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Bundesamt für Energie BFE

Schlussbericht 15. Dezember 2008

ARBEITEN FÜR DAS IEA GEOTHERMAL IMPLEMENTING AGREEMENT (GIA)

Jahresbericht 2009

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Zusammenfassung

Die Arbeiten der Geowatt AG für das IEA GIA im Rahmen des Projektes Nr. 153'758 wurden 2008 durch L. Rybach ausgeführt. Sie umfassten seine als IEA GIA Executive Committee Officer (konkret: Vice Chairman) getätigten Aktivitäten, wie auch die Arbeiten für Annex VIII „Direct Use of Geothermal Energy“. Daneben wurden mit diversen GIA Akteuren gemeinsame Veröffentlichungen verfasst. Die Arbeiten verliefen programmgemäss, die Resultate werden mit neun Anhängen dokumentiert.

Abstract

The activities of Geowatt AG for the IEA GIA were performed in 2009 within the framework of project no. 153'758 by L. Rybach. The work included his duties as GIA Executive Committee Officer (in particular as Vice Chairman) as well as the activities for Annex VIII “Direct Use of Geothermal Energy”. In addition, several joint publications have been completed, in co-authorship with various GIA actors. The activities proceeded as planned, the results are documented in nine Appendices.

1. Ausgangslage

Die Schweiz ist Teilnehmerin des IEA GIA seit Anbeginn (März 1997). Der Vertrag Nr. 153'758 (Projekt Nr. 41'661) ist Grundlage der Arbeiten der Geowatt AG in 2009; diese wiederum setzt L. Rybach als Bearbeiter ein.

2. Ziel der Arbeit

Im IEA GIA Executive Committee (ExCo) wirkt L. Rybach als Vice Chairman mit. Durch den Vertrag Nr. 153'758 soll die Ausführung der Obliegenheiten von L. Rybach als ExCo Officer gewährleistet werden. Daneben wird die Mitwirkung der Schweiz an zahlreichen GIA Publikationen auf internationaler Ebene gesichert.

3. Lösungsweg

Die Aktivitäten des Berichterstatters werden einerseits durch die Teilnahme an den ExCo Meetings, an ausgewählten Annex Meetings sowie an besonderen IEA Veranstaltungen (Workshops, Seminare) wahrgenommen, anderseits umfassen sie den umfangreichen Schriftverkehr zwischen den Officers (Präsident, zwei Vizepräsidenten, GIA Sekretär).

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

Eine besondere GIA – IGA Veranstaltung, namentlich der Workshop “Geothermal Energy - Its Global Development Potential & Contribution to Mitigation of Climate Change”, fand am 5. und 6. Mai 2009 in Madrid statt, unter massgeblicher Beteiligung von L. Rybach.

Um die GIA Aktivitäten weit herum bekannt zu machen, werden Beiträge zu internationalen Tagungen erarbeitet, dort präsentiert, und schliesslich veröffentlicht. In der Berichtsperiode hat L. Rybach an mehreren diesbezüglichen Publikationen mitgearbeitet.

Darüber hinaus hat L. Rybach die Schweiz im Annex VIII „Direct use“ vertreten, u.a. durch Leitung des Task E „Design Configurations, Engineering Standards“.

4. Ergebnisse

4.1 Arbeiten als GIA ExCo Vice Chairman, d.h. als GIA ExCo Officer

GIA-IGA Workshop "Geothermal Energy - Its Global Development Potential & Contribution to Mitigation of Climate Change"

Der Workshop fand am 5. und 6. Mai 2009 in Madrid statt. Gemeinsam mit Vertretern der IGA haben dabei GIA ExCo Mitglieder, IGA Vertreter, sowie ausgewählte Experten die Thematik in Panel meetings behandelt und diskutiert. Die Vorbereitung des Workshops sowie die Ausarbeitung des Programmes besorgten M. Mongillo (GIA Secretary) und L. Rybach. Die Präsentationen sind inzwischen auf der IGA Webseite (www.iea-giea.org) platziert. Die vom Workshop resultierenden Erkenntnisse sind nun integrierende Bestandteile von Chapter 4 „Geothermal Energy" des IPCC Special Report Renewable Energy (SRREN). Unter den Autoren des Chapter 4 ist das GIA ExCo gut vertreten: R. Goldstein (Australien) ist Coordinating Lead Author, C. Bromley (Neuseeland) und H. Muraoka (Japan) sind Lead Authors. L. Rybach ist Contributing Author und wurde kürzlich vom IPCC zum Expert Reviewer des gesamten SRREN-Reports ernannt.

Inputs zu GIA Beiträgen in IEA Dokumentationen

Regelmässig wird die GIA vom IEA Sekretariat aufgefordert, zu Dokumenten der IEA während ihrer Ausarbeitung Stellung zu nehmen, diese zu überprüfen, zu erweitern etc. Meist ist die Frist für die Stellungnahme von der IEA sehr kurz angesetzt. Da die Zeit für eine Konsultation der ExCo Mitglieder i.a. nicht ausreicht, obliegt die Abfassung der Inputs den ExCo Officers.

In der Berichtsperiode betraf dies insbesondere die IEA Dokumente

- Renewable Energy in Cities
- Renewable Energy Essentials: Geothermal

Evaluation von Finanzierungsanträgen von ExCo Mitgliedern zuhanden des GIA Common Fund

Neuerdings können Anträge zur Finanzierung gezielter Aktivitäten von ExCo Mitglieder eingereicht werden. Für die Bewertung der Anträge wurde durch Motion 21/4 des GIA ExCo ein Proposal Review Committee etabliert, bestehend aus den GIA ExCo Officers. Dementsprechend wurden die Anträge von den ExCo Officers bewertet und dem ExCo die Annahme bzw. Ablehnung beantragt. Die folgenden Anträge wurden in diesem Rahmen behandelt:

- Antrag von Neuseeland zum Editing des Geothermics Special Issue "Sustainability" (durch GIA Secretary M. Mongillo)
- Antrag von Kanada (CanGEA) zur Teilfinanzierung einer Geothermie-Webseite
- Antrag von Kanada (CanGEA) zur Finanzierung der Studie „Global Geothermal Policy Best Practices Study"

Vermittlung von lokalen Logistik-Kontakten

Für die Vorbereitung und logistische Abwicklung des 23rd GIA ExCo meetings, welches in Nusa Dua (Bali, Indonesien) am 22. und 23. April 2010 stattfinden soll, wurden Kontakte des GIA Sekretariats zum World Geothermal Congress 2010 vermittelt, welcher anschliessend gleichenorts stattfinden wird. Insbesondere konnten Kontakte zu Surya Darma, WGC2010 Secretary General vermittelt werden.

