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Teilnahme am GIA - das Geothermal Implementing Agreement der IEA (Annex III, Hot Dry Rock, sowie Aufgaben des Chairman of the Executive Committee):

Jahresbericht 2001

Bericht ausgearbeitet durch

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für die Arbeitsgemeinschaft GIA

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IEA – Hot Dry Rock

Annual Report for 2001 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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Summary

From the organisational point of view the year 2001 has seen a consolidation of the GIA structure, together with its further development into new Annexes. Of particular interest is Annex VII, started on US initiative and devoted to collecting and distributing information on advanced methods for reducing geothermal drilling costs. In addition the co-operative agreement for accelerated global market development between the GIA, the World Bank and the United Nations has come into effect. It is being incorporated into the GIA activities in the form of Annex IX, which is currently undergoing formulation and preparation.

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

- data collection and organisation for specific sites and projects and
- definition of data requirements for a generic HDR project.

Over the past three years the concept of the generic project has been built up. Data requirements for the early stages of planning a realistic HDR plant are added continually, and in 2001 work has started on the construction of a means of presenting and viewing the data requirements.

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1. Tasks of the Chairman of the Executive Committee (ExCo)

Overview of activities

The scope and intensity of the Chairman's activities have increased strongly in the current year in comparison with past years due to the increased worldwide interest in geothermal energy. The main activities undertaken have been:

- Preparation and Chairing of the 6th meeting of the Executive Committee, Brussels 8th-9th March, 2001;
- Preparation for the 7th ExCo meeting, scheduled to take place in Mexico in November 2001, but cancelled due to the international political situation;
- Meetings and presentations for the newly established World Bank/Global Environmental Facility - GIA Alliance:
  - Meeting in Brussels on 7 March, co-chaired by L. Rybach (see Appendix 1 for Meeting Notes);
  - Representation of GIA at the *International Workshop on Geothermal Development in Central and Eastern Europe* in Copenhagen, on 8-9 October (see Appendix 2 for presentation overheads);
- Production of successive versions of the GIA End of Term Report and work for the prolongation of GIA beyond March 2002 (see Appendix 3 for second draft – Nov. 2001);
- Work as Member of the REWP (Renewable Energy Working Party) IA ExCo Chairmen's Group, especially for the IEA Renewable Energy Market Initiative (see Appendix 4 for presentation material for meeting at IEA headquarters in Paris on 4th April 2001);
- Leadership of the GIA Planning Committee and in particular the finalising of the format for the new Annex VII - Advanced Geothermal Drilling Technology;
- Undertaking routine work for administration, promotion and development of the GIA ExCo

Comments on the activities

The extension of the GIA for a further five years beyond March 2002 has been formally approved by both the REWP and the CERT (Committee for Energy Research & Technology) at IEA and announced by the IEA secretariat, although a third version of the End of Term report has been requested.

The seventh plenary meeting of the Executive Committee has now been re-organised to take place on March 7th and 8th 2002 at the IEA headquarters in Paris.

2. Organising and Archiving HDR project data

Management of technical data within the project - collecting, organising, archiving and documenting:

An initial concept for data archiving was developed between 1995 and1998 and a test application was set up for the former HDR project at Rosemanowes in Cornwall. The concept has now been successively extended and improved on the basis of external feedback and implemented for the European HDR R & D project at Soultz-sous-Forêts, in Alsace. During 2001 a full version of the Data Index for the project at was completed. This is now available on a CD.

The concept was also recommended for use by other projects in countries cooperating in the HDR Annex of the new Geothermal Implementing Agreement of the International Energy Agency. Some progress has been made with data from the Japanese research project at Hijiori and with the pioneering former U.S. project at Fenton Hill, New Mexico. Both the archiving concept and the data indexing software have proven to be easily applicable to the different sites and projects.

The essential features of the archiving concept are:

- Physical separation of archived test data and literature from a data catalogue, called the data-index;
- Storage approach for the test data, which in general enables location by date and by data type. For the moment, microseismic raw data form an exception;
- Creation of the data-index documenting the project history and linking information on activities, test data, documents and addresses of the corresponding responsible organisations. The data-index also contains the filenames and storage locations of the test data and the literature, if digitally available.

The structure and the use of the data-index, programmed as a Micro Soft Access 97 database, is documented in detail in Hopkirk and Mégel (1998). The improvements have been documented in previous annual reports and the latest extensions are briefly reported in the present report.

The data-index is available on a CD as an Access 97-file, as a runtime Access 97 version for those potential users not in possession of Access 97, and as an Access 2000 file.

New extensions to the data-index structure:

The master “HDR Data Index” application has been extended to include the following three features:

A. Details of measuring tools used to acquire data

B. Storage locations of digitally archived documents

C. 3 new auxiliary data input forms for entry and modification of the parameters for the above extensions A and B.

Information on measuring tools

A clear identification of the instrument used for acquiring a specific data set is usually of central importance for the interpretation. Hence the following tool information should be entered into the data-index for each data set:

- Name of the company or institution which constructed the tool.

- Arbitrary information about the used tool

The tool information is entered within the Activity/Data Set-form (see Hopkirk and Mégel, 1998).

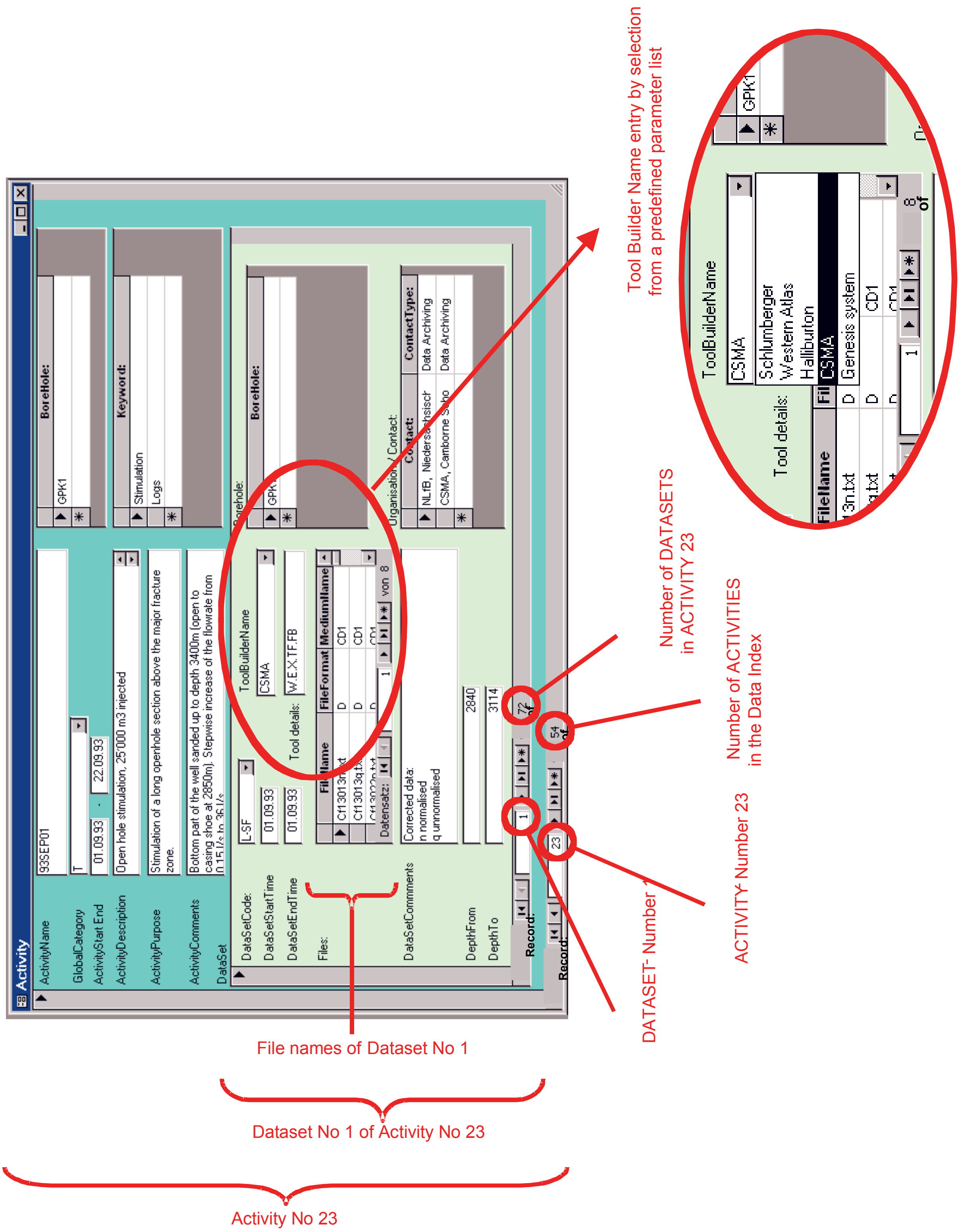

Fig 2.1: New Activity-form for the entry and modification of activity and data set data

For this extension it was necessary to introduce the following data fields into the “HDR Data Index” structure::

field name	field format
Tool Builder Name	Entered by selection from a predefined list of tool builders. For the modification of the predefined list see section C, below.
Tool details	Arbitrary text

Location of digitally archived documents

For the Soultz HDR project a number of items of literature are being digitally archived. The file name and storage location of each item referenced in the data-index must be defined to ensure its accessibility. The following information, therefore, must be available:

- Name of the literature file
- Format of the literature file:
- Medium name, since the literature files may be stored by their file names on several archiving media of the same type.
- Type of medium such as CD-ROM, DVD-ROM, DAT tape, etc.

The location of the digital literature archive is entered within the Literature-form (see Hopkirk and Mégel, 1998). The additionally required field names and their formats are as follows:

field name	field format
File Name	Arbitrary text
File Format	Selected from the following given list: - txt : pure ASCII text files - pdf : Adobe Acrobat files
Medium Name	Arbitrary text
Medium Type	Selected from a predefined list. For the modification of the predefined list see section C, below.

