IGA NEWS

Newsletter of the International Geothermal Association

Quarterly No. 80

IGA ACTIVITIES

Message from the President

Ladsi Rybach

Dear IGA member

This is the tenth message from your current President.

I have just returned from WGC2010. What an event! By far the largest, most exciting geothermal conference ever held, in terms of participants, oral & poster contributions, exhibitors, etc. What stood out was the excellent organization, fascinating social events, manifold short courses and field trips, and - most importantly - it was a global gathering of practically all geothermal players. A separate report by François-David Vuataz in this issue describes the Congress highlights.

Personally, I was very impressed with the great achievements of the host country in developing its rich geothermal resources and particularly with the presence of the President of Indonesia, Susilo Bambang Yudhoyono as well as of the President of Iceland, Olafur Ragnar Grimsson. They both fascinated the Congress at the Opening Session with deep geothermal knowledge and visionary statements. If geothermal gets such support worldwide, it can really "Change the World"!

The efforts and dedication of a great number of people have made the Congress such a success. Here, I can name only a few: Herman Darnel Ibrahim (OC Chairman), Surya Darma (OC Secretary) and, from IGA, Gordon Bloomquist with his Steering Committee. Roland Horne and Nenny Saptadji kept the Technical Program constantly under full control, besides having managed all the manuscripts for the Conference Proceedings CD. This CD represents a fantastic reference library. Many thanks also to Pacto Convex Ltd. for the really professional implementation of all technicalities. All the organizers can be proud of their great success!

Presidents Susilo Bambang Yudhoyono of Indonesia (center back) and Olafur Ragnar Grimsson of Iceland (second from right, in profile) visiting the Exhibition

The great number of new developments worldwide as reported in panel discussions and sessions, the numerous new products and services now available as demonstrated in the Exhibition created a special spirit: the feeling that geothermal now is in full swing! In this spirit, the Congress issued the "Bali Declaration", urging for further action to promote geothermal worldwide.

Some other important actions took place during the Congress: the signing of several geothermal development projects and of the aforementioned Bali Declaration as well as of the Memorandum of Understanding to hold the World Geothermal Congress 2015 in Melbourne, Australia.

Contents

Participants in the 49th BoD meeting

For IGA, a General Meeting was held during the Congress on 28 April, preceded by a Meeting of the Western Pacific Regional Branch. The IGA GM finalized the Bali Declaration and dealt with current issues like the upcoming BoD elections.

The 49th BoD meeting took place in the Westin Resort Hotel on 1 May. At the end of the meeting, the Memorandum of Understanding was signed with Geothermische Vereinigung - Bundesverband Geothermie e.V. to operate the IGA Secretariat in Germany.

The next (50th) BoD meeting is to be held in Sacramento, California/USA on 28 October. This will be the last meeting of the current Board. At the 51st meeting on 29 October the new Board will assume its duties.

Zurich, 4 May 2010

UPCOMING EVENTS

13th International Symposium on Water-Rock Interaction (WRI-13), 16-20 August, Guanajuato, Mexico. Website: http://wri13.cicese.mx/.

The World Energy Congress 2010, 12-16 September 2010, Montreal, Canada, Website: www.wecmontreal2010.ca

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

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

RENEXPO 2010, 7-10 October 2010, Augsburg, Germany. Website:www.renexpo.de

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

2010 GSA Annual Meeting-Topical Session 14: Enhanced Geothermal Systems, 31 October-3 November 2010, Denver, Colorado, USA. Website: www.geosociety.org/meetings/2010/.

Der Geothermiekongress 2010, 16-18 November 2010, Karlsruhe, Germany. Website: www.geothermie.de

Australian Geothermal Energy Conference, 16-19 November 2010, Adelaide, Australia. Website: www.agea.org.au.