Vorbereitung des 22nd GIA ExCo meeting (Reno/NV, USA; 1. – 2. Oktober 2009)

- Beiträge zu Draft Minutes 21st GIA ExCo meeting
- Beiträge zur Bereinigung der Traktandenliste (mehrere Durchgänge)
- Mitarbeit an der Zulassungs-Selektion von Gästen und Beobachtern
- Korrespondenz und Vorbereitung der Berichterstattung betr. „Prospective Participants“

Teilnahme an Annex meetings (Reno/NV, USA am 30. September 2009) und am 22nd GIA ExCo meeting

Infolge Verhinderung des Annex VIII Leaders E. Gunnlaugsson (Island) hatte L. Rybach das 7th Annex VIII meeting vorzubereiten und zu leiten. Anschliessend verfasste er –unter Mithilfe von Y. Song (S.Korea)– den Bericht über das 7th Annex VIII meeting.

Am 22nd GIA ExCo meeting hat L. Rybach verschiedentlich referiert, insbesondere über die Kontakte zu „Prospective Participants“. Es sind dies Länder oder Sponsoren, welche für einen Beitritt in das GIA in Frage kommen. Der Status der Beitrittsverhandlungen mit Irland, Ungarn, Polen (Länder) und Alta Rock Energy/USA und EGEC (Sponsors) wurde am 1.10.2009 präsentiert, aufgrund der mit diesen Parteien geführter Korrespondenz. Die Aussagen wurden protokolliert und erscheinen in den Minutes of the 22ndGIA ExCo Meeting.

4.2 Publikationen

Die Bekanntmachung der GIA Tätigkeiten ist ein ständiges Anliegen des GIA ExCo. In der Berichtsperiode wurden keine neuen Broschüren oder Flyers erarbeitet, dafür mehrere Vorträge und Publikationen vorbereitet. L. Rybach ist Koautor all dieser Veröffentlichungen; deren Autorenschaft wiederspiegelt die Internatonalität des GIA.

Renewable Energy 2008, Busan (S.Korea)

Der Beitrag zu diesem grossangelegten internationalen Kongress wurde noch 2008 erarbeitet, nun ist die entsprechende Publikation im Druck (Muraoka et al. 2010).

Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems (2009)

Dies ist ein im Rahmen der GIA erarbeiteter Wegweiser für EGS Entwickler betr. sozialer Akzeptanz der EGS Technologie und gilt als offizielle, von der ExCo genehmigte GIA Position. Sie ist unter Publikationen auf der GIA Webseite zu finden: http://www.iea-org/publications.asp

GRC 2009 General Assembly

Zu diesem Kongress wurde der Beitrag Mongillo et al. (2009) vorbereitet und ist in *GRC Transactions* Vol. 43 publiziert.

WGC2010

Der alle fünf Jahre stattfindende World Geothermal Congress ist die wichtigste internationale Kongressveranstaltung der Geothermie-Szene. WGC2010 findet, veranstaltet durch die IGA und die Indonesian Geothermal Association, in Nusa Dua (Bali, Indonesien) Ende April 2010 statt. Für diese Tagung wurden mehrere Beiträge erarbeitet; die entsprechenden Publikationen durchliefen die Review-Prozedur und sind nun allesamt für den Druck angenommen:

- Axelsson et al. (2010)
- Mongillo et al. (2010)
- Muraoka et al. (2010)
- Song et al. (2010)

Sie werden in den *WGC2010 Proceedings* publiziert.

Geothermics Special Issue „Sustainability"

Die GIA hat am 10. November 2008 in Taupo/Neuseeland den *International Geothermal Sustainability Modelling Workshop* veranstaltet. Die dort präsentierten Beiträge sowie weitere, erbetene Papers werden in einer Spezialnummer der Zeitschrift *Geothermics* veröffentlicht. Für dieses wichtige GIA Produkt hat L. Rybach mit W. Eugster einen Schweizer Beitrag erarbeitet (Rybach and Eugster, 2010), der nach dem *Geothermic*s-spezifischen Reviewverfahren angenommen wurde und nun im Druck ist.

Ferner wurde L. Rybach vom Guest Editor der Spezialnummer, M. Mongillo, mit dem Reviewen des Manuskripts J Szanyi & .B. Kovács „Experiences on 40 years operation of geothermal systems in South-East Hungary**"** (*Geothermics* manuscript GEOT-D-09-00045) beauftragt.

DIE TITELBLÄTTER DER PUBLIKATIONEN BEFINDEN SICH IN DEN ANHÄNGEN I - VIII.

4.3 Laufende Administration als GIA Officer

Der Berichterstatter wirkte als GIA ExCo Vice Chairman und Officer auch in 2009 an allen Vernehmlassungen und Entscheidungen mit. Die weiteren Officers sind C. Bromley/Neuseeland (ExCo Chairman), J. Ketilsson/Island (ExCo Vice Chairman), und M. Mongillo/Neuseeland (GIA Secretary). Die Arbeiten wurden weitgehend per e-mail abgewickelt. Im Durchschnitt erfolgte täglich mindestens ein e-mail- Wechsel. Diese Arbeiten nahmen entsprechend viel Zeit in Anspruch.

4.4 Arbeiten für IEA GIA Annex VIII „Direct Use of Geothermal Energy“

Infolge Verhinderung des Annex VIII Leaders E. Gunnlaugsson (Island) hatte L. Rybach das 7th Annex VIII meeting vorzubereiten und am 30. September 2009 in Reno, Nevada/USA zu leiten. Anschliessend verfasste er –unter Mithilfe von Y. Song (S.Korea)– den Bericht über das 7th Annex VIII meeting (**ANHANG IX: Titelseite des 36-seitigen Dokuments**). Zudem ist der Bericht auf der IEA GIA Webseite www.iea-gia.org passwortgeschützt unter Members Area zu finden.

