the number of full operation hours per year is as large as possible. The economics of a project are strongly dependent on this parameter.

In the following some results from a case study based on the DHS of the city of Geneva are given. The Geneva DHS is fuelled essentially by natural gas. In the future, the use of heat from an waste incineration plant, from a wood fired power plant and/or from an EGS is possible. The results for two cases are shown in table 2.2-2 and in the figs. 2.2-1 and 2.2-2.

These case studies illustrate the importance of a thorough analysis of the existing DHS and the other relevant (competing) heat sources. The presence of a base load heat source such as a waste incineration plant might considerably reduce the amount of heat energy a DHS could absorb from an EGS.

2.2.4 Environmental impact studies

Another very important aspect of site-related studies concerns environmental issues. Taking the DHM Basel project as an example, terms of reference for an environmental impact assessment have been outlined. The following table 2.2-3 gives an overview of the environmental aspects to be considered. This table refers to a site in a densely populated area. For an EGS project in a remote location, some of the listed criteria will be less relevant.
The detailed methodology of an environmental impact assessment depends on the local legislation (in Switzerland there is a general regulation by the federal government [UVPV] but the details are left to the Cantons).
Usually the assessment starts with an analysis of the situation without the project as a baseline. The changes caused by the construction and operation of the projected plant are then compared to the baseline.

The construction of an EGS system will result in a considerable environmental impact in a manner similar but on a smaller scale to that experienced with the construction of hydro-electric or nuclear power plants. During the operational phase these initial emissions are "recuperated" by the production of very low emission energy. In order to obtain a comprehensive ecological assessment of an EGS system, a Life Cycle Assessment (LCA) will be required.
The LCA is also required if the energy produced by the EGS is to be sold as certified "green power", e.g. in Switzerland under the label "naturemade basic" or "naturemade star" [AESE]. An internationally accepted LCA method is "Eco-indicator 99" [ECO99] which has been used for the assessment of other energy systems such as biomass power generation. The method includes two major tasks:

- Inventory of the emissions that will occur and of raw materials used during the life of a project
- Assessment of the impacts of these emissions and raw material depletions

There are LCA software tools available, which are compatible with the ISO 14040 [ISO] series recommendations.

1	**Primary loop**	Unit	Design point value
	No. of boreholes injection		1
	No. of boreholes extraction		2
	mass flow injection	kgs^{-1}	100
	water loss	kgs^{-1}	10
	overall pressure loss	Mpa	10
	Temperature at top of extraction hole	°C	200
	Temperature at top of injection hole (electricity prod.)	°C	120
	Temperature at top of injection hole (heat prod.)	°C	100
	Injection pump efficiency	%	0.75
	Injection pump input power	kW	*1333*
	Extracted thermal power (electricity prod.)	kW	*30146*
	Extracted thermal power (heat. prod.)	kW	*37683*
2	**Power conversion unit (PCU)**		
	Turbine inlet temperature	°C	185
	Condenser temperature	°C	20
	Cooling water inlet temperature	°C	15
	Cooling water outlet temperature	°C	20
	Cooling water mass flow	kgs^{-1}	1000
	PCU gross output	kW	4500
	PCU net output	kW	3000
	Waste heat thermal power	kW	*20935*
	No. of full operation hours/year	h	3000
	Net electricity production/year	MWh	*9000*
	No. of full operation hours/year	h	7000
	Net electricity production/year	MWh	*21000*
3	**District heating system (DHS)**		
	Main heat exchanger outlet temp.	°C	170
	Main heat exchanger return temp.	°C	100
	secondary loop mass flow	kgs^{-1}	*122.14*
	Thermal power injected into DHS	kW	*35799*
	Electric power consumption	MWh	6000
	No. of full operation hours/year	h	4000
	Net heat production/year	MWh	*143195*

Table 2.2-1: Design point values of the main EGS parameters (values in *italics* are calculated from the other values)

	Unit	Case A (fig. 1) EGS as base load	Case B (fig.2) Waste heat as base load, EGS as middle load
DHS Energy demand	GWh	142	142
Waste heat capacity	MW	5	5
Waste heat injection	GWh	0	43
EGS heat capacity	MW	20	20
EGS heat injection	GWh	119	90
EGS coverage of demand	%	84	63
EGS full operation hours	h	5950	4500

Table 2.2-2: EGS heat injection into a DHS without (case A) and with existing base load heat source (case B).

Environmental fields	**Possibly Relevant Aspects**
Water (groundwater, surface waters)	Contamination, change of ground water level and/or flow direction
Soil	Contamination, deposition and treatment
Air	Emission of pollutants, smoke and odour
Noise	Noise emission generated during construction, operation and related transports
Vibrations	Ground vibrations caused by construction, operation and related transports
Traffic	Change of traffic volume
Induced seismicity	Change of seismicity through activities in deep rock formations

Table 2.2-3: Overview of environmental aspects relevant to EGS projects in populated areas

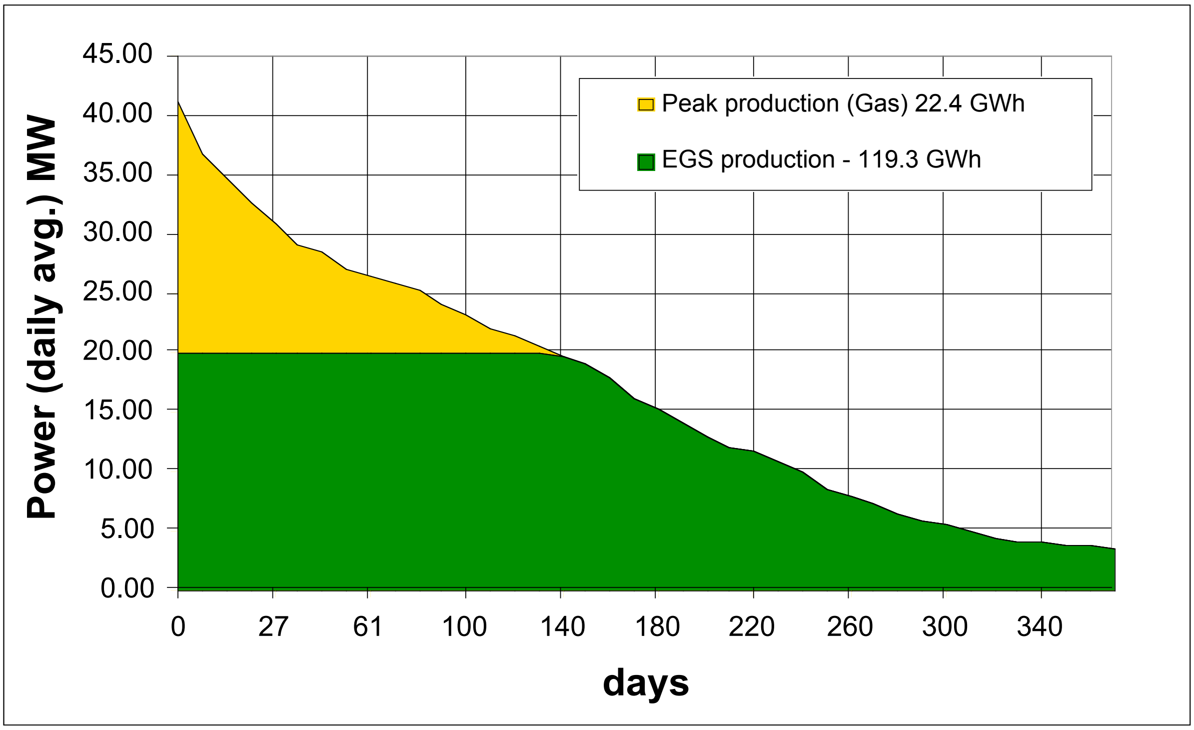


Figure 2.2-1: Power duration curves for DHS heat demand and possible EGS injection

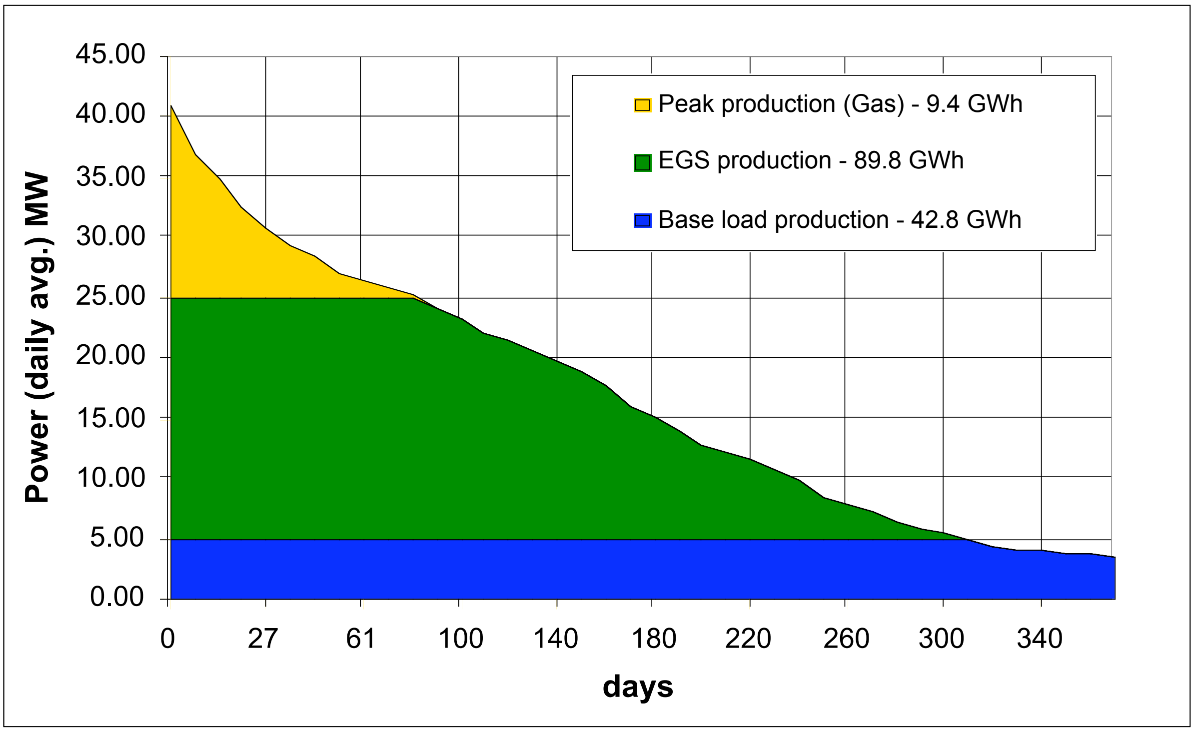


Figure 2.2-2: Power duration curves for DHS heat demand, base load heat source and possible EGS injection

2.2.5 References for section 2.2

[UVPV] Verordnung über die Umweltverträglichkeitsprüfung (UVPV, 814.011) vom 19. Oktober 1988 (Status on 28. March 2000)

[AESE] Association for environmentally sound electricity (AESE), CH - 8001 Zurich, www.naturemade.org

[ECO99] The Eco-indicator 99 - A damage oriented method for Life Cycle Impact Assessment Methodology Report 17 April 2000, Mark Goedkoop and Renilde Spriensma PRé Consultants B.V., NL-3821 BB Amersfoort

[ISO] www.iso-14001.org.uk/index.htm

2.3 The HDR/EGS literature collection

2.3.1 Introduction to the HDR/EGS literature database

This references database in the field of Hot Dry Rock technology (HDR) was first created in 1997 and has been under development since then. It includes all the terminology variations around HOT DRY ROCK, such as Hot Wet Rock (HWR), Hot Fractured Rock (HFR), Enhanced Geothermal Systems (EGS), Deep Heat Mining (DHM), etc.

The origins of the references collected and implemented in the database are diverse: GEOREF database, literature, scientific journals, proceedings of congresses, references lists from annual or final reports, references lists received directly from past or active HDR programs.

Table 2.3-1: Characteristics of the database

Name of the database	• **HDR_REF.enl** (EndNote Hot Dry Rock references database)
Version	• 01.03 (January 2003)
State of the database	• Total of 2'445 references
Code used	• Modified with EndNote 6 for Macintosh • EndNote is a Registered Mark of ISI ResearchSoft, Berkeley, CA, USA • See also : http://www.endnote.com/ for more information.
Compatibility	• EndNote (.enl) modified with EndNote version 6 for Macintosh is fully compatible with EndNote for Windows.
Trial version of EndNote	• If you do not have EndNote, you can find a trial version on this CD-ROM or download a free « trial version » : http://www.endnote.com/ for Macintosh or Windows. • The trial version works fully for one month, but switches to *search mode only* after this time. Installation is fast and simple!

EndNote provides a simple way to search online bibliographic databases and retrieve the references directly into EndNote. It specialises in storing, managing and searching for bibliographic references in an EndNote personal library. EndNote is capable of building up lists of cited works automatically, to insert citations into word processing documents and to scan those documents for in-text citations in order to compile a bibliography in any format. It is also possible to insert footnotes in a form compatible with Microsoft Word.

The great majority of the references concern one of the HDR past or present Hot Dry Rock programme, such as Fenton Hill (USA), Rosemanowes (UK), Bad Urach (D), Hijiori and Ogachi (J), Soultz-sous-Forets (F), Fjaellbacka (S), Deep Heat Mining (CH), Hunter Valley (AUS). However, a fair number of references are also taken from the literature dealing with conventional geothermal technology or hydrothermal systems.

EndNote references lists can be edited in Word to conform with a great number of types of formats corresponding to existing journals, most of them already pre-selected in EndNote.

Each reference is filed into a reference type: journal article, book, book section, edited book, newspaper article, conference proceedings, thesis, personal communication, computer programme, report, map, etc.

All reference data are organised around different fields, according to the reference type: author, year, title, journal name, volume, issue, pages, date of the conference, publisher, ISBN/ISSN, edition, label, keywords, notes, abstract, etc.