2010 New Zealand Geothermal Workshop and GeoNZ 2010, 22-24 November 2010, Auckland, New Zealand. Website: www.geothermal.org.nz

Exploring and Harnessing the Renewable and Promising Geothermal Energy, Djibouti, 22-25 November 2010. Contact: argeo-c3-djibouti@intnet.dj

36 Stanford Workshop on Geothermal Reservoir Engineering, 31 January-2 February 2011, Stanford, California, USA. Website: http://pangea.stanford.edu/ERE/research/geoth/conference/workshop.html

Signature ceremony of the Bali Declaration

THE BALI DECLARATION

"Geothermal Energy to Change the World"

We are more than 2500 members from World Geothermal Communities represented by 85 countries assembled in Bali, Indonesia, for the World Geothermal Congress 2010. The Congress has been convened by the International Geothermal Association and the Indonesian Geothermal Association. Indonesia is a country that has been blessed with abundant, sustainable natural sources of energy including perhaps the world's largest readily accessible geothermal resources. In light of the long history of geothermal energy development here in Indonesia and throughout the world it is only appropriate that we, the participants of the World Geothermal Congress 2010 so assembled, do hereby declare:

FIRSTLY – Energy constitutes a basic and continuing human need

a. Humankind is learning to develop technology to effectively and efficiently manage this diverse energy need in an environmentally responsible manner.

b. Natural resources should not be considered merely as an inheritance from our ancestors, but that which has been entrusted to us for our children and grandchildren.

c. Without energy other natural resources cannot be developed, industrialization cannot occur; food production will always be a problem, unemployment will continue to be a major issue, and health services will be extremely limited.

d. Geothermal energy can be a major player in making significant changes in that situation and is reflected in the theme of the Congress. Geothermal: The Energy to Change the World.

SECONDLY – It is established that

a. The world needs energy, now and in the future. Geothermal energy is hugely abundant.

b. Climate change must be well managed and energy must be provided at a reasonable cost to our growing world wide population.

c. Geothermal energy is indigenous, sustainable and environmentally responsible, counteracting global warming by displacing carbon-intensive energy usage.

d. Geothermal energy can generate electricity as well as provide for the development of a wide range of direct uses including heating and cooling buildings, various industrial processes and agricultural production, as well as balneological and recreational health resorts.

e. Geothermal energy is the only renewable energy source which is totally independent of daily, seasonal and climatic variation, allowing it to provide power with a higher availability than any other energy source including fossil fuels and nuclear.

f. Geothermal energy technology is well established, though it is continuously being improved.

g. Geothermal energy has to date only been developed to a very limited extent compared to the potential resource base. Obtaining financing, and legal, institutional and regulatory barriers are two of the limiting factors.

h. Geothermal technologies based on higher temperature resources have life-cycle costs competitive with other forms of energy. Cost competitiveness is steadily being extended down the resource curve as technology improves, but at the lower end of the temperature scale pro-active policies or incentives are still needed to increase geothermal competitiveness.

i. The importance of extending geothermal energy usage to lower temperatures is that not only is the resources base increased exponentially as the minimum temperature is reduced, but the range of geographies where it can be applied also greatly increases.

THRIDLY: We the assembled therefore do urge that

a. Large investment is secured for national, regional and local geothermal projects in developing as well as developed countries and economies in transition. Greater acceptance of geothermal by international funding agencies can play a major role.

b. Legislative and administrative barriers be removed and reformed.

c. All technocrats, decision makers, politicians and world leaders, whether they are in the developed or developing countries strive to create a favorable political climate by molding public opinions that are conducive to the sustainable development of geothermal energy. This can include for example government support in the areas of risk mitigation insurance, cost sharing, loan guarantees and production tax credits.

d. Investments can be provided in many forms (financial incentives from government, loans and capital investment from banks, private investors, venture capital funds) and policies need to be established to facilitate accessing all of these sources.

e. Recognition be given to the important role of existing utilities as the off taker for electrical output, that Renewable Portfolio Standards be adopted, that Integrated Resource Planning be fully implemented and standard offer contracts including feed-in tariffs be made available.

f. Substantial funding be committed to research and development to improve the cost competitiveness of geothermal energy production, particularly where it means it can be extended into new situations, such as at low temperatures and into different geological settings.

g. Know-how transfer from developed to developing countries is facilitated and supported through effective international cooperation among government, private and academic institutions, especially by joint training and education, capacity building, and technical assistance.

FOURTHLY – All this will

a. Avoid additional carbon dioxide emissions and reduce current emission levels;

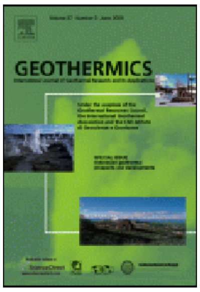
b. Create employment opportunities, increase industrial development and agricultural production and improve the standard of living of citizens of the world;

c. Secure adequate and environmentally responsible energy supply for generations to come; and last but not least

d. Effectuate "geothermal energy to change the world" toward a sustainable peaceful, healthy and clean environment in a world to live in and consequently the lasting prosperity of the people through out the world.