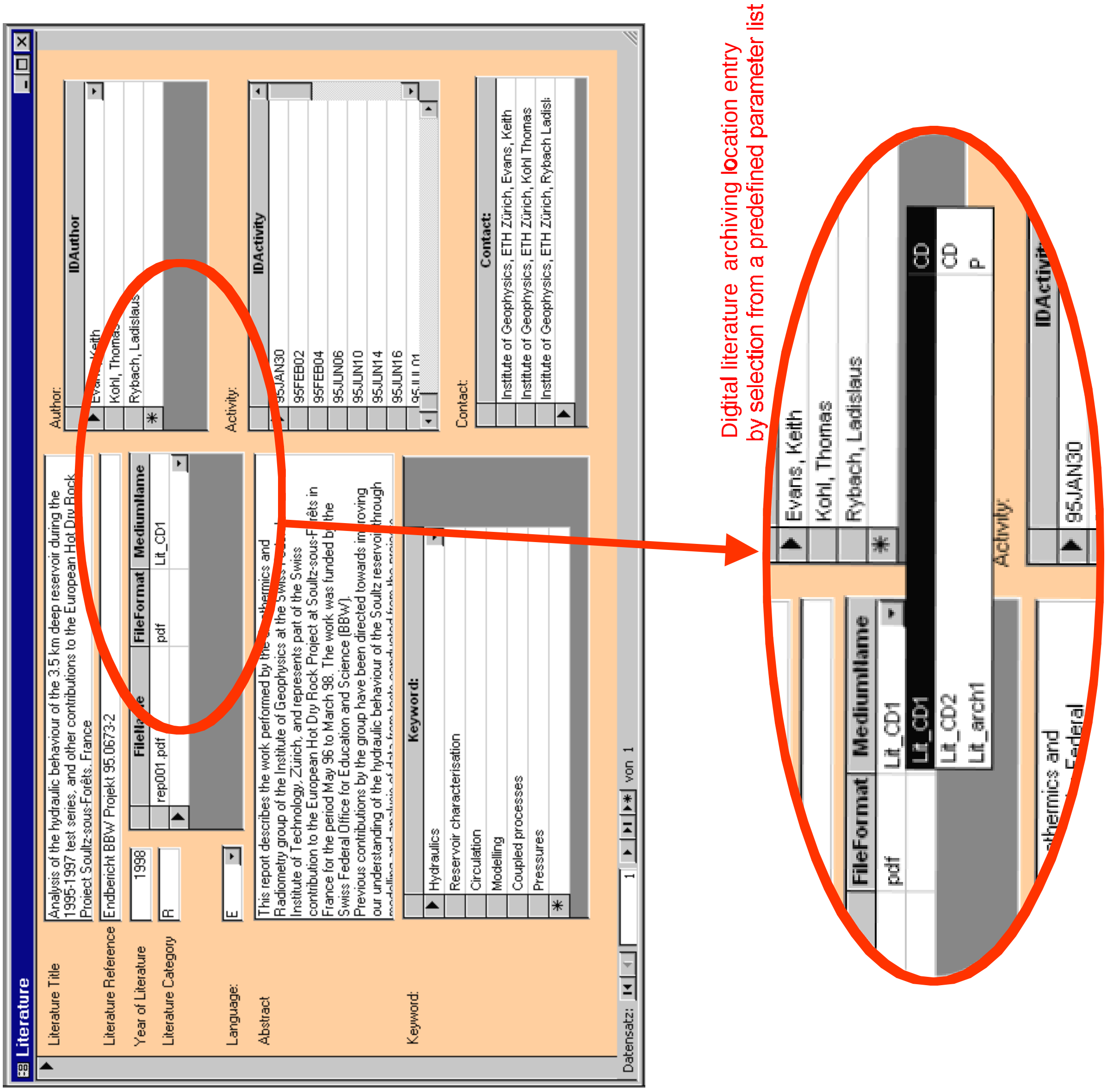

Fig 2.2: New Literature-form for the entry and modification of literature data

New Toolbar buttons

Corresponding to the new data entry possibilities the toolbar of the “HDR Data Index” application has been extended by 3 buttons to call up the new auxiliary input forms:

toolbar name	**description**
Lit. Medium Name	Entry or modification of the names and the corresponding types of the digital literature archiving mediums
Lit. Medium Type	Definition of the literature medium type codes with the corresponding description
Tool Builder	Definition of the list of the tool builders

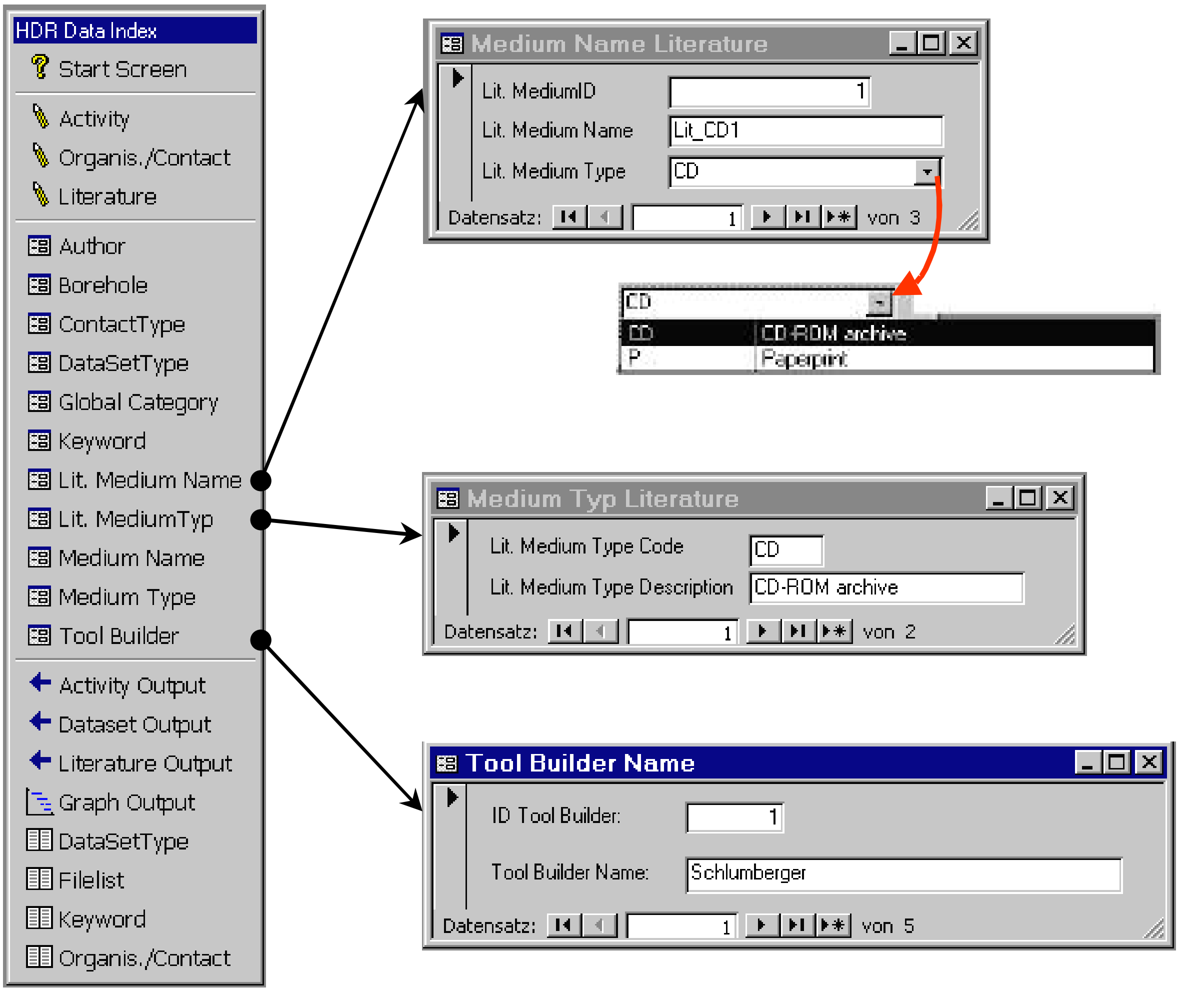

Fig 2.3: New auxiliary input forms for the entry and modification of the parameter lists

Indexing and archiving of measured data

The data sets and the literature data included in the Soultz data-index are classed into 66 activities covering the period from 1.1.1987 to the 31.12.1999. At present 823 datasets and 1199 file-locations are stored in the Soultz data-index. An overview is given in Table 2.1 below. However, no claim can be made for completeness, since at any stage, neither all data types nor all data records can be included. The list will be extended as archiving work and the project itself develop.

dataset code	dataset type	number of datasets	number of files
ENG	Engineering data	11	9
GWLVLS	Groundwater levels	5	4
L-AC	Acoustic Log	1	1
L-ARI	Azimuth resistance imager	3	3
L-BGT	Borehole Geometry Tool	15	15
L-BHTV	Accoustic Borehole TV	2	1
L-CAL	Caliper log	10	8
L-CFM	Calibrated Flowmeter Log	39	41
L-CNL	Compensated Neutron Log	1	
L-DLL	Dual laterolog	1	1
L-DSI	Digital Sonic Imager, Diple Sonic Imager	1	
L-Elec	Electrical Logs	1	1
L-FMI	Formation Micro-Imager	3	1
L-FMS	Formation Microscanner	1	1
L-GEOG	Geological log	17	16
L-GR	Gamma ray	4	3
L-Ind	Induction Logs	1	1
L-LD	Litho-Density Log	2	1
L-MSFL	Microspherically focused resistivity	1	1
L-NGT	Natural gamma ray spectrometry	1	
L-Nuc	Nuclear Logs	5	5
L-Pcp	Physico-chemical parameters	3	3
L-SF	Spinner Flowmeter	36	37
L-Son	Sonic Logs	5	5
L-SP	Sonic (P-waves) log	2	1
L-SS	Sonic (S-waves log	1	
L-TEMP	Temperature log	275	294
L-UBI	Ultrasonic Borehole Imager	3	2
MSLOCS	Microseismic event locations	12	15
PQ	Pressure,Flow	7	61
PT	Pressure, Temperature	288	303
PTQ	Pressure,Temperature, Flow	66	365
Totals	**32 dataset types**	**823 datasets**	**1199 files**

Table 2.1: Summary of indexed datasets and corresponding file-locations

The 1199 data files indexed so far have been collected and archived in ASCII format.

Indexing and archiving of project literature

So far 801 literature references with 380 abstracts have been collected and indexed in the Soultz data-index, whereof 70 reports have been scanned and archived as pdf-files. An overview is given in Table 2.2 and Table 2.3 below.

literature type	number of references	number of files
Paper	188	9
Report	493	56
Internal Report	7	5
Map	113	-
Totals	**801 references**	**70 files**

Table 2.2: Summary of literature types

literature language	number of references	number of files
English	634	61
French	136	6
German	29	5
Italian	2	-
Totals	**801 references**	**70 files**

Table 2.3: Summary of literature languages

3. Presentation of data requirements for the generic project

One of the aims of Subtask C of Annex III is to produce a compendium of the types of data required during the planning, construction and operation and closure of a Hot Dry Rock power plant and its reservoir. As far as possible with today's level of knowledge it is intended to define which data are required at which time and which methods can be used to obtain them.

A study of data requirements have been undertaken over the past four years, running parallel to the project planning for the Swiss "Deep Heat Mining" HDR pilot plant. A method for organising and presenting the assembled data requirements for a theoretical, generic HDR reservoir and energy conversion plant has been sought, so that what might be simply a useful guideline or check list becomes in addition an accessible and useable tool. In 2001 work has started on this aspect of the task. The purpose of the present chapter is to explain the approach taken so far. It is probable, but by no means certain at this time, that this will lead to the creation of a small relational database application.

The principle data requirements during a life cycle of an HDR power plant are answers to 4 basic questions (table 3.1). The answers to the questions 1-3 are organised in a database matrix. Based on the database matrix a critical path analysis will give the answers to question 4 showing synergies and hence time- and cost-saving procedures.

Table 3.1: The 4 basic questions for each project phase

<table>
<tr><th colspan="2">Needs</th><th>Organisation by...</th></tr>
<tr><td>1.</td><td>What is the present need of information ?</td><td rowspan="3">database matrix</td></tr>
<tr><td>2.</td><td>Which data are needed for (1) ?</td></tr>
<tr><td>3.</td><td>What are the methods/sources to acquire the data for (2)?</td></tr>
<tr><td>4.</td><td>When must the specific acquisitions be carried out ?
This will depend upon:
- seasonal conditions
- availability of tools, laboratories, personnel, contractors
- synergies for time and cost reduction</td><td>critical path analysis</td></tr>
</table>

The database matrix

The life cycle of a geothermal energy exploitation by means of an HDR reservoir and a surface power plant has been divided into 5 distinct phases, separated from each other by 6 principle milestones:

Table 3.2: Phases and milestones

milestone	**phase**	**task**
start project		
	concept phase	planning, design, principle site evaluation, economic pre-feasibility
start reservoir exploration		
	exploration phase	drilling, first reservoir creation and reservoir characterisation, long-term tests, predictive modelling
start reservoir creation and system completion		
	development phase	system completion, final installations in boreholes, surface installations
start production		
	production phase	energy production and delivery, monitoring of reservoir behaviour
end of production, start decommissioning		
	abandonment phase	controlled decommissioning of the installed operation
decommissioned		

During each phase, specific information must be made available to reach the next milestone. The information needed is based on specific data, divided into 7 data domains. These data are obtained by specific methods, usually but not necessarily acquired within the corresponding phase.

