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Umwelt, Verkehr, Energie und Kommunikation UVEK

Bundesamt für Energie BFE

Schlussbericht, 26. November 2007

ARBEITEN FÜR DAS IEA GEOTHERMAL IMPLEMENTING AGREEMENT (GIA) 2007

Jahresbericht 2007

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Inhaltsverzeichnis

Zusammenfassung

Mit der Präsenz im Geothermal Implementing Agreement (GIA) der IEA kann die Schweiz regelmässigen Kontakt mit führenden Geothermie-Ländern pflegen, was den Weg zu ansonsten unzugänglichen Informationen öffnet. Zugleich lassen sich Schweizer F&E-Resultate international positionieren und durch die Kanäle der IEA verbreiten. Die Arbeiten für das IEA GIA wurden 2007 durch Prof. L. Rybach ausgeführt. Er ist Vice Chairman des Executive Committee; somit ist die Mitwirkung der Schweiz an allen Entscheidungen garantiert. Ergänzendes Mitglied des GIA ExCo ist Dr. Rudolf Minder (Minder Energy Consulting, Unterlunkhofen). Die Arbeiten laufen programmgemäss, die Resultate sind auf der IEA GIA Homepage ersichtlich und werden zudem durch sechs Anhänge dokumentiert.

Abstract

The participation of Switzerland in the IEA Geothermal Implementing Agreement (GIA) enables regular contacts and exchange with leading geothermal countries and opens pathways to otherwise unaccessible information. Swiss geothermal R&D results can be positioned internationally and disseminated through official IEA channels. The Swiss activities for the IEA GIA were performed in 2007 by Prof. L. Rybach. He is Vice Chairman of the Executive Committee, which guarantees the direct involvement of Switzerland in all decision making. Alternate Member of the GIA ExCo is Dr. Rudolf Minder (Minder Energy Consulting, Unterlunkhofen). The activities proceed as planned, the results are to be seen on the IEA GIA website and are further documented in six Appendices.

1. Ausgangslage

Die Schweiz ist Teilnehmer des IEA GIA seit Anbeginn (März 1997). Die Teilnahme wird durch das BFE finanziert. Grundlage der Arbeiten in 2007 ist Vertrag Nr. 152'517, Projekt Nr. 41'661. Ende März 2007 wurde die IEA GIA für eine weitere 5-Jahresperiode verlängert. Neu ist die Schweiz den IEA GIA Annexes I und VIII beigetreten.

2. Ziel der Arbeit

Durch die Teilnahme der Schweiz am GIA wird im F&E Bereich ein regelmässiger Erfahrungsaustausch mit Ländern, die in der Geothermie führend sind, auf hohem Niveau ermöglicht. Hier sind insbesondere Informationen bezüglich Neuentwicklungen (z.B. EGS, *Enhanced Geothermal Systems*) zu erwähnen. Anderseits kann das spezifische know-how und die Errungenschaften der Schweiz im internationalen Rahmen eingebracht werden und somit Anerkennung erfahren und Verbreitung finden. Es sind weiterhin interessante und wertvolle Informationen und Kontakte zu erwarten, u.a. zu den neuen EGS-Projekten in Australien.

3. Lösungsweg

Die Präsenz der Schweiz wird einerseits an den ExCo Meetings, an ausgewählten Annex Meetings, sowie an besonderen IEA Veranstaltungen (Workshops, Seminare) wahrgenommen, anderseits durch umfangreichen Schriftverkehr zwischen den Officers (Präsident, zwei Vizepräsidenten, GIA Sekretär) sichergestellt. Die Schweiz ist an diversen Annexe beteiligt, seit 2007 auch in Annexes I und VIII.

Besonders zu erwähnen ist hier die führende Rolle der Schweiz im GIA ExCo: Der Berichterstatter amtete 1997 – 2001 als Chairman, seit 2002 ist er Vice Chairman (mit besonderer Verantwortung in *Policy* und *New Participants*) und damit auch GIA Officer. Dadurch ist die Schweiz an allen Entescheidungsprozessen direkt beteiligt.

Darüber hinaus wird das IEA GIA an Veranstaltungen der IEA öfters durch ExCo Vice Chairman L. Rybach vertreten, so auch am *Deploying Demand Side Energy Technologies Workshop* (8.-9. Oktober 2007 in Paris) und am *European Geothermal Congress EGC 2007* (30. Mai – 2. Juni 2007 in Unterhaching b. München).

4. Ergebnisse

4.1 Arbeiten in Annex-Sitzungen

Vorgängig der 17. IEA GIA ExCo Sitzung fanden in Nice/F am 21. März Annex-Sitzungen statt, der Berichterstatter nahm daran Teil. An der Annex I Sitzung referierte er über den Stand des Basler Deep Heat Mining Projektes; an der Annex III Sitzung wurde die Reorganization der Annex-Arbeiten beschlossen (Operating Agent: Geodynamics Ltd., Australien; Annex Leaders Roy Baria und Doone Wyborn) und die weitere Teilnahme der Schweiz insbesondere mit Task C (Leader: Dr. T. Mégel/Geowatt AG Zürich) diskutiert ; an der Annex VIII Sitzung wurden die Ergebnisse der von Dr. Yonhoo Song (KIGAM, S. Korea) und L. Rybach ausgearbeiteten und durchgeführten Fragebogen-Aktion präsentiert.

Anlässlich der 18. ExC Sitzung fanden Annex I und Annex III Sitzungen in Kandel/D statt; insbesondere wurde für Annex III die Weiterführung der Schweizer Aktivitäten unter *Task C Data Acquisition and Processing* erbeten.

Alle Resultate werden im IEA GIA Annual Report 2007 dargestellt, insbesondere in den Berichten der verschiedenen Annexe (in Bearbeitung). Diese werden zur gegebenen Zeit auf die IEA GIA Webseite aufgeschaltet (www.iea-gia.org).

4.2 Arbeiten im ExCo

4.1.1 ExCo Sitzungen

Die 17. Sitzung des IEA GIA ExCo fand am 22. und 23. März im Hotel La Pérouse in Nice/F statt. Die notwendigen Vorbereitungsarbeiten (u.a. Mitwirkung an den Arbeiten für die zu behandelnden Geschäfte) begannen schon im Januar 2007. An der Sitzung nahmen ausser dem Berichterstatter auch Dr. Rudolf Minder und Dr. Thomas Mégel (Geowatt AG Zürich) teil.

Dem Berichterstatter obliegt im ExCo die Koordination der Arbeiten für neue *GIA Participating Countries*. Anlässlich der 17. ExCo-Sitzung wurde der Stand der Bestrebungen präsentiert, für die GIA weitere Teilnehmer zu gewinnen. Frankreich trat –nach langer Vorbereitung– kurz vor dem 17. ExCo meeting dem IEA GIA bei; nachdem die türkische Firma ORME Jeotermal Bereitschaft signalisiert hat dem GIA als Sponsor beizutreten, hat L. Rybach die offiziellen Einladungsschreiben am 16. November unterzeichnet.

Die 18. Sitzung des IEA GIA ExCo fand am 25. und 26. Oktober im Energie-Infozentrum Kandel/D statt. Dabei hat der Berichterstatter der *Swiss Country Report 2006* mit definitiven Zahlen beigesteuert **(Anhang I)**; der umformatierte, ergänzte Bericht ist Bestandteil des *GIA Annual Report 2006* (s. unten). Ferner hat er ein Swiss Country Update präsentiert, welches die aktuellen Entwicklungen beinhaltet (**Anhang II**).

Die umfangreichen Sitzungsprotokolle werden, sobald genehmigt, auf die GIA Webseite **www.iea-gia.org** gestellt.

4.1.2 Weitere Arbeiten für die IEA GIA

- Der umfangreiche und aufschlussreiche GIA Annual Report 2006 wurde nach diversen Vorläuferversionen, an denen der Berichterstatter massgebend beteiligt war, ist in Fertigstellung durch das GIA Sekretariat in Neuseeland (wird aufgeschaltet auf http://www.iea-gia.org/publications.asp).

- Für IEA GIA Annex VIII (Direct Use of Energy) hat er Berichterstatter (zusammen mit Dr. Yonhoo Song, KIGAM/S.Korea) ein Questionnaire ausgearbeitet. Die gemeinsam erstellte Auswertung der eingegangenen Antworten wurde am Annex VIII meeting am 17. März in Nice/F präsentiert.

- Im Rahmen von IEA GIA Annex I (*Environmental Impacts of Geothermal Energy Development*) untersucht Task D (*Seismic Risk From Fluid Injection Into Enhanced Geothermal Systems*) die bei EGS-Systemen möglicherweise auftretende, künstliche Seismizität. Das Referat "What happened to the Deep Heat Mining Project Basel" des Berichterstatters, vorgetragen am Annex I meeting in Nice/F am 17. März, fand allgemein grosses Interesse.

- Eine weitere Tätigkeit von des Berichterstatters für das GIA ExCo war dessen Vertretung am *European Geothermal Congress EGC 2007*. Gemäss ExCo-Beschluss vom 23.3.2007 hat er mit GIA-Sekretär Dr. Mike Mongillo eine Publikation erarbeitet, welches am EGC2007 am 1. Juni 2007 vom Berichterstatter präsentiert wurde. **(Anhang III)**.

- Ferner hat der Berichterstatter, zusammen mit Dr. C. Bromley (ExCo Chairman) für das LATSIS-Symposium 2007 (17.-19 September, ETH Zürich) ein Poster erarbeitet und präsentiert (**Anhang IV**).

- Schliesslich fand am 8.-9. Oktober bei der IEA in Paris das *Workshop ETP 2008 Deploying Demand Side Technologies – in support of the G8 Plan of Action* statt. Gemäss ExCo-Beschluss vom 23.3.2007 hat Prof. L. Rybach die GIA in seiner Eigenschaft als ExCo Vice Chairman vertreten. Die GIA Präsentation „Geothermal heating and cooling of buildings" des Berichterstatters befindet sich auf dem Workshop Proceedings CD-ROM (Titelseite siehe **Anhang V**) kann von der IEA Webseite unter
  http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=323

  abgeladen werden. Diese Tätigkeiten (Vorbereitung, Teilnahme, Spesen) wurden durch einen separaten Kleinauftrag (Projekt Nr. 41'661, Vertrag Nr. 152'991) gedeckt.

4.1.3 Laufende Administration

Der Berichterstatter wirkt als GIA ExCo Vice Chairman und Officer an allen Vernehmlassungen und Entscheidungen mit. Die weiteren Officers sind Dr. Chris Bromley (ExCo Chairman), Dr. Allan Jelacic/USA (ExCo Vice Chairman), Dr. Mike Mongillo/New Zealand (GIA Secretary). Die Arbeiten werden weitgehend per e-mail abgewickelt. Im Durchschnitt erfolgt täglich mindestens ein e-mail- Wechsel(!). Diese Arbeiten nehmen entsprechend viel Zeit in Anspruch.