2.3.2: Search of references

EndNote is a powerful tool for searching specific references. Requests can be carried out on any field or on specific field(s), such as author, year and keywords for example. Keywords can be of course localised in the keywords field (about 4'100 keywords), but also in the label field (17 labelling words), or even in the title itself or in the abstract.

In the **HDR-REF** database, the references can be sorted by means of one label registered in the labels field, which allows to search for a category of topics:

100% of the references have a label in the labels field (see list of labels below),
100% of the references have keywords in the keywords field,
29% of the references have an abstract.

Table 2.3-2: Total number of references per period

Period	No. of references
2002-1998	339
1997-1993	752
1992-1988	628
1987-1978	538
< 1978	151
year unknown	37
Total	**2445**

Table 2.3-3: References per label and covered topics

Label	Topics covered	No. of refs.
corrosion + scaling	corrosion, scaling	62

drilling	drilling technology, well completion, well equipment	215
economics	financing, economic modelling	49
energy production	electricity production, heat production	11
environmental aspects	surface and underground environmental aspects, air, water, soil	34
geochemistry	hydrochemistry, chemical monitoring, tracer tests, geochemical modelling	478
geology	geology, tectonics, petrology, fractures analysis	116
geophysics	well logging, seismic monitoring,	454
geothermics	heat flow, heat exchange, HDR program, general aspects	393
hydrogeology	regional hydrogeology	18
legal aspects	energy policy	3
planning	programming, meetings, progress reports	79
powerplant	heating plant, power plant	7
public relations	promotion, advertising	8
reservoir engineering	reservoir creation and development, flow tests, packers	272
rock mechanics	stress field, rock properties, tests	141
thermo-hydraulic modelling	reservoir modelling	105
Total: 17 labels		**Total: 2'445**

2.3.3 Summary of progress

During the past year, further progress is being made with the bibliography of HDR / EGS. In 2001 the HDR-REF database contained 2180 references and was prepared under EndNote 3.1 for Macintosh, but fully compatible with Windows. The database has been now adapted to the version 6.1. At the end of 2002, the literature database contains 2445 references and all remaining double references have been removed. The additional references mainly originate from the World Geothermal Congress 2000 in Japan, from the Stanford Geothermal Workshop on Reservoir Engineering (1975 to 2001) and from a recent list of references from the Soultz-sous-Forêts EGS project.

Although EndNote is the most powerful and versatile tool for creating, managing and using a large literature database, its use is unfortunately limited to universities and research laboratories. Recently, it was found that a run-time version of EndNote is available. Therefore, a CD-R of the updated database is being created, including the run-time version of EndNote, which allows numerous functionalities. Finally, the latest version of EndNote permits both HTML and WORD documents also to be created. In order to be able to put this HDR/EGS literature on an Internet site, the HTML version will also be supplied.

A copy of the CD-mounted literature database is an Annex to this report.

2.4 Presentation of data requirements for a generic HDR/EGS plant

Apart from the continuing collection of data required at each stage of an HDR/EGS plant's construction and life, as for example the on-going work concerning the site aspects **(section 2.2, above),** efforts are being made to develop the most appropriate form for presentation of project data requirements and data flow to make them of practical use.

2.4.1 Modifications to the database matrix developed in 2001

The data structure developed in 2001 and before, based on phases of the complete life cycle of the plant has proved itself to be a good and robust starting point for a simple reference document in electronic or paper form. The concept of a database application with which the first tentative data structure analysis was made has now been completely abandoned.

2.4.2 The new HDR/EGS-PMDA Data Listing tool

The HDR/EGS-PMDA-tool must have the following features:

- It must be convertible/exchangeable between different computer platforms/ operating systems (Mac-OS and Microsoft Windows)
- It must be simple in its use, without special knowledge
- Appending and modifying data must be easy

It has been decided that a programmed spreadsheet application using Microsoft EXCEL will fulfil all these needs best.

The Data Listng application consists of one main sheet with the database matrix and five sheets with lists of the data codes used in the database matrix and corresponding explanatory text (see Figure 2.4-1 on the following page). The data codes in the database matrix and the texts in one of the five lists are referenced automatically by a VBA-code each time a data cell in the database matrix is selected. This simple text-based referencing allows the user to introduce, delete and modify data codes in the database matrix and in the corresponding text lists in a completely arbitrary and free way.

The application allows the user to scroll to the project phase and the activity domain currently being planned and to check on the necessary information packets.

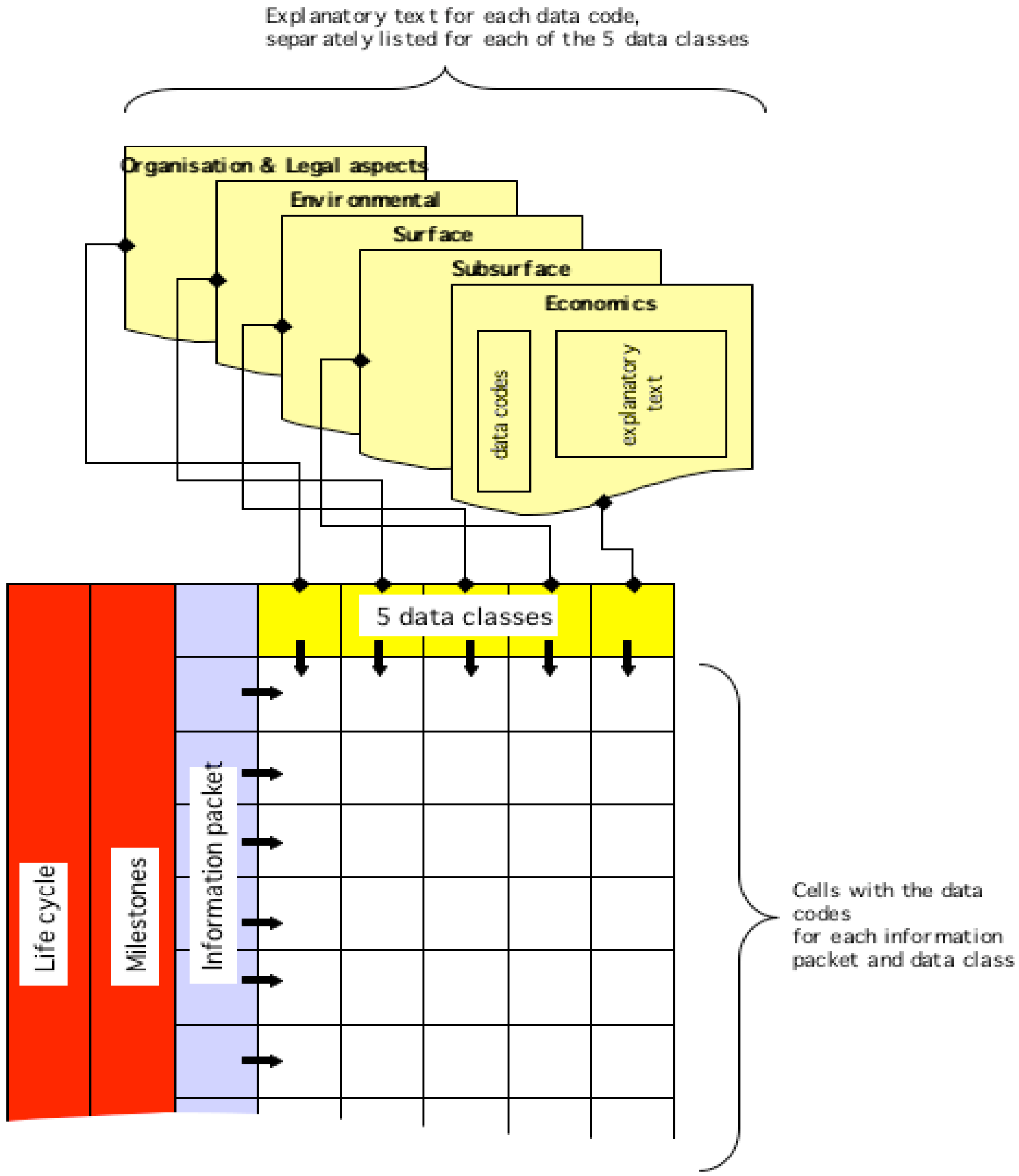


Figure 2.4-1: Current state of the data structure

The principle of the PDMA Data Listing application is as follows (see also figure 2.4-2):

1. Information packet:

   This column contains all information packets needed to reach the subsequent milestone. The information packets are ordered in 3 classes of project tasks, each of which is allotted a class code:

l	Predominantly legal tasks
t	Predominantly technical tasks
e	Predominantly economic tasks

   Even the class of predominant task may give a hint which class of data are mainly needed to work out a specific information packet, data from all data classes could be principally involved. The class code of a particular project task suggests also the kind of codename for the information packet in question.

   Thus each information packet receives an identifying data codename, as explained by the following example:

   Codename cl1_04:

c	concept phase (life cycle)
l	predominantly legal task
1	go/no-go information packet, 2: principal resolvable
_04	running number

2. Data cell:

   The data cells contain the data codes for a specific information packet. An arbitrary number of data codes can be introduced. (new line in an Excel cell by entering Alt-Return). Selecting a data cell automatically starts the search for the corresponding explanatory text and prints it out in an output field situated at the top of the database matrix sheet.

3. List of explanatory text for the data codenames:

   The explanatory text for a data codename is entered in the corresponding Excel sheet. The only constraints are that empty cells between two data codenames are not allowed and each codename must be unique.

4. Output of the selected data cell:

   The explanatory text for the data codenames in the selected cell are read out and printed in the output field at the top of the database matrix sheet.

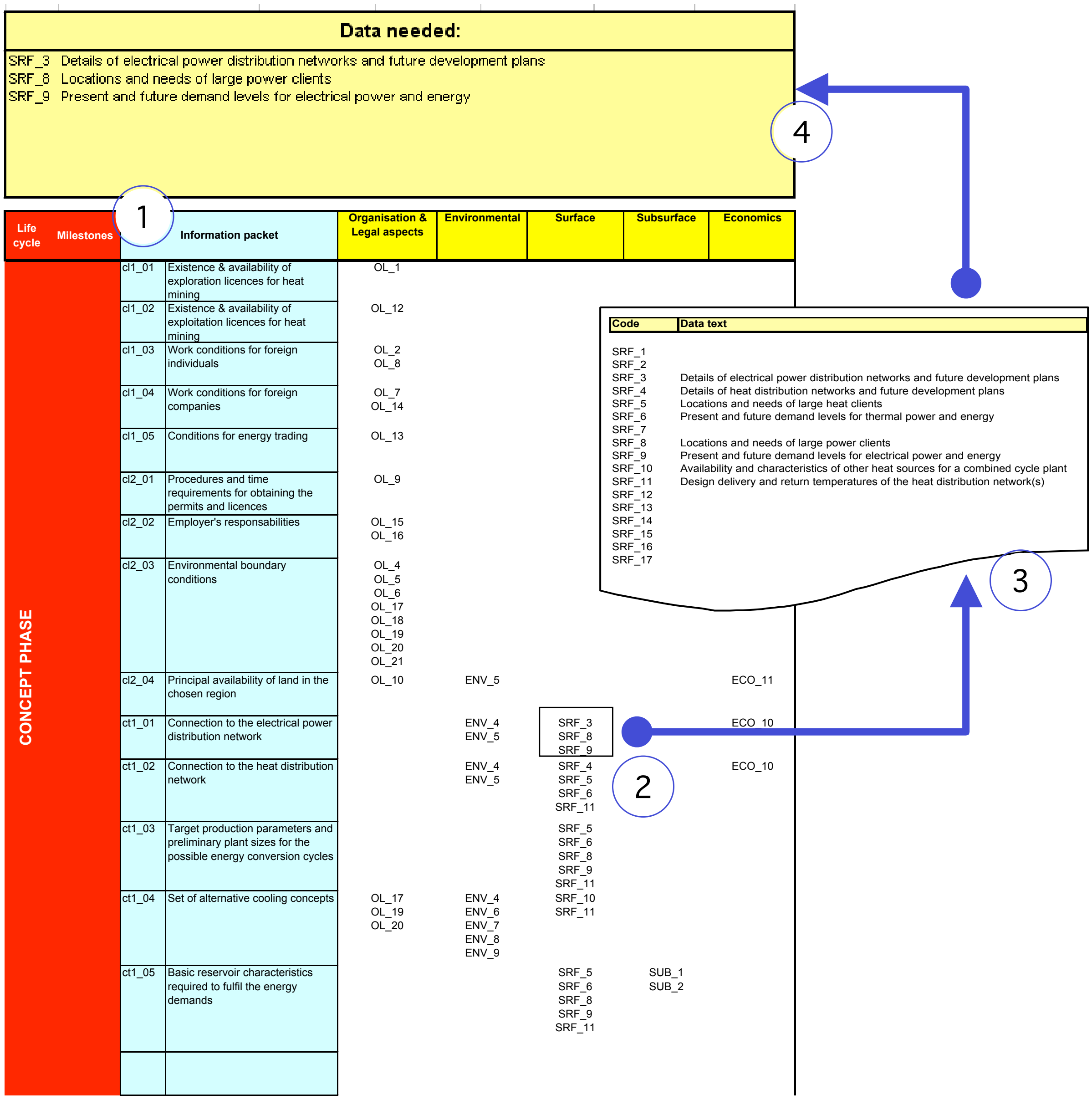


Figure 2.4-2: Principle of the Data Assistant in its present showing the hyperlinks to levels of increased detail. At present only two levels are included.