Table 3.3: Database matrix

			life cycle				
			start reservoir exploration	**start reservoir creation and system completion**	**start production**	**start decommissioning**	
			Concept phase	**Exploration phase**	**Development phase**	**Production phase**	**Abandonment phase**
		Code	C	E	D	P	A
data classes	**Organisational / Legal data**	OL	OL_C	OL_E	OL_D	OL_P	OL_A
	Infrastructure / Site data	INF	INF_C	INF_E	...		
	Environmental data	ENV		...			
	Drilling / Logging data	DL	DL_C	DL_E	DL_D	DL_P	DL_A
	Experimental data	EXP		...			
	Economic data	ECO					
	Financial data	FIN					

The database matrix (Table 3.3, above) is therefore a representation of the required information, the base of data and the acquisition method for each data domain and each phase of the life cycle. Each field is identified by an unique code and can be subdivided into sub-phases and sub- milestones and represented separately (see later).

In the fields and sub-fields of the database matrix the specific information needed (**information packets**), the items of data needed (**data**) to build up this paackage of information and the corresponding methods/sources (**method**) to acquire the data are identified by an unique code.

The meaning of these codes are indicated in lists of items of information needed, lists of data and lists of methods/sources.

The milestones indicate the point, where the go-no go decision must be taken. This decision depends on the availability of information from most of the data domains. Therefore each phase of the data matrix is represented separately for inscribing the specific codes for needed information, the data and the methods (if defined). Some of the needed information may be of general validity, some may be site-specific. Items of information constituting stand-alone go/no-go criteria have the highest priority.

The general organisation of the overall data matrix concept at present is given in the following sections. The tables and figures included here illustrate the breakdown of the early parts of a project to fit the data matrix concept. The breakodowns reflect some aspects of experience gained with the Swiss HDR-project in Basle (definition of the sub-milestones). The figures are purely illustrative. The tables contain some items, but are not yet complete.

The Concept Phase - its general validity

The presentation of details of the generic data matrix commences with Figure 3.1 on the following page for the concept phase alone. This phase has been selected not only because it is infact the first phase, but also since at present it appears to be the most generally relevant to the situations in developed countries of all the lifetime phases. Subsequent phases may be more site, country or project-specific.

Figure 3.1 gives an overview of the Concept Phase with a first view of the seven classes of data to be considered. The data items themselves make up data lists needed for each of the information packets. In their turn, groups of information packets allow the major domains of activity to be completed in the progress towards reaching the next milestone – in this case, the start of reservoir exploration.

life cycle:			**Concept phase**													
milestones:																**start reservoir exploration**
Information domains:			Permission					Economic			Technical					
Information packets:			Cp_11	Cp_12	Cp_13	Cp_21	Cp_22	Ce_11	Ce_12	Ce_21	Ct_11	Ct_12	Ct_13	Ct_14	Ct_15	Ct_21
data classes	**Organisational / Legal data**	OL	OL_1	OL_2	OL_1 OL_5	OL_4 OL_6	OL_3								OL_3 OL_6	
	Infrastructure / Site data	INF			INF_1	INF_2					INF_3	INF_4 INF_5 INF_6			INF_7	
	Environmental data	ENV				ENV_1									ENV_2 ENV_3	
	Drilling / Logging data	DL				DL_1										
	Experimental data	EXP											EXP_1 EXP_2	EXP_3		EXP_4
	Economic data	ECO			ECO_1 ECO_2					ECO_1 ECO_2						ECO_3
	Financial data	FIN			FIN_1					FIN_2 FIN_3 FIN_4						

Figure 3.1: An overview of the information requirements for the Concept Phase

Table 3.4: Information packets for the concept phase

Items of information needed up to the first milestone, to be acquired during the concept phase

1. priority : go/no-go items	
Cp_11	Principal availability of a permission for geothermal heat extraction
Cp_12	Principal availability of permissions for foreign companies
Cp_13	Production permission

Ct_11	Availability of an electric network
Ct_12	Availability of a district heating network
Ct_13	Expected minimum heat production
Ct_14	Expected minimum electricity production
Ct_15	Cooling concept of the power conversion system

2. priority : needed items for the next milestone	
Cp_21	Drilling permission
Cp_22	Permitting

Ce_21	Expected rentability of the HDR system

Ct_21	Operation concept of the engine station

3. priority : needed items for later milestones	
Ct_31	

Table 3.5: Data-list for the concept phase

Data required in order to obtain the items of information needed

Legal data		**Method/ source**
OL_1	National/Local mining laws and ordinances	A_1
OL_2	National/Local business laws and ordinances	A_2
OL_3	National/Local policy	A_4
OL_4	National/Local laws for noise protection	A_3
OL_5	National/Local nature protection zones	A_3
OL_6	Laws for groundwater protection	A_3

Infrastructure/site data		**Method/ source**
INF_1	Local land usage plan	A_4
INF_2	Map of noise protection zones	A_3
INF_3	Electric network map	A_5
INF_4	District heating network maps	A_5
INF_5	Heat consumer statistics	A_5
INF_6	Renovation plan of the heat central	A_6
INF_7	Availability of cooling water	S_2

Environmental data		**Method/ source**
ENV_1	Noise immission	S_1
ENV_2	Groundwater impact	S_1
ENV_3	Landscape protection impact (in case of cooling tower)	S_1

Drilling/Logging data		**Method/ source**
DL_1	Noise emission of the drilling rig	R_1

Experimental/Modelling data		**Method/ source**
EXP_1	Estimate of minimum temperature range above a critical depth	M_1
EXP_2	Estimate of depth-dependent minimum production rate range	M_2
EXP_3	Estimate of the heat-electricity conversion	M_3
EXP_4	Range of depth dependency for production rate and temperature	M_4

Economic data		Method/ source
ECO_1	Cost estimation of the whole HDR system	E_1
ECO_2	Pricing estimation for the operation phase	E_1
ECO_3	Price of conversion systems	E_2

Financial data		Method/ source
FIN_1	Principal availability of investors	E_1
FIN_2	Estimates of rates of interest for the whole life cycle	E_1
FIN_3	Capital availability	E_1
FIN_4	Risk analysis	E_1

Table 3.6: Method/source list for the concept phase

Method/source		Task	Signature
Authorities	A_	Contacting local/national mining authorities	A_1
		Contacting local/national business authorities	A_2
		Contacting local/national environmental protection authorities	A_3
		Contacting political authorities	A_4
		Contacting authorities of the district heating networks	A_5
		Contacting authorities of the electric networks	A_6
Studies	S_	Impact study	S_1
		Hydrological site study	S_2
Economics	E_	Business plan	E_1
		Market research for conversion systems	E_2
References	R_	Technical reference of drilling rig	R_1
Modelling	M_	Depth-dependent temperature calculations (simple analysis)	M_1
		Flow calculations (simple analysis)	M_2
		Efficiency study for heat-electricity conversion	M_3
		Temperature and flow calculations (detailed study)	M_4

The Development Phase – first considerations

In the same way that Figure 3.1 showed the nature and structure of data requirements for the concept phase, the two figures 3.2 and 3.3 are included below to illustrate the similar breakdown of the development phase.

life cycle:		**Exploration phase**											
sub-milestones		1st monitoring well (basement depth)			1st deep hole (ca. 5 km)			2nd + 3rd monitoring wells			2nd deep hole (ca. 5 km)		
information domains:		Perm.	Econ.	Techn.	Perm.	Econ.	Techn.	Perm.	Econ.	Techn.	Perm.	Econ.	Techn.
information packets:		...											
data classes: **Organisational / Legal data**	OL												
Infrastructure / Site data	INF												
Environmental data	ENV												
Drilling / Logging data	DL												
Experimental data	EXP												
Economic data	ECO												
Financial data	FIN												

Figure 3.2: Overview of the whole exploration phase

		life cycle:	**1st part of Exploration Phase**													
		sub-milestones:														1st monitoring well
		information domains:	Permission					Economic			Technical					
		information packets:	Ep_11	Ep_12	Ep_21	Ep_22		Ee_11	Ee_21		Et_11	Et_12	Et_21			
data classes	**Organisational / Legal data**	OL	OL_1	OL_3	OL_2											
	Infrastructure / Site data	INF														
	Environmental data	ENV				ENV_1										
	Drilling / Logging data	DL				DL_1										
	Experimental data	EXP														
	Economic data	ECO														
	Financial data	FIN														

Figure 3.3: The first part of the site investigation leading to the drilling of the first monitoring well –work still in progress

Information packets for the exploration phase

The information needed for reaching the next milestone, to be acquired during the sub-phases DL_Expl_a and DL_Expl_b, are listed in the following tables:

Table 3.7: DL_Expl_a (before drilling of exploration well)

1st priority : go/no-go criteria		
11	Which sites are available for exploration drilling	a_11
12	Which environmental protection criteria must be fulfilled for drilling permission at this/these site(s)	a_12
13		

2nd priority : needed for the next step		
21	List of suitable drilling companies	a_21
22	List of suitable logging companies	a_22
23	List of suitable construction companies for site preparation	
24	Infrastructure needed for the selected drilling company at the site(s)	
25		

3rd priority : needed for later steps		
31	Projected vertical temperature profile to possible reservoir depths	a_31
32	Chemistry of formation water and of host rock	a_32
33	Parameters of the stress tensor in the host rock	a_33
34	Depth of the top of the host rock below surface	a_34
35	Indications of deep natural convection cells	a_35
36	Orientations of all fracture sets at exploration depth, open and closed	a_36
37	Which sites are potentially available for further wells	a_37
38		

*Table 3.8: DL_Expl_b (after drilling of exploration well***)**

1st priority : go/no-go criteria		
11	Reservoir depth necessary to reach a useful temperature range	b_11
12	Which environmental protection criteria must be fulfilled for drilling permission at this site	b_12
13		b_13

2nd priority : needed for the next milestone		
21	Projected direction of growth of the reservoir volume due to stimulation	b_21
22	Suitable location(s) and trajectories of the production and injection boreholes	b_22
23		

3rd priority : needed for later milestones		
31	Necessary stimulation overpressure at reservoir depth	b_31
32	Data collection for thrermal-hydraulic predictive modelling	b_32
33		

Data list for the exploration and development phases

Table 3.9: Data necessary to obtain the desired information for all steps

***Domain:* Characteristics of the potential reservoir rock**				
Subdomains		***Data***		***Sign***
Tectonics	Tct_	1 2 3	Tectonic features Distribution at depth of faults and discontinuities Density and orientation of faults	Tct_1 Tct_2 Tct_3
Petrology	Ptr_	1 2 3 4 5	Rock mineralogical composition Hydrothermalised faults Secondary mineral assemblages Open vs. closed fractures evaluation Fluid-bearing fractures	Ptr_1 Ptr_2 Ptr_3 Ptr_4 Ptr_5
Rock mechanics	Mch_	1 2 3 4	Stress field features Azimuth and magnitude of the stress components Impedance Pore pressure	Mch_1 Mch_2 Mch_3 Mch_4
Hydraulics	Hyd_	1 2 3 4 5 6	Pre- and post-stimulation permeability Transmissivity Porosity Natural flow productivity Fracture openings Inflows and outflows from fractures	Hyd_1 Hyd_2 Hyd_3 Hyd_4 Hyd_5 Hyd_6
Temperature	Tmp_	1 2 3 4 5 6 7	Maximum depth temperature Geothermal gradients in sediments and in the basement Heat flow as a function of depth Evidence of natural free convection systems Natural internal heat generation rates in the host rock Data for thermo-hydraulic modelling Rock thermal conductivity Evaluation of the thermal blanketing of the sedimentary cover	Tmp_1 Tmp_2 Tmp_3 Tmp_4 Tmp_5 Tmp_6 Tmp_7
Calibration for seismic velocities	Csv_	1 2	Reference borehole for seismic profiles Seismic velocities of each formation	Csv_1 Csv_2
***Domain:* Characteristics of the fissure and rock matrix fluids**				**Fluid_**
Subdomains		***Goals***		***Signature***
Fluid and gas composition	Fgc_	1 2 3 4 5 6 7 8	Origin of the fluids Water-rock interactions Hydrochemical database Deep temperature forecast Relations with the interface between top crystalline and the sedimentary cover Fluid density Deep temperature forecast Origin of the gases	Fluid_Fgc_1 Fluid_Fgc _2 Fluid_Fgc _3 Fluid_Fgc _4 Fluid_Fgc _5 Fluid_Fgc _6 Fluid_Fgc _7 Fluid_Fgc _8
***Domain:* Monitoring**				**Mntr_**
Subdomains		***Goals***		***Signature***
Microseismic events monitoring	Me_	1	Physical nature and shape of the stimulated reservoir	Mntr_Me_1
Hydraulic head and temperature monitoring	Hht_	1 2	Long term monitoring of the hydraulic head of the crystalline section Long term monitoring of the bottom hole temperature	Mntr_Hht_1 Mntr_Hht_2