Besonders zu erwähnen sind die zahlreichen, oft umfangreichen Stellungnahmen zu IEA Publikationsentwürfen. Dabei handelt es sich um die verantwortungsvolle Aufgabe, der IEA zutreffendes, aktuelles Zahlenmaterial über die Geothermie zu liefern. Als Beispiel soll die GIA Stellungnahme zur IEA Publikation *Renewable Heating and Cooling – Untapped Potential* genannt werden, ferner die Stellungnahme zum *GIA poster for the IEA Ministerial Fair*, sowie die Angaben zu *Learning rates for geothermal development* (für IEA ETP Office)

Schliesslich sei noch ein Artikel des Berichterstatters in GEOTHERMIE.CH / Nr. 43 erwähnt, welcher die IEA GIA einer weiteren Öffentlichkeit näher bringt (**Anhang VI**).

5 Diskussion

Konkrete, sichtbare Erzeugnisse sind wie erwähnt auf der IEA GIA Homepage sowie aus den **ANHÄNGEN I - VI** ersichtlich. Auch kann vermeldet werden, dass der im Rahmen von GIA Annex III/Task C von der Schweiz (insbesondere Dr. Thomas Mégel, Geowatt AG Zürich) erstellte *Enhanced Geothermal System Project Management Decision Assistant* weiterhin erhältlich ist. Weitere Details sind ebenfalls unter **http://www.iea-gia.org/** zu finden.

Während der mannigfaltigen Tätigkeiten des Berichterstatters für die IEA GIA wurde offensichtlich, dass die für 2007 vertraglich festgesetzte Projektsumme die notwendigen Arbeiten nicht abdeckt hat. Eine Erhöhung der Mittel wird deshalb für 2008 beantragt.

6 Schlussfolgerungen, Ausblick

Es kann vorbehaltlos festgehalten werden, dass die Beteiligung der Schweiz am IEA GIA weiterhin erfolgreich verläuft und die erwarteten Benefits erbringt. Die Schweizer Beteiligung nimmt noch zu; am 12. Juni 2007 hat das BFE auch die Mitarbeit der Schweiz an Annex I (*Environmental Impacts of Geothermal Development*) und VIII (*Direct Use of Geothermal Energy*) offiziell bestätigt.

Gestützt auf das *IEA GIA End of Term Report* sowie auf den *IEA GIA Strategic Plan 2007-2012*, welche unter Mitwirkung des Berichterstatters verfasst wurden, hat die IEA das GIA für eine weitere 5-Jahresperiode (2007-2012) verlängert. Die Weiterführung der Schweizer Beteiligung, insbesondere durch aktive Beiträge an die Annexe I, III und VIII, ist dabei verstärkt anzustreben.

Symbolverzeichnis

IEA	International Energy Agency
GIA	Geothermal Implementing Agreement
ExCo	Executive Committee
ETP	Energy Technology Policy Division
KIGAM	Korea Institute of Geoscience & Resources
BFE	Bundesamt für Energie

Referenzen

Mongillo, M., Rybach, L. (2007): The IEA Geothermal Implementing Agreement (GIA) – Advancing Into Its Third Term. In: Proc. European Geothermal Congress 2007 (CD-ROM).

L. Rybach , C. Bromley: Strategies for sustainable and environmentally friendly geothermal energy utilization – Poster, LATSIS Symposium 2007, ETH Zürich

Rybach, L. (2007): Die Schweiz im Geothermal Implementing Agreement der IEA. GEOTHER-MIE.CH Vol. 45, S. 9

Zürich, 26 November 2007 **L. Rybach**

ANHÄNGE:

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ANHANG III	Mongillo, M., Rybach, L. (2007): The IEA Geothermal Implementing Agreement (GIA) – Advancing Into Its Third Term. In: Proc. European Geothermal Congress 2007 (CD-ROM).
ANHANG IV	L. Rybach , C. Bromley: Strategies for sustainable and environmentally friendly geothermal energy utilization – Poster, LATSIS Symposium 2007, ETH Zürich
ANHANG V	CD-ROM (Titelseite) IEA Workshop ETP 2008 Deploying Demand Side Technologies – in support of the G8 Plan of Action
ANHANG VI	Rybach, L. (2007): Die Schweiz im Geothermal Implementing Agreement der IEA. GEOTHERMIE.CH Vol. 45, S. 9

ANHANG I

Switzerland’s input to IEA GIA Annual report 2006

SWITZERLAND

1. Introduction

The reorganization of the key Swiss player and coordinator in geothermal energy development and utilization, the Swiss Geothermal Association SVG, has been completed. The SVG, an Affiliated Member of IGA, acts now as the Swiss Geothermal Competence Center under the label GEOTHERMIE CH. Its bi-lingual (G/F) Newsletter also carries the name GEOTHERMIE.CH.

Geothermal heat pumps contribute still the largest share to direct use, which grows steadily by about 10 % per year. Quality labels and engineering norms (presently under development) guarantee operation reliability and efficiency.

Increasing participation in international R&D efforts, besides in the IEA GIA, can be reported: Switzerland cooperated in 2006 in the EU projects EGS Scientific Power Plant Soultz/F, ENGINE, I-GET and GROUNDHIT.

As a negative highlight it must be reported that the largest Swiss geothermal project, DEEP HEAT MINING in Basel, has been suspended in December 2006 due to earthquake activity triggered by water injection for stimulation.

2. National Policy

On the political scene the main change is that a CO_2 tax has been introduced; its implementation –e.g. for new gas-fired power plants– is now discussed in the Parliament. The Energy Law already passed both chambers of the Parliament; it shall include promotion measures like a Risk Guarantee for deep geothermal drilling for electricity production.

The governmental energy program *SwissEnergy*, which supports renewable energies, provides the general supportive framework for geothermal R&D. A new phase for the years 2006-2010 is now implemented. Further, more general information about Swiss energy policy is given in previous Swiss Country Reports, which can be found on the IEA GIA website under http://www.iea-gia.org/publications.

Government funding on geothermal R&D provided financing in 2006 for
- Research and Development: 0.5 MCHF,
- Activities of the SVG: 0.5 MCHF

by the Swiss Federal Office of Energy (SFOE).

Expenditure of industry provided significant contributions to the DEEP HEAT MINING project in Basel (> 10 Mio. US$).

3. Current status of Geothermal Energy Use in 2006

a. Electricity Generation

So far there is no electricity generation from geothermal sources in Switzerland.

b. Direct Use

In 2004 a statistical survey was carried out about geothermal energy use in Switzerland; the numbers about installed capacities, energy produced, fossil fuel and CO_2 emission savings etc. are published in the Swiss Country Update Report 2005 (available also at the IEA GIA website under http://www.iea-gia.org/publications. A new statistical survey (Geowatt AG Zurich) provides the numbers for 2006. Table 1 shows the numbers in direct use in 2006 (usage category, installed capacity, and thermal energy used).

Table 1. Geothermal direct use in Switzerland in 2006.

Usage system	Installed capacity (MWth)	Heat produced (TJ/yr)
Heat pumps with borehole heat exchangers	650	4272
Groundwater-based heat pumps	75	438
Geostructures, tunnel waters	14	87
Deep aquifers for district heating	5	64
Spas, wellness facilities	37	1126
Total	**781**	**5987**

The key achievement of Switzerland is still in the use of shallow geothermal resources by ground-coupled heat pumps. An evaluation of available global data reveals that Switzerland occupies a prominent world-wide rank in installing and running geothermal heat pump systems. In 2006, more than 1000 kilometers have been drilled for borehole heat exchangers. Geothermal heat pumps are now increasingly and soon routinely used for heating as well as for cooling.

c. Fossil Fuel Savings

The heat production from geothermal sources ("direct use") enables to save fossil fuels. The annual heat production in 2006, 5987 TJ, corresponds to the saving of 140'000 toe. Geothermal energy in Switzerland thus reduces the emission of CO_2 by about 440'000 tons per year. All direct use –except partly for spas/wellness– is based on electric heat pumps. Here it must be emphasized that electricity in Switzerland is generated nearly completely CO_2-free (with 60 % hydro and 40 % nuclear capacity).

4. Market Development and Stimulation

a. Support Initiatives and Market Stimulation Incentives

Financial support or tax credits of different kind and size can be obtained when installing geothermal heat pumps, depending on the site. Local electric utilities, communities, various entities provide support. This explains at least partly the rapid development of the Swiss geothermal heat pump market. Information about the various sources of support can be downloaded from the website of the Swiss Heat Pump Promotion Association FWS http://www.fws.ch/ under "Zahlen & Fakten" and "Förderbeiträge und Steuervergünstigungen" (= support finances and tax reductions).

b. Development Cost Trends

Technologic progress (e.g. measurable by heat pumps COP), better materials, increasing experience lead to progress on the learning curve; absolute prices are constantly decreasing, see Figure 1.

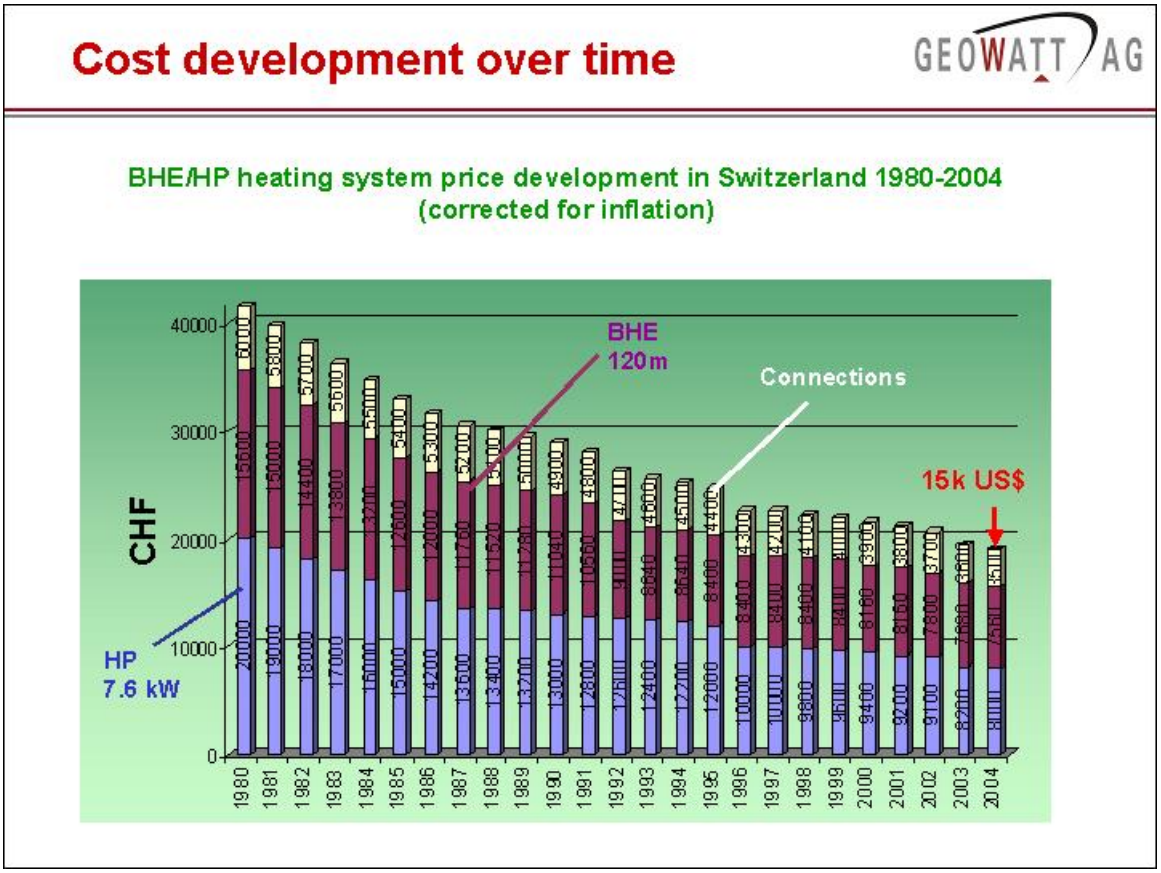

Figure 1. Installation costs of geothermal heat pumps decrease significantly over time (for a typical, singe family dwelling). Diagram from http://www.fws.ch/

5. Development Constraints

For geothermal direct use in general and for geothermal heat pumps in particular there could be –irrespective of already impressive achievements– even more rapid development. Architects as well as engineers responsible for building energy supply are still not enough familiar with geothermal heating and cooling. Often the attitude is “I do not know how to design a geothermal system so I will not going to apply it”. Therefore increased efforts in education and post-graduate training are undertaken (see below).

