IGA NEWS

Newsletter of the International Geothermal Association

Quarterly No. 78

IGA ACTIVITIES

Message from the President

Ladsi Rybach

Dear IGA member

This is the eighth message from your current President.

A new institution, the Center of Excellence for Geothermal Energy Larderello (CEGL), has recently been formed. As its Scientific Advisory Board member I was invited to give the opening Keynote presentation "Geothermal energy within the renewables – Status and prospects" at the CEGL International Workshop on Geothermal Energy Development – Opportunities and Challenges, Pomerance/Italy, 3 – 4 September 2009.

The presentations of the IEA GIA – IGA Workshop "Geothermal Energy - Its Global Development Potential & Contribution to Mitigation of Climate Change", Madrid/Spain, 5-6 May 2009 are now assembled on the IEA GIA Website www.iea-gia.org under "Achievements". The findings are currently being incorporated into the new Chapter 4: "Geothermal Energy" of the IPCC Special Report "Renewable Energy Sources" (SRREN). IGA Officers Ruggero Bertani and Arni Ragnarsson are Lead Authors; I am currently serving as Contributing Author and am foreseen as Reviewing Editor of Chapter 4.

The deliverables of the World Bank – IGA contract have all been completed and submitted. Unfortunately the WB does not intend to continue the cooperation within the GeoFund program; however, negotiations are underway for a new contract within the ARGeo framework.

At the occasion of the GRC General Assembly 2009 in Reno, Nevada/USA I had a discussion with GRC Board Member Marcelo Lippmann, GRC Communications Director John Galbraith and Joseph Moore, chair of GRC's Education Committee. A closer GRC – IGA cooperation is envisaged, especially joint actions like special Workshops, more links between the IGA and GRC websites, cross-referencing publications in the GRC Bulletin and in IGA News. A special Task Force of the IGA BoD is now designing the next steps.

The 48th BoD meeting took place in Antigua Cuscatlan, El Salvador, on 29 October, excellently and generously organized by BoD member Francisco Montalvo (LaGeo, President of the El Salvador Geothermal Association). The meeting was preceded on 28 October by Committee meetings and the 2009 IGA Annual General Meeting, and was followed by the Central American Geothermal Workshop on 30 October. At the Workshop, besides various presentations by IGA Board members, key geothermal representatives of Costa Rica, Dominica, Guatemala, Honduras, El Salvador, St. Kitts and Nevis, and Nicaragua reported on latest developments. The Workshop was followed by a highly informative trip to the Berlin geothermal field.

The 48th BoD meeting finalized the selection process to determine the host of WGC2015: it will be Australia and New Zealand, more precisely the Australian Geothermal Energy Association, the Australian Geothermal Energy Group, and the New Zealand Geothermal Association. The Congress venue will be Melbourne, with field trips in Australia and New Zealand.

Contents

The BoD had already decided that the 49th BoD meeting will be held in Bali/Indonesia, in conjunction with WGC2010. The Board meeting will be on 1 May 2010. The 50th BoD meeting will take place, in conjunction with GRC 2010, on 29 October 2010.

The cooperation between IGA and our partner organizations within the REN Alliance (the International Renewable Energy Alliance) develops well with increasing activity. The new, powerful institution IRENA (International Renewable Energy Agency, established in Abu Dhabi) invited IGA to participate in a meeting on RE potential database in Paris on 5 November 2009. Executive Director Arni Ragnarsson represented IGA.

The submission deadline for papers to WGC2010 has now been passed (over 1000 have been received). Hopefully most IGA members have taken advantage of the benefits of early registration (before 30 November).

The real good news at the end: the new IGA website (www.geothermal-energy.org) is now up and running! Many thanks are due to all organizers and designers, first and foremost to Eduardo Iglesias, Zbigniew Malolepsy, Arni Ragnarsson and Benedikt Steingrímsson.

I look forward to continuing to working with all of you in our joint effort to promote geothermal and thank you for your support.

Ladsi Rybach

Snapshots of the WGC 2010 Technical Program

Roland Horne and Nenny Saptadji, WGC 2010 Technical Program Co-Chairs

There are 1040 received papers; there will be 650 oral presentations in 130 sessions, running 10 in parallel and 390 posters. The Technical Program will be formulated and made available to the authors (and public) on 1 February 2010.

Assembling a 1000-paper program is a big task. The 1040 papers are from about 80 different countries. The papers have been reviewed by an international panel of 142 experts. The revised papers have been edited for English by a team of 8 people at Stanford University, and reformatted by a team of 20 at Institut Teknologi Bandung, Bandung, Indonesia.

UPCOMING EVENTS

35th Stanford Workshop on Geothermal Reservoir Engineering, 1-3 February 2010, Stanford, California, USA. Website: http://pangea.stanford.edu/ERE/research/geoth/conference/workshop.html

GeoPower Americas, 15-17 February 2010, San Francisco, California, USA. Website: www.geopowerseries.com

Renewable Energy World Noth America Conference and Exposition, 23-25 February 2010, Austin, Texas, USA. Website: www.renewableenergyworld-events.com

GeoTHERM – expo & Congress, 25-26 February 2010, Offenburg, Germany. Contact: Sandra Kircher kircher@messeoffenburg.de

World Geothermal Congress 2010, Bali, Indonesia, 25-29 April 2010. Website: www.wgc2010.org

International Geothermal Conference 2010, 19-20 May 2010, Freibug, Germany. E-mail: agentur@enerchange.de

Renewable Energy World Europe 2010, 8-10 June 2010, Amsterdam, The Netherlands. Website: www.renewableenergyworld-europe.com

Renewable Energy 2010, 27 June-2 July 2010, Yiokohama, Japan. Website: www.re2010.org

2010 IAHR International Groundwater Symposium – Session on Mass Transfer in Geothermal Systems, 22-24 September 2010, Valencia, Spain. Website: http://iahr2010-gw.com

11th World Renewable Energy Congress and Exhibition, 25-30 September 2010, Abu-Dhabi. Website: www.wrenuk.co.uk

34th GRC Annual Meeting, 24-27 October 2010, Sacramento, California, USA. Website:www.geothermal.org

EUROPE

Germany

Deep geothermal projects and micro-seismicity

The following is based on a press release put out by the German Geothermal Association (GtV- Bundesverband Geothermie e.V.) on 21 September 2009, following some

Call for nominations by petition for the 2010-2013 IGA Board of Directors

The election for the 2010–2013 term of the IGA Board of Directors must be held before the end of July 2010. The permanent Nominating Committee of the IGA is currently compiling a list of candidates for the election. Most of these candidates will be nominated from the 29 affiliated member organizations of the IGA. However, through Article 13c of the IGA Bylaws, a candidate may also be nominated for the Board of Directors through a petition signed by at least 30 current members of the IGA. The Nominating Committee hereby notifies members that any such petition must reach the Executive Director of the IGA before Friday 12 March 2010. This deadline is final and petitions reaching the IGA after that date will not be accepted.