Nusa Dua, Bali – Indonesia, 30th April 2010.

All IGA affiliated organizations will be invited to sign the Bali Declaration.



WGC 2010 in Bali: a Record-Breaking Congress

François-D. Vuataz, IGA BoD member, CREGE, Neuchâtel, Switzerland

Introduction

Geothermal, the energy to change the World: this was the motto of the last World Geothermal Congress that took place in Nusa Dua, Bali, Indonesia from April 25 to 30, 2010. The event was convened by the International Geothermal Association (IGA) and co-convened by the Indonesian Geothermal Association (INAGA). Ranked third among geothermal power producers and with its huge potential, Indonesia is today the best country to present the state of the art in geothermal energy. Moreover, the attractive island of Bali and the stunning International Convention Centre in Nusa Dua were the natural place to organize such event.

Programme

The organizing committee and the IGA steering committee did an outstanding job in preparing the congress and, from the participants' point of view, the whole programme ran efficiently and smoothly. The programme itself was composed of the following main events: the Opening session, the 130 Technical sessions and the Closing ceremony with the signature of the Bali Declaration. The social events were marked by a friendly Welcome reception, a spectacular Indonesian cultural night and a hot Farewell party!

If we compare some statistics from WGC 2000 and 2005 with the last one, Bali was the congress of all the records (Table 1).

Similarly, when comparing the status of geothermal development at the period of those last three milestones, one can say that Bali was the witness of a strong geothermal restart (Table 2).

As in other large international gatherings, new contacts were made, agreements were signed and new collaborations were built for the sake of geothermal energy. Moreover, two panel discussions were held - on the international effort to attract investment in geothermal energy, and on the international perspective to support geothermal development in Indonesia.

President of Indonesia Susilo Bambang Yudhoyono opening the Congress with the traditional gong.

Table 1. Statistics of the three last WGCs

Congress	WGC 2000	WGC 2005	WGC 2010
Country	Japan	Turkey	Indonesia
Venue	Beppu & Morioka	Antalya	Nusa Dua, Bali
Participants	1700	1350	2500
Countries	61	80	85
Papers	670	706	1039
Oral presentations	320	330	650
Posters	350	376	350
Technical sessions	64	65	130
Sessions topics	44	26	40
Exhibitors	54	43	47

Table 2. Worldwide geothermal status (data from Bertani, 2010 and Lund et al., 2010 - Proc WGC2010)

Year	2000	2005	2010
		Power generation	
Installed capacity (GWe)	7.97	8.93	10.71
Power production (GWh/yr)	49,261	55,709	67,246
Countries	21	23	24
		Direct use	
Installed capacity (GWt)	15.14	28.27	50.58
Energy use (GWh/yr)	53,014	75,997	121,696
Countries.	58	72	78

Trends

Looking at the relative numbers of papers in the 40 topics proposed during the 130 technical sessions, it is interesting to see where the main efforts are centred. Actually, eight out of 40 topics represent precisely 50% of all the proceedings papers (Table 3).

It appears that indirect and surface methods (geophysics, geochemistry and geology) are still very important in the exploration and management of geothermal resources and reservoirs. Numerous papers about exploration show how active is the quest for new resources. Moreover, never before in a congress have so many papers and sessions been focused on Enhanced Geothermal Systems (EGS). Although for the last five

Welcome reception

years numerous projects have been in progress on several continents, major difficulties linked to drilling and to reservoir stimulation have retarded the development of this technology. As a result, only two small pilot plants are under exploitation today (at Soultz-sous-Forêts, France, and Landau, Germany, both located in the Rhine graben).

Among many interesting and important projects, one stands out particularly: the exploration for supercritical fluids, namely the striking Icelandic Deep Drilling Project (IDDP). The aim of the project is to exploit supercritical fluid at a depth of 4-5 km and a temperature of 400-600°C. At a given flow rate, the amount of power generated with such a fluid would be twice that of a classical high temperature geothermal field. After a first drilling attempt, a 2.1 km well in the Krafla geothermal field (NE-Iceland) had unfortunately to be stopped after a body of molten magma was encountered. The project will continue with the drilling of new wells on other sites.