Life cycle	Milestones	Information packet		Organisation & Legal aspects	Environmental	Surface	Subsurface	Economics
CONCEPT PHASE		cl1_01	Existence & availability of exploration licences for heat mining	OL_1				
		cl1_02	Existence & availability of exploitation licences for heat mining	OL_12				
		cl1_03	Work conditions for foreign individuals	OL_2 OL_8				
		cl1_04	Work conditions for foreign companies	OL_7 OL_14				
		cl1_05	Conditions for energy trading	OL_13				
		cl2_01	Procedures and time requirements for obtaining the permits and licences	OL_9				
		cl2_02	Employer's responsabilities	OL_15 OL_16				
		cl2_03	Environmental boundary conditions	OL_4 OL_5 OL_6 OL_17 OL_18 OL_19 OL_20 OL_21				
		cl2_04	Principal availability of land in the chosen region	OL_10	ENV_5			ECO_11
		ct1_01	Connection to the electrical power distribution network		ENV_4 ENV_5	SRF_3 SRF_8 SRF_9		ECO_10
		ct1_02	Connection to the heat distribution network		ENV_4 ENV_5	SRF_4 SRF_5 SRF_6 SRF_11		ECO_10
		ct1_03	Target production parameters and preliminary plant sizes for the possible energy conversion cycles			SRF_5 SRF_6 SRF_8 SRF_9 SRF_11		
		ct1_04	Set of alternative cooling concepts	OL_17 OL_19 OL_20	ENV_4 ENV_6 ENV_7 ENV_8 ENV_9	SRF_10 SRF_11		
		ct1_05	Basic reservoir characteristics required to fulfil the energy demands			SRF_5 SRF_6 SRF_8 SRF_9 SRF_11	SUB_1 SUB_2	
		ce2_01	Estimating personnel costs	OL_15 OL_16				ECO_8 ECO_9

Figure 2.4-3: Overview of the data packages so far identified as necessary at the present stage of development for the project concept phase

Life cycle	Milestones	Information packet	Organisation & Legal aspects	Environmental	Surface	Subsurface	Economics
CONCEPT PHASE							
	Start site exploration	A concept for a certain region, including political, technical, financial and environmental considerations has been developed. Decision whether or not to proceed to detailed exploration and selection of sites.					
EXPLORATION PHASE							
	Start reservoir exploration	A plant site and potential sites for monitoring wells have been selected, based on the subsurface data acquired and analysed. Decision whether or not to invest now in extending exploration down to the depth needed for the conceptual reservoir.					
	Extend reservoir exploration	Necessary reservoir depth, orientations of injection/production wells and suitable positions of further monitoring wells have been fixed. Decision whether or not to continue the reservoir exploration at depth.					
	Start development phase	Feasibility of creating an adequate HDR reservoir/heat exchanger has been demonstrated. Decision to complete the reservoir and to build the surface plant					
DEVELOPMENT PHASE							
	Start production phase	The HDR reservoir/heat exchanger has been developed and tested and surface plant installed and tested. Decision to start production.					
PRODUCTION PHASE							
	Reservoir re-development	The history of reservoir depletion allows the end of its lifetime to be predicted. Decision whether or not to invest in a redevelopment programme.					
	Start abandonment phase						
ABANDONMENT PHASE							
	End abandonment phase						

Figure 2.4-4: Overview of the milestones outlining the structure of the virtual project

In the following tables the lists of data package names are linked with the code names seen in the top view. The tables are incomplete, but may receive additions at will. From this fact the open nature of this EXCEL application for a user may be seen:

Table 2.4-1: Organisational aspects

Code	Data text: Organisation&legal aspects
OL_1	Laws and permits relevant to drilling and exploring the underground
OL_2	National/Local immigration laws and practices concerning work permits for foreign experts and wor
OL_3	National/Local policy
OL_4	Codified constitutional laws for environmental protection
OL_5	Laws or regulations concerning the need for an environmental impact study
OL_6	Regulations for use and protection of groundwater
OL_7	Conditions imposed on foreign companies working in the country
OL_8	Tax laws concerning short term foreign residents
OL_9	Experiences with relevant authorities
OL_10	Land ownership register
OL_11	
OL_12	Laws and permits relevant to exploiting the underground
OL_13	Regulations for the energy market
OL_14	Import conditions on construction machinery and plant building materials
OL_15	Health and safety regulations
OL_16	Labour laws & trade union requirements
OL_17	Regulations for use and protection of surface waters
OL_18	Limits for noise loading
OL_19	Regulations for protection of air quality
OL_20	Regulations for limiting aesthetic impacts
OL_21	Waste disposal laws and regulations
OL_22	
OL_23	

Table 2.4-2: Environmental aspects

Code	Environmental: Data text
ENV_1	
ENV_2	Groundwater impact
ENV_3	Landscape protection impact (in case of cooling tower)
ENV_4	Areas of natural beauty and nature reserves
ENV_5	Existing and proposed land usage plans and zoning
ENV_6	Sizes and locations of surface water bodies
ENV_7	Annual & seasonal average temperatures of surface water bodies
ENV_8	Annual, seasonal & diurnal average air temperature profiles
ENV_9	Land requirements for each cooling option
ENV_10	
ENV_11	
ENV_12	
ENV_13	

Table 2.4-3: “Surface” data packages

Code	Surface: Data text
SRF_1	
SRF_2	
SRF_3	Details of electrical power distribution networks and future development plans
SRF_4	Details of heat distribution networks and future development plans
SRF_5	Locations and needs of large heat clients
SRF_6	Present and future demand levels for thermal power and energy
SRF_7	
SRF_8	Locations and needs of large power clients
SRF_9	Present and future demand levels for electrical power and energy
SRF_10	Availability and characteristics of other heat sources for a combined cycle plant
SRF_11	Design delivery and return temperatures of the heat distribution network(s)

Table 2.4-4: “Subsurface” data packages

Code	Subsurface: Data text
SUB_1	Estimate/measurements of temperature against depth
SUB_2	Literature
SUB_3	Estimate/measurements of stress field
SUB_4	Estimate/measurements of subsurface water chemistry
SUB_5	Seismic reflection lines
SUB_6	Lithology
SUB_7	Fracture orientation
SUB_8	Geological structure

Table 2.4-5: Economics-related data packages

Code	Economics: Data text
ECO_1	Cost estimate for constructing the whole plant
ECO_2	Cost estimate for the operational phase
ECO_3	Principal availability of investment capital
ECO_4	Prices of energy conversion systems
ECO_5	Estimated interest rates for the whole life cycle
ECO_6	Estimated future energy prices
ECO_7	Risk analysis
ECO_8	Salary levels and social costs
ECO_9	Workforce acommodation costs
ECO_10	Unit costs for central construction, external connections and equipment
ECO_11	Average prices of land for industrial use
ECO_12	Specific prices of short-listed land parcels
ECO_13	Unit costs for geophysical survey campaigns
ECO_14	
ECO_15	
ECO_16	

3. Swiss participation in further subtasks & other activities in Subtask C

Because the NEDO budget has been reduced to 10 million yen, technical and scientific work serving the GIA has now largely ceased in Japan, including the potentially interesting work on Annex III, Subtask D.

In the light of this situation any participation in Subtask D has been no longer possible in 2002.

At the same time there is no further NEDO funding available at present to continue work on Subtask C. The EGS field research projects at Hijiori and Ogachi have been stopped, but efforts are underway to obtain a special credit for documenting and archiving the large amount of data collected over at least 15 years from experimental work on the Hijiori project.

The available budget will serve to fund practically only administrative expenses. METI, now responsible for this funding, assures the GIA that Japan will continue as OA (Operating Agent) for Annex III, at least for the next one or two years.

In Europe the Data Index for the Soultz project continues to be built up by the on-site project team.

4. International contacts

In Australia the research group from the Australian National University (ANU) in Canberra has made considerable progress with its first project. A contracting company, Geodynamics Ltd was registered in November 2000. Exploration rights for geothermal heat resources, a new concept compared with the traditional mineral rights, which has had to be developed together with state authorities, have been granted for two regions in the Hunter Valley in New South Wales and two more in South Australia in the highly promising Cooper Basin on the borders of South Australia and Queensland.

Geodynamics has signed a comprehensive co-operative research services agreement with the CSIRO. The aim is to gain access to expertise within the CSIRO and to avoid fragmentation of HDR efforts in Australia.

The favourable reactions to their proposals and the potential of the selected exploration tenements have led to the launch of Geodynamics Ltd on the Australian Stock Exchange on September 12th of this year..

The Company's business plan is based on three stages, (i) development of an underground heat exchanger; (ii) development of a demonstration HDR geothermal power plant (10-15MWe) and (iii) a commercial scale HDR geothermal power plant capable of generating 100's of megawatts.

The company now has gross funds of $Aus 16.5 million for the first stage of their development programme, including a start-up grant from Ausindustry. This will be used for the "Proof of Concept" development of the underground heat exchanger in the Cooper Basin at a depth of 4400m. The region contains a massive source of energy and is, in principle, capable of generating 1000's of MW's of electricity. Local electricity requirements are low, with 25MWe used for processing and transport of the Cooper Basin oil and gas production

5. Swiss contribution to the shared GIA secretariat

During the extended period of activity of the GIA, it was decided to maintain a common secretariat, a task previously undertaken by Dr. J. Garnish of the CEC in Brussels, now retired. The costs of this exercise have been estimated and distributed amongst the participants on the basis of the OECD “cost sharing” key. The cost repartition has now been made and billed as planned, individually to the participating nations.

6. Next steps in Annex III, Subtask C

In 2002, ways forward have been found for arranging and presenting the HDR literature collection and for the development of the HDR-PMDA and its mode of presentation. Considerable progress has been made in collecting site-related data requirements of all types.

In 2003 it is proposed to continue adding information and refining the details of all of these aspects of Subtask C.

It is furthermore the intention to encourage the continued build-up of a Data Index and data archives for all other active EGS projects.

Appendix 1

INTERNATIONAL ENERGY AGENCY

Geothermal Implementing Agreement (GIA) - Annual Report 2001

L. Rybach *(ETH Zurich/Switzerland; GIA Executive Committee Chairman in 2001)*
J. Garnish *(CEC Brussels/Belgium; GIA Executive Committee Secretary)*

BACKGROUND

The IEA Energy Technology Collaboration Programme (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 three 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 was designed to operate for five years. The first phase ends on 6 March 2002; the prolongation of GIA for another five years has been approved by REWP and CERT in late 2001.

NATURE AND OBJECTIVES

The GIA represents an important framework for a broad international co-operation in geothermal R & D. It brings together significant national programmes and focuses especially on assembling specific know-how and generating synergies by establishing direct co-operative links between geothermal groups/specialists in the different Participating Countries.

A first Strategic Plan for the GIA was established in 1997 and reviewed subsequently by the REWP in 1998; the Discussant confirmed that the GIA activities are well on track. At the 6th ExCo meeting (Brussels, March 2001) the ExCo addressed a new Strategic Plan which is outlined in **ATTACHMENT 2**.

The GIA encompasses practically all kinds of geothermal technology: besides "traditional" uses like power generation and direct use of heat, new technologies (hot dry rock, deep resources) are also covered.

The present phase of the GIA (7 March 1997 – 6 March 2002) operates under the task-sharing mode of financing.

Task/Annexes

Currently there are three active Annexes that started in March 1997:

- *Annex I: Environmental Impacts of Geothermal Energy Development* (3 Subtasks)

  The Work Plan of Annex I was designed for 4 years. Operating Agent is the Institute of Geological and Nuclear Sciences, Ltd. (New Zealand); Task Leader is T. Hunt (IGNS Wairakei).

- *Annex III: Hot Dry Rocks* (4 Subtasks)

  The Work Plan of Annex III was designed for 4 years. Operating Agent is the New Energy & Industrial Technology Development Organization (NEDO, Japan). Task Leader was M. Kuriyagawa (NIRE Tsukuba) until 31 March 2001; his successor is I. Matsunaga from the same Institution.

- *Annex IV: Deep Geothermal Resources* (3 Subtasks)

  The Work Plan of Annex IV was designed for 4 years. The Operating Agent during this period was NEDO (Japan). Task Leader was K. Kimbara (Geological Survey of Japan) from the beginning until February 2000 when M. Sasada (GSJ, Tsukuba - now AIST) took over. NEDO stood down as Operating Agent for this Annex at the end of 2001.

These three Annexes were prolonged for another four years by the GIA Executive Committee (ExCo) in 2001.

A new Annex has been started in 2001:

- *Annex VII: Advanced Geothermal Drilling Techniques* (3 Subtasks)

  The Work Plan of Annex VII is designed for 4 years. Operating Agent is Sandia National Laboratories (USA), Task Leader is J. Finger (Albuquerque)

Detailed Annual Reports of these, prepared by the Task Leaders, are given in **ATTACHMENTS 3** to **6.** The Annual Reports are organized in the following format:

- Introduction
- Work performed in 2001
- Work plan for 2002
- Output (publications).

During 2001, the Executive Committee has considered also the following additional Annexes:

- Annex V: Sustainability of Geothermal Energy Utilization
- Annex VI: Geothermal Power Generation Cycles
- Annex VIII: Direct Use of Geothermal Energy
- Annex IX: Geothermal Market Acceleration

The status of the preparations is different. Special emphasis was given to Annex IX (see below).

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 at present under the task-sharing mode of funding.

Objectives

Article 1 of the GIA defines 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 its environmental drawbacks".

These will all contribute to the broader (but unstated) goal of encouraging the wider use of the geothermal energy option.

PARTICIPATION

At present, 11 countries (Australia, Germany, Greece, Iceland, Italy, Japan, Mexico, New Zealand, Switzerland, United Kingdom, USA) and 1 international organization (Commission of the European Communities, CEC) have signed the Agreement.

The involvement of the Participants in the different Annexes is shown in Table 1 (below). 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 is making an effort to harmonize this situation.

Member Countries

In order to extend the GIA further the ExCo is investigating a possible participation of France and Sweden.

Non-Member Countries

Contacts to China, Turkey and the Philippines to join the GIA are sustained. In fact, Philippine scientists already participate actively in the work of Annex I and IV; their involvement has significantly broadened the range of data and experience available to the formal participants. Input from Turkey would have a similar effect in Annex I.