Im Rahmen des 7th Annex VIII meeting hat L. Rybach auch über Task E „Design Configurations, Engineering Standards“ als dessen Leiter referiert. Die Arbeiten in 2009 umfassten eine Erhebung mittels Umfrage bei den Teilnehmern von Annex VIII über nationale Standards, technische Vorschriften, Richtlinien usw. betreffs geothermische Direktnutzung. Hinsichtlich solcher Richtlinien und Standards ist die Situation in den teilnehmenden Ländern –wie erwartet– höchst unterschiedlich: wenn solche Vorgaben existieren, dann auf unterschiedlichen Niveaus und in den jeweiligen Landessprachen. Die Schweizerische SIA Norm 384/6 „Erdwärmesonden“ findet auch ausserhalb der IEA weite Beachtung, da sie in ihrer Art einzigartig umfassend ist. Die Norm 384/6 ist eine durch das BFE finanzierte Entwicklung; L. Rybach ist Mitglied der SIA Normkommission 384/6.

5 Diskussion

Konkrete, sichtbare Erzeugnisse sind oben beschrieben und teilweise auch auf der IEA GIA Homepage **http://www.iea-gia.org/** zu finden. Ferner sind sie durch die **ANHÄNGE I - IX** ersichtlich.

6 Schlussfolgerungen, Ausblick

Im ExCo war 2009 G. Siddiqi der Schweizer Verteter (ExCo Member). L. Rybach wirkte als Alternate und Vice Chairman; seine Arbeiten sind oben beschrieben und mit neun Anhängen dokumentiert. Die Arbeiten verliefen programmgemäss.

Die Tätigkeiten von L. Rybach für die IEA GIA werden per Ende 2009 eingestellt, diejenigen als ExCo Vice Chairman auf Geheiss des BFE.

Symbolverzeichnis

IEA	International Energy Agency
GIA	Geothermal Implementing Agreement
ExCo	Executive Committee
IGA	International Geothermal Association (President: L. Rybach)
EGEC	European Geothermal Energy Council
BFE	Bundesamt für Energie

Referenzen

Axelsson, G., Bromley, C., Mongillo, M., Rybach, L. (2010): The Sustainability Task of the International Energy Agency's Geothermal Implementing Agreement. Accepted for *Proceedings, World geothermal Congress 2010, Nusa Dua, Bali/Indonesia, 8 p.*

Mongillo, M., Bromley, C., Rybach, L. (2009): IEA-GIA- International geothermal cooperation going from strength to strength. *GRC Transactions Vol. 43, p. 623-628*

Mongillo, M., Bromley, C., Rybach, L. (2010): The IEA Geothermal Implementing Agreement - International efforts to promote global sustainable geothermal development and help mitigate climate change. Accepted for *Proceedings, World geothermal Congress 2010, Nusa Dua, Bali/Indonesia, 11 p.*

Muraoka, H., Gunnlaugsson, E., Song, Y., Lund, J., Bromley, C., Rybach, L. (2010): International database of hydrothermal chemistry: A case of Task A of Annex VIII of IEA-GIA. Accepted for *Proceedings, World geothermal Congress 2010, Nusa Dua, Bali/Indonesia, 6 p.*

Muraoka, H., Gunnlaugsson, E., Song, Y., Lund, J., Bromley, C., Rybach, L. (2010): Host rock controls to thermal water chemistry induced from the global comparison. Accepted for *Current Applied Physics*

"Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems". Accepted by IEA_GIA Executive Committee on 12 February 2009
Available at http://www.iea-org/publications.asp

Rybach, L., Eugster, W.J. (2010): Sustainability aspects of geothermal heat pump operation, with experience from Switzerland. Accepted for *Geothermics*

Song, Y., Gunnlaugsson, E., Muraoka, H., Bromley, C., Rybach, L., Lund, J. (2010): Barrier and opportunity identification in geothermal direct use: A task of collaborative research under IEA-GIA. Accepted for *Proceedings, World geothermal Congress 2010, Nusa Dua, Bali/Indonesia, 5 p.*

Die Titelblätter der Publikationen befinden sich in den Anhängen I - VIII

Zürich, 15. Dezember 2009 L. Rybach

ANHÄNGE:

ANHANG I Axelsson, G., Bromley, C., Mongillo, M., Rybach, L. (2010): The Sustainability Task of the International Energy Agency's Geothermal Implementing Agreement. Accepted for *Proceedings, World geothermal Congress 2010, Nusa Dua, Bali/Indonesia, 8 p.* **TITELBLATT**

ANHANG II Mongillo, M., Bromley, C., Rybach, L. (2009): IEA-GIA - International geothermal cooperation going from strength to strength. *GRC Transactions Vol. 43, p. 623-628.* **TITELBLATT**

ANHANG III Mongillo, M., Bromley, C., Rybach, L. (2010): The IEA Geothermal Implementing Agreement - International efforts to promote global sustainable geothermal development and help mitigate climate change. Accepted for *Proceedings, World geothermal Congress 2010, Nusa Dua, Bali/Indonesia, 11 p.* **TITELBLATT**

ANHANG IV Muraoka, H., Gunnlaugsson, E., Song, Y., Lund, J., Bromley, C., Rybach' L. (2010): International database of hydrothermal chemistry: A case of Task A of Annex VIII of IEA-GIA. Accepted for *Proceedings, World geothermal Congress 2010, Nusa Dua, Bali/Indonesia, 6 p.* **TITELBLATT**

ANHANG V Muraoka, H., Gunnlaugsson, E., Song, Y., Lund, J., Bromley, C., Rybach, L. (2010): Host rock controls to thermal water chemistry induced from the global comparison. Accepted for *Current Applied Physics.* **TITELBLATT**

ANHANG VI "Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems". Accepted by IEA_GIA Executive Committee on 12 February 2009 *Available at* http://www.iea-org/publications.asp . 8 p. **TITELBLATT**

ANHANG VII Rybach, L., Eugster, W.J. (2010): Sustainability aspects of geothermal heat pump operation, with experience from Switzerland. Accepted for *Geothermics*. **TITELBLATT**