Each nomination should be accompanied by a 'Candidate Statement'. This should be of no more than 150 words, describing what the candidate proposes to do if elected to the BoD, indicating on which IGA committee they would be willing to serve, and suggesting what they feel should be the main activities of IGA in the near and long-term future. Nominees must be able and willing to attend at least one BoD meeting every year at their own expense.

'felt' micro-earthquakes in the region of Landau during August and September. These had provoked some public discussion and were thought to be associated with the operation of the local geothermal power plant.

Stressing that the German Geothermal Association, GtV-BV, does not want to prejudge the results of specific investigations, the President Hartmut Gassner said "We welcome the establishment of an expert group by the Rhineland-Palatinate Ministry of Environment, and offer our full support".

GtV-BV points out that, irrespective of the particular details of this case, it is a fact that the construction and the operation of geothermal power plants may trigger micro-seismicity. The same phenomena occur frequently with gas and oil production and in tunneling, and are related to the particular geological structures in the respective regions.

Landau is at the edge of the Upper Rhine Graben, a geologically rather active region. In the Upper Rhine Graben many earthquakes occur naturally; since June 2000 there have been 57 events comparable in strength to the recent one in Landau. Under such tectonic conditions, human interventions can lead to micro-seismicity. Generally, such events will cause little or no damage. In the case that they are related to a geothermal project, the operator's insurance will cover damages.

There is a need for more public information and greater public participation, such as regional civic forums, during construction and operation. This is an important issue for GtV-BV, and its Deep Geothermal section is about to establish a working group on "deep geothermal energy and seismic activity".

In Germany there are currently over 150 mining licences for exploration and exploitation of deep geothermal energy. Many projects are under development in the Upper Rhine Graben, in the Bavarian Molasse basin, and increasingly in the remaining areas of Germany. The opportunity to produce base-load, renewable and CO_2-free electricity, heat and cold from domestic sources needs local support. Many citizens have recognized this opportunity and support the projects of their towns and villages. Unterhaching, Neuried, Pullach, Erding and Aschheim are good examples.

More information on www.geothermie.de.

Contact:

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Switzerland

Basel EGS Project cleared of "deliberate damage"

Robert Hopkirk

The Basel EGS project was suspended in December 2006 following a magnitude 3.4 seismic event almost certainly triggered by hydraulic stimulation in the first 5km deep borehole. Many cases of minor damage were reported and compensation of nearly USD 9 million was paid, even though most of the claims were neither investigated nor verified. The project leader, Dr Markus Häring, was prosecuted by the city authorities for deliberately causing damage to property but, in the week prior to Christmas 2009, he was completely cleared by the court.

The project has confirmed a number of issues for EGS: that not all sites are suitable for EGS systems; that extra time and effort will be necessary in the detailed site evaluation and that communication with the local population is particularly important. The Basel EGS project will not continue, but has been given permission to complete the measurements and tests necessary to further improve the state of knowledge of the site. For geothermal energy and for EGS, it must be regarded as a rather positive, instructive and informative experience. It has confirmed the need for a widespread, active campaign to learn better how to predict on one hand the expected magnitude and intensity of seismic events induced at a given site and on the other hand to assess the risks of damage to property, people and infrastructure in the neighbourhood.

Geothermal team participants in the Second Lead Authors Meeting in Oslo. Left to right: Hirofumi Muraoka, Chris Bromley, Arni Ragnarsson, Luis Gutiérrez-Negrín, Ernst Huenges, Barry Goldstein, Gerardo Hiriart, Vladimir Zui, Jeff Tester and John Lund.

Norway

Geothermal energy and mitigation of climate change

Luis C.A. Gutiérrez-Negrín

The Working Group III (WG III) of the Intergovernmental Panel on Climate Change (IPCC) is devoted to identifying methods that can contribute to mitigation of climate change. WG III has been preparing a new report on the probable impact that the expected use of new energy sources could have on climate change in the coming years. This is called the IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN).

The decision on the main structure of the SRREN was taken by the IPCC plenary meeting in Budapest, Hungary, in April 2008. Currently it comprises the following chapters: 1. Introduction, 2. Bioenergy, 3. Direct solar energy, 4. Geothermal energy, 5. Hydropower, 6. Ocean energy, 7. Wind energy, 8. Integration of renewable energy into present and future energy systems, 9. Renewable energy in the context of sustainable development, 10. Mitigation potential and costs, 11. Policy, financing and implementation. Therefore, there are six 'technical' chapters and five 'non-technical'. In November 2008 the IPCC Bureau of the WG III nominated the coordinating lead-authors (CLA) and lead-authors (LA) for each chapter, who then met in the First Lead Author Meeting in Brazil on January 2009, where the internal structure for each chapter was decided. Since then, CLAs and LAs have invited a number of contributing authors (CA) to write, review and/or comment on their respective chapters. Between February and July 2009 the invited authors prepared a preliminary version of the report, called the Zero Order Draft (ZOD), which was internally reviewed during August. The SRREN is scheduled to be finished by December 2010 and published by early 2011, with a total length of around 400 pages.

The Second Lead Author Meeting was held in Oslo, Norway, through 1-4 September 2009, hosted by the Norwegian Pollution Control Authority (SFT). Objectives of this meeting were, among others, to discuss how the internal comments on the ZOD version would be taken by each chapter and how each chapter would deal with cross-cutting issues, as well as to assure the transfer of information from the technical chapters to the summarizing chapters. Over 110 participants from 50 countries of the five continents were welcomed in the plenary session of this meeting, and heard speeches from Signe Namdal, Director of Industry and Climate of the SFT, Ottmar Edenhofer, Co-chair of the IPPC WG III, and Helene Pelosse, Interim General Director of the newly established International Renewable Energy Agency (IRENA), the new energy agency of the United Nations, that was officially launched in January 2009, includes 75 countries so far and will be based in Abu Dhabi. After the plenary session, authors of each chapter gathered in different rooms of the SFT Conference Center to review and update their respective ZOD versions. Meetings to discuss different cross-cutting themes (metrics and concepts, barriers and potentials, etc.), with a representative for each technology chapter, were also conducted.