Table 1. Task participants as of February 2002

Participating country / organization	Annex I (Environment)	Annex III (Hot Dry Rock)	Annex IV (Deep resources)	Annex VII (Advanced drilling)
Australia		**P**	**P**	
CEC		**P**		**P**
Germany		**P**	**P**	
Greece	**P**			
Iceland	**P, I**			**P**
Italy	**I**	**I**	**I**	
Japan	**P**	**P**	**P**	**P**
Mexico	**P**		**P**	**P**
New Zealand	**P, I**		**P, I**	**I**
Switzerland		**P**		
United Kingdom		**I**		
USA	**P**	**P**	**P**	**P**

Key: P = publicly-funded research institute or university I = industry

ExCo ACTIVITIES

Composition

There were no changes in composition in 2001 except that the UK representatives have exchanged roles: Andy Jupe is now the Member and Alan McGovern the Alternate.

Meetings

The list of current ExCo members and Alternates is attached (see **ATTACHMENT 1**).

The ExCo had one Meeting in 2001: on 8 and 9 March in Brussels, Belgium, organized and hosted by ExCo Secretary John Garnish (CEC). At this Meeting

- The Executive Committee approved by unanimity an extension of the Geothermal Implementing Agreement with a new termination date of 31 March 2007.
- The Executive Committee approved by majority vote the extension of Annexes I, III, and IV (on Environmental Impacts, Hot Dry Rock and Deep Geothermal Resources respectively) with new termination dates of 31 March 2006.
- The Participants in Annex I (Environmental Impacts) and Annex IV (Deep Geothermal Resources) agreed unanimously that the entities designated by the US Contracting Party could participate in these Annexes .
- The Executive Committee agreed unanimously to the withdrawal of the Commission of the European Communities from participation in Annex IV on Deep Geothermal Resources.

A further ExCo meeting was organized to be held in Cuernavaca/Mexico on 12-13 November but it had to be cancelled due to the international political situation in the wake of the 11 September event.

Renewable Energy Working Party (REWP)

- On January 23-24, 2001 in Paris the GIA contributed through its ExCo Chairman to the REWP Cabinet meeting with Renewable Energy Implementing Agreement Chairmen on Renewable Energy Market Acceleration.
- A further GIA contribution was presented at the REWP meeting in Paris on 4 April 2001 by the ExCo Chairman.

These contributions were strongly assisted by the IEA Secretariat (Rick Seller, Laurent Dittrick, Johan Wide).

IEA Market Initiative

Special emphasis has been given in 2001 to the preparation of Annex IX (Geothermal Market Acceleration), especially in view of the well-initiated GIA/UNEP/GEF alliance (see below). A Draft Annex has been prepared by the USA Participant and it is now under consultation within the ExCo.

Alliance with World Bank / UNEP-Global Environment Facility (GEP)

On March 7, 2001 a well-attended co-ordination meeting was hosted by the European Commission in Brussels, jointly organized by GEF and GIA. It was decided that GIA and GEF will join forces in global geothermal market development and form a strategic partnership collaboration. In particular, the objectives and the follow-up agenda/schedule for the GIA-GEF Alliance were agreed. Details are recorded in the Minutes of the 6^{th} ExCo meeting.

The alliance will undertake focused efforts in regions with high geothermal potential like Central & Latin America and Central and Eastern Europe, followed by selected developing countries.

The conditions of collaboration with GEF will be discussed case by case. Generally, for agreed actions GEF will provide 50 % of the project sum.

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 become clear that the increasing scope of activities under the GIA, and particularly the implementation of Annex IX, will require greater resources than can be supplied by the present ExCo Secretary. To carry out the proposed new tasks (e.g. GIA brochure, website, administration of Annex IX) will need a dedicated Secretariat and a Common GIA Fund. The ExCo has agreed to the principle of this enhanced activity and changed method of working, but details (e.g. level of funding) have yet to be agreed formally between the Participants. In any case, an enhanced working level of the ExCo will be inevitable in the planned new phase of GIA.

Dissemination of Results

The GIA follows the normal methods of disseminating research results: publications in scientific/ technical journals and Conference Proceedings. In addition, a draft GIA Website has been prepared by the UK Participant and is now under review within the ExCo.

PLANS FOR 2002

GIA

The GIA Strategic Plan needs to be further developed and expanded to include the definition of long-term goals and the means of their accomplishment by the GIA Participants.

The visibility of GIA work and results needs to be revised, improved and enhanced, especially to explain to non-experts the contributions GIA is making and the strategy for collaborative technology development, deployment, information dissemination, and market acceleration.

The new phase of GIA (2002-2007) might face some uncertainties. The first phase (1997-2002) has shown – and there are some signs for the immediate future too – that governmental funding of geothermal R&D at the national level can be unstable and unpredictable. Besides the year-to-year changes there are contrasting tendencies and trends: whereas in some countries the funding has decreased successively other countries are speeding up their geothermal efforts. These somewhat unclear perspectives call for a strong dedication and efforts in the next phase of GIA activities.

Annexes

For the corresponding plans of the individual Annexes see **ATTACHMENTS 3 – 6.**

Executive Committee

The ExCo will have to find a new Chairman as well as a Secretary for 2002 and beyond.

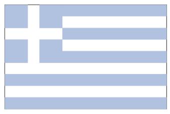
Appendix 2

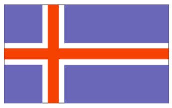
International Energy Agency
Geothermal Implementing Agreement
Strategic Plan for 2002-2007

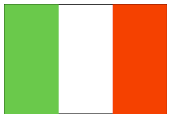
Member Countries

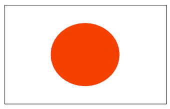
 Australia

 Germany

 Greece

 Iceland

 Italy

 Japan

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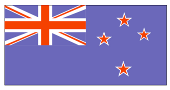
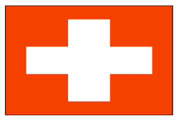
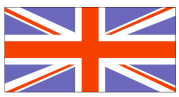
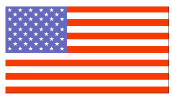
 New Zealand

 Switzerland

 United Kingdom

 United States

 Commission European Communities

Draft 9-30-02

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DISCLOSURE

This document was prepared by Clifton Carwile and Dan Ancona of Princeton Energy Resources International (PERI), under the direction of the International Energy Agency Geothermal Implementing Agreement Executive Committee. Valuable assistance was rendered by Dr. John Garnish, interim Chairman of the Executive Committee; Dr. Allan Jelacic, Vice-Chairman; Professor Ladislaus Rybach, Vice-Chairman; and Dr. George Frye, interim Secretary. PERI is located at 1700 Rockville Pike, Suite 550, Rockville, Maryland 20852 USA.

International Energy Agency
Geothermal Implementing Agreement
Strategic Plan

1.0 INTRODUCTION

1.1 Background

This document is the Strategic Plan for the Geothermal Implementing Agreement, conducted under the auspices of the International Energy Agency (IEA), for the period 2002 through 2007. The IEA Implementing Agreement for a Cooperative Programme on Geothermal Research and Technology (Geothermal Implementing Agreement) (GIA) is one of a number of Implementing Agreements established by the IEA Committee on Energy Research and Technology (CERT), through its Renewable Energy Working Party (REWP). The IEA is an autonomous body, established in November 1974 within the framework of the Organization for Economic Co-operation and Development (OECD) and its 26 member countries.

The IEA Energy Technology Collaboration Programme (ETCP) has included Implementing Agreements with geothermal objectives in the past, such as the 'Man-Made Geothermal Energy Systems Project' (MAGES), 1978 - 1980 and 'Geothermal Equipment Testing', 1979 – 1981. But there were no such activities in succeeding years until 1995, when the IEA Secretariat in Paris initiated an effort to revive geothermal activities. At an ad-hoc meeting in May 1995, convened in conjunction with the World Geothermal Congress in Florence, Italy, representatives of 14 countries expressed general interest in international collaboration under the IEA ETCP umbrella. An IEA Geothermal Expert Panel was formed, specifically to formulate IA Annexes. At two subsequent meetings in Paris (November 1995 and April 1996) the text for the Agreement and three technical Annexes were formulated with the assistance of the IEA Secretariat. The GIA was signed and officially went into effect on March 7, 1997 and was designed to operate for an initial period of five years. The Agreement was subsequently extended, with the approval of the CERT and REWP, until March 31, 2007. At present, 11 countries; Australia, Germany, Greece, Iceland, Italy, Japan, Mexico, New Zealand, Switzerland, United Kingdom, and the United States, along with the Commission of the European Communities (CEC), have signed the Agreement.

The IEA Ministers Communiqué of May 2001 and their position on energy provide the context for the GIA work program. The Ministers stated; "We intend that renewable energy should play an increasing role and accept the European Union's invitation to collaborate in a concerted effort to give new impetus to both the diversity and the efficiency of all forms of energy." They went on to say that energy is an essential ingredient of human progress and prosperity and economic development requires access to secure and affordable energy. Many countries have made significant progress on energy-related policies and actions through commitment to market and regulatory reform. This has contributed to reduced costs and greater efficiency in energy use and has also helped create new opportunities for innovative energy solutions. Technological developments are improving prospects for greater energy efficiency, broader commercial application of cleaner fuel technologies, renewable energy and combined heat and power generation. In light of these considerations and circumstances, the Ministers affirmed the importance of the guiding principles of the IEA shared goals of energy security, environmental protection and economic growth as essential to sustainable development. They further stated that new and flexible responses are required if these goals are to be reached. Geothermal energy can play a major role in furthering a wide range of policy goals. Geothermal energy would make a useful long-term contribution to diversity, security and self-sufficiency of energy supply. It would also provide a platform for long-term cooperation with less developed countries, where energy demands are expected to grow dramatically in the coming years.

1.2 Status of Geothermal Energy

Geothermal energy can provide electric power or direct heat for applications such as district heating, greenhouse heating, aquaculture pond heating, agricultural drying, industrial processes, bathing and swimming, and snow melting. In addition, geothermal heat pumps offer an energy-efficient, environmentally-compatible means of heating and cooling Geothermal for electricity and direct heat applications is a mature technology with a long history in many countries. A large fraction of current geothermal energy deployment is in developed countries, while much of the untapped energy resources occur in developing countries. Barriers such as high initial capital costs, resource risks, and drilling limitations pose a challenge to future development. Investment in geothermal R&D, which is primarily supported by the public sector, has dropped considerably in recent years due primarily to competition from lower-cost alternatives, such as natural gas.

Capital costs for electrical generation plants and associated infrastructure have decreased since 1980; however, it is not likely that capital costs will be reduced much further without substantial new investment in R&D. Improvements in operating procedures and further research into scaling and corrosion problems could reduce operation and maintenance costs. The costs per unit of electricity are therefore likely to decrease, but not significantly. Direct use of geothermal energy is based on established technology, which offers minimal potential for significant cost reduction. Some improvements in scheme design, particularly optimized cascade systems, and scheme management could lead to a modest decrease in the cost per unit of heat. The future growth prospects for the technology are more likely to be determined by the identification of suitable markets, which require large base load electricity and heat demands. Given a significant resource, emphasis should be placed on market analysis and reservoir management.

Geothermal energy development worldwide increased between 1995 and 2000 from 6833 to 7974 MWe. There is thought to be potential for 45% growth in electricity generation between 2000 and 2010, largely because many suitable resources exist, particularly in developing economies of South-East Asia, Latin America, and Africa where demand for electricity is increasing rapidly. Geothermal energy could potentially supply 5% of electricity globally by 2020. A reasonable estimate of the future development potential for geothermal energy is 35000 to 73000 MWe worldwide. The world-installed capacity for direct heating was about 4700MW in 1980, 8664 in 1995 and 16209 in 2000. Future growth in the direct use of geothermal energy is expected to be modest. Opportunities exist, particularly in Central and Eastern Europe, but direct heating is only viable for resources that occur close to areas of high demand.

Clearly, the amount of hydrothermal resources in highly permeable, saturated rock formations is limited. However, there are large areas where the rock temperature exceeds 200°C at depths less than 5 km. In general, the permeability of these formations is low, so that new technology will be necessary to produce energy economically. Projects using such technology have recently become known generically as Enhanced Geothermal Systems (EGS). Since the 1970's, a number of research programmes have worked towards developing technology to exploit heat sources which lack sufficient fluid or permeability or both, first in the USA, Germany, and the United Kingdom, then also France, Japan, and Sweden. Recently, projects have begun in Australia and in Switzerland. Progress to date provides clear indications that the time has arrived for commercialization of Enhanced Geothermal Systems (EGS) energy production.

1.3 Barriers to Development

In the initial stages of renewable energy technology development, technical barriers predominate. However, for the more technically mature technologies, such as geothermal, the priority is to become cost-effective in the marketplace. Barriers to market penetration also can arise from a general lack of public awareness and experience with the technologies. Finally, there are social and environmental barriers linked to lack of experience with planning, regulation, and gaining public acceptance.

A major barrier, which limits the growth of geothermal energy, is the market's perception of cost. This results partly from the failure of the marketplace to fully internalize the external cost of competing conventional technologies, and partly from the market's discrimination against capital-intensive technologies. Another barrier is the difficulty of characterizing the geothermal resource in a country prior to a major commitment of financial resources. Like other renewable energy sources, energy from geothermal resources has significant positive environmental benefits at the global level; however, deployment can have a local impact, and projects do not always enjoy universal local support.

2.0 OBJECTIVES OF THE IMPLEMENTING AGREEMENT (2002-2007)

2.1 Overview

The GIA represents an important framework for broad international cooperation on geothermal issues, especially barriers to development. The Agreement brings together important national programmes and focuses especially on assembling specific know-how and establishing direct co-operative links between experts in the Participating Countries. The GIA is managed by an Executive Committee (ExCo) with members and alternates from each of the Contracting Parties.