Partial list of methods for the exploration and development phases

Table 3.10: List of methods for acquiring the data

Class (Where ?)		***Method (What ?)***		***Signature***
Laboratory	Lab_	ct_	Cuttings analysis Geochemical analyses Chemical and isotopic analyses	Lab_ct_a Lab_ct_gch Lab_ct_itp
		cr_	Core orientation Core analysis Thin sections Fractures analysis Thermal conductivity measurements	Lab_cr_o Lab_cr_a Lab_cr_ts Lab_cr_fr Lab_cr_tcd
		fl_	Fluid analysis	Lab_fl_gch
Logging	Log_	1 2 3 4 5 6 7 8 9 10 11 12	Caliper log Oriented caliper log Gamma-ray log Laterolog Image logging (BHTV, FMS, UBI, ARI, etc.) Temperature log Full length temperature logs Flowmeter log Neutron log Sonic log Fluid resistivity log BHT temperature	Log_cal Log_calo Log_gr Log_dll Log_img Log_tmp1 Log_tmp2 Log_sf Log_nl Log_son Log_flr Log_bht
Downhole	Dnh_	1 2 3 4 5 6 7	Installation of 4 geophones (microseismics) Vertical seismic profiling Pressure probe set below water level Temperature probe set at total depth Hydrofracture test measurements Hydrofracture test measurements between packers Fluid sampling	Dnh_ms_ins Dnh_vsp Dnh_p Dnh_tmp Dnh_hft Dnh_hftp
Surface/Site	Sfc_	1 2 3	Production test Fluid + gas monitoring during drilling of the basement Wellhead sampling	Sfc_prd Sfc_fgm Sfc_whs
Field survey	Fld_	1 ...	...	Fld_1 ...
Modelling	Mod_	1 2 3 4	Geochemical modelling Hydraulic modelling Hydraulic-Thermal modelling Hydraulic-Mechanical modelling	Mod_gch Mod_h Mod_ht Mod_hm

Finally Figure 3.4 below gives an overview of the coupling between the various levels of information shown here concerning the exploration phase and data by repeating some of the figures and tables presented in this section within one diagram:

data classes		Code	Concept phase	Exploration phase	Development phase	Production phase	Abandonment phase
			(life cycle) start reservoir exploration	start reservoir creation and system completion	start production	start decommissioning	
		Code	C	E	D	P	A
data classes	Organisational / Legal data	OL	OL_C	OL_E	OL_D	OL_P	OL_A
	Infrastructure / Site data	INF	INF_C	INF_E	…		
	Environmental data	ENV		…			
	Drilling / Logging data	DL	DL_C	DL_E	DL_D	DL_P	DL_A
	Experimental data	EXP		…			
	Economic data	ECO					
	Financial data	FIN					

life cycle:		Exploration phase											
sub-milestones				1st monitoring hole (2.5 km)			1st deep hole (5 km)			2nd + 3rd monitoring hole (2.5 km)			2nd deep hole (5 km)
Information domains:		Perm.	Econ.	Techn.	Perm.	Econ.	Techn.	Perm.	Econ.	Techn.	Perm.	Econ.	Techn.
Information packets:		…											
Organisational / Legal data	OL												
Infrastructure / Site data	INF												
Environmental data	ENV												
Drilling / Logging data	DL												
Experimental data	EXP												
Economic data	ECO												
Financial data	FIN												

(data classes)

life cycle:		1. Exploration phase													
sub-milestones:															1st monitoring hole (2.5 km)
Information domains:		Permission					Economic			Technical					
Information packets:		Ep_11	Ep_12	Ep_21	Ep_22	1	Ee_11	Ee_21		Et_11	Et_12	Et_21			
Organisational / Legal data	OL	OL_1	OL_3	OL_2											
Infrastructure / Site data	INF														
Environmental data	ENV				ENV_1										
Drilling / Logging data	DL		2		DL_1										
Experimental data	EXP														
Economic data	ECO														
Financial data	FIN														

(data classes)

1

Information packets for the exploration phase

1. priority : go/no-go items	
Ep_11	explanation of 1. priority permission item 1
Ep_12	explanation of 1. priority permission item 2
Ee_11	…
Et_11	…
Et_12	

2. priority : items needed for the next milestone	
Ep_21	
Ep_22	
Ee_21	explanation of 2. priority economic item 1
Et_21	explanation of 2. priority technical item 1

3. priority : items needed for later milestones	
Ep_31	explanation of 3. priority permission item 1

2

Data list for the exploration phase

Legal data		**Method/ source**
OL_1	explanation of legal/organisational data set 1	A_1
OL_2	explanation of legal/organisational data set 2	A_2
Infrastructure/site data		**Method/ source** (3)
INF_1	…	A_4
Environmental data		**Method/ source**
ENV_1	…	S_1
Drilling/Logging data		**Method/ source**
DL_1	…	R_1
Experimental/Modelling data		**Method/ source**
EXP_1	…	M_1
Economic data		**Method/ source**
ECO_1	explanation of economic data set 1	E_1
Financial data		**Method/ source**
FIN_1	explanation of financial data set 1	E_1

3

Method/source list for the exploration phase

Method/ source		**Task**	**Sign**
Authorities	A_	explanation of method/source and task 1	A_1
		explanation of method/source and task 2	A_2
Studies	S_		S_1
Economics	E_		E_1
References	R_		R_1
Modelling	M_		M_1

…

Figure 3.4: Example of project-information-data links to provide an overview

HDR literature collection

Further progress has been made during 2001 with the bibliography of HDR / HWR technology, for which around 2500 entries have now been collected. An alternative format was sought, in order to make the library easily accessible to more people. Instead of the spreadsheet version in Microsoft EXCEL, initially foreseen to supplement the original EndNote database, it has been decided to simply produce a structured and formatted WORD text listing directly from EndNote.

4. Data requirements for the generic surface installations

Background

In parallel with the development of a method for presenting information on the generic HDR project and its data requirements, work on further stages of the project is being undertaken. An important task is the planning of the surface sites and the specification of surface installed plant and equipment. Experience with the situation of the Deep Heat Mining project in Basel serves as the primary basis for all site development considerations. However, in order to increase the valid range of applicability to other sites, it has been decided to vary some plant features by introducing alternative scenarios.

For the present work, a HDR system has been assumed which is intended to deliver both heat to an existing district heating system, and electricity. The direct use of the geothermal heat means that such systems must be installed close to the main ducts of the district heating system since the heat transport over long distance is very expensive. This requirement on the other hand means that the land availability in such urban areas is limited and the land is expensive. The selection of an optimum site therefore has to take account of conflicting conditions.

Basic characteristics

For a case study, the basic characteristics of a DHM co-generation power plant had to be defined. The starting point was the number of boreholes, in the present case one injection hole and two production holes were chosen.

Making use of the experience from other HDR projects and studies - in particular the Soultz project and the Swiss Deep Heat Mining project - a list of main characteristics has been compiled. These values including a basic design point value and minimum/maximum values are shown in table 1. Starting from these data, the land area requirements have been estimated.

Inventory of surface facilities

On the basis of the data from table 1 an inventory of the surface facilities was established. The inventory, shown in table 2, includes permanent facilities as well as those required only during the construction phase. Table 1 is to be considered as a first approach and neeeds to be worked out more deeply in the future. In the following some comments are given for the major positions.

<u>Power conversion unit</u>
This position includes the co-generation plant itself. The system boundaries include the the steam generator/boiler on the hot side, the condenser at the cold side, the heat exchangers for the coupling to the district heating system, and the generator.

Primary loop
This part includes all elements required in the circuit of the geothermal hot water such as injection/extraction pumps, valves, piping etc.

Drilling equipment and infrastructure, construction phase
During the construction phase a large area is required for transportation, loading/unloading, storage of various goods and equipment. Most of the required area can be used during the operation phase for other purposes. However one has to keep in mind that during the exploration phase there might be need to re-install again heavy drilling equipment. Therefore at least on part of the surface no fixed buildings etc. should be erected.

Drilling equipment and infrastructure, operation phase
During the operation phase some light drilling equipment such as a work-over rig must be available on site or nearby. This will be required for maintenance use such as exchanging submerged extraction pumps, borehole cleaning and logging.

Auxiliary facilities
This position includes various indoors and outdoors areas as well as auxiliary equipment. Part of these facilities need not necessarily to be on the spot but can be placed int the neighbourhood of the project site.

Next steps

The present summarised intermediate report presents preliminary findings and data. In the next work steps both the design point data and the inventory of surface facilities shall be worked out in more detail. The study will profit from a close cooperation with the Deep Heat Mining project in Basel. In fact some of the prospective sites of the Basel project will be used for a detailed case study. In addition an “ideal” site, that means a site without restrictions will be studied and compared to the real sites in Basel. Another important aspect to be looked at is the question of stepwise enlargement of a HDR plant, e.g. the area and infrastructure requirements if a 3-borehole plant is extended to 6 or more holes.

		Unit	Design point	Minimum	Maximum
1	**Primary loop**				
	No. of boreholes injection		1		
	No. of boreholes extraction		2		
	mass flow injection	kgs^{-1}	100	80	120
	water loss	kgs^{-1}	10	0	25
	overall pressure loss	Mpa	10	5	20
	Temperature at extraction	°C	200	170	230
	Temperature at injection (electr. prod.)	°C	120	100	150
	Temperature at injection (heat prod.)	°C	100	90	120
	Injection pump efficiency	%	0.75	0.65	0.85
	Injection pump input power	kW	1333		
	Extracted thermal power (electr. prod.)	kW	30146		
	Extracted thermal power (heat. prod.)	kW	37683		
2	**Power conversion unit (PCU)**				
	Turbine inlet temperature	°C	185	160	210
	Condenser temperature	°C	20	15	27
	Cooling water inlet temperature	°C	15	10	22
	Cooling water outlet temperature	°C	20	15	27
	Cooling water mass flow	kgs^{-1}	1000	800	1500
	PCU gross output	kW	4500	3000	6000
	PCU net output	kW	3000	1800	4500
	Waste heat thermal power	kW	20935		
	No. of full operation hours/year	h	3000	2500	4000
	Net electricity production/year	MWh	9000		
	No. of full operation hours/year	h	7000	5000	8000
	Net electricity production/year	MWh	21000		
3	**District heating system (DHS)**				
	Main heat exchanger outlet temp.	°C	170	160	180
	Main heat exchanger return temp.	°C	100	80	120
	secondary loop mass flow	kgs^{-1}	122.14		
	Thermal power injected into DHS	kW	35799		
	Electric power consumption	MWh	6000	4000	8000
	No. of full operation hours/year	h	4000	3000	5000
	Net heat production/year	MWh	143195		

Table 4.1: Basic characteristics of a HDR co-generation power plant (the shaded fields contain data calculated from the other values)

Position	Area requirement	
	covered	uncovered
1 Energy conversion		
1.1 Turbine-Generator	X	
1.2 Heat exchangers district heating	X	
1.3 pumps, piping, valves, district heating	X	
1.4 Condenser and cooling circuit	X	
1.5 Cooling water supply and discharge		X
1.6 Air condensers/cooling towers if required		X
1.7 Electrical switchyard	X	
2 Primary loop		
2.1 Borehole connections	X	
2.2 circulation pumps	X	
2.3 Water treatment		X
2.4 Water buffer tank		X
2.5 Filtering		X
2.6 Gas removal system		X
3 Drilling equipment and infrastructure - construction phase		
3.1 Drilling rig		X
3.2 Other heavy equipment (crane, fracturing pumps...)		X
3.3 pipe and casing storage		X
3.4 Schlamm-Mulden, -Zwischenlager, Bohrgut-Reste		X
3.5 cement, chemicals and additives storage	X	X
3.6 containers (office, geology, gas, Bohrkerne, visitors...)	X	
3.7 Transport, loadung, unloading areas		X
3.8 Injection water buffer + particle removal		X
3 Drilling equipment and infrastructure - permanent		
3.1 Work-over rig storage / parking space		X
3.2 shelters	X	
3.3 storage areas		X
3.4 mud and water buffer storage		X
3.5 Transport, loading, unloading areas		X
4 Auxiliary facilities		
4.1 Chemicals and fluids storage	X	
4.2 Spare parts storage	X	
4.3 Maintenance workshop	X	
4.4 Laboratory, data processing	X	
4.5 Emergency generator, diesel tank	X	
4.6 Offices, visitors centre	X	
4.7 Parking lot, unloading space for trucks		X

Table 4.2: Inventory of surface facilities for a HDR co-generation power plant

The work associated with this task will be distributed over a two-year period in order to fit with the available budget. At the same time other aspects of the same complex of planning tasks will be taken further within the framework of the Deep Heat Mining project.