The CLAs of the SRREN chapter 4 (Geothermal energy) are Barry A. Goldstein (PIRSA, Australia) and Gerardo Hiriart (UNAM, Mexico). Besides them, the Second Lead Author Meeting in Oslo was attended by the following lead and contributing authors: Christopher J. Bromley (New Zealand), Luis C.A. Gutiérrez-Negrín (Mexico), Ernst Huenges (Germany), John W. Lund (USA), Hirofumi Muraoka (Japan), Arni Ragnarsson (Iceland), Jefferson W. Tester (USA) and Vladimir I. Zui (Belarus) (see photo). They spent three very productive days reviewing the last ZOD version of chapter 4, which had been assembled with inputs from them and other authors (like Ruggero Bertani, Trevor Demayo, Stephanie Frick, Arthur Lee, David Newell and Ken Williamson, among others). Over these three days, the geothermal team produced the first FOD version of the chapter 4, which now is being updated, complemented, and reviewed in order to produce the final FOD version by December 2009. Then, as scheduled, the complete FOD version of the SRREN will be submitted to external scrutiny during February 2010, prior to the Third Lead Author Meeting to be held in March 2010.

It is expected that the important role that geothermal energy can play in mitigating climate change by replacing fossil fuels in the production of electric energy and heating (and cooling with geothermal heat pumps) can be appropriately highlighted in the final version of the IPCC SRREN, and then governments and policymakers can adopt the proper decisions. Geothermics is not only a mature industry with more than a century of experience worldwide and major players in the energy market but also has the potential to become an important contributor to mitigation of climate change in the coming decades.

SPAIN

SPAIN'S "GREEN SHOOTS" - Joining the GeoPowGen Club

Iñaki Etxebarria Lekanda, UGARRIZA S.L. General Manager, Bizkaia (Basque Country)

INTRODUCTION

As stated in our last country report, written by Jose Sanchez Guzman (TRT) and Celestino Garcia de la Noceda Marquez (IGME), geothermal resource exploration, assessment and evaluation started throughout Spain in the 1970s with a general geological and geochemical survey of known thermal springs and other areas showing signs of thermal activity.

After deciding on the most promising areas, investigations were made over the following decades using various techniques, including deep drilling, thus enabling evaluation of the geothermal potential in the most important areas.

In recent years, several public and private institutions have thrown their weight behind the establishment of a real market. Among these are the Industry Ministry (with its Minister Mr. Sebastian), IGME (Geological and Mining Institute), APPA (Renewables Private Producers Assoc.), IDAE (Institute for Energy Saving and Diversification) and its leaders Enrique Jimenez, Enrique Gavilanes and Renewables Director Jaume Margarit, the Spanish Centre for Industrial Technology Development (CDTI) and many more.

While some areas of the country are fixated on the short-term potential of low enthalpy exploitation, there are some decentralized regions, like Catalunya, where their institutions are laying the ground work for the future of high enthalpy by taking some solid steps to deploy market initiatives that could help geothermal electricity become a reality.

THE SPANISH ELECTRICITY MARKET

Even though affected by the ongoing deep and generalized global crisis, the Spanish geothermal stakeholders are showing high levels of resilience (the positive ability of a system to adapt itself to a new scenario after drastic changes), to overcome this tough period and jump start a new market of high potential.

It should be borne in mind that Spain's 40+ million population, with its ever-growing electricity market (with steady annual average increase of 5%) and together with its government's Renewable Energy (RE) support scheme, make the country one of the most interesting spots for geothermal investment and will soon make Spain one of the leading actors of the EU geothermal theatre.

Spain has become a benchmark with regard to the development of some renewables. With solar and wind energy markets already solidly established (the Aeolic Grid, just this past Nov 8th, provided the country with 50% of its demand!!), the geothermal market will also awake; it's just a matter of time.

Despite this, even greater changes will be required to achieve the new and ambitious targets established by the EU for all member states, with the requirement that a total 20% of EU electricity consumption must come from renewable sources by 2020. For that, each State must elaborate an Action Plan (PAN) which must be submitted to the European Commission before June 30th next year.

Although the current Spanish Plan for Renewable Energy (PER) 2005-2010 already sets targets for the different areas, with the global objective of covering at least 12% of total primary energy demand from RE sources by 2010, nowadays a new PER 2011-2020 is being prepared by the Government at the same time as a new Law on Energy Efficiency and Renewable Energy.

The new PER 2011-2020 will go into consolidated areas in depth and it will incorporate other new ones, such as geothermal energy and its concrete objectives (thermal and electric objectives), by 2020.

SPANISH GEOTHERMAL POTENTIAL

Even though very important steps have been taken, the progress of geothermal energy in Spain will require further exploration drilling and the development of new investigation and exploration techniques to discover the geothermal potential in areas with very low amount of information. This will involve a combined effort of both national and regional governments, together with private initiatives.

Today, more than 50 geothermal exploration and investigation licences have already been taken out by private initiatives, covering an area of approximately 7,500 km². Millions of euros are to be spent by private institutions and the leading private companies over the next three years, mostly on early exploration programs.

As far as the different possibilities are concerned, Spain has areas for conventional (volcanic) geothermal systems, as in the Canary Islands; hydrothermal sedimentary systems as in the Madrid, Duero, Guadalquivir, Catalunya, Betic and Pyrenees (internal) basins; and extended areas for EGS.

PRIVATE MOVES

Private businesses are also deeply involved. Among all the actions being undertaken by the leading stakeholders ACCIONA, EYRA, IBERDROLA RENOVABLES, MOLINOS DEL EBRO, NORVENTO, TRT and UGARRIZA, the Spanish branch of PETRATHERM is definitely leading the way. They have many Geothermal Exploration Licences (GELs), like those held on Tenerife, the largest of the seven islands in a Spanish archipelago located off the west coast of North Africa. The Canary Islands, known for their volcanism, are considered an excellent site for exploiting conventional geothermal technology.

On Tenerife, Petratherm España, in preparation for the feasibility study for a hydrothermal project, is currently involved in an extensive magneto-telluric (MT) survey across the volcanic island to decide on the best locations for a deep test well. Many estimate that, if successful, this company could start power generation in this area as soon as 2013.

Early results obtained in the area showed evidence for a potential conductive zone which may represent a clay alteration cap above a hydrothermal reservoir. The data suggest that a 200ºC reservoir occurs at about 2000 m depth. The historical well Tenerife-1 was spudded in August 1992 and was drilled to a total depth of 1060 m. The well showed positive signs, ending in 60 m of extensively clay altered rock which coincided with an increase in logged temperatures. The intersection of this altered zone correlates with the expected top of the interpreted hydrothermal clay cap modelled in the MT data. The bottom 160 m well section records a temperature gradient of 94 ºC/km.