ANHANG VIII Song, Y., Gunnlaugsson, E., Muraoka, H., Bromley, C., Rybach, L., Lund, J. (2010): Barrier and opportunity identification in geothermal direct use: A task of collaborative research under IEA-GIA. Accepted for *Proceedings, World geothermal Congress 2010, Nusa Dua, Bali/Indonesia, 5 p.* **TITELBLATT**

ANHANG IX Report *7th IEA GIA Annex VIII meeting, Wednesday, 30th September 2009, Peppermint Hotel, Reno/Nevada, USA.* 36 pages. **TITELBLATT**

ANHANG I

Axelsson, G., Bromley, C., Mongillo, M., Rybach, L. (2010): The Sustainability Task of the International Energy Agency's Geothermal Implementing Agreement. Accepted for *Proceedings, World geothermal Congress 2010, Nusa Dua, Bali/Indonesia, 8 p.*

TITELBLATT

Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

The Sustainability Task of the International Energy Agency's Geothermal Implementing Agreement

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Keywords: IEA, GIA, sustainability, sustainable development, international cooperation

ABSTRACT

The Geothermal Implementing Agreement (GIA) provides a framework for international geothermal cooperation under the auspices of the International Energy Agency (IEA). The promotion of sustainable utilization of geothermal energy is the main aim of the IEA-GIA's current 5-year term. Therefore, a task was set up under Annex I (Environmental Impacts of Geothermal Development) of the IEA-GIA dealing with sustainable geothermal utilization. The aim of the Task is to collect information, identify research needs, facilitate international collaboration on the issue through workshops and meetings, as well as facilitate the publication of scientific papers and reports on geothermal sustainability studies and research. To date, the sustainability issue has been discussed at several Annex I meetings; with some relevant definitions established and several significant research needs identified. A number of recent papers and reports have also been assembled and made available through the IEA-GIA's website. In addition, a successful one-day international workshop dealing with sustainability modelling was held in late 2008, in Taupo, New Zealand, with over 40 participants and 17 presentations from 7 countries. As a result a special issue of a geothermal research journal, supported by the IEA-GIA Annex I, devoted to sustainable geothermal utilization has been prepared; with particular emphasis on long utilization case histories and sustainability modelling studies. Further workshops devoted to the sustainability issue and continued information gathering and dissemination are also planned. Another achievement of the Task is the lively sustainability discussions it has stimulated within the geothermal community.

1. INTRODUCTION

The potential of the Earth's geothermal resources is enormous, both compared with its utilization today and the future energy-needs of mankind. Stefánsson (2005) estimated that the technically feasible potential of identified geothermal resources is 240 GW_e (1 GW = 10^9 W), which is only a small fraction of hidden, or as yet unidentified, resources. He also estimates that the most likely direct use potential of lower temperature resources is 140 EJ/yr (1 EJ = 10^{18} J). In comparison the worldwide installed geothermal electricity generation capacity was about 10 GW_e in 2007 and the direct geothermal utilization amounted to 330 PJ/yr (1 PJ = 10^{15} J) according to IEA-GIA (2008a). About 1/3 of the direct use is through ground-source heat-pumps. Fridleifsson *et al.* (2008) have estimated that by 2050 the electrical generation potential may have reached 70 GW_e and the direct use 5.1 EJ/yr, 600 and 1450 % increase, respectively. There is, therefore, ample space for accelerated use of geothermal resources worldwide in the near future. Geothermal resources also have the potential of contributing significantly to sustainable development and to help mitigate climate change.

The Geothermal Implementing Agreement (GIA) provides a framework for international geothermal cooperation under the auspices of the International Energy Agency (IEA). The promotion of sustainable utilization of geothermal energy is the main aim of the GIA's current 5-year term. Therefore, a task was set up under Annex I (Environmental Impacts of Geothermal Development) of the GIA dealing with sustainable geothermal utilization.

This paper describes the work conducted under the Sustainability Task of the IEA-GIA. It starts out with a brief description of the IEA-GIA, followed by a discussion of the concept of sustainable geothermal utilization and a discussion of the work associated with the Sustainability Task. Mongillo *et al.* (2010) describe the IEA and the IEA-GIA in detail, only a short review is presented here. A more detailed analysis of sustainable geothermal utilization is presented by Axelsson (2009).

2. IEA AND IEA-GIA

The International Energy Agency (IEA) is an intergovernmental organization founded in 1974 (in response to the first oil-crisis) and based in Paris (Mongillo *et al.*, 2010). The IEA now acts as an energy policy advisor to its 28 member countries dealing with energy security, economic development, environmental protection, alternative energy sources and energy efficiency, to name a few issues. The IEA operates an extensive programme of data compilation, energy research, publication and public dissemination.

IEA coordinates collaboration through a network of 41 Implementing Agreements (IAs) that guide the IEA's collaborative program activities (Mongillo *et al.*, 2010). IA members are either representatives of member countries or industrial- or organizational sponsors. IA activities, named Tasks, are organized in Annexes. An Executive Committee (ExCo), consisting of one representative from each member, manages the activities of each IA and is responsible for disseminating results and reporting to the IEA. Each Annex is led by an Operating Agent that is usually an institution.

The Geothermal Implementing Agreement (GIA) was established in 1997 and as of 2007 it's in its third 5-year term (Mongillo *et al.*, 2010). The general scope of the GIA is to strengthen international collaboration to: compile and exchange information on global geothermal energy R&D,

ANHANG II

Mongillo, M., Bromley, C., Rybach, L. (2009): IEA-GIA - International geothermal cooperation going from strength to strength. ***GRC Transactions Vol. 43, p. 623-628.***

TITELBLATT

IEA-GIA-International Geothermal Cooperation—Going from Strength to Strength

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Keywords

Geothermal Implementing Agreement, GIA, International Energy Agency, IEA, international geothermal cooperation, sustainable utilization, climate change mitigation

ABSTRACT

The global demand for energy continues to grow, with fossil fuels expected to remain the dominant sources well into the future. In 2008, the International Energy Agency (IEA) reported that if current government policies continue (Reference Scenario), the total global primary energy need in 2030 will be 45% greater than in 2006. This will likely lead to energy security problems and a large increase in greenhouse gas (GHG) emissions, with related significant climate change effects. However, if renewable energy options using current technology are implemented, GHG emissions could drop to about 20% lower than for the Reference Scenario; and with significantly more effort and technology development, the drop could be more than 35%. These outcomes provide a strong incentive for increased use of clean, renewable energy resources, including geothermal energy, which can make a significant contribution. Success, however, requires international cooperation.