5. Participation in further subtasks

In the current year the level of activity of the Swiss group in other subtasks has been extremely low and has been confined to maintaining contact and following developments..

6. Next steps in Annex III, SubtaskC

Development continues of a generic HDR energy project and the assembly of data requirements during each phase. These data are required for organisation and planning, for the ordering of services and materials and for the construction of both reservoir and surface plant.

Effort is being concentrated towards the development of an appropriate form for presenting the results of studies into data needs, which have been made on the generic project during the past four years and are still continuing. Ideally the data requirements should be linked to a project network plan. During the next year, three main directions of work are planned. These are similar to those reported in the present document, and represent a continuation of the tasks started in 2001:

1. reworking and detailling the information packets, data items and methods listed here for the concept and exploration phases (and in part also the development phase).

2. extending the assembly of information necessary, the data needed to provide the information and the methods for obtaining them to later phases.

3. pre-planning the techniques for presentation and usage of the generic HDR project work.

Appendix 1

GEF-IEA Global Market Development Coalition Dialogue

Notes of a meeting held at the European Commission, Brussels, 7 Mar 2001

by Johan Wide (IEA)

1. Welcome & Introduction

Ladislaus Rybach started the meeting by thanking the European Commission for the local organization of the event.

Frank Rittner introduced the GEF background in this area, by pointing to the excellent links the GEF has with the financing community, and in working with broader risk-sharing beyond direct grants. He noted that a recent CEC study would provide interesting background information for looking at geothermal potentials in e.g. Latin America, Eastern & Central Europe, and Asia. He identified key constraints being in regulatory frameworks for providing e.g. efficient IPP conditions as well as financing for exploratory risks. Initially, he also saw an IEA role in strategic technical expertise for identifying regions and countries with best opportunities in geothermal market segments. Overall, he hoped the meeting would conclude with a follow-up agreement and recommendations to feed into e.g. the ongoing G8 process, the IEA Ministerial meeting, as well as the GEF Council spring meeting.

2. Constraints, Opportunities and Strategic Organizational Objectives

Andrea Merla highlighted the opportunities of improving international co-operation for using the tools for barrier removal that the GEF has available, for example with a range of implementing agencies, such as the World Bank/IFC, UNDP, UNEP, and regional development banks. It was also noted that the third GEF financial replenishment is currently ongoing, aiming to enable implementation of additional project activities for years to come. It was seen as important that also geothermal projects to be funded would be programmatically coherent, both with increased private sector participation, and focusing on hitherto undeveloped areas of known potential. The presence of the Mexican participants was acknowledged, anticipating they would be able to share considerable experiences in this area. It was also noted that GEF already supports several projects on direct geothermal use, and that in order for the private sector networks to bring in broader risk sharing, they would need to the work through the implementing agreements, who would then administratively link up with the GEF Secretariat through the standard proposal life cycle.

Ted Kennedy highlighted the World Bank's renewable energy partnership with the GEF that is geared to enable long-term ten-year adaptable program lending on a national client level, for which currently $150 million is available overall. An upstream project development facility for geothermal activities was suggested (cf. attachment), addressing the major needs in terms of 'front-end lubrication'. Such a facility could aim at reducing exploratory risk, building capacity, formulating legal, policy, and pricing structures, as well as attracting private sector participation. The major benefits of geothermal applications were seen as climate change mitigation potential, energy portfolio diversity, and reliable capacity relative to other renewable energy options, as well as the cost-effectiveness of geothermal applications after resource confirmation. Specifically, it was suggested that contingent financing be applied to the maximum leverage possible, and that an updated international inventory of near-term opportunities would be synthesized, based on available studies. Currently, the World Bank has 4-5 geothermal project under preparation in the Eastern and Central Europe region, and is also looking at Latin American opportunities, subject to client-driven demand.

Gunter Schramm underlined IFC's different role in terms of opportunities and constraints for being involved in geothermal activities, i.e. purely on a commercial basis, and with a maximum 25 percent stake in financing. Geothermal applications were seen as sometimes very efficient alternatives for distributed power, and complementary within a broader renewable energy portfolio. It was seen important to work for providing reasonable guarantees for PPA frameworks, and GEF could specifically assist through its readiness to take part of shared risk with e.g. repayable guarantee mechanisms. The IFC already has 4-5 geothermal activities in its portfolio.

Rybach highlighted the fact that geothermal energy costs are estimated to be the lowest on a longer-term of all renewable options identified in the recent WEA report. The major objectives of the GIA is currently to look into opportunities for new applications, such as direct use in Eastern

European countries, as well as continued technical R&D, and increasingly international market initiative work, incl. participation also beyond the IEA membership context.

Johan Wide of the IEA Secretariat gave an overview of their strategic renewable energy focus. During the last two years, remarkably increased international attention has been paid to market deployment of new renewable options, as highlighted by e.g. the 1999 IEA ministerial, the ECOFIN request for increased long-term diversification, the G8 renewable energy task force process, and the World Bank-GEF strategic renewable energy partnership. It is also interesting to note that renewable energy stocks have started to outperform environmental technology related ones during the last year. The overall strategic approach for the IEA in renewables is also based on 'the three Es': economic development, energy security, and environmental protection. This is currently being done on an international level, increasingly with non-member countries, and for all the renewable energy technology areas. The geothermal implementing agreement is the first to have a specific coalition dialog session in conjunction with their executive meetings. Recent IEA work on experience curves of emerging long-term energy technology options has indicated the need to focus on efficient learning investments in order not to create a lockout from an economically viable, diverse and environmentally sound global energy system overall. Given the specific value and benefits of renewables, market acceleration strategies are looking beyond conventional R&D, manufacturing improvements, and scale effects into also externality-related market opportunities, such as in the form of green pricing, certificate trading, and adjusting for reduced portfolio risk of renewables. Institutional/policy issues are prime impediments to geothermal development and would warrant more detailed analysis. Thus, in the case also of geothermal applications, it would be important overall to in parallel look at key opportunities in terms of optimal policy frameworks, long-term technology priorities, increased market integration through international collaboration, and recommendations for realigned financing for implementation and aggregation of jointly recognized opportunities.

3. Shared Goals –Complementary Perspectives

John Garnish, Piet Zegers and Günter Israel introduced the organizational objectives of the CEC as related to geothermal markets by noting that this meeting was highly welcome, since the major issues have increasingly been seen as largely non-technical: geothermal energy is an established technology and the principal barriers to uptake are legal and regulatory, financial (long-term pricing, predictable interest rates) and risk mitigation. The CEC has funded a considerable number of demonstration projects in geothermal energy already, and has also been looking at related experience curve analysis. Within the upcoming sixth framework program, only hot dry rock applications are currently remaining to be included for RD&D support, but in principle e.g. applied research in the form of socio-economic analysis and tools on critical risk parameters could be considered under the program. Some concerns with reinjection have been identified with geothermal applications, although this has also been noted to be very site-specific.

Tony Batchelor and Jim Randle consistently noted that key geothermal entrepreneur players are currently missing in the marketplace, and typically the private sector interest is only focused where national authorities are involved to a large extent.

NEDO announced their intention to present a proposal for international geothermal development collaboration at a later stage.

4. Towards a Geothermal Market Development Coalition

Rittner initiated the main discussion session by posing what possible elements could be highlighted in a continued joint dialog on geothermal development. Rybach underlined that successful geothermal activities would need to be characterized by adequate risk mitigation and coverage, well tailored permit arrangements, standardized sale contracts, and adequate government and industrial awareness of the potentials. It was suggested that specific provisions for such success in increasingly deregulated marketplaces could be synthesized. This could possibly be founded on model cases, as well as on database information. Wide outlined a possible sequential chain of complementary roles in the life cycle of geothermal projects, with IEA involved upfront in feasibility and policy analysis, the GEF taking a lead in contingent financing for feasibility and exploration risk, the World Bank supporting implementation of identified high-priority public government project opportunities, and IFC correspondingly in identified private sector activities. Furthermore, it was suggested in that geothermal applications in certain cases could be assigned a specific share under a long-term RPS program. Under such general rules, a greater risk control could also be achieved by averaging over a number of aggregated projects. Randle, inter alia, repeatedly emphasized that all forms of geothermal energy should be included in follow-up work, differentiated into at least three different types of market segments, such as direct heat use, large grid applications, and decentralized grid systems. Due to an earlier declining trend of geothermal entrepreneurs, new competent players would need to be attracted. To enable this, appropriate risk insurance could provide a good basis, as could also highlighting the value of carbon mitigation credits. Furthermore, clear PPA structures would help private sector entry significantly. Specifically, it was suggested that further co-operation on a global level could suitably be achieved through (a) compiling a global inventory of geothermal opportunities, (b) involving 3-4 leading client/non-member countries in direct dialog events, which, if successful, could be extended to (c) more systematic network/GIA participation, e.g. with UNEP-GEF efforts currently under preparation. Some of the individual market analysis information could also possibly be compiled into best practice studies, with specific funding from the World Bank Group context. GEF indicated a possibility to match up to 50 percent of total funding needed for global level market to activities, where incremental activities beyond the baseline would also be targeted, and the IEA could take a lead role in providing guidance for terms of reference for such activities.

5. Conclusions and Agreement on Follow-up agenda /schedule

In conclusion to the major discussion earlier, a roundtable wrap-up further emphasized that resource mapping would need to maximally build on existing data. In the potential assessment/mapping all forms of geothermal energy utilization need to be considered.Allan Jelacic suggested a preliminary report compiled by the US Geothermal Energy Association could be a useful starting point, and complement the one recently carried out by the CEC. Also, David Nieva indicated that high priority Latin American sites could be identified through earlier work that OLADE has performed. The GEF Leyte project was mentioned as a role model case for project activities. It was confirmed that the World Bank could support activities for government exploration of geothermal sites, and would be prepared to co-ordinate a proposal for funding of a best practice publication. The European Commission would be prepared to provide EU data, but availability of further funding would need additional clarification. Further, institutional/policy issues which are the prime impediment to geothermal development need to be tackled.

The GEF could support continuing a more systematic dialog based on successful pilot activities, and would like to involve government, financing, scientific, and NGO representatives in a near-future dialog. The GEF would also be interested in providing a flexibly administered support for incremental networking activities in geothermal market development. The immediate next steps on the GIA side were to be to discuss how this type of new international collaboration could be specifically implemented in the form of a new task annex, to be discussed at their meeting on 8 March, to which all present were invited by the GIA chairman. Subsequent to those deliberations, further follow-up dialog would be carried out. Finally, it was noted that the meeting had been an historic event in the form of being the first GEF -- IEA global market dialogue of its kind, and as such signalling the entering into a new era of strategic partnership collaboration.