Activities under the GIA are directed primarily toward the coordination of the ongoing national activities of the Contracting Parties. All R&D activities are carried out under annexes to the GIA. If the ExCo identifies specific issues that should be explored cooperatively, tasks that address those issues are organized into an annex to the GIA. Participating Countries have the option to join the annex as their ability to contribute and interests dictate. A background description of the annexes currently in place or under consideration can be found in the appendix.

2.2 Goals and Objectives

The Implementing Agreement, initially signed in 1997, states that the programme is to consist of international scientific collaborative efforts to:

- Compile and exchange improved information on geothermal energy research and development worldwide concerning existing and potential technologies and practices,
- Develop improved technologies for geothermal energy utilization and
- Improve the understanding of the environmental benefits of geothermal energy and ways to avoid or ameliorate environmental drawbacks.

These efforts, augmented with additional ones focused on increasing the use of geothermal energy, are considered appropriate for the next five years of the Agreement. The basic environment for the work of the IEA, including the GIA, has changed since 1997 and continues to evolve. This Strategic Plan reflects the actions underway or being considered in the GIA in response to market, management and government policy dynamics, as well as technological advances. The specific goal and objectives planned by the ExCo are summarized herein.

During this next term, the overall goal of the GIA will be to advance and support the use of geothermal energy on a worldwide scale such that at least 5 percent of new heat and power facilities constructed, planned or announced in developing countries use geothermal energy. In working towards this ambitious five-year goal, the ExCo will direct its efforts towards the following objectives:

Expand R&D collaboration – Geothermal energy technology development is progressing and new areas of collaboration are needed. Recently an Annex was added to the Agreement on geothermal well drilling. Other new technical Annexes are being considered on geothermal power cycles, geothermal resource depletion and sustainability, and on direct heat applications. The ExCo will consider and implement these additions and will continuously monitor and discuss the R&D needs of industry to determine areas where additional collaboration could be useful.

Increase outreach to Non-Member countries with large geothermal energy potential - The electricity markets in many countries were opened to competition in the 1990s. As energy markets deregulate, they are driven more by market forces and less by government programs and intervention. Environmental impacts of energy have become increasingly important. New regions are opening up as international energy markets expand. Although advanced technology research is still needed on deep resources and hot dry rock, the GIA will adapt to this changing environment and expand its efforts on market development. A new annex, dealing with market acceleration, is being considered containing possible mechanisms for the GIA to help in market expansion.

Evaluate market stimulation mechanisms - In ExCo efforts to expand geothermal heat and power markets in both OECD and non-OECD countries, research actions are clearly important and indeed essential, but they are not in themselves sufficient to open up markets. Market stimulation is also needed to create an expanded market for geothermal energy. Substantial incentive programs for renewable resources have been introduced in many countries to stimulate market development. Incentive and deployment programs are generating a wealth of information of use to other countries. These programs will be evaluated to identify those that might work best under a variety of conditions based on regional or country-specific factors.

Improve dissemination of information about geothermal energy - The ExCo has recognized its role in promoting the use of geothermal energy, but more emphasis is needed on open distribution of high quality and attractive information products. Several specific actions are planned. The ExCo will sponsor and maintain a comprehensive website to keep interested persons and groups informed about GIA activities and developments in geothermal energy around the world. The website will provide access to a variety of products from the ExCo and Contracting Parties including new publications. The ExCo will issue brochures, pamphlets, and other materials useful in keeping the public informed.

Leverage limited R&D funding – The R&D budgets in many of the Contracting Parties have been declining, and the need for cost-shared collaboration is increasing. An affiliation with the IEA brings added value to activities other than funding. The IEA reputation of technical competence and broad unbiased excellence can be leveraged to obtain support from industry and other multilateral organizations and financial institutions. For example, discussions are underway with World Bank and the United Nations Environmental Programme (UNEP) regarding possible joint activities beginning in 2003.

3.0 MEANS

3.1 Planning Considerations

In its efforts to foster the development of geothermal energy, the GIA has a number of strengths. These include:

- Easy access to key information. Through its members, IEA GIA has access to major public sector programs in geothermal energy. The exchange of information has supported progress in the national activities of the members and helped to avoid unnecessary duplication in member country R&D programs.
- International forum. The GIA provides an international forum dedicated to geothermal energy. In combining the efforts of several nations, the GIA can plan, support, and undertake projects beyond the capability of any single country or group.
- Partnership with the OECD/IEA. The GIA can draw on and contribute to the efforts of sponsoring organization, the OECD/IEA.
- Cooperation with other international organizations. The GIA can join in cooperative efforts with the UNEP and other project financing agencies.
- National programs. R&D activities in the participating countries provide a strong technical base for GIA outreach.

The GIA has limited financial resources, and in the past the ExCo has relied primarily on task-sharing and in-kind contributions from members to satisfy commitments under individual annexes. As the ExCo's interests expand and move beyond narrow technical issues of R&D, the financing of work through cost-sharing becomes increasingly important.

3.2 Actions

In carrying out the stipulations of this Plan, the ExCo will take into account both administrative and technical factors as well as policy guidance from IEA.

ExCo Officers – During 2003 a new Chairperson will be elected from among the Contracting Parties to replace the interim Chairperson. An annual, rotating position of Chairperson will be established among the members. A part-time Secretary will be hired as an employee of the ExCo. The Secretary will be responsible for organizing ExCo meetings, preparing the minutes of meetings, maintaining communication with Member Countries, developing new information products, maintaining the GIA website, and composing the annual report to IEA. The Secretary will receive remuneration from annual contributions of the Contracting Parties to the ExCo Common Fund.

GIA Membership - Increasingly, geothermal development is occurring outside of the traditional membership of the IEA. Supporting extension of participation to both OECD and non-OECD non-participating countries with significant geothermal resources is an objective of this Strategic Plan. As a first step, the ExCo has agreed to invite China, France, the Philippines, Sweden and Turkey to participate in the Agreement. Formal invitations will be issued to those countries to become GIA members. In addition, and particularly in the light of the discussions on a market acceleration strategy, the ExCo would like to establish contact with countries in Eastern Europe, Latin America and other countries with geothermal potential with a view to possible participation in the GIA.

R&D Collaboration – The ExCo will determine the desirability to expand the number of active annexes to cover a broader range of topics, such as geothermal power cycles, geothermal resource depletion and sustainability, and direct heat applications. Other topics of a more specific nature may be considered as proposed by any one or more of the Contracting Parties. New annexes may be funded through either task sharing or cost sharing as determined by the Participants, acting in unanimity.

The focus of technology development will be Annex III, Hot Dry Rock, whose objective is to address HDR geothermal technologies as well as any other new and improved technologies, which can be used to stimulate a geothermal resource to enable commercial heat extraction. The term "Hot Dry Rock" originally evolved with reference to geothermal resources located in hot, impermeable, crystalline rocks. However, the term is now used synonymously with Hot Wet Rock (HWR), Hot Fractured Rock (HFR), Deep Heat Mining (DHM) and Enhanced Geothermal Systems (EGS) to indicate energy production resulting from engineering improvements to a geothermal reservoir.

Market Acceleration - In general, the ExCo would define what actions should be taken to evaluate markets on a regional or national scale. The issues to be addressed should cover technology development, policy, finance, and regulation. Specifically for the GIA, the members participating in this activity will identify target countries with a focus on developing countries.

The GIA strategy for market acceleration will include:

- Provide national policy overviews
- Conduct geothermal resource evaluations
- Mobilize market investment and risk reduction
- Promote international cooperation and leverage resources
- Conduct workshops and conferences in ‘hot spots’

- Participate on Country RE Teams
- Perform pre-feasibility studies for possible projects
- Provide Technical assistance and information dissemination
- Study incentives and government programs pursued in various countries for supporting geothermal energy

These tasks will be performed by one or more contractors to the Participants, paid from a common fund, with the free exchange of information among the Participants. The ExCo will perform an oversight function.

Information Exchange - The GIA website will become a primary means of disseminating information about GIA activities to interested persons, groups, and organizations. The ExCo will also sponsor workshops or symposia to review current issues, ongoing research, and the need for future research. This process provides a variety of outputs such as research reports and data that can be used by government and industry in the countries that participate in that task. Furthermore, the results of tasks will be made available for use by the geothermal energy community worldwide. As the need arises, the ExCo will authorize the preparation of brochures or other documents that describe the GIA, its activities, and the benefits of geothermal energy. These materials would be made available at appropriate meetings, conferences, and other venues suitable to highlight the values and benefits of geothermal energy. The ExCo will develop an Annual Report of its activities and plans that will be edited to make it more useful to organizations and key decision makers in government and industry.

Periodic review of strategic plan – The ExCo will periodically (at least annually) review this plan and revise and update it as necessary.

4.0 ORGANIZATIONAL AND FINANCIAL STRUCTURE

4.1 Executive Committee (ExCo)

Control of the GIA is vested in the ExCo. Decisions made by the ExCo are binding on the Contracting Parties. The ExCo consists of one voting member from each Contracting Party; an alternate may serve on the ExCo if the designated member is unable to do so. The ExCo meets twice a year and manages all administrative activities resulting from or affecting the GIA. During ExCo meetings the members report on national programs, exchange information and results of work under annexes, and consider ongoing or arising issues. The ExCo is chaired by a person elected from and by the Contracting Parties for a minimum term of one year. The Chairperson is assisted by two Vice-Chairpersons, one responsible for planning, the other responsible for technology. The Vice-Chairpersons are also elected from and by the Contracting Parties.

4.2 Secretary

The GIA provides for a Secretary to support the ExCo. The basic duties of the Secretary, defined fully in Art.5 of the Agreement, but excluding any issues that might arise from future Annexes, are to:

- Make and distribute agendas, minutes and other documents
- Prepare decisions and recommendations

- Assist the Officers in carrying out their responsibilities
- Assist the committee in overall coordination of the work in the Annexes
- Administer any common funds at the ExCo level
- Undertake such other activities as may be required by the ExCo

Although a voluntary secretary had been adequate during the first term of the GIA, more frequent meetings and expanded workload dictate a paid secretary supported from a common fund.

4.3 Standing Committees

At its March 2001 meeting, the ExCo established a Planning Committee consisting of the Chairperson, the two Vice-Chairs and the Secretary to address the issue of a new Strategic Plan for the extension of the GIA. This committee will continue in place as a standing committee to deal with future issues related to GIA policy and plans. The ExCo may elect to appoint other standing committees as the need arises.

4.4 Budgets and Costs

During the GIA's initial term, Annex activities in general and the ExCo's work in particular were implemented under the task-sharing mode. As the scope of work under the GIA broadened and the need for a paid Secretary became apparent, the ExCo has moved toward accepting some cost-sharing activities. The mode of support for new activities accepted by the ExCo will be decided on a case-by-case basis.

Contracting Parties will continue to cover the travel expenses for their members to attend meetings and workshops. Travel costs will be minimized by doing business by mail and email whenever possible. To the extent practicable, meetings will be scheduled to coincide with other events to minimize travel costs. Each Participant bears all the costs it incurs in carrying out its Task activities, including reporting and travel expenses. Unless otherwise specified, the cost of publishing annex reports and summary assessments shall be borne by the Operating Agent.

The expenses for the Secretary and other common costs of the ExCo will be budgeted from a Common Fund. The Secretary will prepare an annual budget of planned activities stemming from this Plan for the calendar year and submit the budget for approval by the ExCo. Expenditures against the budget can only be authorized by the Chairperson, who must notify the ExCo at once of any exceptions to the approved budget.

To support the creation of a Common Fund, the IEA has provided general guidance on a fair apportionment of monetary contributions in the form of shares assigned to different Member States of the OECD. Based on current membership, the apportionment for the GIA is:

Australia	2	Japan	4
E. Commission	4	Mexico	1
Germany	4	New Zealand	1
Greece	1	Switzerland	2
Iceland	1	U.K.	2
Italy	2	U.S.	4

Total = 28 shares

With the addition of new Contracting Parties or the withdrawal of current members, the total shares will increase or decrease, affecting each member's contribution. Contributions will be made annually on a calendar year basis. The number of shares assigned to new Contracting Parties who are non-members of OECD will be determined by the ExCo acting in unanimity. A Custodian, currently the National Renewable Energy Laboratory (USA), will be responsible for administering the Common Fund and providing periodic accounting reports to the ExCo.

Participants wishing to share the costs of a particular task may agree in the appropriate task annex to establish a separate common fund. Share contributions to a common fund for an annex will be apportioned in the same manner as the ExCo Common Fund. The designated Operating Agent will serve as the Custodian of the annex common fund.

All arising issues of finance and budgeting will be decided based upon the conditions and requirements of Art.7 of the GIA.

4.5 Term

This Strategic Plan, in present form or as subsequently modified by the ExCo, will remain in effect for the term of the Agreement; March 7, 2002 – March 31, 2007.

APPENDIX: GIA Annexes

The status of each annex considered by the ExCo during the first term of the Agreement is presented in the table followed by a summary description:

ANNEX NO.	TITLE	STATUS
Annex I	Environmental Impacts of Geothermal Development	Active
Annex II	Shallow Geothermal Resources	Closed
Annex III	Hot Dry Rock	Active
Annex IV	Deep Geothermal Resources	Active
Annex V	Sustainability of Geothermal Energy Utilization	Draft
Annex VI	Geothermal Power Generation Cycles	Draft
Annex VII	Advanced Geothermal Drilling Techniques	Active
Annex VIII	Direct Use of Geothermal Energy	Draft
Annex IX	Geothermal Market Acceleration	Draft

Annex I: Environmental Impacts of Geothermal Energy Development (3 Subtasks)
To further the use of geothermal energy, possible environmental effects need to be clearly identified, and countermeasures devised and adopted to avoid or minimize their impact. To assist in this, Task I of the GIA entitled "Environmental Impacts of Geothermal Energy Development" was set up, as formulated in Annex I of the GIA.