Table 3. Most important topics ranked by their number of papers in the Proceedings (≥ 50 papers)

Main topics	Number of papers	Number of sessions
Geophysics	73	9
Exploration	71	8
Country updates	67	7
Reservoir engineering	64	9
Geology	64	7
Geochemistry	63	6
Enhanced geothermal systems (EGS)	61	9
Environmental & societal aspects	50	7
Total	513	62

Final remarks

WCC 2010 was definitely a great event in a very friendly atmosphere. The excellent planning and organization were a decisive point. But above all, the handling and review of over 1000 papers by the Technical Programme Committee and their implementation on the IGA database, as well as the preparation of the proceedings CD is to my view the one key-element for developing geothermal energy during the next five years, by allowing professionals to be informed of the latest results and experiences worldwide until WGC 2015 in Melbourne.

Poster session.

WORLDWIDE GEOTHERMAL UTILIZATION 2010

John W. Lund[1] & Ruggero Bertani[2]

[1]Geo-Heat Center, Oregon Institute of Technology, Klamath Falls, Oregon, USA

[2]ENEL, Rome, Italy

UTILIZATION IN 2010

Based on 68 country update papers submitted to the World Geothermal Congress 2010 (WGC2010), the following figures on worldwide geothermal electric and direct-use capacity are reported. From WGC2000, WGC2005, and WGC2010, a total of 78 countries have reported some utilization of geothermal energy: electrical, direct-use or both (Lund and Freeston, 2001; Lund, et al., 2005 and 2010; Bertani, 2005 and 2010) (Table 1).

Table 1. Total Geothermal Capacity and Use in 2010

Use	Installed Power (MWe)	Annual Energy Use (GWh/yr)	Capacity Factor	Countries Reporting
Electric Power	10,715	67,246	0.72	24
Direct Use	50,583	121,696	0.27	78

The figures for electric power capacity (MWe) appear to be fairly accurate; however, several of the countries' annual generation values (GWh) had to be estimated, although these amounted to only 0.5% of the total. The direct-use figures are less reliable and probably are understated by as much as 20%. The authors are also aware of at least five countries that utilize geothermal energy for direct-heat applications but did not submit reports to WGC2010. The details of the present installed electric power capacity and generation, and direct-use of geothermal energy, can be found in Bertani (2010), and Lund, Freeston and Boyd (2010). These data are summarized in table 2.

A review of the above data shows that in electric power generation each major continent has approximately the same ratio between installed capacity and energy produced, with the Americas and Asia having over 75% of the total. With the direct-use figures, however, the ratio of installed capacity to energy use drops significantly for the Americas (28.9 to 18.4%) due to the high percentage of geothermal heat pumps with low capacity factor for these units in the United States and Canada. On the other hand, the ratios are approximately constant for the remainder of the world due to a lesser reliance on geothermal heat pumps, and the greater number of operating hours per year for these units.

Electric Power Generation

Geothermal power is generated by using steam or a hydrocarbon vapor to turn a turbine-generator to produce electrons. A vapor-dominated (dry steam) resource can be used directly, whereas a hot water resource needs to be flashed by reducing the pressure to produce steam. Low temperature resources, generally below 150°C, require the use of a secondary low boiling point fluid (hydrocarbon) to generate the vapor, in a binary or organic Rankine cycle plant. Usually a wet or dry cooling tower is used to condense the vapor after it leaves the turbine to maximize the temperature drop between the incoming and outgoing vapor and thus increase the efficiency of the operation. The worldwide installed capacity has the following distribution: 27% dry steam, 41% single flash, 20% double flash, 11% binary/combined cycle/hybrid, and 1% backpressure (Bertani, 2010).

