

**Programme**  
**GIA-IGA Workshop**  
**Geothermal Energy-**  
**Its Global Development Potential &**  
**Contribution to Mitigation of Climate Change**  
**29 April 2009 (revised participants 15 June 2009)**

**INTRODUCTION**

**Expected Output:** 1) Proceedings in the form of a collection of all the PPTs and summaries of workshop discussions, 2) A joint GIA-IGA statement on regional and global geothermal potentials and their contribution to the mitigation of climate change and 3) A “peer reviewed” document, which includes current and new information needed for the geothermal chapter of the IPCC Special Renewable Energy Report that is not easily available in other published documents, and which can be referred to in the IPCC report. This will be considered a “published” document when posted in final form on the GIA website.

Several references, including a preliminary draft of the proposed geothermal document, will be available on the GIA website (see the homepage: [www.iea-gia.org](http://www.iea-gia.org)) several weeks before the workshop to assist with preparation for the workshop; with the goal of discussing, and finally agreeing on current/new information/data and deployment projections for inclusion in the IPCC report.

In addition, a paper summarizing relevant information will be submitted to WGC 2010 by the IPCC lead authors, and will be referred to in the draft IPCC report as: “in press”, with details updated when the final paper is officially published (see Appendix 1 for WGC 2010 IPCC abstract).

**Key Topic Area: Future deployment of geothermal energy**

**PROGRAMME**

*Tuesday (5 May 2009; 9 am – 5:30 pm)*

*Morning Session (9:00 am – 1:00 pm)*

**I. Introduction**

**A. Brief explanation of the workshop and how it will operate (~ 5 minutes)**

- Aims of workshop
- Structure of workshop operation
  - Panel groups will discuss topics, followed by general discussion
  - The Chair of each Panel group will provide a brief introduction to each major discussion
  - Can include brief presentations (< 10 PPT slides and 5-10 minutes in length) from each Panel speaker
  - Will call for votes on acceptance of information, data, statement, and document, to obtain geothermal community support (GIA & IGA plus)

**B. Senior Spanish Representative to welcome participants and open Workshop (~ 5 minutes)**

## II. Geothermal Resource Potential: categories and definitions

(Chair: Bromley; Panel: Baria, Huenges, Ketilsson, Lawless, Rybach)

- Subtopics will conclude with open discussions; goal is to reach agreement on definitions.

### A. Geothermal Resource Types and Categories [see Table 1, based on the IPCC Workshop discussions held in Brazil in January 2009]

- i. Definitions of the various types of geothermal resource
  - Near-surface geothermal resources
  - Conventional hydrothermal resources
  - Advanced geothermal resources
    - Enhanced [Engineered] geothermal systems (EGS)/hot rock
    - Supercritical temperature (including magma)
    - Geopressured/deep sedimentary aquifers
    - Offshore (e.g. Mexico)
    - Hot water with oil/gas production (e.g. Ormat)
- ii. Divisions into low and high temperature resources (e.g. Table 1)
  - Low temperature resources
    - Direct use requirements (Lindal diagram- heat pumps, district heating, pools/spas, desalination, greenhouses, industrial, other)
    - Electricity generation requirements (binary, other?)
  - High temperature resources
    - Direct use requirements (district heating, industrial applications, other)
    - Electricity generation requirements

### B. Categories of Potential (general definitions only)

- i. Theoretical (with or without access<sup>#</sup>/extraction constraints)
  - ii. Technical (with or without advances in technology)
  - iii. Economic (with or without benefits of research and economies of scale to reduce costs, or benefits of environmental and financial incentives)
- <sup>#</sup> Access refers to land accessibility issues

**~ LUNCH (1-2 pm) ~**

***Tuesday Afternoon Session (2:15 pm – 5:30 pm)***

## III. Geothermal- Current Use and Current Theoretical and Technical Potentials

- Need to consider regional (geographic and grid sense) and global assessments (for economic and fossil fuel displacement implications and deployment rate factors)
- Open discussion follows each subtopic; goal to reach agreement on theoretical and technical potentials.

### A. Low Temperature Resources

(Chair: Rybach; Panel: Boissier, Lawless, Ragnarsson)

- i. Direct Uses
  - Current installed capacities and use (most recent data)
    - Heat pumps, district heating, pools/spas, desalination, greenhouses, industrial, other
  - Potential (theoretical and technical) capacities by application and in total

- ii. Electricity generation (binary, other)
  - Current installed capacities (most recent data)
  - Potential (theoretical and technical) capacities and in total

## **B. High Temperature Resources**

(Chair: Brophy; Panel: Boissier, Ketilsson, Lawless, Rybach)

- i. Electricity generation (hydrothermal [flash and binary], EGS/hot rock, supercritical, geopressured, offshore)
  - Current installed capacities for each mode (most recent data)
  - Potential (theoretical and technical) capacities for each mode/resource type and total
- ii. Direct Uses
  - Current installed capacities and use (most recent data)
    - District heating, industrial applications, other
  - Potential (theoretical and technical) capacities for each mode/resource type