Petratherm is also well advanced on a large-scale 8 MWth deep geothermal district heating project for the northern Madrid area, and is already surveying the market for final consumers with an estimated 2011 delivery date. Petratherm's Madrid project has been highlighted as one of six RE projects of interest to the Madrid Regional Government's RE Cluster project that is seeking to advance REs in the Region.

Finally, Petratherm is also the holder of additional geothermal investigation permits covering areas within the Valles and Ebro Basins, in Canoves, Montbui and Vic areas. The permit areas are located about 30 km N-NE of Barcelona (Catalunya) and in close proximity to major electricity transmission systems with a capacity in excess of 2 GW. According to their company's spokesman, the permits cover locations of known high heat flow with local hot aquifers evidencing temperatures of between 115ºC to 130ºC at depths of 1.5 to 2.0 km. A 1 km deep geothermal well (Samalus 6) on the northern edge of the Valles basin has a measured temperature of 90 ºC. The heat source arises from high heat production granites that underpin the Valles Basin and outcrop in the adjacent ranges. The basin thickness is estimated at around 3 km.

For some of these projects, Petratherm has a greatly experienced collaborating agent, Jose Sanchez Guzman and his TRT company.

COLLABORATIVE APPROACH

One of the most successful initiatives has been the putting together of a High Enthalpy Geothermal Group inside APPA, which pursues a GeoMarket from a collaborative point of view. All agents already involved or with profound interests in GeoPowGen are working together, meeting with government officials, sharing information and leading initiatives that will ultimately generate a demonstration geothermal power plant, with a turnkey estimate of maybe as soon as 2015.

The strategic objectives of the group are to study Spanish geothermal resources, define basic exploration lines to improve the resource, define specific investigation lines and financing mechanisms, study the legal framework applicable to the geothermal development, define the appropriate financing mechanisms and feed-in tariffs to make geothermal business attractive and contribute to the Spanish Geothermal Renewables National Plan objectives. It is already deeply involved in an independent in-depth study to evaluate the potential for geothermal electricity generation and its possible impact on the 2010-2020 RE PAN.

The group members are also collaborating with the International Energy Agency (IEA) through its energetic Geothermal Implementing Agreement (GIA), and working together with the European Geothermal Energy Council (EGEC) for the putting together of the Research Agenda for Geothermal Energy 2008-2030 and a Geothermal Regulation Framework, sharing legal guidelines and financial incentives to set the rules for a European geothermal sector.

From one of the "engines" of this group (Margarita de Gregorio, APPA) came also the idea for the establishment of an all-new Spanish Geothermal Technology Platform (www.geoplat.org), with the main aim of identifying and developing sustainable strategies for the promotion and marketing of geothermal energy in Spain. The group works together in a coordinated way to ensure the commercial settlement of this RE and its continuous growth, in a competitive and sustainable manner.

It is also an important priority for APPA's High Enthalpy Section to influence the Spanish Government to include geothermal objectives in the next national PER 2011-2020 and PAN, both leading the way and learning from elsewhere, trying to build on the best from other already-successful national plans like Germany's.

The key for the group's success is collaboration. Rather than competing, the members are working together.

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Participants in the Short Course

AMERICAS

EL SALVADOR

Geothermal Short Course in El Salvador and the Central American Geothermal Workshop, in October 2009

Benedikt Steingrímsson, Chairman IGA Information Committee

The "Short Course on Surface Exploration for Geothermal Resources" for young professionals in Central America and the Caribbean was held during October 17th to 30th, 2009 in El Salvador. The course was organized by UNU-GTP and LaGeo as a two week course and focused on geophysics and geochemistry. This is the third workshop/short course that UNU-GTP and LaGeo have organized in El Salvador. The first week consisted of fieldwork at the Ahuachapan geothermal field where the participants were trained to conduct geophysical prospecting using resistivity methods (Schlumberger, TEM and MT) and gravity, magnetic and soil temperature measurements as well as sampling of geothermal fluids from geothermal manifestations in the area and CO_2 soil flux measurements. The data gathered were evaluated and discussed at the end of the week. The second week of the course was held at LaGeo's headquarters in Santa Tecla and was dedicated to lectures and exercises and application

At the Workshop

of relevant computer software. The papers and the presentation at the short course will soon be available on the UNU-GTP website: http://www.unugtp.is.

More than fifty geothermal professionals participated in the course. The students came from Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Dominica and St. Kitts & Nevis. Session instructors were professionals from LaGeo of El Salvador, ICE of Costa Rica, Ormat of Nicaragua, and UNU-GTP and ISOR of Iceland.

During the last day of the course the participants attended the Central American Geothermal Workshop, which was organized by El Salvador Geothermal Association (ESGA), LaGeo, UNU-GTP and IGA at LaGeo's headquarters and held in conjunction with the IGA Annual General Meeting and the 48th BoD meeting in El Salvador on October 28th and 29th. At the workshop Ladsi Rybach gave a presentation on Geothermal Sustainability and John Lund on Direct Use Projects. Then several IGA board members and participants in the short course gave presentations on the geothermal situation in their home countries. The presentations for the Workshop will be available on the LaGeo´s ftp server.

Finally, LaGeo organized a one day excursion to the Berlin Field on October 31st. The participants were impressed by LaGeo's operations, both the geothermal operation and the social responsibility LaGeo is accepting and operating in co-operation with the surrounding communities.

MEXICO

Geothermal energy in Mexico: Background and present status

Rosa María Barragán Reyes[1], Víctor Manuel Arellano Gómez[1], Luis C. A. Gutiérrez-Negrín[2]

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Introduction

Due to its location in the "Ring of Fire", Mexico has vast geothermal resources. The inventory of resources with geothermal springs at temperatures higher than 28°C contains 2,332 sites distributed in 27 of the 32 states of the Republic (Arellano et al, 2008), (Figure 1). It has been documented that in Pre-Colombian times Mexico's low/moderate temperature geothermal resources were used extensively (Gutiérrez-Negrín, 2009). Nowadays, however, the main use of geothermal energy is in electricity generation. Present geothermal electric installed capacity in the country is 958 MW, distributed in four high-temperature geothermal fields: Cerro Prieto,