Electric power has been produced from geothermal energy in 27 countries; however, Greece, Taiwan and Argentina have shut down their plants for environmental and economic reasons. Since 2000 the installed capacity in the world has increased by almost 3,000 MWe, with additional plants being installed in Costa Rica, France (Guadeloupe in the Caribbean), Iceland, Indonesia, Kenya, Mexico, and Philippines. In 2004 Germany installed a 210-kWe binary plant at Neustadt Glewe, and 56-MWe plants have been installed on Papua New Guinea to generate electricity for a remote mine. Russia has completed a new 50-MWe plant on Kamchatka. More recently, a 200 kW binary plant using 74°C geothermal water and 4°C cooling was installed at Chena Hot Springs Resort in Alaska (Lund, 2006). The operating capacity in the United States has increased since 1995 due to completion of the two effluent pipelines injecting treated sewage water at The Geysers. In an attempt to bring production back, the Southeast Geysers Effluent Recycling Project is now

Table 2. Summary of Regional Geothermal Use in 2010

	ELECTRIC POWER			DIRECT-USE		
Region	**% MWe**	**% GWh/yr**	**#countries**	**%MWt**	**%GWh/yr**	**# countries**
Africa	1.6	2.1	2	0.1	0.6	7
Americas	42.6	39.9	6	28.9	18.4	15
Asia	34.9	35.1	6	27.5	33.8	16
Europe	14.5	16.2	7	42.5	45.0	37
Oceania	6.4	6.7	3	1.0	2.2	3

Table 3. Leading Countries in Electric Power Generation (>100 MWe) (Bertani, 2010)

Country	Installed Capacity (MWe)	Running Capacity* (MWe)	Annual Energy Produced GWh/yr	Running Capacity Factor	Number of Units Operating
United States	3,093	2,024	16,603	0.94	209
Philippines	1,904	1,774	10,311	0.66	56
Indonesia	1,197	1,197	9,600	0.92	22
Mexico	958	958	7,047	0.84	37
Italy	843	843	5,520	0.75	33
New Zealand	628	628	4,055	0.74	43
Iceland	575	575	4,597	0.91	25
Japan	536	422	3,064	0.83	20
El Salvador	204	192	1,422	0.85	7
Kenya	167	167	1,430	0.98	10
Costa Rica	166	166	1,131	0.78	6

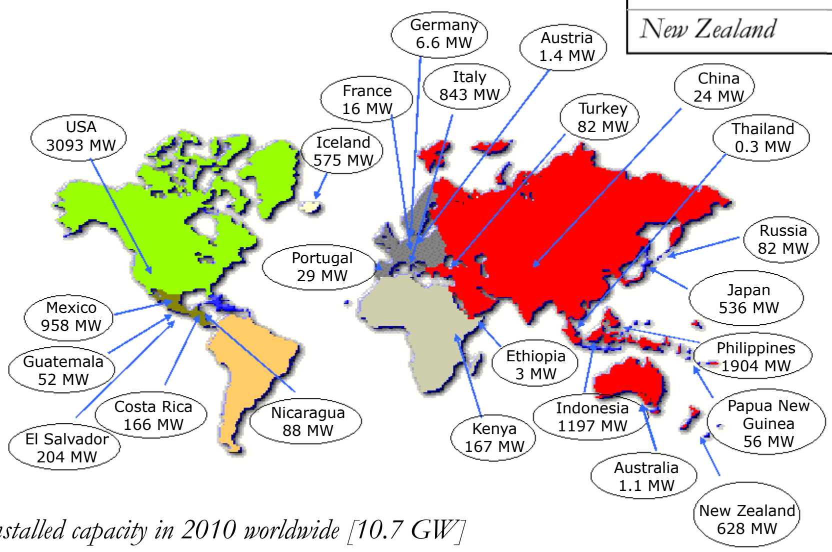
**Note: some running capacity figures were not available, and thus were assumed equal to the installed capacity.*

injecting 340 l/s of treated wastewater through a 48-km long pipeline from Clear Lake, adding 77 MWe. A second, 66-km long pipeline from Santa Rosa was placed on-line in 2004, injecting 480 l/s that are projected to add another 100 MWe to The Geyser's capacity. Table 3 lists the leading countries producing electric power.

One of the more significant aspects of geothermal power development is the size of its contribution to national and regional capacity and production of countries. Based on preliminary data from country update papers in WGC2010, the following countries or regions lead in this contribution with more than 5% of the electrical energy supplied by geothermal power (Table 4).