The IEA Geothermal Implementing Agreement (GIA) is one of 10 IEA collaborative renewable energy technology projects. It provides a versatile scheme for international cooperation in geothermal R&D activities, with a focus on enhancing effectiveness through establishing direct cooperative links among geothermal experts in the participating countries, industries and organizations.

Since its establishment in 1997, the GIA has worked vigorously to have geothermal's capabilities recognized by energy planners, political and financial decision makers, and the public; and to support and advance the development of these vast and widespread energy resources for electricity generation and direct heat applications. Now well into its 3rd 5-year term (2007-2012), the GIA's key efforts are aimed at promoting and accelerating sustainable geothermal development and thereby contributing to the mitigation of climate change.

GIA's current activities continue to cover four broad topics, managed through Annexes: Annex I- Environmental Impacts of Geothermal Energy Development, Annex III- Enhanced Geothermal Systems (EGS), Annex VII- Advanced Geothermal Drilling Techniques and Annex VIII- Direct Use of Geothermal Energy. Recognition of new important issues has also led to the addition of several new investigations, including: induced seismicity studies (Annex I), examination of sustainable geothermal energy use (Annex I), and novel ways to present information/data to the public via the internet using Google Earth (Annex VIII). In addition, Annex III efforts have been completely revised and new studies added due to the recent concerted effort on EGS development in Australia, the USA and Europe. The GIA has expanded activities to non-Members by sponsoring international technical workshops on induced seismicity and sustainability modelling; and a joint GIA-IGA workshop on geothermal's potential for climate change mitigation held in May 2009. GIA annual report content has grown, making it more informative and useful to participants and financial and government institutions. The GIA website continues to develop, with emphasis placed on information dissemination to both participants and the general public. Distribution of GIA information and research results has increased significantly.

The GIA maintains strong involvement with the IEA, through participation in their international workshops and seminars; and via contributions to their influential publications.

GIA's membership continues to grow, having nearly doubled to 19 Members in the past 3 years, and now includes: 12 countries (Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Republic of Korea, Spain, Switzerland and the United States), 4 companies (Geodynamics, Green Rock Energy, ORME Jeotermal and Ormat Technologies), 2 organizations (Canadian Geothermal Energy Association [CanGEA] and Geothermal Group of the Spanish Renewable Energy Association [GG-APPA]), and the European Commission (EC).

The GIA has grown from strength to strength, and sees a bright future ahead. This paper provides a brief description of the IEA and GIA, and discusses the GIA's achievements and future prospects.

ANHANG III

Mongillo, M., Bromley, C., Rybach, L. (2010): The IEA Geothermal Implementing Agreement - International efforts to promote global sustainable geothermal development and help mitigate climate change. Accepted for *Proceedings, World geothermal Congress 2010, Nusa Dua, Bali/Indonesia, 11 p.*

TITELBLATT

Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

The IEA Geothermal Implementing Agreement- International Efforts to Promote Global Sustainable Geothermal Development and Help Mitigate Climate Change

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Keywords: IEA, GIA, international cooperation, sustainable use, environmental issues, EGS, advanced drilling, direct use, climate change

ABSTRACT

The Geothermal Implementing Agreement (GIA) provides a flexible and powerful framework for international cooperation on geothermal research and technology under the auspices of the International Energy Agency (IEA). It connects national and industry programmes for exploration, development and utilization of geothermal resources and establishes direct cooperative links among experts in the participating countries, industries and organizations, thus helping increase effectiveness. The GIA's activities are chiefly directed towards the coordination of national and industry geothermal programmes, with joint participation of members on specific studies. Emphasis is on sharing of information, developing techniques and best practices, and producing and disseminating authoritative information.

Current IEA scenarios indicate that unless governments implement energy saving and renewable energy options, energy security problems and a sharp increase in CO_2 emissions with related significant climate change effects are likely. The IEA recently extended the mandate of the GIA for a 3rd 5-year term (to 2012), and the IEA-GIA embraced these challenges in its new 3rd term mission: ***to promote sustainable use of geothermal energy worldwide by improving existing and developing new technologies to render exploitable the vast and widespread global geothermal resources, facilitating the transfer of know-how, providing high quality information and widely communicating geothermal energy's strategic, economic and environmental benefits***, and thereby contribute to the mitigation of climate change. To accomplish this mission, the GIA is concentrating its current efforts in four major areas, pursued in the following Annexes: I- Environmental Impacts of Geothermal Energy Development, II- Enhanced Geothermal Systems, III- Advanced Geothermal Drilling Techniques and VIII- Direct Use of Geothermal Energy. GIA's activities within these topics have grown significantly in the past few years with the addition of: induced seismicity studies associated with EGS reservoir development/production; investigation of sustainable use strategies; development of economic guidelines for EGS reservoir economic models; development of recommended procedures to create, test and evaluate EGS parameters, and development of new forms for geographic display of data on the internet.

Geothermal is gaining a growing recognition as one of the major renewable energy options, with vast worldwide potential and ability to make a significant contribution. As a result, worldwide geothermal development is now in a rapid state of growth. The IEA-GIA is increasing its efforts to support and help accelerate this growth in a sustainable manner, including: by convening international workshops on special topics like induced seismicity and sustainability, by attempting to determine the global development potential of geothermal energy (conventional, EGS, *etc.*) and estimating the contribution it could make towards the mitigation of climate change (useful as input for the IPCC 2010 renewable energy report), by producing a Geothermics Special Issue on Sustainability (2009); and by participating in international renewable energy conferences and workshops to raise awareness of geothermal energy and educate the public, government and finance decision makers, *etc.*

The IEA-GIA, now well into its 3rd 5-year term and 12th year of operation, is experiencing significant growth in membership, having nearly doubled in the past 3 years, and as of May 2009, with 19 members, including: 12 countries (Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Republic of Korea, Spain, Switzerland, United States), the EC, 4 industries (Geodynamics, Green Rock Energy, ORME Jeotermal, Ormat Technologies) and 2 national organizations (CanGEA and Geothermal Group [APPA]).