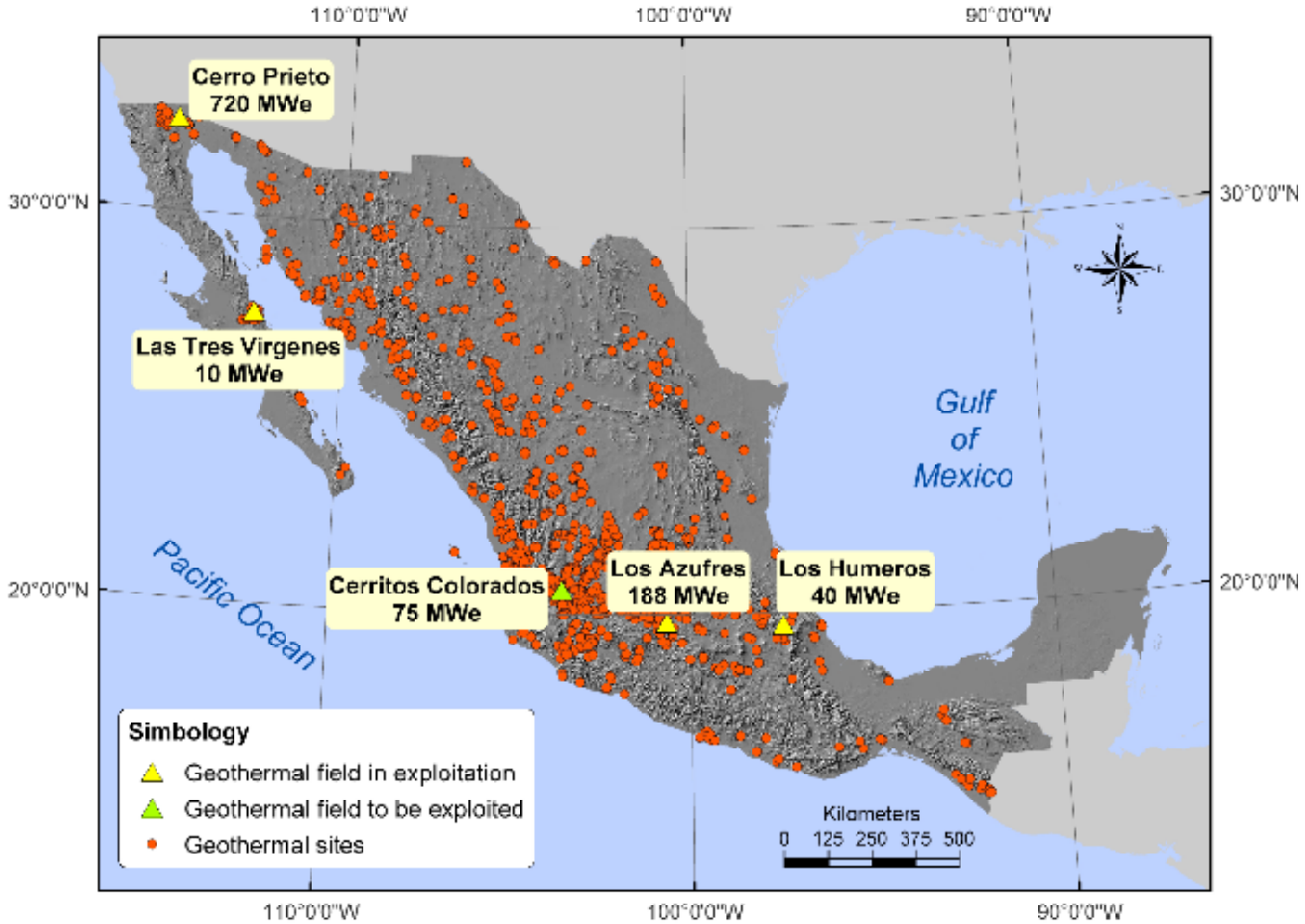

Figure 1. Location of main geothermal fields, zones and sites in Mexico

Table 1. Review of chronological development of geothermal energy in Mexico (1940s-1973) for electricity generation.

1940s	- CFE started interest on geothermal resources to generate electricity
1950	- Studies for geothermal exploitation started
1955	- The "*Comisión de Energía Geotérmica*" was established - Pathé (Hidalgo) geothermal zone (~300 km north of México city) started development
1956	- One well drilled at Pathé, steam production
1958	-First (steam) well drilled at Ixtlan de los Hervores (Michoacan) -Exploration studies for the Cerro Prieto geothermal field began -An agreement between Larderello and CFE was held with the purchase of one 3.5 MW unit to be installed at Pathé
1959	-Pathé started electricity generation (first in America). 17 wells were drilled. The plant was in operation until 1973 (Arellano et al, 2008) -People gained experience
1959-1960	Three exploration wells were drilled at Cerro Prieto
1963	First deep well drilled at Cerro Prieto (M-3)
1967-1968	14 wells drilled at Cerro Prieto (CP-I)
1969	Starting construction of two 37.5 MW units
1973	Both 37.5 MW units started power generation at CP-I

Baja California (720 MW); Los Azufres, Michoacán (188 MW), Los Humeros, Puebla (40 MW) and Las Tres Vírgenes, Baja California Sur (10 MW). Based on its installed generation capacity, Mexico is ranked fourth in the world after USA (2957.9 MW), Philippines (1967.7 MW) and Indonesia (992 MW); (http://www.earthpolicy.org/Updates/2008/Update74_data.htm#table1). Electricity generation from geothermal resources in Mexico in 2008 amounted to

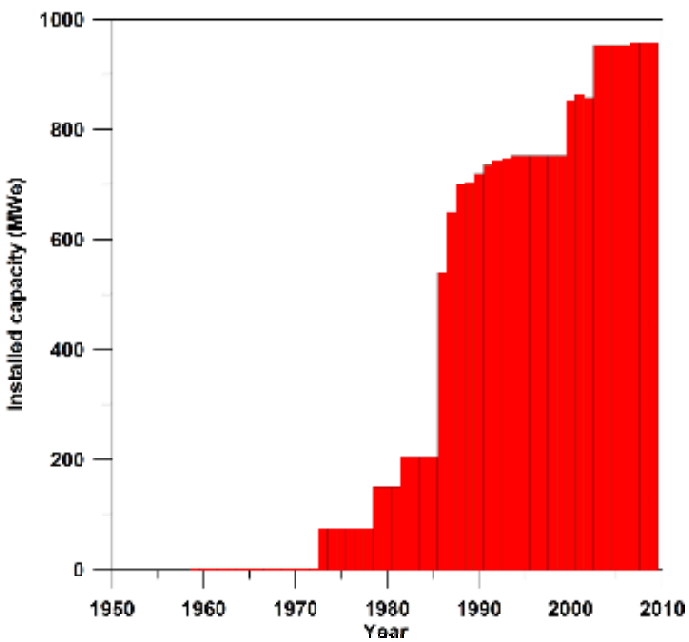

Figure 2. Trend of installed electricity generation capacity in Mexico.