Table of Acronyms

CEC	Commission of the European Communities
ESMAP	Energy Sector Management Assistance Program
GEF	Global Environment Facility
GIA	IEA geothermal Implementing Agreement
IEA	International Energy Agency
IFC	International Finance Corporation
IPP	Independent power producer
NGO	Non-governmental organization
PPA	Power purchase agreement
RPS	Renewable portfolio standard
UNDP	UN Development Programme
UNEP	UN Environment Programme
WEA	World Energy Assessment

List of Participants

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Possible Elements of an Geothermal Upstream Project Development Facility

Draft for Discussion – March 1, 2001

Geothermal energy is a potentially significant contributor to the combined development and climate change objectives of the Global Environment Facility and the World Bank Group. Together, these agencies and their affiliates already offer a range of services offering potential support to geothermal development at various stages of the project cycle, but this has generally been provided on a relatively sporadic, bottom-up basis.

From a technological point of view, the technology is mature, robust, and has an excellent long-life track record, and energy costs are attractive once basic infrastructure is in place. However, despite the attractiveness of the resource, the risks of initial exploration/resource confirmation and relatively high-up-front capital costs for both exploration and power plant construction prolong risk uncertainties and increase financing costs. In the developing world in particular, governments may not be aware of the resource, and local energy policy, pricing, and legal structures may not be conducive to attracting developers. While there is significant private sector interest, private investors are not ready to take risks in many markets even in established fields.

A potential 'upstream' project development facility could be supported by the WBG and GEF in conjunction with a broad array of technical, business development, and financial stakeholders from the geothermal community. Other organizations, including additional donors, International Energy Agency, Regional Development Banks, the geothermal trades and IPP developers are also interested in the technology and offer additional services or information that may facilitate project development. It would be aimed primarily at reducing exploration risks and building capacity and interest in recipient countries and facilitating the introduction of legal/policy/pricing structures that accommodate geothermal and attract the entry and participation of the private sector. Upstream activities would be linked to existing sources of feasibility study financing, various combinations of commercial and contingent or grant financing, and project guarantees.

Potential elements/approaches:

- Analysis to inventory key existing or near tem geothermal opportunities in GEF eligible countries and prioritize them for assistance while identifying potential synergies among stakeholders;
- Evaluate up-front risk financing requirements and develop a strategy to maximize cost-effectiveness of existing financing resources, using contingent financing to overcome exploration risk;
- Cultivate targeted projects on an opportunistic basis, promote the availability of project preparation assistance; perform outreach within cooperating institutions, the industry, and countries to develop linkages;
- Prepare and publish a "Best Practice" compendium to disseminate lessons learned on the policy, regulatory, power purchase, and legal arrangements required at the country level, and update these materials based on new project experience gained through the facility.

Potential funding:

- **GEF** could potentially provide up-front support for the facility itself, a limited level ($350k) institutional support per country-based project, a limited level of contingent finance for exploration/confirmation (repaid if successful); for a limited number of projects to help assist global experience and encourage additional exploration finance on a country basis.
- **The World Bank** could provide project finance to governments at IDA/IBRD levels as required for country-requested projects, as well as finance and expertise for policy/regulatory efforts.
- **International Finance Corportation** (IFC) can provide commercial finance to private sector sponsors once the resource is confirmed and prospects for a power purchase agreement are confirmed.
- **Multilateral Guarantee Agency** (MIGA **-** which already has a $200M geothermal portfolio) underwrites guarantees against political risks and promotes foreign direct investment through its Investment Marketing Service –while upfront services are limited, it can provide a 'sniff-test' on projects and provide advice on the ultimate form of financing/guarantees that will likely be required.

Appendix 2

Geothermal Projects in CEEC
-
The IEA GIA perspective

L. Rybach (ETH Zürich)
Chairman, IEA Geothermal Implementing Agreement (GIA) Executive Committe

- **GEOTHERMAL PROJECT PREREQUISITES**
- **IEA BASICS, GIA ACTIVITIES**
- **GEOTHERMAL MARKET ACCELERATION**
- **GEOTHERMAL POTENTIAL INDICATORS IN CEEC**

Geothermal project prerequisites

- **Confirmed resource**
  (by prefeasibility & feasibility study)

- **Permits OK**
  (legal & environmental issues)

- **Customers ready (PPC, HPC)**

- **Project structure viable**
  (technical skill, reliability of management)

- **Financing established ←**

The International Energy Agency (IEA) was founded in 1974 within the OECD. At present, the IEA is the energy forum of all EU member countries (plus the CEC), Australia, Canada, S.Korea, Japan, New Zealand, and USA (a total of 26 countries, also CZ and H).

The IEA's objectives include improvement of the world energy supply and demand structure, more efficient use of energy, development of alternative energy sources to reduce dependence on any one source, assistance in integration of environmental and energy policies.

Besides periodic reviews of national policies, the IEA fosters international collaboration in energy technology in

- **Fossil fuels**
- **Nuclear fusion**
- **Renewable energies**
- **Energy end-use.**

IEA Geothermal Implementing Agreement (GIA)

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

- The GIA went into effect in March 1997 to operate for four years; now prolonged until 2006.

GIA objectives

- Article 1 of 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".
-

GEOTHERMAL MARKET ACCELERATION
IEA GIA Draft Annex

<u>Objectives</u>

❖ **Develop strategies to promote the use of geothermal resources**

- by disseminating geothermal technologies, in conjunction with GEF and others
- in selected target regions or countries (a.o.: Central America, <u>CEEC</u>)

❖ **Goal: increase the use of geothermal energy to supply to a significant share of global energy demand**

GEOTHERMAL MARKET ACCELERATION
IEA GIA Draft Annex

Means

- ***Subtask A:*** Track worldwide status of geothermal development („mapping“)

- ***Subtask B:*** Characterize opportunities for geothermal development by SWOT* analysis

- ***Subtask C:*** Develop Market Action Plan based on SWOT results

*) SWOT = **S**trength – **W**eakness – **O**pportunities - **T**hreats

GEOTHERMAL MARKET ACCELERATION
IEA GIA Draft Annex

Expected results

Guidelines for market acceleration

- **development**
- **legislation**
- **environment**
- **resource access**
- **management of risk**
- **incentives**
    - ***emission reduction***
    - ***green power production credits***
    - ***loan guarantees***
    - ***portfolio***

Geothermal indicators in CEEC*

Country	Potential data	Answers to IGA Questionnaire
Albania	✓	✓
Belarus	✓	✓
Bosnia & Herzegovina	-	-
Bulgaria	✓	✓
Croatia	✓	✓
Czech Republic	-	-
Estonia	-	-
Hungary	✓	✓
Latvia	-	-
Lithuania	✓	✓
Macedonia	✓	✓
Poland	✓	-
Romania	✓	✓
Russia	✓	✓
Slovakia	✓	✓
Slovenia	✓	✓
Ukraine	✓	-
Yugoslavia	✓	✓

*) Data source:

- WGC2000 Proceedings (2000)
- Geothermal Energy in Europe (2000)
  State-of-the-Art and Necessary Actions & Measures to Accelerate Development (IGA & EGEC Questionnaire)

IGA Questionnaire items

- National energy policy
- Social & political matters (e.g. acceptance)
- Legal & environmental m. (e.g. licensing)
- Promotional m. (e.g. brochures, media)
- Planning & management m.
- Organisational & financial m.
- Government support, incentives
- Marketing m. (market players)
- Educational m.
- Technical m . ➔

Technical matters

- Reconnaissance surveys (regional scale)
- Prefeasability studies (sectorial scale)
- Feasibility studies (local scale)
- Demonstration projects
- Field development
- Fluid utilization
- Rational energy use, co-generation

Appendix 3

INTERNATIONAL ENERGY AGENCY

Geothermal Implementing Agreement (GIA)

END-OF-TERM REPORT 1997 – 2001

Revised

Prepared by: **October 2001**

L. Rybach and J Garnish

Chairman and Secretary, GIA Executive Committee

This document follows the revised "Guidelines for End-of-Term Reports" which were approved by the CERT on 27 June 2001. After review and approval by the GIA Executive Committee (ExCo) this report is forwarded to the REWP as an End-of-Term Report.

The Implementing Agreement for a Co-operative Programme on Geothermal Energy Research and Technology ("Geothermal Implementing Agreement", GIA) started in March 1997 and the present term will end in March 2002. The first Annexes under the GIA (Annexes I, III and IV) also started in March 1997 and their first phase ended in March 2001. At the 5th ExCo meeting in October 2000 it was agreed that these Annexes should be prolonged for 4 further years.

At the 6th ExCo meeting in Brussels (8-9 March 2001) all GIA Participants voted, by unanimity, for an extension of the GIA with a new termination date of 31 March 2007.

A) NATURE

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

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

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

B) OBJECTIVES

Article 1 of the GIA defines its objectives as "international collaborative efforts to compile and exchange improved information on geothermal energy research and development world-wide 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 take-up of the geothermal energy option.

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 1**.

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.

Following a meeting with World Bank / Global Environment Fund in March 2001, the ExCo recognized the need to broaden the scope of the GIA from essentially technical issues in order to address a broader marketing strategy. A proposed Annex IX is in preparation.

C) WORK PROGRAMME

Ongoing Annexes

- *Annex I: Environmental Impacts of Geothermal Energy Development* *(1997 -)*

  Subtask A: Impacts on natural features

  Subtask B: Discharge and reinjection problems

  Subtask C: Methods of impact mitigation and Environmental Manual

  The work, performed on a task-sharing basis, covers:

  - the nature, effect and cause of environmental impacts from existing geothermal developments, including the effect on natural features;
  - analysis of the most serious impacts that might occur in the future;

- identification of environmentally-sound development policies.

Many of the detailed results obtained to date have already been published (see **Attachments 2 and 3**), but the intended Environmental Manual has had to be deferred for lack of funding.

Plans for the period 2001-2005 include

- continuation of data collection and analysis as before;
- 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 to the general public.

➢ *Annex III: Hot Dry Rock (1997 -)*

Subtask A: Hot Dry Rock Economic Model

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

Subtask C: Data Acquisition and Processing

Subtask D: Reservoir Evaluation

The work of this Annex draws on the shared experience gained from field projects operated by the participants and, again on a task-sharing basis, has addressed the following topics:

- development of an economic model, to predict production costs and to identify the most cost-sensitive parameters on which to focus the research;
- the opportunities for technology transfer between conventional geothermal developments and HDR / EGS (Enhanced Geothermal Systems);
- collection and archiving in consistent formats of data from the field projects;
- evaluation of various techniques for evaluation of reservoirs, based on shared experience from the field projects.

The Annex has also been used as an umbrella to facilitate the exchange of personnel and equipment between the US, European and Japanese groups.

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 (1997 -)*

Subtask A: Exploration Technology and Reservoir Engineering

Subtask B: Drilling and Logging Technologies

Subtask C: Material Evaluation Programme

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.

The results from Sub-task A are being prepared for publication in a Special Issue of *Geothermics* (late 2001).

Work planned for the future includes:

- Sub-task B - derivation of a standard classification of job categories in drilling operations in order to rationalize the database. The outcome of this analysis will be used to develop a future programme aimed at reducing overall drilling costs.
- Sub-task C , while continuing with literature compilation, will focus on corrosion problems and materials guidelines for deep acidic wells.

➢ *Annex VII: Advanced Geothermal Drilling Techniques (2001 -)*

Subtask A: Documentation of Drilling Costs

Subtask B: Geothermal Drilling Best Practices

Subtask C: Advanced Drilling Collaboration

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.