Strange enough, a bottleneck becomes evident at the other end: the Swiss companies active in drilling for borehole heat exchangers (more than twenty) have so many orders that the waiting time to get borehole heat exchangers installed can be up to 5-6 months.

The stop of the Deep Heat Mining project in Basel ordered by authorities due to induced seismicity had also repercussions on plans and expectations about geothermal power generation and EGS projects in Switzerland in the future: the Swiss vision (Figure 2: 50 MWe EGS plants at 50 sites, mostly in densely habitated areas) has to wait until basic questions about seismic risk and heat extraction efficiency are answered.

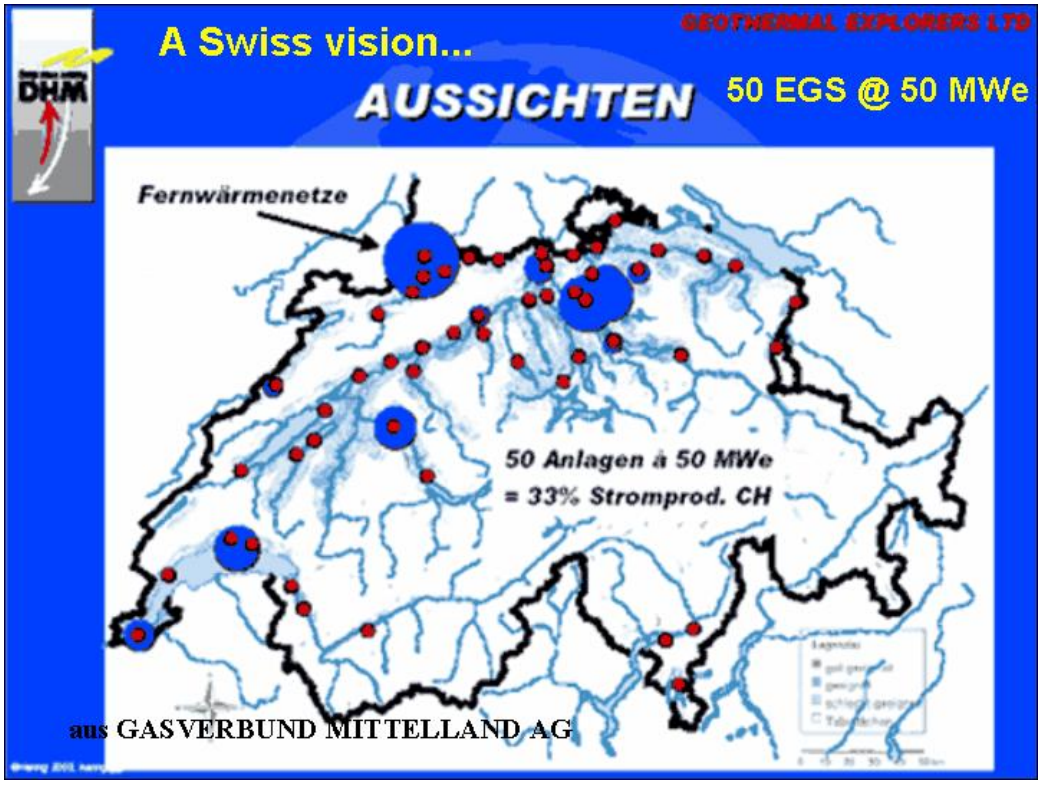

Figure 2. Vision of 50 EGS plants, each with 50 MWe, to provide 33 % of Swiss electricity. “Fernwärmenetze” : existing district heating systems.

The Deep Heat Mining Project in Basel attempted to establish an EGS facility for co-generation (20 MWth and 3 MWe capacity to produce 20 GWh/year power and 80 GWh/year heat), with three 5 km deep wells (1 for injection, 2 for production). The 1st well (Basel-1) reached target depth of 5‘000 m on 27 October 2006. Stimulation started on 23 November 2007: pre-stimulation with injection flow rates < 10 l/s, the main stimulation (planned for 3 weeks with 50‘000 m^3 water total volume) on 2 December 2006 with p_{max} = 295 bar and Q_{max} = 63 l/s. Meanwhile the drilling rig moved over to Basel-2.

The stimulation caused thousands of microseismic events for reservoir development. Early morning on 8 December a seismic event happened with M_L=2.7. Event management actions have been taken by the project developer (Geopower AG Basel) according to the „Traffic Light Action Plan“ (details about the Traffic Light Procedure see on the GIA website http://www.iea-gia.org/publications.asp, under “Draft protocol”). Nevertheless an event with M_L=3.4 took place at 17:48, the event was not announced but widely felt in the area. The next day the local Government stopped the project because of „frigthtenig the population“ (=public offence by Swiss law); the drilling rig and crew had to leave. The injection has been stopped and water was bleeded off. The hypocenters of the seismic events were located at 5 km depth near hole bottom.

The induced seismic events hit a completely uninformed, unprepared urban population. Nobody got injured but many citizens became upset. A large number of damage claims has been raised, also from neighbouring Germany and France. The project developer has 25 MCHF (20 MUS$) indemnity insurance. Until end of 2006 about 60 MCHF (50 MUS$) has been spent for the project. The extensive documentation of the stimulation, the seismic events created, and the reaction of the local Authorities can be found (in German) on http://www.bd.bs.ch/geothermie. Before the Government can decide whether the project could continue (under restrictions) or is to be abandoned a seismic risk study („risk of triggering of larger quakes“) must be elaborated.

6. Economics

Concerning geothermal heat pumps their economy becomes, in view of generally rising fossil fuel prices and the CO_2 tax, increasingly competitive. The geothermal option for heating alone is already favourable; in summer it is the only system that can also provide space cooling.

No new cost comparison with other heating systems has been performed in 2006, therefore the data from 2005 are repeated here (Table 2):

Table 2. Cost comparison of heating systems in Switzerland (reference system capacity 10 kW), from Hubacher/FWS 2005.

Heating system	Efficiency (η/SPF*)	Investment (CHF)	Capital cost (Annuity, CHF)	Operating cost (CHF)	Total annual cost (CHF)
Oil boiler	**0.85**	**18'000**	**1'741**	**1'483**	**3'224**
Gas boiler	**0.95**	**14'500**	**989**	**1'882**	**2'871**
Biomass (pellets)	**0.90**	**33'500**	**2'692**	**1'814**	**4'506**
Geothermal heat pump (with BHE)	**3.4**	**30'500**	**2'055**	**872**	**2'929**
Air-source heat pump	**2.6**	**25'500**	**1'876**	**1'110**	**2'986**

*) Seasonal performance factor

There is no official statistics about the number of people employed in the geothermal sector; from the number of drilling companies, institutions active in geothermal R&D a rough estimate yields about 100 – 120 people.

7. Research Activities in 2006

The national activities financed by the Swiss Federal Office of Energy (SFOE) comprised

- feasibility study AGEPP (Alpine geothermal power production)
- software development "Groundwater Energy Designer"
- establishment of a hydrochemical data base for deep aquifers
- documentation and evaluation of failures with geothermal heat pumps
- economic feasibility study for an EGS installation at Geneva
- energy conversion processes for the use of geothermal heat.

All research projects have to deliver their final reports; these can be downloaded from the SFOE database: http://www.bfe.admin.ch/dokumentation/energieforschung/ .

The EGS project Deep Heat Mining Basel, financially the most focussed geothermal endeavour in Switzerland, is organized and managed by the shareholder company Geopower Basel AG. The project is financed from public and private sources; financing status was 53.2 MCHF (approx. 40 MUS$) end of 2005. The project has been suspended by the local authorities; now a risk study (including seismic risk) shall provide the decision basis for definite project end or continuation (with restrictions).

8. Geothermal Education

Also in 2006, significant efforts were undertaken for education and information dissemination. Besides regular courses at universities and technical schools there have been numerous special geothermal courses, workshops and excursions: Special training for students (7 courses; 165 participants), Postgraduate training (18 courses, 6 technical excursions, 800 participants), this year mainly concentrating on western and southern Switzerland. The activities are planned and implemented by GEOTHERMIE.CH and

financed by the Swiss Federal Office of Energy (SFOE). Since the establishment of the educational activities in 2001, totally 88 events have been organized with over 3'000 participants. Figure 3 shows the development over the years; the events are taking place in all parts of Switzerland: the French speaking Romandie, the Italian speaking Tessin, and the German speaking Deutschschweiz.

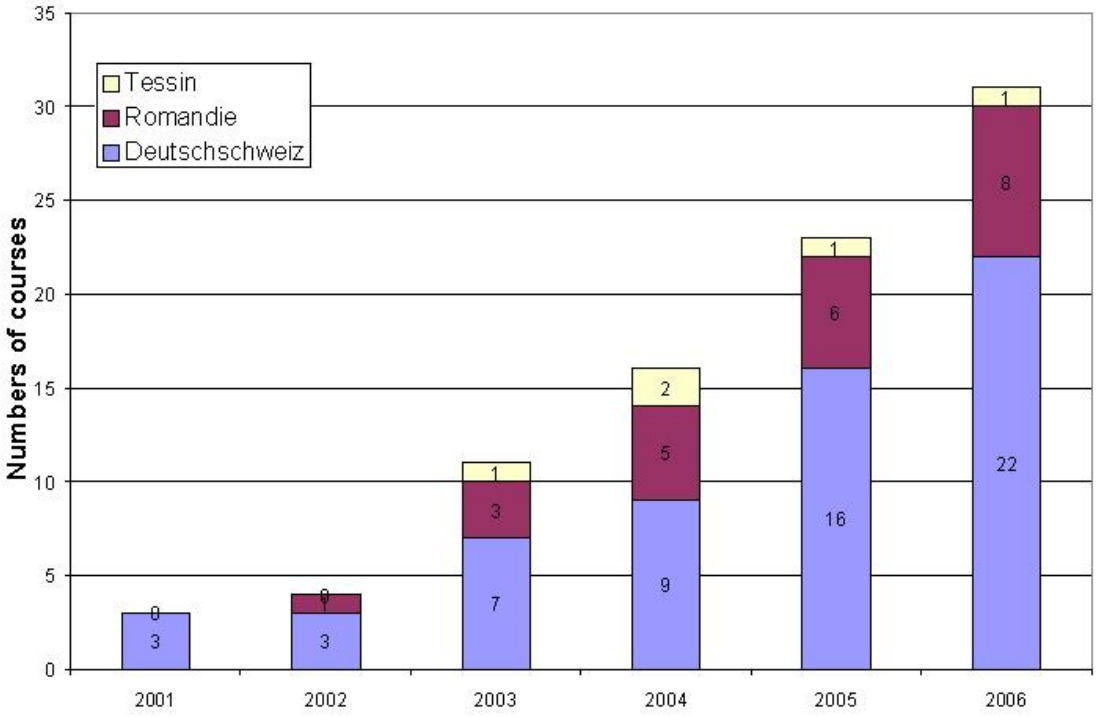

Figure 3. Geothermal educational events in Switzerland 2001 – 2006 (Geowatt AG Zurich).