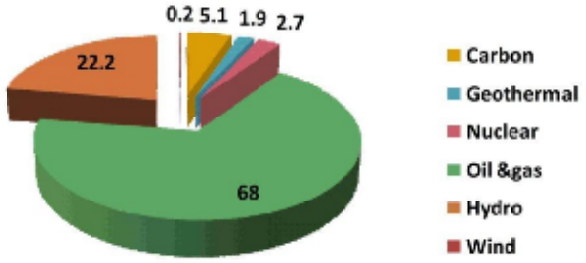

Figure 3. 2008 electricity generation installed capacity in Mexico.

7,047 GWh, equivalent to crude oil savings (resources that would have been required to generate the same amount of electricity) of 13.5 mboe (Gutiérrez-Negrín, 2009). For the same reason, electricity generation from geothermal resources in 2008 avoided CO_2 emissions of 5.65 million tons by comparison with oil-fuelled production. This work presents a brief background of geothermal development in the country and an update regarding electricity generation based on geothermal energy together with plans to increase capacity in the near term.

Background and present geothermal electricity status

A brief review of the development of geothermal energy for electricity generation in Mexico since the 40s to 1973 is given in Table 1. The first generation plant in Mexico, a 3.5 MW power unit installed in Pathé, Hidalgo, started generation in November 1959 (Arellano et al, 2008). This plant produced only 600 kW and was operating until 1973. At that time, the Cerro Prieto geothermal field started generation (2 units of 37.5 MW each) and since then the installed power capacity of the country has increased steadily (Figure 2).

The Cerro Prieto geothermal field is located 30 km south of Mexicali city near the USA border (Figure 1). Exploration activities at Cerro Prieto began in the 1950s. Currently four sectors have been developed with a total installed capacity of 720 MW. CP I sector consists of 5 power units: 2 x 37.5 MW that started generation in 1973, 2 x 37.5 MW units that started operation in 1979 and one 30 MW unit that has been operating since 1981. CP II and CP III consist of 2 x 110 MW plants in each sector, and started generation between 1985 and 1987. CP IV sector has 4 x 25 MW units that started generation in 2000 (Arellano et al, 2008).

The Los Azufres geothermal field is located in the northern part of the Mexican Volcanic Belt, about 200 km west of Mexico city (Figure 1). Exploration activities began during the 1950s and the first production wells were drilled in 1977. Electricity generation started in 1982 with the operation of 4 x 5 MW units, and the capacity was increased subsequently: in 1986 a 5 MW plant was added, in 1988 a 50 MW unit started production and then two more 5 MW units started generation in 1990 and 1992. Two 1.5 MW binary cycle units were then added and, in 2003, a further 4 x 25 MW units, bringing the present

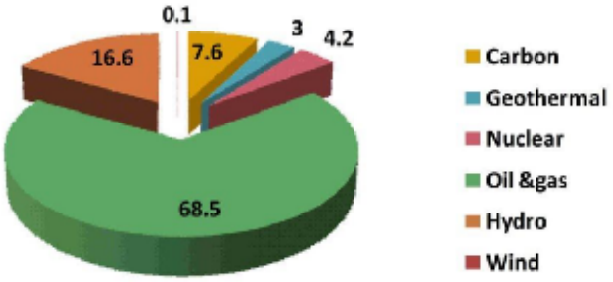

Figure 4. 2008 electricity generation in Mexico.

capacity to 188 MW (Gutiérrez-Negrín et al, 2010).

The Los Humeros geothermal field is located at the eastern part of the Mexican Volcanic Belt about 200 km from Mexico city (Figure 1). Exploration studies at Los Humeros began in 1968 and the first deep well was drilled in 1982. Commercial exploitation started in 1990 with the generation of 5 MW. At present there are 8 x 5 MW generation units, with a current capacity of 40 MW (Arellano et al, 2008).

The Las Tres Vírgenes geothermal field is located in the northern part of Baja California Sur in the Baja California Peninsula (Figure 1). Exploration studies began in 1982 and the first well was drilled in 1986. Exploitation of this resource started in 2002 with the installation of 2 x 5 MW units, providing the present capacity of 10 MW (Gutiérrez-Negrín et al, 2010).

According to Comisión Federal de Electricidad (CFE) data, the 2008 installed geothermal power capacity was 958 MW, which represented 2% of total installed capacity in Mexico (Figure 3) and ~3.07% of the total electricity produced (Figure 4). As seen in both figures, a large part of electricity generation in Mexico is still dependent on fossil fuels.

However, although at a country level the percentage of geothermal electricity seems to be very low, it can represent up to 80% of the Baja California state production (Figure 5). As both the Baja California and the Baja California Sur states are isolated from the National T & D grid, geothermal energy has made an important contribution at a more local level (Gutiérrez-Negrín, 2009). Besides this, and due to the location of the Cerro Prieto field close to the USA border, part of the electricity generated is being exported to USA, which represents benefits to Mexico's economy (Gutiérrez-Negrín, 2009; http://www.publicradio.org/columns/kpcc/kpccnewsinbrief/2009/02/la-dwp-buys-geothermal-energy.html).

Near-future electricity projects

New developments in the country that will increase the installed geothermal generation capacity are planned to start operating as early as 2011 and include the following projects (Gutiérrez-Negrín et al, 2010):

(a) Cerro Prieto V (CP-V sector, 100 MW): Construction and commissioning of two 50 MW condensing units at Cerro Prieto geothermal field. This project will also remove two 37.5 MW units from CP I sector, so the net capacity increase for this field will be 25 MW. Currently this project is under bidding process but is planned to be completed in 2011.

(b) Los Humeros II: Construction and commissioning of one 25 MW condensing unit to be in operation in 2011. At present this project is underway. A further capacity increase of 25 MW, using binary cycle plants, is planned to take place in this field in 2013.

(c) Los Azufres III: This project involves the replacement of 7 x 5 MW backpressure units by 2 condensing units (50 and 25 MW) to increase the capacity from 188 to 225 MW (Torres et al, 2008). This project is planned to be accomplished in 2015.

(d) Cerritos Colorados. 75 MW is planned to be installed at Cerritos Colorados, Jalisco geothermal field. 25 MW capacity is scheduled for installation in 2013 while the remaining 50 MW will be installed in 2014.