The goals of this Task are to:

- Encourage the sustainable development of geothermal energy resources in an economic and environmentally responsible manner;
- Quantify any adverse or beneficial impacts that geothermal energy development may have on the environment,
- Identify ways of avoiding, remedying or mitigating such adverse effects have on the environment.

At the start of 2001, six countries were formally participating in Annex I: Greece, Iceland, Japan, Mexico, New Zealand, and United States of America. One further country, Turkey, is expected to join soon.

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

- Sub-Task A: Impacts on natural features
- Sub-Task B: Discharge and reinjection problems
- Sub-Task C: Methods of impact mitigation and Environmental Manual

Plans for the period 2001-2005 include

- Continuation of data collection and analysis;
- Establishment of a Web site and the organization of lectures and courses to widen the understanding of environmental impacts among technical non-specialists;

- Further publications in journals and conferences, and preparation of the Environmental Manual;
- Dissemination of information to the general public.

Annex II: Shallow Geothermal Resources
This Annex reached a Draft stage but was closed by decision of the ExCo at the October 2000 Meeting. At that time, the ExCo decided to include geothermal heat pumps within the IEA market Initiative.

Annex III: Hot Dry Rock
The objective of the Hot Dry Rock Task is to 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.

Countries and organization participating in Annex III are Australia, Germany, Japan, Switzerland, UK, USA and CEC.

Annex III, during 2002-2005, will consist of three Subtasks:

- Subtask B: Application of Conventional Geothermal Technology to Hot Dry Rock (HDR)
- Subtask C: Data Acquisition and Processing
- Subtask D: Reservoir Evaluation

(Subtask A, Hot Dry Rock Economic Model, was completed in 2001.)

Plans for 2002-2005 include:

- Completion and final publication on a web site of the economic model;
- Extension of collaboration to new Australian and German partners;
- Continued exchange of personnel, information and experience between the projects.

Annex IV: Deep Geothermal Resources
The objective of the Task is to address the issues necessary for the commercial development of deep geothermal resources at depths of about 3 000 meters and deeper. .

Participants in Annex IV are New Zealand, Japan, Mexico, United States, Germany and Italy.

The work addresses, on a task-sharing basis:

- Sub-task A - collaborative research on exploration technologies and reservoir engineering for deep, hot reservoirs;
- Sub-task B - collaborative research on drilling and logging technologies, with review and collation of experience from within participating countries;
- Sub-task C - exchange of information and establishment of a database on fluid chemistries, materials properties and corrosion issues, together with field testing.

Future plans for Annex IV are being discussed among the participating countries.

Annex V: Sustainability of Geothermal Energy Utilization
Although geothermal energy is commonly considered a renewable resource, geothermal reservoirs are depleteable if they are improperly managed. With proper operation of producing geothermal fields they may be considered to be "sustainable" in the sense of the World Commission on Environment and Development (Brundtland Commission) to indicate use that "meets the needs of the present generation without compromising the needs of future generations."

The objective of this task is to study important facets of the production of energy from geothermal resources with the view of determining the long-term economic sustainability of such production. It became clear in discussion that ExCo members had different interpretations of the meaning of 'sustainable'. It was the consensus of the ExCo that work on developing the annex should continue.

Annex VI: Geothermal Power Generation Cycles
A draft Annex has been prepared. This would be a task-sharing annex. The sub-tasks would cover reference scenarios as a basis for comparison of cycles, plant performance and availability, economics and environmental impact & mitigation. The latter implies strong links to Annex I. The output would be in the form of a database and guidelines of best practice. The ExCo agreed that Annex VI should be implemented as soon as two or more participants agreed to join.

Annex VII: Advanced Geothermal Drilling Techniques
Drilling is an essential and expensive part of geothermal exploration, development, and utilization. Drilling, logging, and completing geothermal wells are expensive because of high temperatures and hard, fractured formations. The consequences of reducing cost are often impressive, because drilling and well completion can account for more than half of the capital cost for a geothermal power project.

There are three Subtasks:

- Subtask A: Documentation of Drilling Costs
- Subtask B: Geothermal Drilling Best Practices
- Subtask C: Advanced Drilling Collaboration

The objectives of the Advanced Geothermal Drilling Task are:

- Quantitatively understand geothermal drilling costs from around the world and identify ways to reduce those costs, while maintaining or enhancing productivity.
- Identify and develop new and improved technologies for significantly reducing the cost of geothermal well construction to lower the cost of electricity and/or heat produced with geothermal resources.
- Inform the international geothermal community about these drilling technologies.
- Provide a vehicle for international cooperation, field tests, etc. toward the development and demonstration of improved geothermal drilling technology.

Plans for 2002-2005 include

- Developing a draft of Best Practices Handbook
- Employment of economic modeling to predict cost savings by advanced drilling techniques

- Compilation of cost data to a database.

Annex VIII: Direct Use of Geothermal Energy
A draft for this annex was first proposed by Iceland in 2001. After discussion, it was agreed that Iceland should be asked to develop the annex further.

Annex IX: Geothermal Market Acceleration

Special emphasis will be given to launching Annex IX (Geothermal Energy Market Acceleration), because of interest in possible cooperation with UNEP and the GEF. The alliance will undertake efforts in regions with high geothermal potential like Africa, Central & Latin America and Central and Eastern Europe. This cooperative will be considered along with other efforts in that direction underway at IEA headquarters.

Collaborative activities under the auspices of the IEA GIA can accelerate the use of geothermal energy in new markets and applications by communicating simple and accurate technology information, identifying and promoting new and innovative applications, conducting research to remove market barriers, enhancing the technology performance and economics, developing and standardizing equipment, and promulgating engineering standards and practices.

Appendix 3

CERT Project on “Technology Options for Achieving Significant Greenhouse Gas Emissions Reductions from Energy over the Long Term”

Draft input from Geothermal Implementing Agreement (September 2002)

Background

Geothermal energy embraces a variety of different technologies aimed at the use of heat from the earth. This resource is so large that it can be treated for all practical purposes as renewable, and geothermal energy is unique among the renewable energies in being able to provide a firm, dependable supply of electric power and heat energy, available day and night, summer and winter. Geothermal development has sometimes been perceived as being environmentally damaging, but this perception arises primarily from the effects of natural manifestations like volcanoes and geysers. While some early developments did give rise to harmful emissions, they were rarely worse than the conditions that existed naturally prior to the development. Emissions from modern plant are typically minimal and can be reduced virtually to zero.

Time frame : present day to 2020

Electricity generation from high grade resources

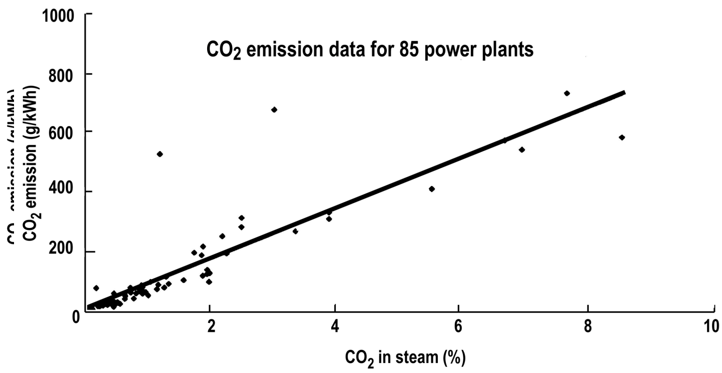
The best geothermal resources reside in those countries possessing deposits of steam and hot water (>160°C) at shallow depths in permeable rock formations. Electricity generation from such reservoirs has been a commercial reality since the 1920s. Currently, 21 countries generate power from geothermal fluids; the status in 2000 was summarized by Huttrer (2001):

> “ …the installed capacity has reached 7 974 MWe which is a 16.7% increase since 1995 [and] the total energy generated is at least 49 261 GWh [annually].

> “ The geothermal work done in Central America, Italy, New Zealand and Iceland is very impressive and the prognoses from fourteen nations suggest that by 2005 growth of almost 43% to about 11 400 MWe might be possible. The author believes that in the next five years, the Southeast Asian economic situation will improve, oil and gas prices will be higher that they have been for many years and the world will increasingly appreciate the “green” benefits of geothermal energy use.”

Greenhouse Gas Emissions

While geothermal facilities do release some CO_2, those emissions are significantly less than from an equivalent amount of fossil-fired generation and may in any case be lower than occurs naturally in the same region. A survey by the International Geothermal Association of 85 geothermal power plants in 11 countries (IGA, 2001a) showed a wide spread in CO_2 emission rates (from 4 g/kWh to 740 g/kWh with a weighted average of 122 g/kWh). Some 73% of the units surveyed had emission rates of less than 150 g/kWh with a weighted average of 37.4 g/kWh. Any CO_2 emitted by geothermal plant originates almost exclusively in the geothermal fluid, and high emissions correlate with high original CO_2 content. In many of the latter cases there was previously a high level of CO_2 emission from geysers, fumaroles and hot springs in these areas, and exploitation of the geothermal fluid may well reduce this natural background.



In general terms, net emissions of CO_2 per kWh generated from a modern geothermal plant will normally be less than 10% of those from fossil fired generation. Even in those cases where the geothermal fluid has a high natural CO_2 content, it is possible to capture the CO_2 at the plant and dispose of it or put it to use (as is done at Kizildere, Turkey, for example, where the CO_2 is sold to food manufacturers).

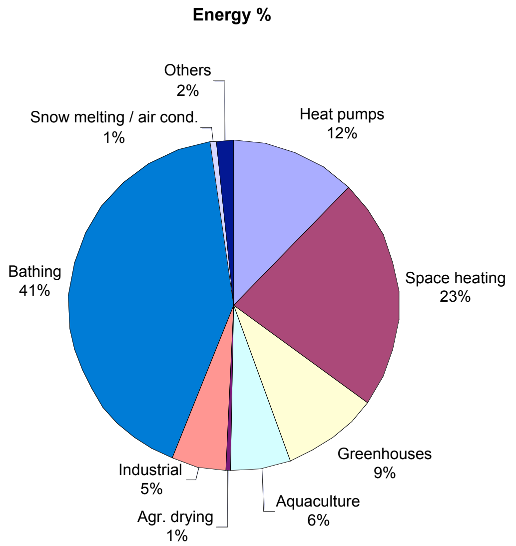
Electricity production from natural geothermal fluids will continue to increase, especially in Central America and Southeast Asia, where it could become the dominant power producer. Excellent geothermal resources also exist in the Rift Valley of East Africa, along the Andes Mountains of South America, and in many other parts of the world. However, the necessary combination of geological circumstances (heat, permeability, and water) is comparatively rare and the historical world-wide annual growth rate of 4-8% must be expected to level out within the next few decades, barring significant technological advancements. With present technology an ultimate installed capacity of 30-50 GWe, supplying some 300 TWh/y, seems realistic. By displacing coal- and oil-fired generation, this would save some 200 million tonnes of CO_2 per year.

Direct heat supply

Low temperature (<100°C) fluids geothermal fluids are much more widespread, and some 58 countries now exploit such resources in direct heating applications. The major uses are space heating and bathing; geothermal heat pumps, which use the earth as a storage medium, also contribute a significant share.

The total energy supplied during 2000 was estimated at 190 699 TJ/y (Lund & Freeston, 2001). This total implies the saving of some 7-10 million tonnes of CO_2. There is, however, much greater potential for growth in these lower temperature developments. A recent study by the International Geothermal Association (IGA, 2001b) suggested that the long-term potential could reach 1 400 million TJ/y.

Geothermal heat pumps represent a relatively recent but fast-growing development. This technology has the advantage of being applicable at the scale of an individual dwelling as well as group- or district-heating systems. This feature, combined with the ability to offer cooling as well as heating, has resulted in rapid growth in US and Europe and can be expected to account for much of the growth in total direct heat applications over the next decade or so.



Direct applications of geothermal resources in 2000 (from Lund & Freeston, 2001)

Measures for market acceleration

All the systems described above are based on established commercial technologies, and the projected future growth can be achieved without the need for technological breakthroughs. Such research as is needed will come about as a natural consequence of commercial pressures. Government support for research on exploration technology, resource verification, and reservoir production can accelerate this process in cases where industry lacks adequate means to fund a comprehensive research program.

There remain, however, significant institutional barriers to geothermal growth, the majority of which require action at government or even international level. IGA has summarized these as follows (IGA, 2002):

Measures for market acceleration

The following high level measures can be envisaged:

- The United Nations, the World Bank, and other institutions must include strong geothermal energy components in their programmes, and should promote and encourage expanded international cooperation in geothermal energy research, and in the development and demonstration of new and improved technologies.
- National governments should
  - Support dissemination of information on geothermal energy use at various levels, from decision makers to potential consumers and the public at large
  - Encourage and, where necessary, support assessments of their country's geothermal resource potential for use in electrical power generation, heating and cooling of homes and buildings, food processing, fish farming, refrigeration, and a myriad of other uses
  - Make strong commitments to developing their indigenous geothermal resources for the benefit of their own people, humanity and the environment
  - Adopt policies, laws and regulations that promote investment in development of their indigenous geothermal resources
  - Support education and training, both for specialists and general public
  - Encourage a positive public attitude toward geothermal energy
  - Create a political and public environment and market conditions favourable for geothermal energy

Time frame : post-2020

"Hot Dry Rock" / Enhanced Geothermal Systems

All the existing developments listed above, except for geothermal heat pumps, rely on the geological coincidence of water-bearing, hot permeable rocks occurring at economically accessible depths. This is a comparatively uncommon situation and constrains the usable resource in contrast to the extremely large resource base. The usable resource is also site specific and distributed unevenly among countries. On the other hand, the resource base comprises a huge amount of useful heat stored in rocks that are technically accessible but lack the natural permeability necessary for heat extraction. Moreover, such heat stores are much more widely distributed and so offer a geothermal potential to many countries where conventional resources are absent. Even in those areas where good conventional geothermal resources exist, there is usually a much greater volume of heated rock than can be exploited with current techniques. The importance of this 'potential' resource can be judged by noting that cooling one cubic kilometre of rock (which is about the scale of a geothermal reservoir) by 1°C will provide the energy equivalent of 70 000 tonnes of coal. A recent report *(McLarty et al., 2000)* expressed the potential for the United States in another way:

> " The U.S. Geological Survey has calculated the heat energy in the upper 10 kilometers of the earth's crust in the U.S. is equal to over 600 000 times the country's annual non-transportation energy consumption. Probably no more than a tiny fraction of this energy could ever be extracted economically. However, just one hundredth of 1% of the total is equal to half the country's current non-transportation energy needs for more than a century, with only a fraction of the pollution from fossil-fueled energy sources."