Operating Agents and Task leaders are:

Annex	**Operating Agent**	**Task Leader**
I “Environment”	Institute of Geological and Nuclear Sciences/ New Zeland	Dr. T. Hunt (IGNS Wairakei, N.Z.)
III “Hot Dry Rock”	NEDO/Japan	Dr.I. Matsunaga (AIST Tsukuba, Japan)
IV “Deep resources”	NEDO/Japan	Dr. M. Sasada (GSJ, Tsukuba, Japan)
VII “Advanced Drilling”	Sandia National Laboratories/USA	Dr. John T. Finger (Sandia Laboratories, Albuquerque, USA)

Annexes in preparation

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

D) TECHNOLOGY / MARKET STATUS AND BARRIERS

Electricity generation for geothermal resources

Worldwide annual production still outweighs solar and wind energy. However, the pace of development slowed down from > 16 % annual increase in installed capacity before 1985 to < 4 % afterwards. The reason is insufficient legal and institutional framework as well as the lack of sufficient financing schemes.

Direct use

Whereas the traditional areas of direct utilization of geothermal heat (e.g. district heating) are still evolving to some extent, some new lines like geothermal heat pumps have shown remarkable market penetration. This breakthrough is, however, not universal: spectacular in some countries like USA and Switzerland, but practically non-existent in others. The main obstacle is simply the lack of knowledge/information.

The new Annex IX “Geothermal Market Acceleration” will be specifically established, following an IEA/REWP initiative, to address these difficulties.

E) PARTICIPATION

At present, 11 countries (Australia, Germany, Greece, Iceland, Italy, Japan, Mexico, New Zealand, Switzerland, United Kingdom, USA) and 1 international organization (European Commission) have signed the Agreement. Three of these joined the GIA during 2000: Italy in May, Germany in July, and Iceland in December. The involvement of the Participants in the different Annexes is shown in Table 1 (overleaf).

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 2001

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

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

F) COORDINATION WITH OTHER BODIES

IEA CERT

In November 1998 the GIA ExCo prepared and submitted an input document for the CERT Ministerial paper, as requested by the IEA Secretariat.

IEA REWP

- On 11 October 2000 the REWP organized a Workshop in Paris on "Developing a New Generation of Sustainable Energy Technologies – Long Term R&D Needs". This Workshop aimed to summarize and to evaluate appropriate long-term R&D topics, their benefits and possible market pathways. The GIA contribution is included in the Workshop Report *"Developing a New Generation of Sustainable Technologies – Long-term R&D Needs"*.
- On January 23-24, 2001 in Paris the GIA contributed to the REWP Cabinet meeting with Renewable Energy Implementing Agreement Chairmen on Renewable Energy Market Acceleration. The contribution was strongly assisted by the IEA Secretariat (Rick Seller, Laurent Dittrick, Johan Wide).
- A further GIA contribution was presented at the REWP meeting in Paris on 4 April 2001.

International Geothermal Association (IGA)

Every five years the IGA organizes an International Geothermal Congress. The last one, the WORLD GEOTHERMAL CONGRESS 2000 (WGC2000) took place in Japan, 30 May - 10 June 2000. WGC2000 was the main international geothermal event of the past five years (1 500 participants). During Plenary Session IV "International Co-operation in Geothermal R&D" (Morioka, 5 June), Dr. H.-J. Neef, Head of Energy Technology Collaboration Division of IEA, reported on IEA activities in renewable energy technology in general, and about the GIA activities in particular. The platform of WGC2000 was used for an extensive presentation of GIA activities and results: 7 Special GIA Sessions were held with 34 oral communications, accompanied by 13 poster presentations; for details see **Attachment 2.** These contributions have been published in the Conference Proceedings (printed and CD-ROM versions).

World Bank & UNEP-Global Environment Facility (GEF)

On May 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 6th ExCo meeting.

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

G) DISSEMINATION OF RESULTS

The GIA follows the normal method of disseminating research results: publications in scientific/technical journals. Special emphasis is given to Conference Proceedings.

A Special Issue (Vol. 29, 4/5, 175 pages) of the journal *Geothermics*, entitled "Environmental aspects of geothermal development", was published in 2000. This journal is one of the leading international scientific journals focused on geothermal science and technology. The Special Issue was edited by Dr T. Hunt, and contains a Foreword by Prof. L. Rybach. It contains a total of 10 papers, drawn from: Japan (1), Iceland (1), Mexico (1), New Zealand (5), Turkey (1), and The Philippines (1). Subjects covered include:

- Exploitation-induced ground subsidence
- Effects of development on natural thermal features and methods for their preservation
- Use of economic instruments to minimize environmental effects
- Rainwater acidity
- Sulphur gas emissions

The individual papers are listed in **Attachment 3**.

A total of 47 GIA-derived papers were published in the WGC2000Conference Proceedings, as already mentioned above. These papers (see **Attachment 2**) were presented in the following Special Sessions:

- Session F2: IEA Hot Dry Rock (Hijiori/Japan)
- Session F3: IEA Hot Dry Rock (Ogachi/Japan)

- Session G3: IEA Environment I
- Session G4: IEA Environment II
- Session F4: IEA Hot Dry Rock (Soultz/France)
- Session F6: IEA Deep Geothermal Resources I
- Session F7: IEA Deep Geothermal Resources II.

Several further publications deal with GIA work and activities related to it (see **Attachment 4**).

The dissemination of GIA results by a brochure and by a GIA website is still in preparation.

H) SCALE OF ACTIVITIES

Executive Committee

In the report period (1997 – 2001) the ExCo held 6 meetings: Sendai/Japan, 10 March 1997; Wairakei/New Zealand, 10 November 1997; Washington D.C./USA, 18 September 1998; Paris/France, 8 November 1999; Soultz-sous-Forêts/France, 6 October 2000; Brussels, 8-9 March 2001. A further meeting in 2001 is scheduled for 12-13 November in Cuernavaca/Mexico. Prof. L. Rybach/Switzerland has served as ExCo Chairman since 1997, having been re-elected annually. ExCo Vice Chairmen were T. Imanaga/Japan (1997-1999) and Dr. A. Jelacic/USA (2000-).

There was no formal ExCo Secretary in the first two years of the GIA's existence and the administrative work was done by temporary volunteers in the ExCo and/or by the ExCo Chairman. Dr. J. Garnish (EC) has been the ExCo Secretary since 1999.

The ExCo prepared and submitted to IEA the Annual Reports 1997, 1998, 1999, and 2000 (see **References**). Detailed Minutes of all ExCo meetings are available.

To date, the Annex activities in general and the ExCo work in particular have been implemented under the task-sharing mode. This includes also the work of the Operating Agents. A special Planning Committee of the ExCo was established at the 2000 ExCo meeting especially to work out the requirements for increased GIA activities (e.g. Market Acceleration Annex, GIA-GEF Alliance), the Secretariat (GIA brochure and website), and the related financial implications (establishing a Common GIA Fund, see **Outlook**).

Annexes

The ongoing Tasks organize their own meetings, workshops, field trips etc. The following events should be mentioned:

- Start-up meetings for Annexes I, III and IV at the NEDO International Geothermal Symposium (Sendai/Japan; 12 March 1997)
- Annex IV meeting in conjunction with the GRC 1997 Annual Meeting (San Francisco/USA; 14 October 1997), Annex IV field trip (Mexico, USA; 17-20 October 1997)
- Annex I and IV meetings/technical sessions at the 29th New Zealand Geothermal Workshop (Auckland/N.Z.; 12 November 1998), Annex IV field trip (New Zealand; 14-16 November 1998)
- Annex III meeting in conjunction with the 4th International HDR Forum (Strasbourg/France; 27 September 1998)

- Annex III/Subtask C&D meeting (Sendai/Japan; 19 March 1999)
- Annex IV workshop (Pisa/Italy; 10 November 1999), Annex IV field trip (Italy, 11-12 November 1999)
- Start-up meeting for Annex VII at WGC2000 (Morioka/Japan, 7 June 2000)

I) ACHIEVEMENTS AND BENEFITS

The GIA has contributed to world-wide geothermal technology development through information sharing and task-shared co-operative research. In particular, the GIA has been instrumental in uniting national forces and programmes in geothermal R&D, and in facilitating the exchange of personnel and equipment. The increasing number of Participating Countries demonstrates clearly the great interest of key geothermal countries in the GIA work. The regular contacts between ExCo members and their feedback to national authorities enable better co-ordination of ongoing and new geothermal projects, especially in the various fields of geothermal technology.

The publication of GIA/Task results in journals and Conference Proceedings, as well as the intensive discussions with scientists and engineers not directly involved in GIA-related activities, help the advancement of geothermal energy utilization all over the world. The extension of GIA activities to developing countries and their involvement has not yet been tackled but remains an interesting prospect.

J) OUTLOOK, PLANS BEYOND 2002

Ongoing and new annexes

The continuation of Annexes I, III and IV has been decided by the ExCo; the work plans beyond 2002 (cf. WORK PROGRAMME) are currently under review and revision. Annex VII has just started, its work plan for 2002 is in preparation by the Operating Agent. Annexes V, VIII and IX are at various stages of preparation.

Special emphasis will be given to launching Annex IX (Geothermal Market Acceleration), especially in view of the well-initiated GIA/UNEP/GEF Alliance. 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.

Change in funding arrangements

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.

This new phase might face some uncertainties. The reporting period (1997-2001) has shown – and there are some signs for the immediate future too – that governmental funding of geothermal R&D at the national level is unstable and unpredictable. Besides the year-to-year changes there are contrasting tendencies and trends: whereas in some countries the funding has decreased successively some 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. It will be necessary to adapt the GIA Strategic Plan to the changing environment.

Acknowledgements

It is the pleasure of the ExCo to acknowledge gratefully the constant and efficient support of IEA: Dr. H.-J. Neef, Dr. R. Sellers, Dr. L. Dittrick, and, especially, Dr. J Wide in various stages of the ExCo work. Lynette Rogers-Goderum was often helpful in administrative matters.

K) REFERENCES

Annual GIA ExCo Reports 1997 (15 pages), 1998 (24 p.), 1999 (18 p.), 2000 (30 p.).

The Annual Reports follow the same format: Background, Nature and Objectives, Participation, ExCo Activities in the Reporting Year, Plans for the Next Year; Annex Reports.

The Annex Reports include

- Introduction
- Work performed in the reporting year (by Subtasks)
- Work plan for the following year (by Subtasks)
- Output (publications).

GIA related publications

Publications other than in the WGC2000 Proceedings (see **Attachment 2**) are listed in **Attachment 4.**

ATTACHMENT 1: GIA Strategic Plan (outline)

ATTACHMENT 2: Presentation of GIA results at WGC2000

ATTACHMENT 3: Content of IEA Special Issue of *Geothermics*

ATTACHMENT 4: Further GIA related publications

ATTACHMENT 1

International Energy Agency

Geothermal Implementing Agreement

Strategic Plan

Draft outline prepared by A Jelacic, USDOE (8 February 2001)

Contents

ATTACHMENT 2

PRESENTATION OF
IEA GEOTHERMAL IMPLEMENTING AGREEMENT RESULTS
AT THE *WORLD GEOTHERMAL CONGRESS 2000*
(28 May – 10 June 2000, Japan)
ORAL PRESENTATIONS AT SPECIAL IEA SESSIONS

Tuesday, June 6

9:00 - 10:40 Session F2: IEA Hot Dry Rock (Hijiori) Room F
Chair: Michio Kuriyagawa and Paul Kruger

9:00	F2-1	Activities of HDR under the IEA Geothermal Implementing Agreement ***M. Kuriyagawa, H. Herzog, L. McLarty, R. Hopkirk and T. Yamaguchi***
9:20	F2-2	Geochemical evaluation of the Hijiori HDR reservoir at Yamagata, Japan ***I. Matsunaga, H. Tao and N. Tenma***
9:40	F2-3	Fracture network modelling of Hijiori Hot Dry Rock reservoir by deterministic and stochastic crack network simulator (D/SC) ***K. Tezuka and K. Watanabe***
10:00	F2-4	The numerical modelling study of the Hijiori HDR test site ***S. Yamaguchi, S. Akibayashi, S. Rokugawa, Y. Fujinaga, N. Tenma and Y. Sato***
10:20	F2-5	Analysis of heat extraction from the Hijiori and Ogachi HDR geothermal resources in Japan ***P. Kruger, H. Karasawa, N. Tenma and K. Kitano***
Reserve Papers		Analysis in preparation for Hijiori long term circulation test ***T. Okabe, K. Kirihara, K. Hayashi, K. Karasawa, D. Swenson and R. Schroeder*** Determination of stress state at the Hijiori HDR site from focal mechanisms ***S. Sasaki and H. Kaieda***