*Wednesday (6 May 2009) (9:00 am – 5:00 pm)*

*Morning Session (9:00 am – 1:00 pm)*

## **IV. Future Geothermal Potentials: Technical and Economic Factors; Barriers and Opportunities, Estimates and Predictions**

- Need realistic and justifiable potential estimates for 2030 and 2050
- Should consider regional (geographic and grid sense) and global estimates for economic deployment, regional factors affecting deployment rates, and fossil fuel displacement implications.
- Open discussion to follow each subtopic; goal to reach agreement on future potentials

**The following issues need to be considered for each subtopic under A. and B. below:**

- Potential (technical & economic) for each use based on current technology and in total
- Barriers and required R&D to attain maximum potentials
  - i. Availability of drill rigs- bottleneck for EGS and other development?
- Best estimate of maximum potentials (2030 and 2050) by use and in total

### **A. Deployment of Geothermal Energy (Huenges)**

### **B. Low Temperature Resources- Potentials for 2030 and 2050**

(Chair: Rybach; Panel: Antics, Boissier, Song)

- i. Direct Uses- Heat pumps, district heating, pools/spas, desalination, greenhouses, industrial, other
- ii. Electricity generation (binary, other)

*~ LUNCH (1-2 pm) ~*

### *Wednesday Afternoon Session (2:15 am – 5:30 pm)*

#### **C. High Temperature Resources- Potentials for 2030 and 2050**

(**Chair:** Bertani; **Panel:** Baria, Goldstein, Ketilsson, Lawless, Thompson)

- i. Electricity generation (hydrothermal [conventional], binary [bottoming cycle], EGS/hot rock, supercritical, geopressured, offshore)
- ii. Direct Uses

#### **D. Contribution to the Mitigation of Climate Change\***

(**Chair:** Fridleifsson; **Panel:** Bertani, Bromley, Huenges, Rybach)

- i. Greenhouse gas production from geothermal developments (CO<sub>2</sub>, H<sub>2</sub>S, other)
- ii. Greenhouse gas reduction (CO<sub>2</sub>, H<sub>2</sub>S, other)
- iii. Greenhouse gas avoidance (CO<sub>2</sub>, H<sub>2</sub>S, other)
- iv. Possible impact of climate change on use of geothermal resources
- v. Estimate of contribution to mitigation of climate change using current technology and best estimate of maximum potentials considering

\* The IPCC will make the estimates for each renewable energy's contribution to the mitigation of climate change based upon the data in the RE chapters. There are no specific sections in the RE chapters to provide this information. However, we can provide input specific to geothermal developments.

#### **V. Outputs**

- 1) Proceedings in the form of a collection of all the PPTs and summaries of workshop discussions (on CD-Rom and on GIA and IGA websites)
- 2) A joint GIA-IGA statement on regional and global geothermal potentials and their contribution to the mitigation of climate change<sup>¶</sup>
- 3) A “peer reviewed” document, which includes current and new information needed for the IPCC Special Report<sup>¶</sup>

<sup>¶</sup> To be discussed at the end of the Workshop and accepted at the GIA ExCo/IGA BoD Meeting gathering at the end of Friday 8 May 2009.

**Table 1** Geothermal resources- their use and potential<sup>¥</sup>

	Low Temperature Resources				High Temperature Resources								
	Direct Use				Electricity	Direct Use		Electricity					
	Heat Pumps	District heating	Pools/ Spas	Desalination, Greenhouses, Other	Binary?	Hydrothermal	Hot Rock	Hydrothermal Conventional	Binary	Hot Rock	Supercritical	Geopressured	Offshore
<b>Existing</b>								Bertani (2007)		Bertani (2007?)			
<b>Planned?</b>													
<b>Market?</b>													
<b>Potential</b>													

<sup>¥</sup> Table 1 is based upon a table suggested by geothermal group for IPCC Report who met in Brazil in January 2009; included for information purposes only.  
 Bertani (2007) World Geothermal Generation in 2007. Proceedings European Geothermal Congress 2007, Unterhaching, Germany, 30 May -1 June 2007, 11 p.

## Appendix 1 WGC 2010 Abstract

### **Contribution of Geothermal Energy to Climate Change Mitigation: the IPCC Renewable Energy Report**

Chris Bromley, Barry Goldstein, Gerardo Hiriart, Ruggero Bertani, Ernst Huenges,  
Hirofumi Muraoka, Arni Ragnarsson, Jeff Tester, Vladimir Zui

#### **ABSTRACT**

A special report on renewable energy has been commissioned by the IPCC (Inter-Governmental Panel on Climate Change) to provide guidance on future mitigation options for climate change through reducing CO<sub>2</sub> emissions. A better understanding is required of potential global and regional geothermal resources, across a natural continuum from convecting high-grade hydrothermal to conduction-dominated thermal energy, in both sedimentary and crystalline crustal rocks. Other important issues include: energy security and sustainability, status of current utilisation applications, future technology advances, cost predictions, projected deployment rates, energy integration and infrastructure requirements, environmental risks and benefits, technology transfer, and policy options.