The same report noted also that:

> " Experts estimate that up to 6 GWe in the U.S. and 72 GWe worldwide could be produced with current *[i.e. conventional geothermal]* technology at known hydrothermal sites. With enhanced technology, these estimates increase to 19 GWe and 138 GWe."

In a similar vein, a study by Shell – which now participates in the European Hot Dry Rock research project – suggested that exploitation of the prime sites in Europe could support generation on a scale comparable to that of Europe's current nuclear programme (40-80 GWe), while the total exploitable resource could be 100 times greater.

Turning this potential into an exploitable resource has become known as the "hot dry rock" (HDR) problem or, more recently – in recognition of its importance to extending the conventional resource, as "Enhanced Geothermal Systems" or "EGS". It has been the subject of large scale international research since the 1970s, with major projects in US, Japan and Europe. Several other projects are now being planned.

On the basis of recent very positive results, the European project has begun drilling the deep wells for a 'scientific' pilot plant of four 1.5 MWe generating units, to be followed in the event of success by a commercial pilot of 25-30 MWe. This latter could be commissioned around 2012. In parallel with this work, several other pilots should be commissioned within the decade, so that – by 2020 –substantial commercial growth can be expected.

On the basis of the resource estimates quoted above, it is realistic to foresee a situation by 2030-2050 where HDR/EGS technologies could permit significant levels of electricity generation in many countries that are not currently considered to possess geothermal resources. In Europe as a whole, for example, power generation could occuron a scale comparable to existing nuclear systems. This would imply some 10-20% of total electricity demand.

As the majority of HDR/EGS developments would extract heat from crystalline basement rocks, the levels of CO_2 dissolved in the produced fluids would, in most cases, be substantially lower than those from natural aquifers. In addition, such systems would probably operate in a closed loop with reinjection of spent fluids and gases, so emissions of greenhouse gases (other than water vapour) to the atmosphere would be low. Therefore, by displacing fossil-fired units, development on the scale foreseen could result in avoided CO_2 emissions of around 100 million tonnes CO_2/y in Europe, and several times this figure world-wide.

Research and other needs to achieve market penetration

- Continued technological research is required before pilot plants can provide convincing demonstration of the practical and economic aspects of HDR/EGS systems. Geothermal reservoirs are large and evolve slowly, so the time constant is large. Several years of successful operation will be required before private industry could be expected to develop confidence in the systems. The early involvement of industry (as at Soultz) will help to speed this process.
- By comparison with conventional geothermal developments, such systems are likely to be much less site-specific so research and demonstration in this sector is a prime candidate for international co-operation.
- The same non-technical and institutional barriers listed for conventional systems will also need to be addressed. The difference will be that, as the new technology should be applicable in many countries currently regarded as effectively non-geothermal, legislative and regulatory issues will need to be addressed in those countries as well. No developer can be expected to invest capital in a resource where the regulatory questions (and even, in some cases, the ownership) remain undefined.

Key messages

Geothermal energy is a long-established commercial technology that already supplies a significant amount of energy, as electricity or in direct heat applications, in a number of countries. For all practical purposes renewable, it provides a firm, constantly available source of energy. CO_2 emissions are low and can be reduced almost to zero. There are no significant emissions of SOx or NOx or – in modern plant – any other pollutants. The recent rapid uptake of geothermal heat pumps broadens the user base from the more traditional group heating system to the individual dwelling.

Research on HDR/EGS systems is approaching the pilot plant stage. Success in these developments will greatly increase both the scale of the usable resource and the number of countries that can benefit from this large indigenous energy resource.

In many cases, the major inhibitors to growth are non-technical issues such as lack of public awareness and an inappropriate regulatory environment. Public bodies at both the national and international level can contribute to the resolution of these issues.

References

Huttrer, G W (2001) : The status of world geothermal power generation 1995-2000, *Geothermics*, **30**(1), 1-27

Lund, J W, Freeston D H (2001) : World-wide direct uses of geothermal energy 2000, *Geothermics*, **30**(1), 29-68

IGA (2001a) : *Geothermal power generating plant : CO_2 emission survey*. Internal report available from the International Geothermal Association.

IGA (2001b) : *Report of the IGA to the UN Commission on Sustainable Development, Session 9*

IGA (2002) : *Contribution to the World Summit for Sustainable Energy, Johannesburg*

McLarty L, Grabowski P, Entingh D, Robertson-Tait A (2000) : Enhanced geothermal systems R&D in the United States, *Proc. World Geothermal Congress 2000*, pp.3793-3796

John Garnish
(September 2002)

Appendix 4

International Energy Agency - Geothermal Implementing Agreement

Executive Committee (ExCo)

draft

Minutes of the Eighth Meeting,

6-7 November 2002, Instituto de Investigaciones Eléctricas (IIE), Cuernavaca, Mexico

Vice Chairman Jelacic called the meeting to order at 9:35 AM, 6 November. Attending were IEA-GIA ExCo members Rybach,, Bromley, Hashimoto, Nieva, Jelacic, Schuppers and alternate members Kristmannsdottir and Finch. Also attending were ExCo observers Kawasaki (Annex III OA), Matsunaga (Annex III leader), Finger (Annex VII leader), Kubo (Annex VII) and Frye (NREL independent contractor and interim secretary). Members of IIE staff Garcia and Santoyo attended intermittently. There was no representation from member countries Australia, Germany, Greece, Italy and United Kingdom. ExCo Chairman Garnish was unable to attend, due to sudden illness. Vice Chairman Rybach chaired the Meeting on 7 November.

ACTION ITEMS FROM 8th ExCo MEETING

8/1 Jelacic will revise and shorten to Background section of the draft “Strategic Plan for 2002-2007”
8/2 Iceland will submit a draft “Direct Use- Annex VIII” in January 2003.
8/3 Solicit contributions to the Common Fund (Frye).

AGREED ACTIONS

8/1 Invited articles for special issue of “Geothermics” on “Environmental Impacts of Geothermal Development” Annex I (target date: late 2003)
8/2 Approved Frye continuing as interim secretary until 9th ExCo meeting spring 2003.
8/3 Adopted an interim 2003 budget of $22,800. This budget will be reviewed at 9th ExCo meeting in spring 2003.
8/4 ExCo tabled revised draft Annex IX pending clarification of IEA CERT (Committee on Energy Research and Technology) directives.
8/5 Working draft on Annex V - Sustainability (tabling of draft by Jelacic continues).
8/6 Interim officers to serve until the 9th ExCo meeting.

ACTION ITEMS FROM 7th ExCo MEETING

7/1 Review submittals and recommend selection of Secretary. *Deferred until Spring 2003*
7/2 Solicit contributions to the Common Fund (Frye). *Continuing*
7/3 Edit and release to the public the GIA web site (Wason and Frye).
7/4 Final draft of End of Term Report (Frye). *Web Design under review by ExCo officers*
7/5 Draft Annex IX – Market Acceleration (Comments from all members to Jelacic by 31 March 2002). *tabled*
7/6 Germany to formally accept lead on Annex IV – Deep Resources (Wempe) *no Activity Report presented*

ACTION ITEMS FROM PREVIOUS ExCo MEETINGS (italic font indicates an update)

6/1 Annex I: - Request English version of Greek socio-economic study from Karytsas. (*task accepted by **Bromley***)

6/4 Annex V: - Sustainability- Jelacic requests input from Italy (**Baldacci**), Mexico (**Nieva**), New Zealand (**Hunt**), and Iceland (**Björnsson**). *tabled by Jelacic*

6/5 Annex VI - Geothermal Power Cycles **Baldacci** to promulgate new draft and solicit member participation. *no progress reported.*

6/6 Annex VIII - Direct Use of Geothermal Energy - **Björnsson** to promulgate new draft and solicit member participation. ***Kristmannsdottir** reported that Iceland will submit a draft in January 2003*

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1. **Call to Order:** Vice Chairman Jelacic called the meeting to order at 9:35 AM.

2. **Adoption of Agenda of 8th ExCo Meeting:** The draft agenda of the 8th ExCo meeting prepared by the Chairman was approved as modified by the ExCo.

3. **Adoption of Minutes of 7th ExCo Meeting:** The draft minutes of the 7th ExCo meeting prepared by the Secretary was approved unanimously.

4. **Selection of Officers:** Garnish retired from European Commission in May 2002 but consented to extend his role of Chairman of the ExCo until the next meeting in March 2003. Rybach has retired from his teaching position but he is willing to be a Vice Chairman. Jelacic is willing to remain as Vice Chairman (administration).

5. **Selection of Secretary:** Four bids have been received (Mexico, two from NZ and USA) for the position solicited by the ExCo officers. Bids to be reviewed by an Ad Hoc committee chaired by Rybach with ExCo member countries not submitting a bid. (Rybach, and ExCo member countries not submitting bids to request additional clarification to evaluate bids). In the interim, Frye will continue as acting secretary.

6. **Establishment of Common Fund:** Common fund established at NREL and NREL has billed member countries. The common fund is administered in conformance with accounting principles generally accepted in the U.S., with full accountability, documentation, and an annual audit to ensure propriety. Once the GIA Executive Committee members establish an annual budget, that budget will be considered as prior authorization for expenditures as corresponding invoices are submitted. The expenses of the Secretary of the Executive Committee of the GIA are also charged against the common fund. Any invoices outside the authorized budget or expenses for the Secretary, will be sent to the Chairman of the Executive Committee for approval prior to payment. An annual audit of the account by an independent auditor from within NREL will be conducted within three months of the end of the Fiscal Year on 30 September. An independent auditor report will be submitted to the Executive Committee at the fall meeting. NREL manages this fund with full intent to service the needs of the GIA Executive Committee, and there are absolutely no foreseeable situations wherein NREL will draw money from the common fund for NREL use. This fund is administered for GIA Executive Committee as a courtesy with no administration expense charged. Invoices have been submitted to member countries for their country's contribution for the fiscal year 2002. The U.S. established the fund with a deposit of $28,800 (US), including the U.S. 2002 and 2003 contributions. The balance as of October 31, 2002 was $29,378.80.

7. **GIA Web Site:** A draft web site Wason presented in March 2002 ready to be released to IEA

8. **Annex IX - Market Acceleration**: Allan Jelacic presented a revised draft of Annex IX -Geothermal Energy Market Acceleration. Discussion continued from the 7th ExCo meeting on member (and private industry) participation and funding. Questions were raised on the expense reimbursement of proposed Renewable Energy Technology Implementation Teams (RE Teams). Market acceleration actions organized by the Renewable Energy Working Party were discussed. Additional comments included the practicality of funding and timing in order to match UNEP/GEF funds. Jelacic again expressed the need to receive comments from participating countries. Jelacic suggested this new draft of Annex IX be tabled; he reported that the Wind IA ExCo had taken similar action awaiting further direction from CERT.

9. **Annex I - Environmental:** Bromley invited articles for special issue of "Geothermics" on "Environmental Impacts of Geothermal Development" Annex I (target date: late 2003). Michael Sorey, USGS is working on the environments effects of natural H_2S discharges. Bromley to review potential of updating OLADE "Guide for Assessing the Environmental Impact of Geothermal Developments for Energy Purposes." This guide was printed in both Spanish and English in June 1994.

10. **Annex III – Hot Dry Rock:** Kawasaki reported that NEDO budget has been reduced to 10 million yen (largely from other sources). The sum will fund almost exclusively administrative expenses only. The Hijiori project has been completed and the site abandoned. The 100 kW plant produced 50 kW net for three months. Formation of anhydrite scale was not anticipated. Kawasaki has assurances from METI that Japan will continue as OA (Operating Agent) for one or two years more. Rybach presented Bob Hopkirk's progress in Annex III, subtask C. (Data Acquisition processing General Tool for Hot Dry Rock) and PMDA (Project Management Decision Assistant). PMDA is financed by the Swiss Government.

11. **Annex IV – Deep Geothermal Resources:** Germany has become new task leader but did not send a representative. Kawasaki reported that the Japanese website has been updated.
<http://www.nedo.go.jp/chinetsu/iea/db.htm>
Kubo made a presentation of the new (but not commercially available) instrumentation and equipment presented on pages 11 - 18 of the website.

12. **Annex V – Sustainability:** Tabled by Jelacic; decision to continue deferred until next ExCo meeting. EGS (Enhanced Geothermal Systems) efforts in the US may change aspect of geothermal sustainability.

13. **Annex VI – Power Generation:** Presentation by Balducci submitted electronically essentially the same as he presented in March 2002. No action taken.

14. **Annex VII – Geothermal Drilling:** Finger discussed the three major subtasks:
Subtask A: Compile Geothermal Well Drilling Cost Information
Subtask Leader: The New Energy and Industrial Technology Development Organization (NEDO), Japan.

The concept of a cost database was directed toward establishing baseline costs for geothermal drilling and identifying high-cost drilling problems that are common to different geothermal areas around the world, thus focusing drilling research on solution of those problems. During extensive discussion of this sub-task, the following points were raised:

- Confidentiality of data is a problem in most countries. In the US, for example, cost data resides with the operators and they are uniformly unwilling to release it. In Europe, all requests for drilling bids must go to all members of the EU, and the contractors are also reluctant to disclose costs that may enter into competitive bidding.