The current global energy scene and geothermal's potential contribution are outlined; brief reviews of the IEA and the GIA operation and structure are presented; and the GIA's current activities and achievements for supporting sustainable geothermal development and thereby aiding the mitigation of climate change are described. Comments on the GIA's future plans are also included.

1. INTRODUCTION

This paper provides a major update and amplification of the IEA-GIA paper presented at the WGC 2005 (Mongillo *et al.*, 2005) and other recent papers by Bromley *et al.* (2008) and Mongillo and Rybach (2007). More details about the IEA and the recent work of the IEA-GIA can be found in the GIA 2002-2007 End of Term Report (IEA-GIA EoT, 2006), Strategic Plan for 2007-2012 (IEA-GIA SP, 2006) and in the comprehensive IEA-GIA annual reports available on the IEA-GIA website. Note that all website addresses are included in the Reference section.

2. CURRENT GLOBAL ENERGY SCENE

The growth in global demand for energy is expected to continue well into the future, with fossil fuel likely to remain the dominant providing source. The IEA has recently examined several energy utilization and production scenarios (IEA, 2007; 2008a; 2008b) in attempts to forecast the situation to 2030, and beyond. The *Reference Scenario*, which assumes the continuation of current (as of mid-2008) government policies and measures, indicates that the total global primary energy need will grow by 45% between 2006 (11,740 Mtoe [492 EJ_{th}]) and 2030, with demand reaching 17,010 million tonnes of oil equivalent (Mtoe)

ANHANG IV

Muraoka, H., Gunnlaugsson, E., Song, Y., Lund, J., Bromley, C., Rybach, L. (2010): International database of hydrothermal chemistry: A case of Task A of Annex VIII of IEA-GIA. Accepted for *Proceedings, World geothermal Congress 2010, Nusa Dua, Bali/Indonesia, 6 p.*

TITELBLATT

Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

International Database of Hydrothermal Chemistry: a Case of Task-A of Annex VIII of IEA-GIA

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Keywords: hydrothermal resource, chemistry, thermal water, resource characterization, global comparison, IEA Geothermal Implementing Agreement

ABSTRACT

Under a framework of the Geothermal Implementing Agreement (GIA) of the International Energy Agency (IEA), an international database of hydrothermal chemistry is now under construction among the six participating countries including Iceland, Japan, South Korea, USA, Switzerland and New Zealand. The pH value of thermal water in Iceland shows 9 or 10, that is evidently higher than those of other silicic crust countries. It is ascribed to the host rock controls that hydrothermal water only attacks anorthite in basalt. Thermal water in Japan separately forms a strong acid cluster associated with sulfur-rich andesite volcanoes. The boron and chloride components of thermal water in Iceland are significantly lower than those in Japan and the USA. Their variation ranges show that the boron component in Iceland is 1 magnitude lower than other two countries and the chloride component is 0.5 magnitudes lower. It is also explained by the host rock controls that the basaltic crust in Iceland is 1 magnitude lower in boron and 0.5 magnitudes lower in chloride than the silicic crust in Japan and the USA. An attempt at mapping of the discharge temperature of thermal water delineates outlines of geothermal fields. The database can be applied to the characterization of hydrothermal systems for multiple purposes and more numbers of participating countries will be expected in the near future.

1. INTRODUCTION

Geothermal Implementing Agreement (GIA) of the International Energy Agency (IEA) provides a flexible framework for wide-ranging international cooperation. One of the operating Annexes is "Direct Use of Geothermal Energy", where the Task A is conducted for " Resource Characterization". Participating countries are currently Iceland, Japan, New Zealand, South Korea, Switzerland and the USA.

Chemistry of hydrothermal water has often been compared through binding individual country reports, but the direct diagrammatic comparison by the international database has seldom been made until the present. The framework of the IEA-GIA enables us to achieve this. We have preliminarily reported an interim result of this database (Muraoka et al., 2008), but the data sets are still updating. We here show the global comparison of thermal water chemistry as an updated result in this task.

2. METHODOLOGY

2.1 Data Sets

Numbers of submitted hydrothermal chemistry data sets are as follows: 352 from Iceland, 7,203 from Japan, 404 from South Korea and 6,675 from the USA. New Zealand and Switzerland are under preparation to submit the data sets. The numbers of the data sets depend on the availability of hydrothermal systems related to volcanoes in general. South Korea is a less volcanic country, but relatively large numbers of the data sets are obtained from hot springs developed by shallow-depth wells mostly with a depth of several hundreds meters. The data sets from Japan, Korea and the USA completely provide coordinates and those of Iceland partially provide coordinates. The data sets of Korea are lacking for boron analyses. The data sets of the USA were already published as CD-ROM (Geo-Heat Center, 2004), and geographically cover western part of the country. The data sets of the USA include a small number of fluids from high-temperature geothermal wells and special attention is required for their interpretation. The data sets of Japan were already published as an atlas (Muraoka et al., 2007) as well as CD-ROM (Geological Survey of Japan, 2009).

2.2 Tectonic Settings

Participating countries are still few, but the combination of the four countries is interesting from a comparative point of view: Iceland represents a spreading ocean ridge, South Korea represents a less-volcanic continental margin, Japan represents an active island-arc and the USA represents an active continental margin (Figure 1).

In terms of composition of the earth's crust, Japan, South Korea and the USA are fundamentally composed of silicic or granitic crust, whereas Iceland basically consists of basaltic crust, making it unique in comparison to hydrothermal chemistry.