9. International Cooperative Activities

First of all the participation of Switzerland in the IEA Geothermal Implementing Agreement should be mentioned. The Enhanced Geothermal System Project Management Decision Assistant (EGS PMDA), completed under Annex III, Subtask C (Leader: Th. Mégel, GEOWATT AG, Zurich), received international attention in 2006. The EGS PMDA can still be ordered through http://www.iea-gia.org/publications.asp .
The paper *Geothermal Sustainability - the View of the International Energy Agency Geothermal Implementing Agreement (IEA-GIA)* has been prepared by L. Rybach and M. Mongillo and presented at the GRC 2006 Annual Meeting in San Diego/USA where it received a Best Paper Award.

Switzerland is also active within R&D programs of the European Union. Cooperation is ongoing in the following geothermal projects:

- EGS Scientific Pilot Plant Soultz/F
- ENGINE
- I-GET
- GROUNDHIT

Strong involvement is to be reported especially in the project ENGINE ("ENhanced Geothermal Innovative Network for Europe"): ENGINE Workshop no. 3 "Stimulation of reservoir and induced microseismicity" was organized by Geowatt AG Zurich and held 26 June – 1 July in Ittingen/TG. L. Rybach is member of the ENGINE Executive Group, the governing board of the project.

10. Geothermal websites in Switzerland

SVG/GEOTHERMIE.CH	www.geothermal-energy.ch
BFE (SFOE)	www.bfe.admin.ch
CREGE	www.crege.ch
FWS/Heat Pump Promotion Association	www.fws.ch
Swiss Deep Heat Mining Project	www.dhm.ch
Geopower Basel AG	www.geopower-basel.ch
Geothermal Explorers Ltd.	www.geothermal.ch
Geowatt AG	www.geowatt.ch

Acknowledgement

The participation of Switzerland in the IEA GIA is financed by the Swiss Federal Office of Energy (SFOE), Berne. The continuous support of Markus Geissmann, responsible for geothermal energy at SFOE and of Rudolf Minder, Geothermal R&D Project Leader SFOE, is gratefully acknowledged.

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ANHANG II

Swiss Country Update for 18th IEA GIA ExCo meeting

Swiss Geothermal Update Report to 18th GIA ExCo

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- This is the 2nd Swiss update in 2007; the full 2007 report will be part of the IEA GIA Annual Report 2007. Again the actual highlights are given this time.
- The report covers the
  - Institutional framework
  - The current geothermal scene (incl. energy use, status of the Basel project)
  - Market development
  - Publications/meetings, education, websites
  - International activities

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THE INSTITUTIONAL FRAMEWORK (1)

Federal government level

On the political scene the main change is that electricity feed-in tariffs have been defined for renewable sources; Table 1 shows the numbers now in consultation.

Besides, a risk guarantee scheme (for deep geothermal drilling, 50 % risk coverage) has been designed, now also in consultation.

An accepted parliamentary initiative shall provide 60 MCHF (~50 MUS$) for deep geothermal R&D. The Swiss Federal Office of Energy shall implement and coordinate the activities.

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Table 1: Envisaged feed-in tariffs for geothermal electricity (revision of the Swiss Feredal Energy Order)

Capacity class P_{el}	Tariff (Rp/kWh)
up to **5** MW	**28.0 (17 c€)**
up to **10** MW	**25.0 (15 c€)**
up to **20** MW	**19.0 (11 c€)**
above **20** MW	**15.0 (9 c€)**

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THE INSTITUTIONAL FRAMEWORK (2)

Geothermal initiatives

Two long-term geothermal R&D plans have been formulated:

•FEGES: the Swiss Geothermal Association designed a long-term R&D plan for geothermal power production in Switzerland;

•PROGEOTHERM: a group of Swiss geothermal players defined a general R&D Plan for 2008-2012, including research, P&D and education (Master of Advanced Studies in applied geothermics offered annually).

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For geothermal, the Swiss Federal Office of Energy (OFEN) provides financing in 2007 for

- Research and Development 0.70 MCHF (0.60 MU$)
- Pilot & Demonstration (ending) 0.13 MCHF (0.1 MUS$)
- Activities of the Swiss Geothermal Competence Center (the **Swiss Geothermal Association SVG)** 0.51 MCHF (0.425 MUS$)
- The representation of Switzerland in the IEA GIA

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The reorganized and restructured Swiss Geothermal Association SVG (Affiliated Member of IGA) is the key geothermal player.

The SVG acts as the Swiss Geothermal Competence Center, in the form of the Umbrella Organisation GEOTHERMIE CH.

Its bi-lingual (G/F) Newsletter also carries the name

GEOTHERMIE.CH

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Status of the Deep Heat Mining project Basel

- **Project expenditure until end of 2006 was approx. 60 MCHF (~50 MUS$);**
- **Operational activities are suspended since the generation of „ground strokes“ in December 2006, felt and frightened the local population as well as in neighbouring Germany and France;**
- **Seismic monitoring continues (decreasing number and intensity of events, see Figure 1; largest events at the outscirts of the seismic cloud; see Figure 2); the events are near or above bottom hole;**
- **The responsible local Authorities published a call for Risk Study offers; the Risk Study shall especially address the risk of triggering larger earthquakes. Details under http://www.bd.bs.ch/geothermie**
- **The Risk Study should provide decision help about project continuation or definitive stop (in 1 – 2 years from now).**

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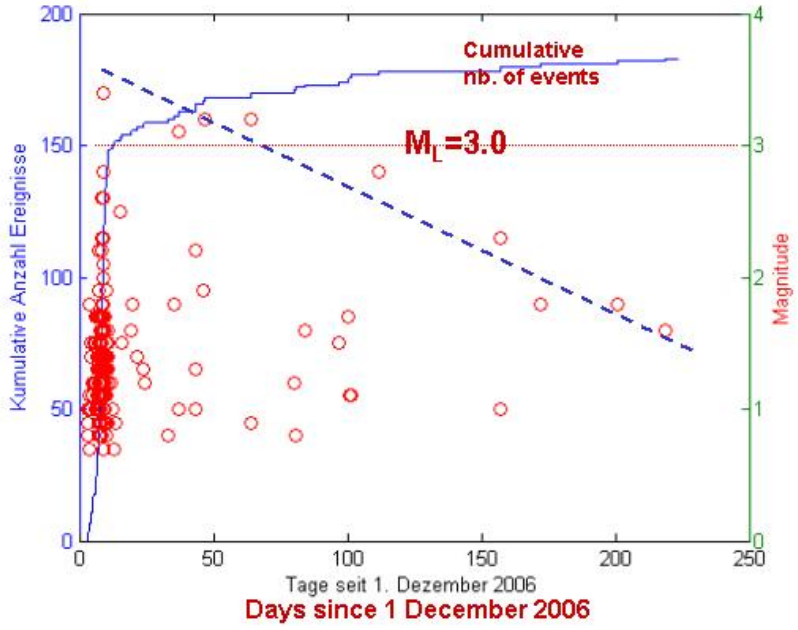
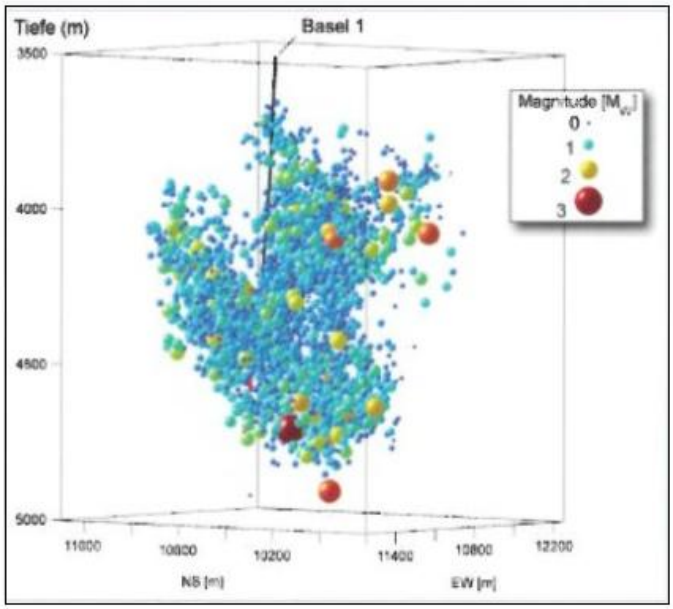


Figure 1: Seismic events in Basel, December 2006 – July 2007

Source: Swiss Seismological Service



Size of stimulated volume: ~700m high ~ 200m wide

Open hole section: 4.7 – 5.0 km

Figure 2: The largest seismic events are at the outscirts of the event cloud *(source: Geothermal Explorers Ltd.)*

Direct use

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The key achievement of Switzerland is still in the use of shallow geothermal resources by geothermal heat pumps (GHP).

An evaluation of available global data reveals that Switzerland occupies a prominent world-wide rank in installing and running GHP systems: on the average there is one GHP installation every km^2.

GHPs are now increasingly and soon routinely used for heating as well as for cooling.

Direct use is in other categories is also increasing, albeit al lower rates. Table 2 shows the 2006 vales, Figure 3 the % contributions.

Use in 2006 increased by 45 % since 2000 or by 250 TJ/a.

Table 2: Geothermal direct use in Switzerland in 2006

Use	Installed capacity MWth	Heat production (TJ/yr)
Geothermal heat pumps with borehole heat exchangers and horizontal loops	650	4272
Groundwater heat pumps	75	438
Geostructures, tunnel waters	14	87
Deep aquifers for district heating	5	64
Balneology, wellness	37	1116
Total	**781**	**5987**

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Fossil fuel and CO_2 emission „savings“

- The heat production from geothermal sources (“direct use”) enables to save fossil fuels.
- The annual heat production in 2006, 5987 TJ, corresponds to the substitution of 140’000 toe.
- This saving corresponds to avoiding the emission of about 400’000 tons of CO_2 per year.