- It is also difficult to present costs in a uniform format that accounts for inflation and differing exchange rates. There is also lack of consistency in the specific costs that are included in the total costs for various wells (i.e., some well costs include lease and royalty fees, or drilling engineering, that are not fundamental costs of drilling.)
- There was a strong consensus that performance data, in contrast to cost data alone, can be very useful and may be more easily obtained, especially in consideration of the above difficulties. Several participants stated a belief that operators or governments would be more willing to release performance information, even if it is only rudimentary data such as a time/depth curve, than cost data. An intermediate format, combining time intervals for specific tasks with some cost data and equipment specifications, has been supplied by Japan as an example of data collection. There was also a comment that examination of such simplified data as the time/depth curve could help to focus on a narrower range of costs that we should attempt to collect.
- A participant commented that detailed cost records are burdensome if the drilling personnel are required to keep them.
- A participant pointed out that a complete matrix of information—costs, equipment specifications, time, geology, process, and material—would be the optimum case but probably not practical.
- Each country participating in Annex VII would be responsible for data from that country, but it is likely that data from non-participating countries such as Indonesia or the Philippines would be available. That data should be acquired and added to the database.
- There is also a considerable amount of performance data already in the public domain, such as the records kept by the California Department of Oil, Gas, and Geothermal Resources.

Action to be taken for Sub-task A: S. Kubo and J. Finger will distribute a sample spreadsheet, in Microsoft Excel format, of drilling time and costs from three Japanese wells. This spreadsheet contains total well costs, divided into major categories such as drilling cost for each interval, casing cost, etc. It also contains basic specifications for the drill rig and other major equipment. We propose that this format shall become the standard format for collection of cost and performance data. Each of the participating countries will be requested to provide comments of the suitability and value of this format, as well as suggestions for changes or additions to the format. Each participating country will also be requested to provide an estimate of how much data in that country is currently available in the public domain. Responses to these requests will be due by the end of January 2003.

Subtask B: Geothermal Drilling Best Practices Handbook
Co-Subtask Leaders: Comisión Federal de Electridad (CFE), Mexico (Electricity); Orkustofnun – Iceland (Direct use)

The original concept for the Handbook was a document that described drilling, logging, testing, and maintenance for both high-temperature (electrical generation) and low-temperature (direct use) wells. This is still a goal, but much discussion of this sub-task concerned the manpower that would be necessary to write a book covering this much material. There was also some lack of consensus on the Handbook's audience—is it for drilling engineers, drilling contractors, lecturers, operators, or all these together? The following points were made during extensive discussion of this sub-task.

- Because of the effort required to finish the full scope of the Handbook, we should narrow the focus to one topic and finish a document that fully covers that topic. That first publication could then be circulated and used for a year, gaining feedback on the content and format for a more comprehensive volume. The topic chosen for the initial effort is high-temperature drilling, with no coverage of testing, well maintenance, or reservoir assessment.
- The new handbook should take advantage of existing documents such as the New Zealand Standard

Code of Practice for Deep Geothermal Wells and Sandia Laboratories' Slimhole Handbook and lecture notes from existing geothermal study programs.

- Once the new handbook, or the initial portion of it, is complete there are a number of ways to distribute it—reproduced paper copies, electronic versions on CDs, or formal publication as a bound book. The consensus of the working group was that a few paper copies should be printed, but that primary distribution should take place through an electronic link to a Web site. This format would not only be inexpensive for the users but would facilitate periodic updates as new information became available.
- The Handbook should emphasize techniques or processes that have been demonstrated as successful. Theoretical background should be included where relevant and available, but topics should not be excluded because they lack theoretical support. Where obvious technology needs exist, these should also be identified.
- We should investigate the possibility of a special session of the 2003 Geothermal Resources Council Annual Meeting at which geothermal researchers would be invited to submit papers on specific subjects, with these papers becoming part of the Handbook.

Action to be taken for Sub-task B: H. Gutierrez, S. Thorhallsson, and J. Finger will each produce an expanded outline for the high-temperature drilling portion of the Handbook. After iteration of these outlines and agreement on a single version for the Handbook, that version will be circulated to the Annex VII working group for comment. The three expanded outlines will be due by 15 Jan 2003 and the unified version will be distributed at least one month before the next meeting, where the outline and comments will be discussed in detail. H. Gutierrez will investigate the possibility of a special session at the GRC Meeting and will report on this at the next meeting.

Subtask C: Advanced Drilling Collaboration

Subtask Leader: Sandia National Laboratories - USA

This sub-task is designed to facilitate drilling technology transfer among countries with established geothermal industries. The mechanism for this process will be solicitation of proposals for collaborative testing from the participating countries. Collaboration may take at least the following three forms: experiments in fields or reservoirs that are different from those in which a researcher has experience; use of drilling hardware or software in unfamiliar conditions; or data exchange for improved validation of various drilling models or simulators. The following points appeared during discussion of this sub-task.

- A. Garcia presented a description of a numerical model for estimation of formation temperatures. Although the model has been tested against measurements in a few wells, it would be useful to have data sets from other locations that could be used for additional validation.
- S. Thorhallsson described the Iceland Deep Drilling Project (IDDP), which is expected to penetrate extremely high temperatures and pressures, and indicated that proposals for experiments or for use of new drilling technology in this hole could be considered for approximately one year, or until the drilling program is fixed.
- S. Kubo described recent Japanese developments—high temperature bits, high temperature drilling fluid, high temperature cement, and others—in both drilling and production technology. Several of these developments could find application in other countries, but it appears that they are little known outside Japan.

Action to be taken for Sub-task C: Related to the topics above, the following activities were defined. (1) A. Garcia and J. Finger will coordinate definition of a data set necessary for testing the numerical model. This definition will then be circulated to participating countries in an effort to gain partners in data exchange. (2) Researchers interested in possible work in the IDDP should see its description at http://www.os.is/iddp/ and should draft proposals for possible collaboration. Proposals will be discussed at the next Annex VII meeting. (3) S. Kubo and J. Finger will prepare a list of recent Japanese developments with contact names for each technology. This will enable potential users to acquire detailed information on technical and availability aspects of each technology.

15. **Annex VIII – Direct Use: Kristmannsdottir** reported that Iceland will submit a draft in January 2003. Draft to be reviewed at 9th GIA ExCo meeting.

16. **GIA Strategic Plan:** Jelacic presented a draft of the GIA Strategic Plan. The ExCo edited it and the edited draft was submitted to the officers of the ExCo. Jelacic will revise and shorten the Background section.

17. **GIA Annual Report:** Frye will ask for contributions of the Task Leaders and subsequently prepare the report. It should be produced in an appealing style (design, photographs etc.). Expenses for design, production and printing can be charged to the Common Fund.

18. **Next OC Meeting:** The 9th ExCo meeting is scheduled for 13-14 March 2003 at the International Energy Agency, Paris.

19. Vice Chairman Rybach **thanked Nieva** for th excellent hosting of the Meeting.

20. **Adjournment:** The 8th ExCo meeting adjourned at 14:20, 7 November 2002.

Appendix 5

An Overview of GIA Annex III Subtask C

by members of

The Swiss GIA working consortium

Robert J. Hopkirk

Thomas Mégel

Rudolf Minder

François-D. Vuataz

Developing a project management decisional assistant (HDR-PMDA) for easing the path towards regular use of Hot Dry Rock technology

Compiling information to create an easily understandable management decision tool for new HDR project teams is a task of peculiar complexity.

Nevertheless, the use of data to aid decision-taking and progress is an integral part of every construction project.

A (PMDA) for HDR projects must have the 4 following characteristics:

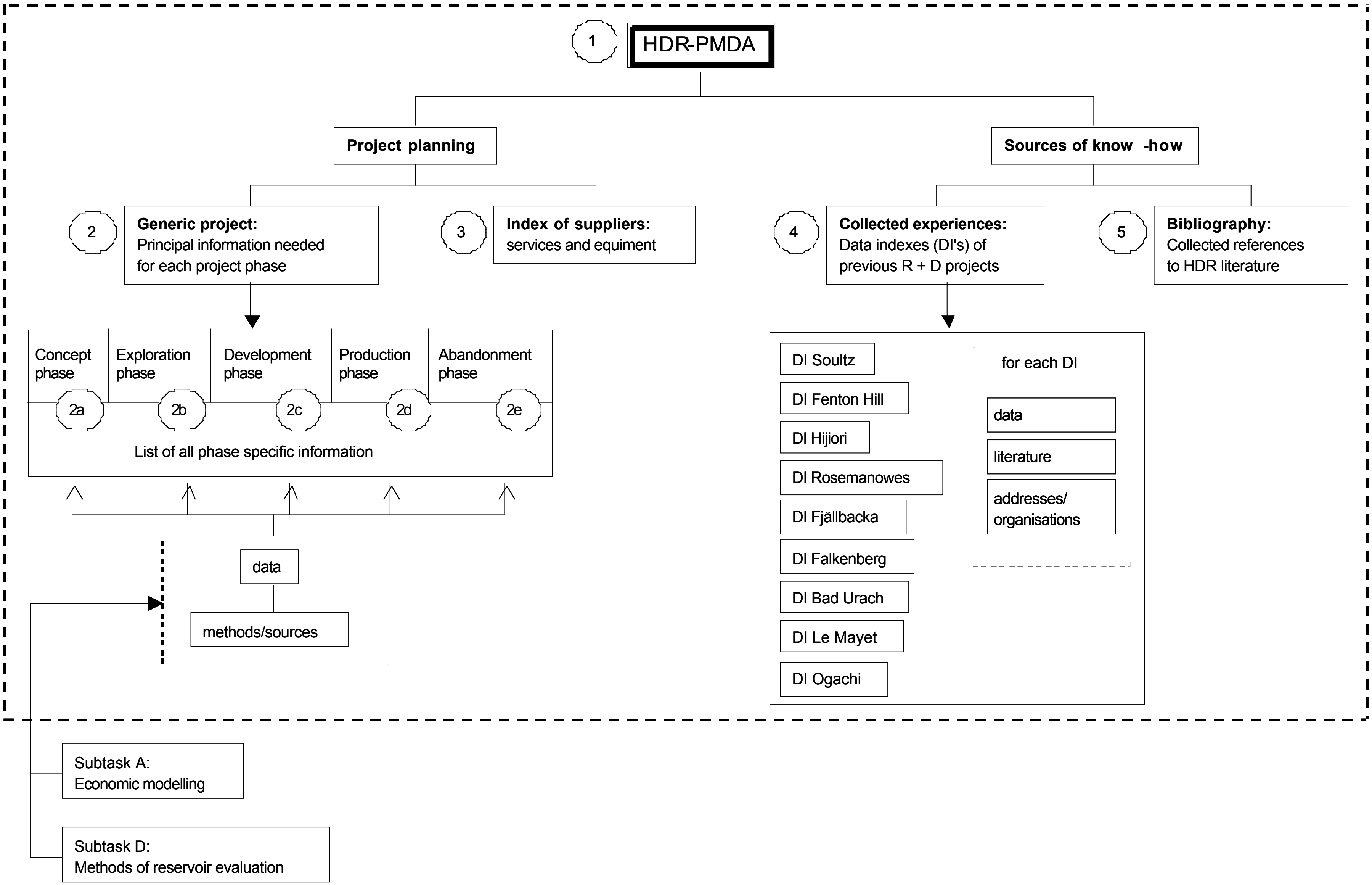
1. It should indicate which data are needed at each stage of the planning, construction and operation and how they may be acquired.

2. It should as far as possible be based on all the experience, practical and theoretical gained to date across the World.

3. It must be easy to understand and to use by project teams new to HDR.

4. Certain parts of it should be readily adaptable to any particular project.

Subtask C: development of a Project Management Decision Assistant - PMDA



PMDA components

1 Data indexes (DI's)of previous R + D projects		
Project	**Status**	**Format**
Soultz (F)	data sets: - 1199 data sets indexed - over 800 data sets archived literature: - over 800 references indexed - 70 pdf-files archived	HDR data-index
Fenton Hill (USA)	data sets: - most of the data sets indexed - no data sets archived literature: - over 500 references indexed - no pdf-files archived	HDR data-index Responsible - PERI
Hijiroi (J)	data sets: - some of the data sets indexed - no data sets archived literature: - no references indexed - no pdf-files archived	HDR data-index Responsible - NIRE
Rosemanowes (GB)	data sets: - nearly 500 data sets indexed - no data sets archived literature: - over 350 references indexed - no pdf-files archived	HDR data-index
Fjällbacka (S)	data sets: not available literature: reports available	-
Falkenberg (D)	Nothing available	
Bad Urach (D)		
Le Mayet (F)		
Ogachi (J)		

2. Bibliographic Collection		
2500 articles and reports	v. 3 available with status as of early 2001	**EndNote** application exists New format for v. 4

PMDA components

3. Status of the various components at the start of 2002		
Task-Nr	**Task**	**Status**
1	Development of the PMDA concept	concept exists, detailed refinements continue
2	Generic HDR project	
2a	Concept phase	content assembled and awaiting completion
2b	Exploration phase	assembly started
2c	Development phase	assembly started
2d	Production phase	-
2e	Abandonment phase	-

Summary of Work planned for 2002

Task No.	Task title	Work planned
2	Generic HDR project	Establishing the techniques for presentation and application of the generic HDR project work.
2a+2b	Concept and Exploration phases	To make progress in reworking and detailing information packets, data items and methods for the concept and exploration phases (and in part also the development phase) for integration into the new document form.
2b+2c +2d	Exploration, Development and Operation phases	Extending the assembly of information, data and methods to later phases. Important at this stage is to specify the demands placed on the surface site at all times and its effects on the project in a range of scenarios.
5	Bibliography	Updating and reformatting