3. RESULTS

3.1 Discharge Temperature Mapping

Coordinated data of chemistry of hydrothermal water enable to draw a variety of maps such as an individual

ANHANG V

Muraoka, H., Gunnlaugsson, E., Song, Y., Lund, J., Bromley, C., Rybach, L. (2010): Host rock controls to thermal water chemistry induced from the global comparison. Accepted for *Current Applied Physics.*

TITELBLATT

Current Applied Physics xxx (2009) xxx–xxx

Contents lists available at ScienceDirect

Current Applied Physics

journal homepage: www.elsevier.com/locate/cap

Host rock controls to thermal water chemistry induced from the global comparison

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ARTICLE INFO

Article history:
Received 5 November 2008
Accepted 27 July 2009
Available online xxxx

Keywords:
Hydrothermal resource
Chemistry
Thermal water
Global comparison
IEA Geothermal Implementing Agreement

ABSTRACT

Under a framework of the Geothermal Implementing Agreement (GIA) of the International Energy Agency (IEA), chemistry of thermal water is compared among Iceland, Japan, South Korea and the USA. The pH value of thermal water in Iceland shows 9 or 10, that is evidently higher than those of other silicic crust countries. It is ascribed to the host rock controls that hydrothermal water only attacks anorthite in basalt. The boron and chloride components of thermal water in Iceland are significantly lower than those in Japan and the USA. Their variation ranges show that the boron component in Iceland is 1 magnitude lower than other two countries and the chloride component is 0.5 magnitudes lower. It is also explained by the host rock controls that the basaltic crust in Iceland is 1 magnitude lower in boron and 0.5 magnitudes lower in chloride than the silicic crust in Japan and the USA.

1. Introduction

Geothermal Implementing Agreement (GIA) of the International Energy Agency (IEA) provides a flexible framework for wide-ranging international cooperation. One of the operating Annexes is "Direct Use of Geothermal Energy", where the Task A is conducted for "Resource Characterization". Participating countries are currently Iceland, Japan, South Korea, New Zealand, Switzerland and the USA.

Chemistry of hydrothermal water has often been compared through binding individual country reports, but the direct diagrammatic comparison by the international database has seldom been made until the present. The framework of the IEA–GIA enables us to do this. We here show the global comparison of thermal water chemistry as an interim result in this task.

2. Methodology

2.1. Data sets

Numbers of submitted chemistry data sets are as follows: 352 from Iceland, 7203 from Japan, 14 from Korea and 6675 from the USA. These numbers depend on the availability of hydrothermal systems related to volcanoes that are relatively restricted in Korea, although 377 data sets are recently reported by another Korean team [1]. New Zealand and Switzerland are ready to submit their data sets. The data sets from Japan, Korea and the USA completely provide coordinates and those of Iceland partially provide coordinates. The data sets of Korea are lacking for boron analyses. The data sets of the USA were already published as CD-ROM [2], and geographically cover western part of the country. The data sets of the USA include a small number of fluids from geothermal wells and special attention is required for their interpretation. The data sets of Japan were already published as an atlas [3] and as CD-ROM [4].

2.2. Tectonic settings

Participating countries are still few, but the combination of the four countries is interesting from a comparative point of view: Iceland represents a spreading ocean ridge, Korea represents a less-volcanic continental margin, Japan represents an active island-arc and the USA represents an active continental margin.

2.3. Comparison

Discharge temperature mapping is attempted in Japan and the USA where coordinates data are fully obtained. Major components

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1567-1739/$ - see front matter © 2009 Published by Elsevier B.V.
doi:10.1016/j.cap.2009.11.012

ANHANG VI

“Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems“.
Accepted by IEA_GIA Executive Committee on 12 February 2009
***Available at* http://www.iea-org/publications.asp**

TITELBLATT

PROTOCOL FOR INDUCED SEISMICITY ASSOCIATED WITH ENHANCED GEOTHERMAL SYSTEMS

(To be cited as: Majer, E., Baria, R. and Stark, M. (2008). Protocol for induced seismicity associated with enhanced geothermal systems. Report produced in Task D Annex I (9 April 2008), International Energy Agency-Geothermal Implementing Agreement (incorporating comments by: C. Bromley, W. Cumming, A. Jelacic and L. Rybach). Available at: http://www.iea-gia.org/publications.asp.)

(Accepted by IEA-GIA Executive Committee on 12 February 2009)

INTRODUCTION

As the global demand for energy increases, the contribution from geothermal energy could be extremely large, particularly if resources developed with Enhanced Geothermal Systems (EGS) technology are incorporated in the total energy picture. A recent study by MIT (2006) predicts that in the United States alone, 100,000 MW_e of cost-competitive capacity could be provided by EGS in the next 50 years with reasonable investment. The USGS estimates that in the U.S., which uses about 100 quads of energy per year, there are 300,000 quads in the >200°C heat sources down to 6 km depth. Large countries in other continents, such as India and China, have similar heat resources, so the global potential of geothermal energy is enormous. Because implementation of EGS affects subsurface conditions, especially fractures, there exists the potential to cause induced seismicity.

Induced seismicity has occurred in the development and production of several conventional fractured geothermal resources (typically deeper than 1 km), as well as oil and gas resources, large water-impounding dams, and mining applications. In each of these instances, properly monitored and analyzed induced seismicity has provided valuable information in developing the particular resource, but has not prevented the development from proceeding. To help gain acceptance from the general public for geothermal generally and EGS specifically, it would be beneficial to clarify the problems with and beneficial applications of micro-seismicity (seismicity, micro-earthquakes, MEQ) during the development stages of an underground reservoir and the subsequent extraction of the geothermal energy.

This document is intended to serve as a general guide *that identifies steps a geothermal developer can take to address induced seismicity issues.* The proposed protocol includes simple planning steps that would apply to most developments, as well as more elaborate procedures that would apply under particular circumstances to a small number of geothermal developments. Therefore, this protocol is not intended to be a universal prescriptive approach to seismicity management. However, it may be used to build confidence in the manageability of seismicity at geothermal projects. It is directed at geothermal developers, public officials, regulators, and the public at large. This proposed protocol stems from a recently developed paper that reviewed the present state of knowledge of induced seismicity during the development of EGS reservoirs, and during production or injection of fluids in conventional geothermal reservoirs (Majer et al., 2007). The paper also identifies gaps in knowledge that

ANHANG VII

Rybach, L., Eugster, W.J. (2010): Sustainability aspects of geothermal heat pump operation, with experience from Switzerland. Accepted for *Geothermics*.

TITELBLATT

Sustainability aspects of geothermal heat pump operation, with experience from Switzerland

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Abstract

Geothermal heat pumps are the key to utilize the ubiquitous shallow geothermal resources. Theoretical and experimental studies, performed in Switzerland over several years, established a solid scientific base of reliable long-term operation of borehole heat exchanger-coupled heat pump systems. Proper design, taking into account local conditions like ground properties and building needs, secures the sustainability of production from systems with single and multiple borehole heat exchangers. Long-term experience acquired at operational objects confirms the predictions.