Table 4. National and Regional Geothermal Power Contributions

Country or Region	% of National or Regional Capacity *(MWe)*	% of National or Regional Energy *(GWh/yr)*
Libir Island, Papua New Guinea	*75*	*n/a*
Tibet	*30*	*30*
San Miguel Island, Azores	*25*	*n/a*
Tuscany, Italy	*25*	*25*
Iceland	*22*	*27*
El Salvador	*15*	*26*
Kenya	*12*	*17*
Philippines	*12*	*17*
Nicaragua	*11*	*10*
Guadeloupe (Caribbean)	*9*	*9*
Costa Rica	*8*	*12*
New Zealand	*6*	*10*



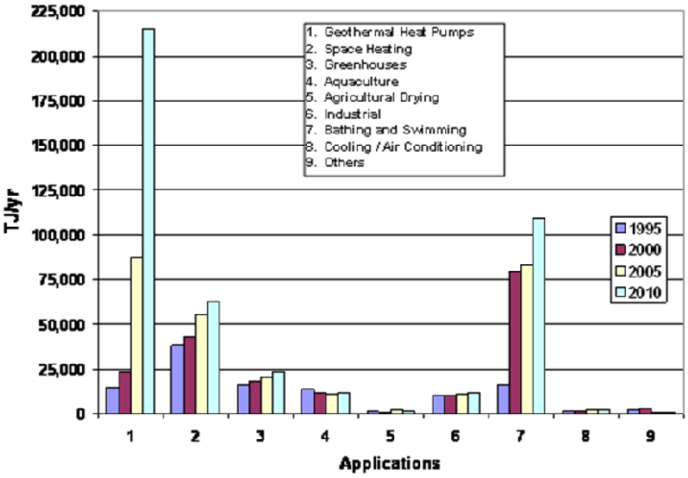
Installed capacity in 2010 worldwide [10.7 GW]

Direct Utilization

Direct-use of geothermal resources is primarily for space heat and cooling. The main utilization categories are: (1) swimming, bathing and balneology; (2) space heating and cooling including district energy systems; (3) agricultural applications such as greenhouse and soil heating; (4) aquaculture application such as pond and raceway water heating; (5) industrial applications such as mineral extraction, food and grain drying; and (6) geothermal (ground-source) heat pumps, used for both heating and cooling. Direct-use of geothermal resources normally involves temperatures below 150°C. The main advantage of using geothermal energy for direct use projects in this low- to intermediate-temperature range is that these resources are more widespread and exist in at least 80 countries at economic drilling depths. In addition, there are no conversion efficiency losses and projects can use conventional water-well drilling and off-the-shelf heating and cooling equipment (allowing for the temperature and chemistry of the fluid). Most projects can be on line in less than a year. Projects can be on a small scale ("mom and pop operations") such as for an individual home, single greenhouse or aquaculture pond, but can also be a large scale operation such as district heating/cooling, food and lumber drying, and mineral ore extraction.

It is often necessary to isolate the geothermal fluid from the user side to prevent corrosion and scaling. Care must be taken to prevent oxygen from entering the system (geothermal water normally is oxygen free), and dissolved gases and minerals such as boron, arsenic, and hydrogen sulfide must be removed or isolated as they are harmful to plants and animals. On the other hand carbon dioxide, which often occurs in geothermal water, can be extracted and used for carbonated beverages or to enhance growth in greenhouses. The typical equipment for a direct-use system includes downhole and circulation pumps, heat exchangers (normally the plate type), transmission and distribution lines (normally insulated pipes), heat extraction equipment, peaking or back-up plants (usually fossil fuel fired) to reduce the use of geothermal fluids and reduce the number of wells required, and fluid disposal systems (injection wells). Geothermal energy can usually meet 95% of the annual heating or cooling demand while sized for only 50% of the peak load. Geothermal heat pumps include both open (using ground-water or lake water) and closed loop (either in horizontal or vertical configuration) systems.

The world direct utilization of geothermal energy is difficult to determine, as there are many diverse uses of the energy and these are sometimes small and located in remote areas. Finding someone, or even a group of people, in a country who is knowledgeable on all the direct uses is difficult. In addition, even if the use can be determined, the flow rates and temperatures are usually not known or reported; thus, the capacity and energy use can only be estimated. This is especially true of geothermal waters



Comparison of worldwide energy use in TJ/yr for 1995, 2000 and 2005.

used for swimming pools, bathing and balneology. Thus, it is difficult to compare changes from one report to the next.