Increased geothermal energy development is well suited to climate change mitigation because it provides base-load power and heating or cooling from a large resource that is well-distributed globally. It has a good track record of sustainable production using existing technology, applicable to both developed and developing countries, and for generating cost-effective and highly-dispatchable power. Geothermally heated fluids are available for a variety of industrial applications, including space heating and cooling, ranging from small-scale to district-wide installations. In addition, geothermal heat pumps are being deployed worldwide enabling substantive gains in heating and cooling efficiency of buildings. Relative to other renewable energy technologies, geothermal resources are utilised at high average availability factors (typically > 90%) for electricity generation. Overall, geothermal has been shown to be socially acceptable with some positive social and environmental impacts, including a relatively small land-use footprint. Adverse impacts are manageable. Sustainable management of water resources is inherent in best practice reservoir management. New technologies under demonstration, and wider deployment of existing technology, have the potential to significantly increase the use of low, high and supercritical temperature geothermal resources. Enhanced Geothermal Systems (EGS) offer the potential for global scale utilization when and where it is needed. For this potential to be realised, research and field testing at commercial scale is required with multi-year government and private support and investment. The benefits will include mitigation of climate change through provision of CO<sub>2</sub> offsets at competitive costs, and improved energy security.

## Appendix 2 Notes from IPCC Workshop held in Sao Paulo, Brazil, in late January 2009

### The IPCC Renewable Energy report (SRREN) geothermal chapter authors are:

Barry Goldstein [Australia], Gerardo Hiriart [Mexico], Ruggero Bertani [Italy], Chris Bromley [New Zealand], Hirofumi Muraoka [Japan], Arni Ragnarsson [Iceland], Jeff Tester [USA], Ernst Huenges [Germany] and Vladimir Zui [Belarus]

The following paper (which can be downloaded from IEA-GIA website: <http://www.iea-gia.org/publications.asp>) was prepared for the IPCC scoping meeting held in early 2008, in Luebeck, Germany, and provides a very useful starting point for the geothermal chapter of the SRREN report:

Fridleifsson, I.B., R. Bertani, E. Huenges, J. W. Lund, A. Ragnarsson, and L. Rybach 2008. The possible role and contribution of geothermal energy to the mitigation of climate change. In: O. Hohmeyer and T. Trittin (Eds.) IPCC Scoping Meeting on Renewable Energy Sources, Proceedings, Luebeck, Germany, 20-25 January 2008, 59-80.

### The IPCC geothermal section group noted that a better understanding was needed of:

1. Global and regional resource potential (future) [very important]
  - Hydrothermal resource development
  - Need to include opportunities for “non-conventional” development, including:
    - Supercritical temperatures
    - Lower temperature resources at depth (EGS, deep sedimentary)
2. Cost predictions
3. Energy security and sustainability
4. Future technology advances
5. Projected deployment rates
6. Energy integration constraints
7. Environmental risks and benefits
8. Technology transfer
9. Policy options for support of geothermal
  - **deployment:** feed-in tariffs, tax breaks, low-cost loans;
  - **innovation:** R&D funding, university grants, industry tax breaks; joint government-industry R&D grants

### Topics to be covered in IPCC report (from Scoping Paper IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation; attachment 1):

#### 4. Geothermal Energy (3-5% of the total IPCC report)

- 4.1 Introduction (Huenges & Goldstein)
- 4.2 Resource potential (Tester & Bromley)
- 4.3 Technology and applications (*electricity, heating, cooling*) (Hiriart & Ragnarsson)
- 4.4 Global and regional status of market and industry development (Bertani & Hiriart)
  - Use information from WGC 2010 Country Updates to get started
    - Bertani for power
    - Lund for direct use
- 4.5 Environmental and social impacts (covered in barriers section) (Bromley & Goldstein)
- 4.6 Prospects for technology improvement, innovation and integration (Goldstein & Ragnarsson)
- 4.7 Cost trends (Ragnarsson, Hiriart & Tester)
- 4.8 Potential deployment (Huenges, Bertani & Muraoka)

**A Special Report on Renewable Energy would provide a better understanding of:**

- resources by region and impacts of climate change on these resources;
- the mitigation potential;
- the linkages between renewable energy growth and co-benefits in achieving sustainable development by region;
- the impacts on global, regional and national energy security;
- the technology and market status, future developments and projected rates of deployment;
- the options and constraints for integration into the energy supply system and other markets, including energy storage options;
- the economic and environmental costs, benefits, risks and impacts of deployment;
- capacity building, technology transfer and financing in different regions;
- policy options, outcomes and conditions for effectiveness; and
- how accelerated deployment could be achieved in a sustainable manner.

The Special Report on Renewable Energy Sources and Climate Change Mitigation will also address the information needs of policy makers, private sector and civil society in a comprehensive way and will provide valuable information for further IPCC publications.