Exploitation feasibility studies are being developed by CFE for the following geothermal zones: Tulecheck (Baja California), Piedras de Lumbre (Chihuahua), El Ceboruco (Nayarit), Acoculco (Puebla), Tacaná and Chichonal (Chiapas). The Acoculco project results after drilling provided very high temperatures but no fluids, hence a HDR system might be considered (Gutiérrez-Negrín, 2009). Furthermore, detailed exploration activities are being planned to estimate potential capacities of the following zones: La Soledad, Los Borbollones and Los Hervores de la Vega (Jalisco); El Domo San Pedro and San Diego el Naranjo (Nayarit); Maguarichic (Chihuahua), Ixtlán de los Hervores, Los Negritos and Purúandiro (Michoacán), Comajilla and San Bartolomé de los Baños

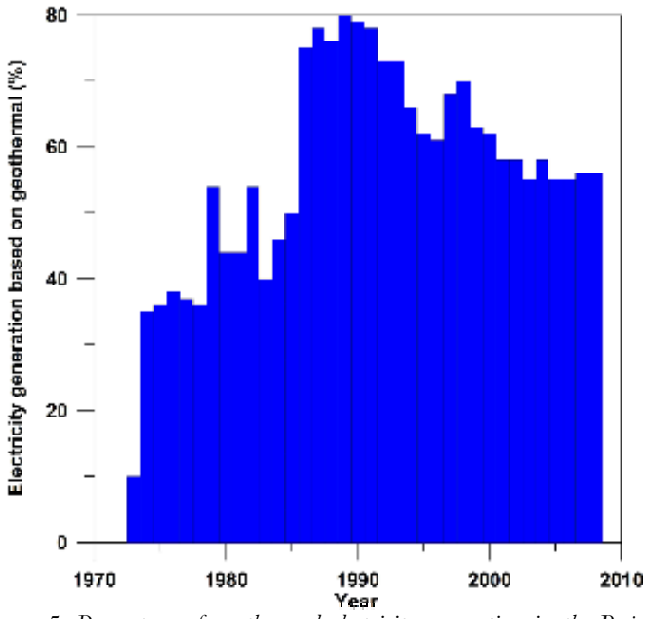

Figure 5. Percentage of geothermal electricity generation in the Baja California state.

(Guanajuato), Pathé (Hidalgo), Las Derrumbadas (Puebla), Laguna Salada (Baja California), Riíto (Sonora), Santispac, Agua Caliente, Los Volcanes de Saquisismunde and Bahía Concepción (Baja California Sur). Possible capacities of all these resources have been estimated to be about 1,000 MW.

Direct uses of geothermal energy in Mexico

At present direct uses of geothermal energy in Mexico are limited to balneology (Spas) and therapeutic usage. Installed capacity for these facilities located at around 160 geothermal sites in 19 country states is 164.7 MWt, (1931.8 TJ/year) produced by ~12,500 t/h hot water at an average temperature of 50°C (Gutiérrez-Negrín and Quijano-León, 2005). Some pilot projects have been developed by CFE at the geothermal fields to illustrate the direct uses of hot fluids. These include: salts recovery at Cerro Prieto, residential heating, greenhouses, fruit and vegetable drying, timber drying, etc. At the same time, research has been developed at the Instituto de Investigaciones Eléctricas (IIE) on heat pumps operated by geothermal and waste heat (García et al, 2007). Another application to be exploited in the country is the installation and use of geothermal heat pumps for space heating and cooling. This technology, although commercially available nowadays, has not been used in Mexico due to the mild temperatures occurring throughout the year.

A first assessment of medium-low temperature (<200°C) geothermal resources was developed at the Instituto de Investigaciones Eléctricas (IIE) (Iglesias & Torres, 2009). A first assessment of medium-low temperature (<200°C) geothermal resources was developed at the Instituto de Investigaciones Eléctricas (IIE) (Iglesias & Torres, 2009). Considering data for 20 states, the total energy was estimated between 3.08 and 3.45 x 10^{17} kJ (8.56 - 9.58 x 10^{10} MWt). According to the temperature distribution (60°C - 180°C) the recoverable energy was estimated between 7.7 x 10^{16} and 8.6 x 10^{16} kJ. Such vast available energy should be used by developing direct use projects that can solve basic requirements (for example refrigeration to preserve foods) which could benefit local economies. For this, it is necessary to identify opportunities for the optimal use of resources, call for the interest of government and investors and inform people about the advantages in the use of geothermal energy.

Conclusions

Currently the main use of geothermal energy in Mexico is electricity generation through the successful exploitation of four high-temperature resources. Direct uses of geothermal heat were important in the past but at the present time are limited to therapeutic uses and Spas. Vast amounts of medium and low-temperature heat are available, for electricity generation through binary cycle plants or for direct applications, depending on the temperatures of the sources. Near-future plans for increases in potential comprise both the installation of new power units and also the replacement of old plants by more efficient ones. Depending on the capacity estimation results to be obtained from a number of geothermal zones which are currently under prospection, the installed electric capacity of the country could be increased in the medium term. This is highly desirable to help mitigate greenhouse effects through reduction in fossil fuel usage along with CO_2 emissions savings. Important increases in geothermal electric capacity in Mexico are expected in the future as the technical/economic feasibility of advanced technologies becomes available. To accomplish this, research programs should be supported that are focused, among other issues, on the efficient extraction/conversion of geothermal heat, minimization of environmental impacts and cascade uses of geothermal resources. Suitable training programs and related university careers to prepare specialized human resources should also be outlined.

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OCEANIA

New Zealand

Book Review by Dr. Ron Keam, Department of Physics, University of Auckland.

"Characteristic Periodic Variations of Surface Geothermal Features". Author: Jonathan Leaver. Publisher: VDM Verlag Dr. Muller Aktiengesellschaft & Co. KG (24 April 2009). Language: English. ISBN-10: 3639148665, ISBN-13: 978-3639148664. Paperback: 292 pages.

Jonathan Leaver's PhD thesis has been reformatted and published by the Mauritius-based VDM Publishing House Ltd as one of its Scientific Monographs. This is a good example of a praiseworthy initiative that is resulting in the much wider distribution of research material that otherwise could well languish un-noticed on the shelves of the host University.