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Market development

GHPs are now increasingly and soon routinely used for heating as well as for cooling. The corresponding drilling activities are steadily increasing, in 2006 nearly 1 million drillmeters have been achieved (=1'000 km!), see Figure 4.

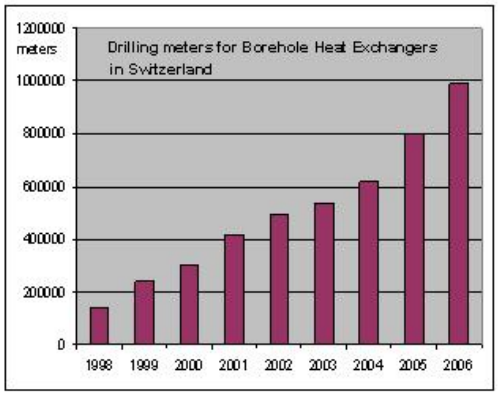

Figure 4: Development of drilling activities 1998 - 2006

Support Initiatives and Market Stimulation Incentives

Financial support or tax credits of different kind and size can be obtained when installing geothermal heat pumps, depending on the site. Local electric utilities like EWZ, EKZ, communities, various entities provide support, e.g. reduced tariffs for heat pumps.

This explains at least partly the rapid development of the Swiss geothermal heat pump market.

Information about the various sources of support can be down-loaded from the website of the Swiss Heat Pump Promotion Association FWS
http://www.fws.ch/
under *"Zahlen & Fakten" and "Förderbeiträge und Steuer-vergünstigungen"* (= support finances and tax reductions).

Publications, meetings

The regular SVG publications:

- **Newsletter GEOTHERMIE.CH (see Figure 5)**
- **Info sheets**
- **Technical brochures**

Regular technical meetings (one per year)

The successful European Geothermal Conference EGC 2007 took place in Unterhaching, Germany, 30 May – 1 June 2007. The SVG was Co-Organizer.

Educational activities

- **Geothermal courses at ETH Zurich, ETH Lausanne, Neuchâtel University**
- **Special training courses for professionals**

are regularly held.

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Figure 5

The latest issue (vol. 17, no. 43) of GÉOTHERMIE.CH contains an article about GIA (p. 9, in German)

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Geothermal websites in Switzerland

SVG/GEOTHERMIE.CH	www.geothermal-energy.ch
BFE (SFOE)	www.bfe.admin.ch
CREGE	www.crege.ch
FWS/Heat Pump Promotion Association	www.fws.ch
Swiss Deep Heat Mining Project	www.dhm.ch
Geopower Basel AG	www.geopower-basel.ch
Geothermal Explorers Ltd.	www.geothermal.ch
Geowatt AG	www.geowatt.ch

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International Cooperative Activities

IEA GIA:

Switzerland is now also Participant in GIA Annexes I and VIII ;

The paper "The IEA Geothermal Implementing Agreement (GIA) – Advancing Into Its Third Term" by M. Mongillo & L. Rybach was presented at the European Geothermal Congress 2007 in Unterhaching ;

The poster "Sustainable and environmentally friendly geothermal energy utilisation" by L. Rybach & C. Bromley was presented at the 2007 LATSIS Symposium in Zurich.

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EU projects:

Switzerland is also active within R&D programs of the European Union. Cooperation is ongoing in the following geothermal projects:

- EGS Scientific Pilot Plant Soultz/F
- ENGINE
- I-GET
- GROUNDHIT

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In summary:

- **Switzerland continues to be a leading country world-wide in geothermal heat pumps. In 2006, 1`000 km boreholes have been drilled for BHEs;**
- **Regardless the suspension of the Deep Heat Mining Project Basel the geothermal scene is active, with several encourageing developments (feed-in tariffs, governmental risk guarantee, special fund for deep geothermal resources, national programs PROGEOTHERM & FEGES);**
- **Switzerland is active in national and international R&D, the latter especially in GIA and new EU projects (ENGINE, I-GET; GROUNDHIT);**
- **The Swiss Geothermal Association is the Swiss Geothermal Competence Center; unified appearance as geothermie.ch**

Acknowledgement

The participation of Switzerland in the IEA GIA is financed by the Swiss Federal Office of Energy (SFOE), Berne. The support is gratefully acknowledged.

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ANHANG III

Mongillo, M., Rybach, L. (2007): The IEA Geothermal Implementing Agreement (GIA) – Advancing Into It Third Term. ***In: Proc. European Geothermal Congress 2007 (CD-ROM).***

Proceedings European Geothermal Congress 2007
Unterhaching, Germany, 30 May-1 June 2007

The IEA Geothermal Implementing Agreement (GIA) – Advancing Into Its Third Term

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Keywords: Geothermal Implementing Agreement, GIA, International Energy Agency, IEA, geothermal cooperation

ABSTRACT

The Implementing Agreement for a Cooperative Programme on Geothermal Research and Technology (GIA) is now beginning its third 5-year term of operation after having very successfully completed its second. The organization recognizes the major challenges that face our world if a sustainable energy future is to be attained, and has developed its new mission accordingly:

To promote the sustainable utilization of geothermal energy throughout the world by improving existing technologies, by developing new technologies to render usable the vast and widespread global geothermal resources, by facilitating the transfer of know-how, by providing high quality information and by widely communicating geothermal energy's strategic, economic and environmental benefits.

To help fulfill this mission, the GIA has developed new strategic objectives that will *identify and promote policies to stimulate energy technology research, development, demonstration and deployment; enhance development of analytical tools; foster international networking and collaboration; and effectively communicate the key lessons learned.*

The GIA operates by providing a versatile framework for comprehensive international cooperation in geothermal RD&D under the auspices of the International Energy Agency (IEA). It connects national and industry programmes, with the aim of building specific expertise and enhancing effectiveness through establishing direct cooperative links among geothermal experts in participating countries and industries. The GIA's current activities are directed principally toward coordination of country member geothermal programmes and assisting with industry member efforts; though, new activities are also initiated and implemented when needs are demonstrated.

GIA project activities are defined and organized in *Annexes*, and participants must take part in at least one. Currently, participants in the IEA-GIA are working in four broad areas covered by the following Annexes:

- Annex I- Environmental Impacts of Geothermal Energy Development
- Annex III- Enhanced Geothermal Systems (EGS)
- Annex VII- Advanced Geothermal Drilling Techniques
- Annex VIII- Direct Use of Geothermal Energy

Two other topics which are being considered for study and for which draft Annexes have been developed are:

- Annex V- Sustainability of Geothermal Energy Utilization
- Annex VI- Geothermal Power Generation Cycles

As of April 2007, 11 countries: Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, the Republic of Korea, Switzerland and the United States; the European Commission; and three industry Sponsors: Geodynamics Limited, Green Rock Energy Limited and ORMAT Technologies Inc., are members of the GIA.

The IEA-GIA is open for participation to those IEA Member and non-Member Countries, as well as those industries, that are actively working in geothermal energy RD&D. Interested parties should contact the GIA Secretariat at: mongillom@reap.org.nz or visit the GIA website: www.iea-gia.org.

1. INTRODUCTION

This paper summarizes the current status, achievements and future plans of the International Energy Agency (IEA) Geothermal Implementing Agreement (GIA) as it begins its third 5-year term of operation. It also provides a brief description of the structures of the IEA and the GIA. Further details may be found in the GIA 2002-2007 End of Term Report, the GIA Strategic Plan 2007-2012 and the GIA annual reports, all available in the Publications section on GIA website: www.iea-gia.org.

1.1 The IEA and Its Implementing Agreements

The International Energy Agency (IEA) was created in 1974 in response to the 1973-74 oil crisis. It is an autonomous international governmental agency, based in Paris, France, and consists of a cooperative group of 26 Member countries of the Organization for Economic Cooperation and Development (OECD). The Commission of the European Communities also participates. Further information about the IEA and its activities may be found on its website: www.iea.org.

The IEA encourages international collaboration in energy technology through a network of over 40 active Implementing Agreements (IAs), which provide the management structure and legal mechanism for guiding the activities of the IEA's collaborative multilateral programmes. Participants typically include research institutions, utilities and industries. There are two categories of Participants in the IAs: Contracting Parties (representing countries) and Sponsors (industry members). OECD non-Member countries, or entities of OECD non-Member countries, may also participate.

The activities, or tasks, undertaken in the IAs are defined and organized in *annexes*. The annexes specify the R&D task objectives, schedules, funding provisions (if any), and identify the participants and define their obligations. An Executive Committee (ExCo), consisting of individuals from each Contracting Party and Sponsor, coordinates and manages the activities of the IA. An Operating Agent, generally an institution, leads each annex. Funding for IA activities can be of two types: *task-sharing*, whereby the participants allocate specified resources and personnel to conduct a portion of the Annex work at their own expense; or *cost-sharing*, in which participants contribute to a common fund that is used for research, equipment purchase, information processing and exchange, operation of a secretariat, *etc*.

2. THE IEA GEOTHERMAL IMPLEMENTING AGREEMENT (GIA)

2.1 Overview

The GIA was established on 7 March 1997, reviving IEA cooperation in geothermal research after a 16-year hiatus. Following a successful first 5-year term, the Renewable Energy Working Party (REWP) and the IEA Committee on Energy Research and Technology (CERT) approved the extension of the GIA for a second 5-year term, to 31 March 2007. In February of this year (2007), the IEA CERT, acting on the recommendation of the IEA REWP, unanimously agreed to extend the GIA's operation for a third 5-year term, taking its activities to 31 March 2012.

The GIA provides a flexible framework for wide-ranging international cooperation in geothermal R & D. It brings together national and industry programmes for exploration, development and utilization of geothermal resources, with a focus on assembling specific expertise and enhancing effectiveness by establishing direct cooperative links among geothermal experts in the participating countries and industries. The GIA's present activities are directed primarily toward the coordination of the ongoing national programmes, with contributions from the Sponsor members.

The GIA's general scope of activity, as specified in its operating document, the IEA Implementing Agreement for a Cooperative Programme on Geothermal Energy Research and Technology, consists of international scientific collaborative efforts to:

- *Compile and exchange improved information* on worldwide geothermal energy research and development concerning existing and potential technologies and practices
- *Develop improved technologies* for geothermal energy utilization
- *Improve the understanding of the environmental benefits* of geothermal energy and ways to avoid or minimize its environmental impacts

The GIA's present activities encompass a range of geothermal topics, from "traditional" uses like power generation and direct use of heat, to new technologies pertinent to enhanced geothermal systems (EGS) and deep resources and the examination of sustainable use strategies. New activities are also pursued when needs are established.

As of April 2007, the European Commission (EC); 11 countries: Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, the Republic of Korea, Switzerland and the United States; and 3 industry Sponsors: Geodynamics, Green Rock Energy and ORMAT, were Members (Table 1). Participants take part in those annexes to which they can contribute, hence are not necessarily active in every one.