One of the significant changes for WGC2010 was the increase in the number of countries reporting use. Six countries were added to the list in the current report as compared to 2005. In addition, the authors are aware of three countries (Malaysia, Mozambique, and Zambia) that have geothermal direct-uses but did not provided a report for WGC2010. Thus, there are at least 81 countries with some form of direct utilization of geothermal energy.

Another significant change from 2005 is the large increase in geothermal (ground-source) heat pump installations. Over the five-year period to the year 2010, they increased by 229% in capacity (18% annual growth) and 245% in energy supplied (20% annual growth) . At present (2010), they are the largest portion of the total direct-use installed capacity (69.7%) and 49.0% of the annual direct energy use. The equivalent number of 12-kWt units installed (the average size) is approximately 2,940,000 in 43 countries, mostly in the United States, Canada and Europe; however, the data are incomplete. The equivalent number of full-load heating operating hours per year varies from 2,000 in the U.S. to over 6,000 in Sweden and Finland, with a worldwide average of 2,200 full-load hours/year.

A summary of direct-use installed capacity and annual energy use is as follows (excluding geothermal heat pumps at 69.7% and 49.0% of the total); bathing/swimming/spas 43.6% and 48.8%, space heating 35.1% and 28.2% (district heating accounts for approximately 85% of the space heating use); greenhouse heating 10.1% and 10.4%; aquaculture 4.3% and 5.2%; industrial 3.5% and 5.3%; agricultural drying 0.8% and 0.7%, cooling and snow melting 2.4% and 1.0%; and others 0.2% and 0.4%. .

In terms of the contribution of geothermal direct-use to the national energy budget, two countries stand out: Iceland and Turkey. In Iceland, geothermal provides 89 % of the country's space heating needs, which is important since heating is required almost all year and saves about USD100 million in imported oil. Turkey has increased its installed capacity over the past five years from 1,495 MWt to 2,084 MWt, mostly for district heating systems. A summary of some of the significant geothermal direct-use contributions to various countries is shown in Table 5 and the leading countries shown in Table 6.

Table 5. National Geothermal Direct-Use Contributions

Iceland: provides 89% of country's space heating needs;

Turkey: space heating has increased 40% in the past 5 years, supplying 201,000 equivalent residences. 30% of the country will be heated with geothermal in the future.

Tunisia: greenhouse heating has increased from 100 ha to 194 ha over the past 5 years;

Japan: over 2,000 hot spring resorts (onsens), over 5,000 public bath houses, and over 15,000 hotels, visited by 15 million guests per year, use natural hot springs;

Switzerland: has installed 60,000 geothermal heat pumps (= one/km^2), and 2,000 km of boreholes were drilled in 2009. Drain water from tunnels is used to heat nearby villages and they have also developed several geothermal projects to melt snow and ice on roads;

United States: has installed 1,000,000 geothermal heat pump units, mainly in the midwestern and eastern states, with a 12.5% annual growth. The installation rate of these units is around 100,000 to 120,000 per year.

Table 6. Top Direct-Use Countries

Country	GWh/yr	MWt	Main Applications
China	20,932	8,898	bathing/district heating
USA	15,710	12,611	GHP
Sweden	12,585	4,460	GHP
Turkey	10,247	2,084	district heating
Japan	7,139	2,100	bathing (onsens)
Norway	7,001	3,300	GHP
Iceland	6,768	1,826	district heating
France	3,592	1,345	district heating
Germany	3,546	2,485	bathing/district heating
Netherlands	2,972	1,410	GHP
Italy	2,762	867	spas/space heating
Hungary	2,713	655	spas/greenhouses
New Zealand	2,654	393	industrial uses
Canada	2,465	1,126	GHP
Switzerland	2,143	1,061	GHP

ENERGY SAVINGS

Using geothermal energy obviously replaces fossil fuel use and prevents the emission of greenhouse gases. If we assume that geothermal energy replaces electricity generation with a conversion efficiency of 0.35 (35%), the savings using geothermal energy can be estimated as shown in Table 7 (Goddard and Goddard, 1990). If the replacement energy for direct-use is provided by burning the fuel directly, then about half this amount would be saved in heating systems (35% vs. 70% efficiency). Savings in the cooling mode of geothermal heat pumps are also included in the figures in Table 7. The savings in fossil fuel oil a equivalent to about three days (1%) of the world's consumption.