Keywords: borehole heat exchanger, unique GHP data base, production stability, ground thermal recovery

Introduction

In general, geothermal energy is labelled as renewable. It is, therefore, listed together with solar, wind and biomass alternative energy options in governmental R&D programs, in materials promoting geothermal energy etc. This attribute applies only with certain restrictions, which must be addressed in a fully objective manner.
The original definition of sustainability goes back to the Bruntland Commission (1987; reinforced at the Rio 1991 and Kyoto 1997 Summits):

> ***"Meeting the needs of the present generation without compromising the needs of future generations".***

It is generally accepted that the principle of sustainability relies on three basic pillars: economy, ecology, society. Nowadays a broadening of involvement is evident: environmental, traditional and cultural aspects are often addressed and considered in sustainability discussions. Here we restrict the considerations to geothermal energy.

In relation to geothermal resources and, especially, to their exploitation for geothermal energy utilization, sustainability means the ability of the production system applied to sustain the production level over long periods of time. Sustainable production of geothermal energy therefore secures the longevity of the resource, at a lower production level. A definition of sustainable production from an individual geothermal system has been suggested recently (Orkustofnun Working Group, 2001):

ANHANG VIII

Song, Y., Gunnlaugsson, E., Muraoka, H., Bromley, C., Rybach, L., Lund, J. (2010): Barrier and opportunity identification in geothermal direct use: A task of collaborative research under IEA-GIA. Accepted for *Proceedings, World geothermal Congress 2010, Nusa Dua, Bali/Indonesia, 5 p.*

TITELBLATT

Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

Barrier and Opportunity Identification in Geothermal Direct Use: A Task of Collaborative Research under IEA-GIA

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Keywords: geothermal, IEA-GIA, direct use, barrier, opportunity,

ABSTRACT

Under the IEA-GIA Annex VIII collaborative research framework, we have devised and circulated a questionnaire to identify barriers and opportunities in promoting geothermal direct use. The twelve countries answered to the questionnaire are Australia, Canada, France, Hungary, Spain and Sweden and six original Annex VIII participating countries such as Iceland, Japan, Korea, New Zealand, Switzerland and USA. The questionnaire consists of the three parts and total 13 questions and detailed items are listed under each question.

According to the compiled results of the answers, the prospect of geothermal direct use is ever increasing, especially geothermal heat pump installation with 10-30% annual increase. However to see substantial and sustainable increase of geothermal direct use, some technological problems should be solved, which are needs for a proper method of direct use resource assessment, and engineering standard and qualification procedures. Type and level of government supportive measures such as subsidy, tax credit, electricity rebate are quite different from country to country depending on each country's development stage and legal system.

Although it is getting better, geothermal is still less known to public than other renewables such as wind, solar, bio and so on. At the decision making level, furthermore, lack of lobbying or powerful lobbying from other renewable energy sources may be a threatening factor against making geothermal wide spread. A further study including survey on other countries those are active in direct use such as China, Germany, Poland and Turkey is necessary to help us better understand different situations world wide.

1. INTRODUCTION

A collaborative research program 'Direct Use of Geothermal Energy' is one of the four currently active annexes under the International Energy Agency (IEA) Geothermal Implementing Agreement (GIA). In this annex, six participating countries including Iceland, Japan, Korea, New Zealand, Switzerland and USA endeavor to promote further direct use of geothermal energy by performing various tasks. Among them, Task B titled 'Barrier and Opportunity Identification' is initiating research to remove barriers, to enhance economics and to promote implementation. Its objective also covers identifying and promoting opportunities for new and innovative applications.

Renewable energy technologies generally face barriers to technology uptake, for example immature technology, high initial cost and other obstacles such as environmental and legal constraints and lack of public acceptance, information and education (IEA, 2006). For geothermal power generation like other renewable electricity, these barriers are rather well identified and information is shared to some extent. For geothermal direct use, on the other hand, cost and other barriers are quite different from country to country and sometimes poorly identified. This is also true for opportunities and supportive measures, if any.

Recently, overall analyses have been made on renewable heating and cooling technology and policy in 12 developed countries and European Union (EU) by IEA (IEA, 2007). Some useful information on geothermal heating and cooling is available in the publication, but regional coverage or sufficient details are limited.

To identify the barriers and opportunities in six original participating countries of IEA-GIA Annex VIII first, we devised a questionnaire and have circulated it by June 2006. The questionnaire contained general questions on the present status of direct use geothermal development and questions on various aspects of barriers and opportunities. Cost and performance data were also requested, but it was not possible to compile meaningful results due to the limited information received. After analysis on the answers to the questionnaire in March 2007, we slightly revised the questionnaire and circulated it again to the countries which were not participating in the Annex until then but active in geothermal direct use as well as the six participating countries. Until July 2009, total 12 countries including Australia, Canada, France, Hungary, Spain and Sweden plus the six participating countries of Annex VIII responded.

To share the valuable information gathered from the 12 countries and thus to help countries understand different policies and various issues relevant to geothermal direct use in each country, we list questions of the questionnaire and summarize the compiled results of answers to the questions in this paper.

2. CONTENTS OF THE QUESTIONNAIRE

The questionnaire consists of the three parts and total 13 questions as followings and detailed items are listed under each question.

Part I. General Questions on Present Status: 1. Present status; 2. Development trends; 3. Energy policy

Part II. Barrier and Opportunity Identification: 4. Social and political issues; 5. Information channels for public awareness; 6. Environmental constraints; 7. Legal matters; 8. Financial capacities; 9. Technical and other barriers; 10. Supportive measures; 11. Future concerns

Part III. Other Relevant Issues: 12. International cooperation; 13. Other relevant issues to be added

ANHANG IX

Report *7th IEA GIA Annex VIII meeting, Wednesday, 30th September 2009, Peppermint Hotel, Reno/Nevada, USA*

TITELSEITE DES 36-SEITIGEN DOKUMENTS

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R E P O R T

7th IEA GIA Annex VIII meeting

Wednesday, 30th September 2009

Peppermint Hotel, Reno/Nevada, USA