2.2 Strategy and Objectives

The world's renewable energy resource base has been estimated to be 7,500 EJ/year, two-thirds of which could be provided by geothermal energy (WEA, 2000). The amount of this potential that can be realized is still quite uncertain, with most recent estimates for worldwide geothermal resources located along plate margins ranging up to a total of 1,900 EJ (thermal)/year; about 65 EJ (electrical)/year for electricity generation and 1,400 EJ (thermal)/year for direct use (Stefansson, 2005). These estimates do not include the significant contribution that EGS generation may make, or that from binary generation for temperatures below 130 °C. By comparison, the 2005 installed electrical capacity was 8.9 GW (electrical) [0.3 EJ/year] and installed direct use capacity was 28 GW (thermal) [0.9 EJ/year], and the world total primary energy supply was 463 EJ in 2004 (IEA, 2006a). It is clear that the world's large and ubiquitous geothermal resources are potentially capable of making a very significant contribution towards meeting the accelerating future global energy needs.

The GIA has now begun its third 5-year term of operation, being guided by a new Strategic Plan 2007-2012, which recognizes geothermal's wide-ranging capabilities, including its capacity to assist with meeting the major challenges indicated in the IEA World Energy Outlook 2006 (IEA, 2006b)- to provide adequate and secure energy supplies at affordable prices in a sound environmental manner. The world is now, in the most optimistic case (IEA Alternative Policy Scenario), looking at *reducing the rate of increase* in demand and emissions, which grow by 37% and 30%, respectively, in the period up to 2030 (*ibid*)!

The GIA acknowledges the importance of significantly extending the development and deployment of geothermal energy worldwide by reducing costs and overcoming barriers to promote a clean, economic, sustainable and secure energy supply. In the near term, major geothermal power and direct use development is expected to occur in the countries that currently utilize geothermal and are aware of its economic, environmental and social benefits. However, in the longer term, there is great potential for expanded power development in South East Asia, South and Central America and Africa, where major geothermal resources have already been identified and demand for energy is accelerating; and for direct use in Eastern and Central Europe. The GIA also sees the potential for geothermal in distributed application, both on and off grid developments, especially in rural electrification schemes; and to be integrated into power generation systems with those renewable energy sources that are 'variable' by nature, due to their dependence upon sunshine, climate and weather. Such possibilities will require cooperation with other Implementing Agreements.

The GIA realizes that geothermal energy utilization must be promoted on a global scale and sees itself as an organization that should take the lead in supporting and advancing its development. The GIA aims to advance geothermal technology and to produce quality information that can be used to positively influence government and industry decisions and policy on geothermal RD&D.

To meet these challenges, the GIA Strategic Plan 2007-2012 has set its mission:

To promote the sustainable utilization of geothermal energy throughout the world by improving existing technologies, by developing new technologies to render exploitable the vast and widespread global geothermal resources, by facilitating the transfer of know-how, by providing high quality information and by widely communicating geothermal energy's strategic, economic and environmental benefits.

To accomplish this mission, the following six strategic objectives were designed:

- *To actively promote effective cooperation in geothermal RD&D through collaborative work programmes, workshops and seminars*
- *To collect, improve, develop and disseminate geothermal RD&D policy information for IEA Member and non-Member Countries*
- *To identify geothermal energy RD&D issues and opportunities, and improve/develop geothermal energy technologies and methods to deal with them*
- *To increase membership in the GIA*
- *To encourage collaboration with other international organizations and appropriate IEA implementing agreements*
- *To broaden and increase the dissemination of information on geothermal energy and the GIA's activities and outputs to decision makers, financiers, researchers and the general public*

2.3 Current GIA Research

At present, GIA participants work in four major research areas specified in four annexes to the GIA, with the activities of each divided into several tasks.

(1) Annex I: Environmental Impacts of Geothermal Energy Development (established in 1997): The aim of this continuing annex is to clearly identify possible environmental effects of geothermal development and devise and adopt methods to avoid or minimize their impact. The main activities of this annex are divided into five tasks: to investigate the impacts of development on natural features; to study the problems associated with discharge and reinjection of geothermal fluids; to examine methods of impact mitigation and produce an environmental manual; to investigate seismic risk from fluid injection into enhanced geothermal systems and to investigate sustainable utilization strategies.

(2) Annex III: Enhanced Geothermal Systems (EGS) (established in 1997): The main objective of this annex is to investigate new and improved technologies that can be used to artificially stimulate a geothermal resource to allow commercial heat extraction. The work is spread over four tasks: to review/modify the use of conventional and develop new geothermal technology for EGS application; to collect information necessary for decision making, design and the realization of a commercial EGS energy producing plant; and to conduct field studies of EGS reservoir performance.

(3) Annex VII: Advanced Geothermal Drilling Techniques (established in 2001): This annex pursues advanced geothermal drilling research and investigates all aspects of well construction with the aim of reducing the costs associated with this essential and expensive part of geothermal exploration, development and utilization. Investigations are conducted in three tasks: the compilation of geothermal well drilling cost and performance information and its storage and maintenance on a database; production of a geothermal drilling best practices handbook; and monitoring and exchange of information on drilling technology development and new applications.

(4) Annex VIII: Direct Use of Geothermal Energy (established in 2003): The aim of this annex is to address all aspects of direct use technology with emphasis on improving implementation, reducing costs and enhancing use. Activities are spread out over five tasks: to define and characterize geothermal resources for direct use applications; to identify and promote opportunities for new and innovative applications; to define and initiate research to remove barriers, to enhance economics and to promote implementation; to test and standardize equipment; and to develop engineering standards.

Annex IV: Deep Geothermal Resources: This annex, which started in 1997, was closed in September 2006 as a result of the successful completion of much of its work, with the remaining unfinished studies transferred to other annexes. The objective was to address issues necessary for the commercial development of deep geothermal resources at depths greater than 3,000 m. This annex was successfully involved with deep geothermal development research in Germany and participated in the Soultz-sous-Forêts project in Alsace, France; revised conceptual models of Mexican geothermal fields and analyzed the effects of their prolonged exploitation; and investigated rigorous simulation of heat and mass transport in high-temperature reservoirs with high non-condensable gases. The major results for the first 5 years of activity were compiled on CD- Rom.

The status of all the GIA annexes, including those that have been drafted, completed or are currently active, is provided in Table 2. Funding for Annexes I, III, VII and VIII is of the *task-sharing* mode, though some future activities in Annex VIII may require *cost-sharing*.

2.4 GIA Membership Benefits

Membership in the GIA benefits the research, government, industry and academic sectors, at both technical and policy levels.

GIA collaboration provides researchers with the opportunities for joint R&D cooperation and information exchange on recent R&D developments via meetings, workshops and networking. Members can participate together on R&D projects and to develop databases, models and handbooks. Policy and decision makers can obtain an international perspective on geothermal issues, opportunities and development. In addition, there are benefits to society that arise from environmentally appropriate development of geothermal resources.

More specifically, GIA membership provides the following benefits:

- *Increases R&D capabilities* beyond that of single a country/group by combining the efforts of several nations and industry

- *Provides appropriate focus for R&D*, hence avoids duplication and unproductive research
- *Develops skills and knowledge*
- *Improves R&D cost effectiveness* by sharing research costs and technical resources
- *Provides wider and easier access to key information*, research results and technological capabilities
- *Provides impartial information and analysis* to help guide national policies and programmes
- *Provides the opportunity to review current issues*, ongoing research and the need for future research
- *Helps build a common understanding* of the technical basis for various geothermal issues
- *Investigates barriers* to implementation
- *Helps develop technical standards and methodologies*
- *Contributes to the development of energy policies*

2.5 Structure, Management and Costs of the GIA

Members of the GIA participate in one or more tasks within the annexes. Each annex is binding only upon its Operating Agent and the participants therein, and does not affect the rights or obligations of other Members.

The GIA is supervised by an Executive Committee (ExCo) and its decisions are binding on all Members. The ExCo consists of one voting Member from each Member Country and Sponsor. An Alternate may serve on the ExCo if the designated Member is unable to do so. The ExCo meets twice a year and Members and/or their Alternates are strongly encouraged to attend. Members cover the travel expenses for their representatives to attend meetings and workshops.

The GIA ExCo has a Secretariat, currently based in New Zealand, which provides secretarial, administrative and other services as required for the organization.

The operational expenses for the GIA Secretariat, including the Secretary's salary, and other common costs of the ExCo, are met from an ExCo common fund. Monetary contributions to support the common fund are made by Members through a share apportionment system. The current cost per common fund share is US$ 3,500/year.

3. GIA 2ND TERM SUCCESSES AND ACHIEVEMENTS

The ExCo and the Annexes have been very active during the GIA's second term, and particularly successful in the pursuit of its 2002-2007 mission (GIA, 2003). A few examples that demonstrate the range of GIA activities, its successes and its most significant achievements are presented here. More details can be found in the Publications section on the GIA website: www.iea-gia.org/publications.asp.

An important indicator of the GIA's success this term has been its growth in membership, with the Republic of Korea, France and the first three industry Members, Geodynamics, Green Rock Energy and ORMAT Technologies joining.

The GIA ExCo and Annexes have also been very successful in their information dissemination efforts as illustrated by their over 150 publications and wide-ranging participation at major international forums, including: the International Geothermal Congress Reykjavik 2003, GRC Annual Meetings and New Zealand Geothermal Workshops, which provided opportunities for widespread exchange and interaction. The GIA's participation at the World Geothermal Congress 2005 was particularly successful, with the presentation of over 40 papers and posters by GIA Members, and sponsorship of an exhibition booth that attracted wide attention. The GIA has increased its participation in IEA renewable energy workshops and seminars and its contributions to IEA publications (e.g. OPEN Bulletin #35), thus raising the profile of geothermal energy on a worldwide scale as well as within the IEA and among the other renewable energy technologies.

A new comprehensive GIA website was also developed and went on-line in December 2004. It now provides a very important additional, and easily accessible, means for information dissemination and expands availability to GIA and non-GIA members, as well as the public.

GIA research activities have grown during the second term, with the addition of important new investigations into induced seismicity associated with EGS reservoir development and energy extraction (Annex I); field studies of EGS reservoir development and performance (Annex III); and the commencement of the new Annex VIII, which examines many aspects of geothermal energy direct use. In March 2007, a new task related to the investigation of sustainable utilization strategies was added to Annex I.

Among some of the more important specific recent achievements of the Annexes themselves are:

- *Annex I* published a special environmental issue of *Geothermics* journal; convened three international workshops on geothermal induced seismicity; produced a white paper on Induced Seismicity Associated with Enhanced Geothermal Systems and a draft protocol for dealing with induced seismicity
- *Annex III* completed development of a suite of software interpretational tools for hydrothermal and EGS systems and a high-temperature (≤ 275 ºC) acoustic televiewer; produced an English-language review of circulation and heat extraction and monitoring of the Hijiori EGS on CD-Rom; and compiled the experience of most of the major EGS research and development projects on a "Project Management Decision Assistant" handbook (PMDA) which is currently available and widely distributed
- *Annex IV* was especially involved with deep geothermal developments in Germany and participated in the Soultz-sous-Forêts project in Alsace, France; revised conceptual models of Mexican geothermal fields and analyzed the effects of their prolonged exploitation; and investigated rigorous simulation of heat and mass transport in high-temperature reservoirs with high non-condensable gases
- *Annex VII* is well on the way to producing a *Handbook of Best Practices for Geothermal Drilling*; and has collaborated with Japan on the use of a newly developed downhole high-temperature gauge

- *Annex VIII* recently began operations and has collected a significant quantity of temperature and chemistry data for geothermal features in several countries and produced its first publication (Muraoka, *et al.*, 2006)

4. FUTURE DIRECTIONS- BEGINNING THE 3RD TERM

The GIA began its third term of operation in April 2007 with great confidence, guided by it new strategic plan for 2007-2012. Its organizational vision is clear:

For the Geothermal Implementing Agreement to become a multinational forum with sufficient governmental and industrial strength to positively influence the design of Participants' RD&D plans, to optimize Participants' returns on RD&D investment by coordinating joint projects and sharing information, and to effectively support and complement IEA's efforts to promote geothermal as a clean, economic, renewable energy resource which will contribute significantly to global energy needs and security, and at the same time protect the environment.