As is well-summarized in the book's opening chapter Leaver's research used three New Zealand case studies where characteristic short period (less than 25 hours) variations in several fluid parameters were measured and analysed to find what significant information they contained. The underlying motivation was to see if such an approach would enable time-efficient and resource-efficient monitoring strategies to be developed whereby interested parties – environmental, developmental, scientific – could obtain information of interest and importance for their respective purposes. The three systems studied were quite different, comprising one low temperature, unexploited field (Te Aroha), one high temperature unexploited field (Orakeikorako) and one high temperature exploited field (Rotorua). Natural variations with obvious external causes such as earth tides, rainfall and barometric pressure changes could be identified and removed and the residual changes attributed to system specific thermodynamic and fluid-dynamic causes. For unexploited fields one would seek natural explanations for the periodicities, and for exploited fields one would expect to find anthropogenic influences affecting any periodicities and thereby offering a quantitative assessment of the perturbations being caused.

This book is well structured and contains useful contextual information particularly in its early chapters. Chapter 2 is a concise coverage of geothermal systems in general, and New Zealand systems in particular, and mention is made of several historical conflicts which arose from competing interests for the uses of systems. Chapter 3 considers natural influences on geothermal systems. Chapter 4 considers data analysis and modelling methods in detail and explains the investigative uses of such data processing as cross-correlation and auto-correlation. It also presents methods of Fourier analysis and the more recently developed Wavelet analysis, and provides a comparison of the two approaches.

The main part of the book comprises chapters 5 – 7 where, in turn, the practical and analytical work done in each of the three carefully studied New Zealand systems is presented. Chapter 7 (on Orakeikorako) is divided into two parts, in the second of which a system dynamics model of a hot spring is formulated to assess the fundamental heat and mass transfer occurring in that surface feature and in the substrate whence it is supplied. This is a particularly illustrative case study.

In all, the thesis provides an understanding of the value of studying the effects of periodic forcing functions. Success in such an endeavour relies on high accuracy measurements being taken at sufficiently high sampling rates.

More than 150 maps, diagrams, illustrations, graphs, flow charts etc. are distributed throughout the main text of 242 pages. These are supplemented by eight pages of references and nine brief appendices. There is no index but the table of contents and list of figures are sufficiently comprehensive to ensure that navigation to a specific topic is conveniently facilitated.

In a very few places abbreviations are not explained and a reminder is due to both author and publisher that such minor editing as is required to make the material more readily accessible to the larger readership of a book as compared with just a thesis should not be overlooked.

A perhaps surprising omission is any reference to the New Zealand Geological Survey Bulletin 85 "Geology and Hot Springs of Orakeikorako" by E.F. Lloyd published in 1972. In this pioneering work Lloyd mapped and numbered all the surface features he could find and access at Orakeikorako, so Leaver's spring 1 and spring 2 could have been correlated with Lloyd's identifications. In the same publication Lloyd presented comparisons of Palette Pool water level and atmospheric pressure records during the thirteen month period from January 1962 to January 1963 not long after the lake had been impounded behind Ohakuri dam. Palette Pool lies within a few tens of metres of the springs Leaver monitored.

These are minor blemishes and cannot detract from the value and usefulness of this publication. This is a well-written, comprehensive, and engaging work. The thesis and corresponding book are a significant addition to resources for studying near-surface aspects of geothermal systems. The author is to be congratulated on the quality of his work and on his opening up and demonstrating the value and importance of the methods he has used, both in the field and in his mathematical analysis. I recommend

the book's acquisition by any library with a geothermal section and to the attention of researchers involved in detailed studies of shallow structures and/or the behaviour of surface features in geothermal systems.

Reviewer's Profile:

Dr. Ron Keam is an Associate Professor of physics at the University of Auckland, New Zealand. He has maintained a constant stream of publications and books on geothermal systems since 1955. In 2002 he was a recipient of the New Zealand Science & Technology silver medal for his contributions to geothermal knowledge and conservation of geothermal features.

Author's Profile:

Dr. Jonathan Leaver is an Associate Professor at Unitec New Zealand. Dr. Leaver served as Chief Petroleum and Geothermal Inspector for the Ministry of Commerce from 1991-1998 and worked in the Geothermal Measurement and Reservoir Evaluation Section of Ministry of Works at Wairakei from 1981-1988 becoming the head in 1987. He holds a BE(Hons)(Civil), PGDipEnergyTech(Geoth), and a PhD (Mech) from the University of Auckland and an MS(Petroleum) from Stanford University.

ASIA/PACIFIC RIM

CHINA

IGA WPRB/GCES joint 2009 Annual Activities held in Chengdu, China

Keyan Zheng, GCES, China

The joint 2009 Annual Activities of the Western Pacific Regional Branch (WPRB) of International Geothermal Association (IGA) and of the China Geothermal Energy Society (CGES) were held successfully on 16-22 September 2009 in Chengdu, China. The series of activities consisted of three parts: technical seminar, annual general meeting and geothermal workshop.

In order to promote geothermal development, especially in power generation and enhanced geothermal systems in China, IGA sent three experienced experts to support the Technical Seminar entitled "Geothermal power generation". The training was carried out for three days on 16-18 September. Dr. Graeme Beardsmore (Australia) lectured on "Exploration for non-conventional geothermal in Australia" and explained how to find geothermal resources. Dr. Ernst Huenges (Germany) lectured on "Development of non-conventional geothermal reservoirs in Germany" and explained how to

exploit the resources from geothermal fields. Paul Quinlivan (New Zealand) lectured on "Geothermal power plant design" and explained how to use geothermal fluids to generate electricity. 27 trainees from different regions of the country, including Tibet, attended the seminar. They felt that the training was very satisfactory and that they had gained valuable knowledge of geothermal power generation. In particular, the EGS study will be very useful for the future of our geothermal energy.

The WPRB Annual General Meeting was held also during the activities. Attendees discussed and concluded WPRB's old and new business for the past year.

The WPRB/GCES joint geothermal workshop attracted 87 participants, including foreigners from Indonesia, Kenya and Germany. The keynote speech given by Surya Darma, Secretary General of WGC2010 and President of the Indonesia Geothermal Association, introduced geothermal resources and development in Indonesia, and extended a welcome to attendees of the WGC2010. The Kenyan expert introduced their new geothermal development plan and the German expert introduced advanced drilling equipment. These foreign presentations opened new windows for Chinese geothermal workers. A total of 20 papers were presented on 19-20 September. All presentations addressed the theme of workshop - "Bring Superiority of Geothermal Resources into Full Play on the Strategy of Energy Development" - to bring out aspects of development strategy, resources exploration, energy utilization and new technology etc.. The Australia and New Zealand paper "A code for geothermal resources and reserves reporting" was also introduced. Various questions after each presentation reflected the earnest participation and great interest of the participants. The proceedings, bringing together 32 papers from Western Pacific authors, had been published prior to the workshop. Chinese and foreign geothermal colleagues spent a very pleasant week during the best season of September in beautiful Chengdu.

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