11:00 - 11:20 Session F3: IEA Hot Dry Rock (Ogachi) Room F
Chair: Yoshinio Hori and Howard J. Herzog

11:00	F3-1	Outline of the Ogachi HDR project and character of the reservoirs ***K. Kitano. Y. Hori and H. Kaieda***
11:20	F3-2	Fracture investigation of' the granitic basement in the HDR Ogachi project, Japan ***H. Ito and K. Kilano***
11:40	F3-3	A fully three-dimensional thermo-hydraulic computation of the Ogachi HDR reservoir ***H. Suenaga, T. Yanamoto, Y. Eguchi, K. Kitano and H. Ohnishi***
12:00	F3-4	Ogachi HDR reservoir evaluation by AE and geophysical methods ***H. Kaieda, R.H. Jones, H. Moriya, S. Sasaki and K. Ushijima***
12:20	F3-5	Re-evaluation of reservoir structure at Ogachi HDR field by precise source location of AE multiplet ***H. Moriya, H. Niitsuma and H. Kaieda***
Reserve Papers		Stress state at the Ogachi site ***K. Shin, H. Ito and Y. Oikawa***

11:00 - 11:20 Session G3: IEA Environment (1) Room G

Chair: Trevor Hunt and Kan-ichi Shimada

11:00	G3-1	An enforcement project on environmental impact of geothermal exploitation in Iceland ***H. Kristmannsdóttir, H. Armannsson and K. Arnason***
11:20	G3-2	The influence of effluent water discharged from the Námafjall geothermal field on local groundwater ***S. Hauksdóttir, H. Kristmannsdóttir, G. Axelsson, H. Armannsson, H. Bjarnason and M. Olafsson***
11:40	G3-3	Monitoring of geyser activity in Whakarewarewa, New Zealand ***Y. Nishi, T. Ishido, M. Sugihara, T. Tosha, N. Matsushima and B.J. Scott***
12:00	G3-4	Development and verification of a method to forecast hot springs interference due to geothermal power exploitation ***H. Tokita, H. Takagi, Y. Kiyota, K. Matsuda, H. Hatanaka, K. Shimada, H. Inuyama, R. Young,***

13:40 - 15:20 Session G4: IEA Environment (2) Room G

Chair: Michael Sorey and Mahendra Verma

13:40	G4-1	Geothermal development and changes in surficial features: examples from the Western United States ***M.L. Sorey***
14:00	G4-2	Some environmental changes resulting from development of Ohaaki geothermal field, New Zealand ***T.M. Hunt and C.J. Bromley***
14:20	G4-3	Hot spring interference study for predicting hot spring change in geothermal field ***K. Shimada, F. Inuyama and H. Tokita***
14:40	G4-4	Elevation and gravity changes at geothermal fields on the Reykjanes peninsula, SW Iceland ***H. Eysteinsson***
15:00	G4-5	An investigation of boiling processes in hydrothermal eruptions ***T.A. Smith and R. McKibbin***

13:40 - 15:20 Session F4: IEA Hot Dry Rock (Soultz) Room F

Chair: Hiroaki Niitsuma and Hisatoshi Ito

13:40	F4-1	Over 10 years of geological investigations within the HDR Soultz project, France ***A.Y. Genter, H. Traineau, B. Ledesert, B. Bourgine and S. Gentier***
14:00	F4-2	Heat and fluid flow at the Soultz hot dry rock system in the Rhine Graben ***D. Pribnow and C. Clauser***
14:20	F4-3	Reflection imaging of HDR reservoir at Soultz by means of the AE reflection method ***N. Soma, H. Niitsuma and R. Baria***
14:40	F4-4	The effect of the 1993 stimulations of well GPK1 at Soultz on the surrounding rock mass: evidence for the existence of a connected network of permeable fractures ***K.F. Evans***
15:00	F4-5	***S***oultz-sous-Forêts: main technical aspects of deepening the well GPK2 ***.*** ***J. Baumgärtner, A. Gerard and R. Baria***
Reserve Papers		Steps towards a comprehensive thermo-hydraulic analysis of the HDR test site Soultz-sous- Forêts ***T. Kohl, D. Bächler and L. Rybach***

Wednesday, June 7

9:00 - 10:40	**Session F6: IEA Deep Geothermal Resources (1)**	**Room F**
	Chair: Masakatsu Sasada and Graham J. Weir	

9:00	F6-1	Current state of development of deep geothermal resources in the world and implications to the future ***H. Muraoka, K. Yasukawa and K. Kimbara***
9:20	F6-2	Ohaaki reservoir chemistry: insights into the nature and location of the heat source(s) ***B.W. Christenson, E.K. Mroczek, M.K. Stewart, G. Lyon and B.M. Kennedy***
9:40	F6-3	Contact metamorphism in the Larderello geothermal system ***G. Gianelli and G. Ruggieri***
10:00	FG-4	The deeper parts of the Geysers thermal system - implications for heat recovery ***D. Nielson and J. Moore***
10:20	FG-5	A mathematical model coupling heat and mass flow and extension rate in the Taupo volcanic zone, New Zealand ***G.J. Weir***

11:00 - 12:40	**Session F7: IEA Deep Geothermal Resources (2)**	**Room F**
	Chair: Hideo Kobayashi and H. Muraoka	

11:00	F7-1	Activity report on drilling and logging technology of IEA deep geothermal resources task ***H. Kobayashi***
11:20	F7-2	Advanced drilling system for drilling geothermal wells - an estimate of cost savings ***J. Rowley, S. Saito and R. Long***
11:40	F7-3	IEA deep geothermal resources subtask C: materials, progress with a database for materials performance in deep and acidic geothermal wells ***N. Sanada, Y. Kurata, H. Nanjo, H. Kim, J. Ikeuchi and K.A. Lichti***
12:00	F7-4	The fluid geochemistry and reservoir model for the Kakkonda geothermal system, obtained by NEDO's deep-seated geothermal reservoir survey, Japan ***K.Kasai,Y. Hishi, D. Fukuda, O. Kato, N. Doi, V. Akaku, T. Ominato and T. Tosha***
12:20	F7-5	Deep geothermal drilling, on the Reykjanes ridge - opportunity for international collaboration ***G.O. Fridleifsson and A. Albertsson***

PRESENTATIONS IN POSTER SESSIONS

IEA Hot Dry Rock

PM-086 Steps towards a comprehensive thermo-hydraulic analysis of the HDR test site Soultz-sous-Forêts

T. Kohl, D. Bächler and L. Rybach

PM-087 Progress of the task of HDR evaluation under IEA agreement

T. Yamaguchi, M. Kuriyagawa, I. Matsunaga, N. Tenma and H. Karasawa

PM-088 The European HDR programme: main targets and results of the deepening of the well GPK2 to 5000m

R. Baria, J. Baumgärtner, A. Gérard and J. Garnish

PM-089 Soultz-sous-Forêts: main technical aspects of deepening the well GPK2

J. Baumgärtner, A. Gerard and R. Baria

PM-090 Geological structure around the Ogachi hot dry rock test site using seismic reflection and Csamt surveys

K. Suzulki and H. Kaieda

PM-091 A study of the pressure-flow response of the Hijiori reservoir at the Hijiori HDR test site

N. Tenma, T. Yamaguchi, K. Tezuka and H. Karasawa

PM-092 Study on surface area estimation of the Ogachi HDR reservoir by geochemical method

K. Kiho

PM-093 Stress stale at the Ogachi site

K. Shin, H. Ilo and Y. Oikawa

PM-094 Determination of stress state at the Hijiori HDR site from focal mechanisms

S. Sasaki and H. Kaieda

PM-095 Plugging method for HDR reservoir using hydrothermal processing of smectite clays to improve recovery efficiency

N. Hirano, S. Higashi and N. Yamasaki

PM-096 Analysis in preparation for Hijiori long term circulation test

T. Okabe, K. Kirihara, K. Hayashi, K. Karasawa, D. Swenson and R. Schroeder

IEA Deep Geothermal Resources

PM-104 A summary of results of the IEA task activities of deep geothermal resources

K. Kimbara, H. Muraoka, H. Kobayashi, N. Sanada, K. Fujimoto and K. Ohsato

PM-105 Recent results of “deep-seated geothermal resources survey“ project in the Kakkonda geothermal field, Japan

T. Tosha, K. Koide, T. Ohminato, K. Akaku and N. Doi

ATTACHMENT 3

Content of *Geothermics* Special Issue „Environmental Aspects of Geothermal Development“, Vol. 29, Nos. 4/5, p. 449-625 (2000), T. M. Hunt, editor

ATTACHMENT 4

Further GIA related publications

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Appendix 4

REWP: Meeting of IA Chairmen's Group
Paris, 4th April, 2001

Geothermal IA actions for market acceleration

Actions already taken

- Input for GIA Strategy
- Contributions to REWP meetings in Paris
  - ***10-11 October 2000***
  - ***23-24 January 2001***
- Joint GIA/WB-GEF meeting on 7 March 2001 in Brussels
- Initiation of GIA Market Annex at 6th ExCo meeting on 8-9 march 2001 in Brussels

Planned future activities

- Develop and finalize GIA Market Annex
- (Put up common fund)
- Alliance with GEF

GEOTHERMAL MARKET ACCELERATION

Key issues identified during meeting 07 March 2001
GIA - WB/GEF

- ❖ Public understanding
- ❖ Legal easement
  - ❋ (ownership, permits, etc)
- ❖ Minimization of exploration risk
  - ❋ (“insurance”, contingency funding, ….)
- ❖ Reassurance to developer
  - ❋ (power purchase contracts, predictable financing, etc)
- ❖ Increase pace of development
  - ❋ (management procedures, barriers, etc…..)

GIA Annex IX Geothermal energy market acceleration

A. Description of Technical Sector
B. Objective
C. Means / Subtasks A,B,C
D. Results
F. Time scale
G. Specific obligations and responsibilities
H. Funding
I. Operating Agent
J. Information, Intellectual Property
K. Participants in this Task

DESCRIPTION OF TECHNICAL SECTOR

- ❖ All geothermal products
  - power
  - direct heat
  - co-generation (heat & power)
  - ground source heat pumps
  - by-products (metals, chemicals, CO_2,….)

B. OBJECTIVE

The objective of this Task is to increase the use of geothermal energy to supply up to 5 % of global energy demand by 2010 with an emphasis on meeting growing energy needs in developing countries.

C. MEANS

- Subtask A: Track worldwide status of geothermal development
- Subtask B: Characterize opportunities for geothermal development (resources, SWOT analysis)
- Subtask C: Develop a Market Acceleration Action Plan based on SWOT results

D. RESULTS

- **For use of government policy makers, utility planners, geothermal project developers, geothermal industry executives, potential geothermal users**
  - **Database on worldwide development**
  - **Status & guidelines for market acceleration in developing countries**
  - **Country analysis reports / RE Technologies Implementation Teams**
  - **Newsletter, website**

F. TIME SCALE

- **This Annex shall remain in force for three years from the initiation**
- **May be extended by two or more years by two or more Participants**

G. SPECIFIC OBLIGATIONS AND RESPONSIBILITIES

- **Of the Participants**
- **Of the Operating Agent**

H. FUNDING

- **a) Common Fund**
- **b) Task CostsSharing (incl. Requirements)**
- **Interest on arrears**
- **Changes in number of Participants**
- **Individual financial obligations**

I. POSSIBLE PARTICIPANTS

- **WB / GEF**
- **EC**
- **Iceland**
- **Italy**
- **Mexico**
- **UK**
- **US**

? **Switzerland**
? **Japan** *
? **New Zealand** *
? **Greece**
? **Germany** *

* *possible private sector involvement*