The GIA's 2007-2012 mission and objectives, as discussed above, are aimed at making this vision a reality.

In addition to continuing its work in Annexes I, III, VII and VIII, the GIA is presently considering expanding its range of activities to include investigations into the sustainable utilization of geothermal energy (draft Annex V) and studies of the performance, environmental impact and economics of the geothermal power cycles to establish guidelines for best selection (draft Annex VI). The breaking down of barriers to geothermal development continues to be an extremely important issue, and the expertise of the GIA's new country and industry members will help address it. Options are always open for new collaborative activities to be added to the programme and new proposals are encouraged.

The GIA also recognizes the importance of increasing membership to help advance worldwide geothermal energy use. To this end, the IGA plans to more actively pursue its outreach programme to both non-GIA Members and non-IEA countries, especially those with major geothermal resources and developments. Options to encourage potential Members to join include inviting them to attend ExCo Meetings and seminars.

The GIA plans to continue to build upon its already excellent cooperation with the IEA, which provides important opportunities for international exposure and communication.

Information dissemination and communication will remain major activities for the GIA and there are plans to continue and emphasize their development through its website, the production of brochures and reports, by holding seminars.

5. CONCLUSIONS

It is clear that the global energy demand will continue to accelerate in the coming decades. The world's vast and ubiquitous geothermal resources can play an important role in helping meet this demand by providing secure, clean and affordable energy, both for electricity generation and direct use. However, to do so, it is essential to improve and develop new technologies and promote the benefits of sustainable geothermal utilization.

The GIA has already achieved a great deal towards helping meet the global energy challenges during its first two terms. It is also clear that a significant amount of work remains. The GIA can continue to make major contributions and is confident its activities in the current third term will continue to provide the means for very successful extensive international cooperation in geothermal R&D. At present, the EC, 11 Member countries from Europe, Asia, the Americas and Oceania, and 3 geothermal industries are collaborating to help make geothermal energy the major energy resource of the future.

The GIA invites those national organizations, industry and other groups who are able to contribute to join us. Membership is open to both IEA Member and non-Member countries. Interested parties should contact the IEA-GIA Secretary at: mongillom@reap.org.nz and/or visit the IEA GIA website at: www.iea-gia.org for further information. Membership is formalized through the IEA Secretariat, which has been instrumental in assisting with the growth of the GIA.

ACKNOWLEDGEMENTS

The authors would like to thank Chris Bromley, Clifton Carwile and Allan Jelacic for their valuable comments on previous versions of this paper.

The IEA Geothermal Implementing Agreement (GIA), also known as the Implementing Agreement for a Cooperative Programme on Geothermal Energy Research and Technology, functions within a framework created by the International Energy Agency (IEA). Views, findings and publications of IEA GIA do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.

REFERENCES

GIA (2006a) GIA 2002-2007 End of Term Report. www.iea-gia.org/publications.asp

GIA (2006b) GIA 2007-2012 Strategic Plan (November 2006). Document available at: www.iea-gia.org/publications.asp

GIA (2003) GIA 2002-2007 Strategic Plan (revision December 2003). Document available at: www.iea-gia.org/publications.asp

IEA (2006a) Renewable Energy: RD&D Priorities. OECD/IEA 2006. Paris, France, 71-87.

IEA (2006b) World Energy Outlook 2006- Summary & Conclusions. OECD/IEA 2006. Paris, France, 15p.

Muraoka, H., Sakaguchi, K., Nakao, S. and Kimbara, K. (2006) Discharge temperature-discharge rate correlation of Japanese hot springs driven by buoyancy and its application to permeability mapping. Geophysical Research Letters, 33, L10405, doi:10.1029/2006GL026078, 2006.

Stefansson, V. (2005) World Geothermal Assessment. Proceedings World Geothermal Congress 2005, Antalya, Turkey, 24-29 April 2005, 6 p.

WEA (2000) World Energy Assessment. UNDP, 2000.

WEO (2002) World Energy Outlook 2002. International Energy Agency, 2002, 530 p.

Table 1. Contracting Party and Sponsor Membership in the IEA Implementing Agreement for a Co-operative Programme on Geothermal Research and Technology as of April 2007.

Country	Starting Date of GIA Membership	Current Contracting Party
Australia	August 1997	Primary Industries and Resources SA (PIRSA)
European Commission	March 1997	Commission of the European Communities
France	February 2007	BRGM
Germany	July 1997	Forschungszentrum Jülich GmbH(F-J)
Iceland	December 2000	Orkustofnun (The National Energy Authority)
Italy	May 2000	ERGA Spa (ENEL Group)
Japan	March 1997	New Energy and Industrial Technology Development Organization (NEDO)
Mexico*	July 1997	Instituto dè Investigaciones Eléctricas (IIE)
New Zealand	March 1997	GNS Science
Republic of Korea	September 2005	Korea Institute of Geoscience and Mineral Resources (KIGAM)
Switzerland	March 1997	Swiss Federal Office of Energy
United States of America	March 1997	US Department of Energy (US DOE)
Industry Home Country		**Sponsor**
Australia	June 2006	Geodynamics Limited
Australia	June 2006	Green Rock Energy Limited
United States of America	March 2006	ORMAT Technologies Inc.

* Non-IEA Member Country participant

Table 2. List of GIA Annex titles, operating agents, annex leaders, affiliations & contact e-mail addresses, participating countries and operating status as of April 2007.

Annex Number	Annex Title Operating Agent (OA) Annex Leader (AL); Affiliation; Contact E-mail Participants	Status
I	Environmental Impacts of Geothermal Development OA: GNS Science (GNS), New Zealand AL: Chris Bromley; GNS, New Zealand; c.bromley@gns.cri.nz Participants: EC, Iceland, Italy, Japan, Mexico, New Zealand, USA	Active since 1997, Continuing through 2009
II	Shallow Geothermal Resources	Closed
III	Enhanced Geothermal Systems (EGS) OA: Geodynamics Limited, Australia AL: Roy Baria; MIL-TECH UK Ltd, England; roybaria@onetel.com Participants: Australia, EC, Geodynamics, Germany, GreenRock Energy, Italy, Japan, ORMAT, Switzerland, USA	Active since 1997, Continuing through 2009
IV	Deep Geothermal Resources	Closed 2006
V	Sustainability of Geothermal Energy Utilization	Draft
VI	Geothermal Power Generation Cycles	Draft
VII	Advanced Geothermal Drilling Techniques OA: Sandia National Laboratories, United States AL: Stephen Bauer; Sandia National Laboratories, USA; sjbauer@sandia.gov Participants: EC, Geodynamics, Green Rock Energy, Iceland, Mexico, New Zealand, ORMAT, USA	Active since 2001, Continuing through 2009
VIII	Direct Use of Geothermal Energy OA: Federation of Icelandic Energy and Waterworks, Iceland AL: Einar Gunnlaugsson, Reykjavik Energy, Iceland; einar.gunnlaugsson@or.is Participants: Iceland, Japan, New Zealand, Republic of Korea, Switzerland, USA	Active since 2003, Continuing through 2007
IX	Geothermal Market Acceleration	Closed

ANHANG IV

L. Rybach , C. Bromley: Strategies for sustainable and environmentally friendly geothermal energy utilization
Poster, LATSIS Symposium 2007, ETH Zürich

Strategies for sustainable and environmentally friendly geothermal energy utilisation

L. Rybach[1] and C. Bromley[2]

1) GEOWATT AG, Zurich (Switzerland) 2) GNS Science, Taupo (New Zealand)

Geothermal resources

The basic geothermal resource is the heat content of the Earth's interior. Geothermal heat can be used directly as well as for power generation. The main benefits of geothermal energy are the inexhaustible nature, its daily and seasonal independence (i.e. it can provide base-load electricity), the ubiquitous and indigenous character, and its environmental friendliness. Besides, it is unconspicuous, needs little space and no storage and is for many applications economic. The potential of geothermal energy is the highest among the other renewables (Table 1).

Energy source	EJ/year
Geothermal	5'000
Solar	1'575
Wind	640
Biomass	276
Hydropower	50
Total	**7'541**

Table 1. Technical potential of renewable energy resource base (WEA, 2000).

Geothermal sustainability

The resource is the key component of geothermal sustainability, see Figure 1.

Figure 1. Interplay of sustainability components

Geothermal resources are renewable when viewed over an appropriate timeframe. With proper management the geothermal system can be utilised over a long term (~100 years). Sustainable development calls for cyclic utilization, with local depletion and recovery of pressures and temperatures, and recharge of fluid and heat from depth. Pressure and temperature recovery will then follow, the former occurring more quickly than the latter (Figure 2)

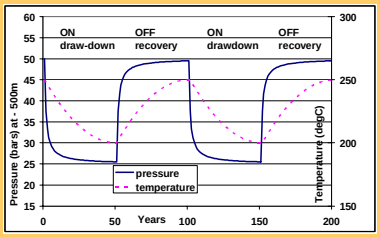


Figure 2. Strategy for cyclic utilization and recovery of a geothermal resource. This provides for long-term sustainability by alternating resource use.

Sustainable and environmentally beneficial geothermal development

Optimised reservoir management involves countering the adverse effects of premature temperature decline with appropriate and flexible production and injection strategies. Such strategies need to be adjusted at times, in order to achieve the correct balance. The ability to use the system over a long term without prejudicing its ability to recover constitutes a sound long-term resource utilisation strategy.

Successful examples are presented below: sustaining the originally declining production level by fluid reinjection at the Larderello power production field (Italy, Figure 3), stabilizing the water level for pumping at the Laugarnes district heating system (Iceland, Figure 4), annual and long-term ground recovery for a borehole exchanger-coupled heat pump system for space heating at Elgg/ZH (Switzerland, Figure 5), and successful recovery of thermal features (Wairakei Terraces, New Zealand).

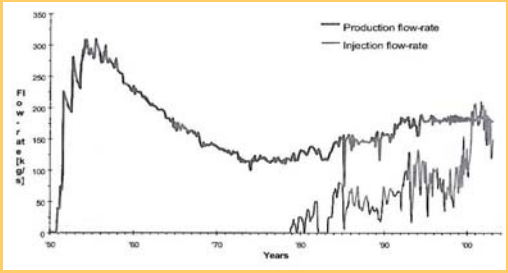


Figure 3. Fluid reinjection enables to sustain production since 1992 (Larderello power production field, Italy).

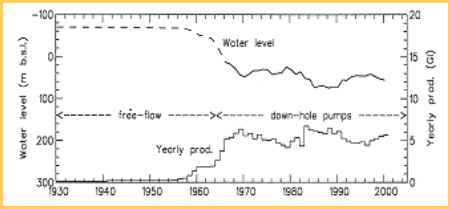


Figure 4. 90 % of the buildings in Iceland are geothermally heated. The Laugarnes district heating system produces hot water from boreholes, since 1968 with constant yield.

Switzerland is world leader in geothermal heat pumps, now increasingly used for space heating and cooling. The example of an installation in Elgg/ZH (one 100 m deep borehole heat exchanger, for heating only) shows the reliable long-term behavior of the system (Figure 5).

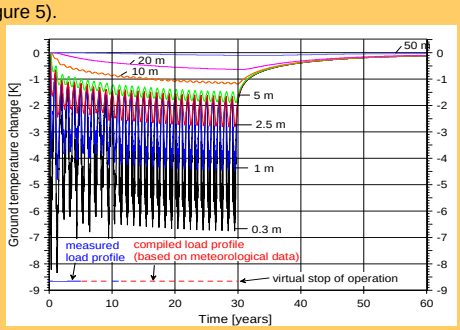


Figure 5. Annual and long-term recovery curves (ground temperatures around a geothermal heat pump installation in Elgg, Switzerland)

Practical environmental protection strategies need to include improved discharges from surface thermal features using targeted shallow fluid injection or production. Avoidance strategies include pressure control to minimize the risks of large induced seismicity or subsidence, and treating or injecting toxic liquid or gas discharges. Sustainable utilisation strategies are also used in geothermal resource assessments in order to determine probable or possible extractable energy reserves under various development scenarios. An example from New Zealand demonstrates the effectiveness of a sound environmental mitigation and enhancement strategy: the historic Kiriohineki hot stream has been restored using waste hot water, and enhanced with the addition of the Wairakei Terraces and a geyser.

Figure 6. Wairakei Terraces/New Zealand, a recent artificial thermal feature enhancement using waste hot water.

International efforts

International collaboration between IEA countries participating in the Geothermal Implementing Agreement (GIA) has facilitated valuable exchanges of research results and international experience with respect to these strategies. Annex I of the GIA "Environmental Impacts of Geothermal Energy Development" now includes also a Task "Sustainable Utilization Strategies". Successful examples from Italy, Iceland, Switzerland and New Zealand are shown above; they demonstrate that sustainable and environmentally friendly use of geothermal resources can be achieved by appropriate development and production strategies.

C. Bromley is Chairman of the IEA GIA Executive Committee; L. Rybach is Vice Chairman. C. Bromley is also Leader of Annex I.

Literature

Mongillo, M., Rybach, L. (2007): The IEA Geothermal Implementing Agreement (GIA) – Advancing Into Its Third Term. In: Proc. European Geothermal Congress 2007 (CD-ROM).

Bromley, C., Rybach, L., Mongillo, M., Matsunaga, I. (2006): Geothermal resources - utilisation strategies to promote beneficial environmental effects and to optimize sustainability. In: Proc. Renewable Energy 2006 Japan, p.1637-1640 (CD-ROM)

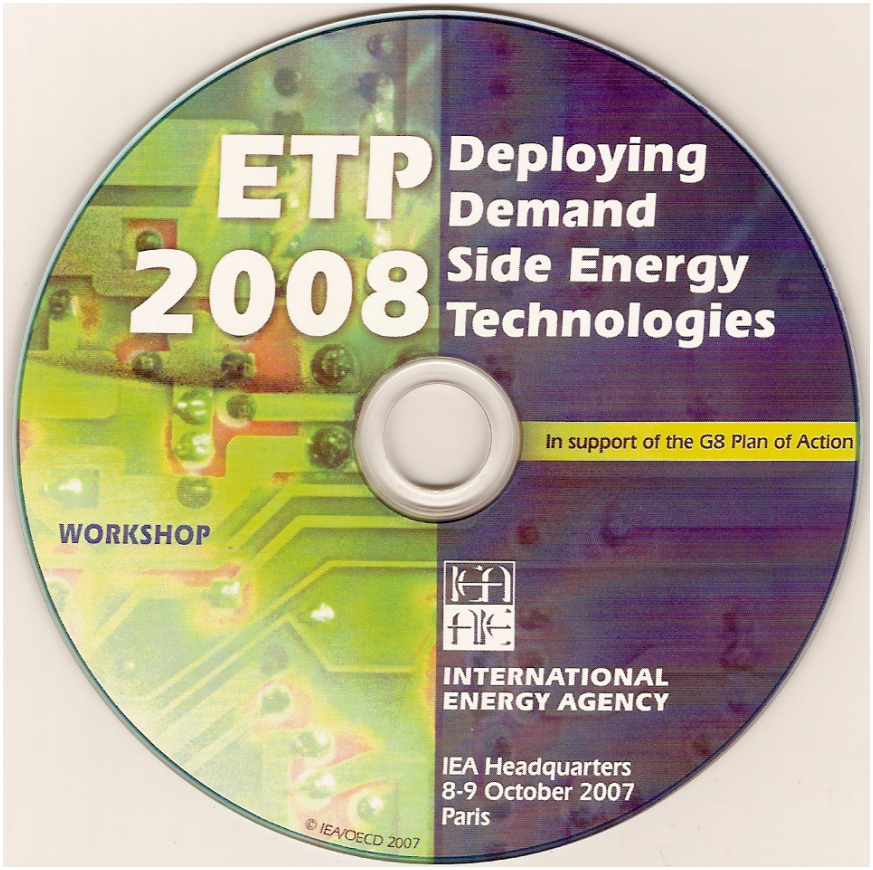
Rybach, L., Mongillo, M. (2006): Geothermal Sustainability – A Review with Identified Research Needs. Geothermal Resources Council Transactions Vol. 30, p. 1083-1090.

LATSIS SYMPOSIUM 2007, ETH Zurich

GEOWATT AG SWISS GEOTHERMAL EXPERT GROUP

ANHANG V

CD-ROM (Titelseite) IEA Workshop ETP 2008 Deploying Demand Side Technologies – in support of the G8 Plan of Action



Proceedings CD-ROM, IEA Workshop ETP 2008 – Deploying Demand Side Energy Technologies (in support of the G8 Plan of Action)

ANHANG VI

Rybach, L. (2007): Die Schweiz im Geothermal Implementing Agreement der IEA. *GEOTHERMIE.CH Vol. 45, S. 9*

Internationale Energie-Agentur (IEA)

Die Schweiz im Geothermal Implementing Agreement der IEA

Durch die Mitgliedschaft im Geothermal Implementing Agreement (GIA) der Internationalen Energie-Agentur kann die Schweiz weltweiten Kontakt mit führenden Geothermie-Ländern pflegen und Informationen austauschen.

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Die Internationale Energie-Agentur (IEA) mit Sitz in Paris stellt eine bedeutende, autonome Regierungsorganisation dar und umfasst 26 Mitglieder aus den OECD-Staaten. Sie fördert die weltweite Zusammenarbeit im Bereich der Energietechnologien durch ein Netzwerk von über 40 aktiven Ausführungsvereinbarungen (Implementing Agreements –IA).

Mitglieder des Geothermal Implementing Agreements (GIA)

Das GIA umfasst 15 Mitglieder: Australien, Frankreich, Deutschland, Island, Italien, Japan, Mexiko, Neuseeland, Südkorea, Schweiz, USA, die Europäische Kommission sowie als Sponsoren Geodynamics Ltd., Green Rock Energy Ltd. and ORMAT Technologies Inc.
Informationen: www.iea-gia.org

Diese gewährleisten sowohl Führungsstrukturen als auch Vertragsmechanismen für die Leitung der Aktivitäten der verschiedenen multilateralen IEA-Programme. Teilnehmer sind grundsätzlich Regierungen, welche ihrerseits Ministerien (Bundesämter), Forschungsinstitutionen, Energieversorger oder Industrien mit der operativen Tätigkeit beauftragen. In den IA gibt es zwei Kategorien: Vertragsparteien (Länder) und Sponsoren (Industriemitglieder).

Seit über 10 Jahren aktiv

Das IA für ein Programm zur Forschung und Entwicklung im Bereich der Geothermie, das Geothermal Implementing Agreement (GIA), bietet die Grundlage für umfassende Kooperationen bei geothermischen Forschungs- und Entwicklungsprojekten. Diese Arbeiten decken heute vier unterschiedliche Forschungsbereiche ab:
- Umwelteinflüsse durch geothermische Vorhaben
- Stimulierte Geothermie-Systeme (EGS)
- Innovative Bohrtechniken für die Geothermie
- Direkte Nutzung von geothermischer Energie

Das GIA befindet sich am Anfang seiner dritten 5-Jahres-Periode, welche Ende März 2012 abgeschlossen sein wird. Als Ziel der aktuellen Periode wird die Förderung einer weltweiten, nachhaltigen Nutzung der Geothermie genannt. Dies soll durch folgende Massnahmen geschehen: Verbessern bestehender Technologien, Entwickeln neuer Technologien zur Nutzung der globalen geothermischen Ressourcen, Vereinfachen des Know-how-Transfers sowie Aufbereiten hochwertiger Informationen und Kommunizieren von strategischen, wirtschaftlichen und umweltrelevanten Vorzügen der Geothermie.

Executive Committee (ExCo) als Führungsinstrument

Die Führungs- und Aufsichtsverantwortung für die GIA nimmt das Leitungskomitee (ExCo) wahr, welches von jedem Land und jedem Sponsor ein Mitglied umfasst. Das ExCo ist für alle administrativen Belange des GIA zuständig. Während ExCo-Meetings berichten die Mitglieder über ihre nationalen Programme, tauschen Informationen und Arbeitsresultate aus und erörtern laufende und künftige Themen. Mitglied der Schweiz ist das Bundesamt für Energie (BFE), das durch Ladislaus Rybach von der Geowatt AG in Zürich vertreten wird. Er ist zugleich Vize-Vorsitzender der ExCo. Ergänzendes Mitglied ist der BFE-Programmleiter für Geothermie-Forschung, Rudolf Minder, von der Minder Energy Consulting in Oberlunkhofen.

Mit der Präsenz im GIA der Internationalen Energie-Agentur kann die Schweiz regelmässigen Kontakt und Austausch mit führenden Geothermie-Ländern pflegen, was den Weg zu ansonsten unzugänglichen Informationen öffnet. Gleichzeitig lassen sich Schweizer Forschungs- und Entwicklungsresultate international positionieren und durch die Kanäle der IEA verbreiten. Und die Internet-Plattform informiert über die neuesten Ergebnisse, beispielsweise zur induzierten Seismizität.<

Résumé

Le GIA (Geothermal Implementing Agreement) de l'Agence Internationale de l'Energie (AIE) avec siège à Paris a commencé sa troisième période de 5 ans en mars 2007. Le but de la période actuelle est la promotion de l'utilisation durable de la géothermie à l'échelle planétaire.