It should be noted, when considering these savings, that some geothermal plants do emit limited amounts of the various pollutants; however, these are reduced to near zero where gas injection is used and eliminated where binary power is installed for electric power generation. Since most direct-use projects use only hot water and the spent fluid is injected, the above pollutants are essentially eliminated.

FUTURE DIRECTIONS

Geothermal growth and development of electricity generation has increased significantly over the past 40 years, approaching 11% annually in the early part of this period and dropping to 3% annually in the last ten years due to the low price of competing fuels. Direct-use has remained fairly steady over the 40-year period at 10% annual growth. The majority of the increase has been due to geothermal heat pumps. At the start of this 40-year period, only ten countries reported electrical production and/or direct utilization from geothermal energy. By the end of this period, 78 countries reported using geothermal energy. This is almost an eight-fold increase in participating countries. At least another 10 countries are actively exploring for geothermal resources and should be online by 2015.

Developments in the future will include greater emphasis on combined heat and power plants, especially those using lower temperature fluids down to 100°C. This low-temperature cascaded use will improve the economics and efficiency of these systems, such as shown by those installed in Germany and Austria and at Chena Hot Springs, Alaska. Also, there is increased interest in agricultural crop drying and refrigeration in tropical climates to preserve products that might normally be wasted. Finally, the largest growth will include the installation and use of geothermal heat pumps, as they can be used anywhere in the world, as shown by the large developments in Switzerland, Sweden, Austria, Germany, Canada, and the United States.

Table 7. Energy and Greenhouse Gas Savings from Geothermal Energy Production

	Fuel Oil (10^6)		Carbon (10^6 t)			CO_2 (10^6 t)			SOx (10^6 t)			NO_x (10^3 t)		
	Barrels	Tonnes	NG	Oil	Coal	NG	Oil	Coal	NG	Oil	Coal	NG	Oil	Coal
Electric	114	17	6	15	17	31	49	58	0	0.3	0.4	3.4	10.1	10.1
Direct-use	154	23	9	23	27	46	74	88	0	0.5	0.5	4.5	13.6	13.6
TOTAL	268	40	15	38	44	77	123	146	0	0.8	0.9	8.9	23.7	23.7

REFERENCES

Bertani, R., 2005. "World Geothermal General 2001-2005 -- State of the Art." Geothermics, Vol 34, No. 6 (Dec.), Elsevier, Amsterdam, Netherlands

Bertani, R., 2010. "Geothermal Power Generation in the World, 2005-2010 Update Report", Proceedings of the World Geothermal Congress 2010, Bali, Indonesia.

Lund, J. W. and D. H. Freeston, 2001. "World-Wide Direct Uses of Geothermal Energy 2000." Geothermics, v. 30, n.1, Elsevier, Oxford, UK, pp. 29-68 (updated and revised).

Lund, J. W., D. H. Freeston and T. L. Boyd, 2005. "Direct application of geothermal energy: 2005 worldwide review." Geothermics, Vol. 34, No. 6 (Dec.), Elsevier, Amsterdam, Netherlands, pp. 691-727.

Lund, J. W., D. H. Freeston, and T. L. Boyd, 2010. "Direct Utilization of Geothermal Energy 2010 Worldwide Review', Proceedings of the World Geothermal Congress 2010, Bali, Indonesia.

So How Long IS that Piece of String ?

Jim Lawless, IGA BoD member and SKM, New Zealand

Two of the presentations at WGC2010 were about the recently released Australian Code for Geothermal Reserves and Resources Reporting (Williams et al., 2010; Lawless et al., 2010). There has also been recent comment from the Canadian Geothermal Association about their even newer version of the same.

So why is this topic so important now and why hasn't it been done before ? Jim Lawless, head of the IGA ad-hoc Committee on Reserves and Resources, made the following comments about the Australian code:

"People have been trying to estimate the usable capacity of geothermal resources ever since large scale geothermal development started over 50 years ago. So in one sense this is nothing new. But what has happened recently is that a much greater proportion of the funding for geothermal development, especially for projects at an early stage, is now being raised on the stock-markets, especially in Canada and Australia. New entrants to the geothermal world in those countries were surprised to find that, unlike for mineral or petroleum deposits, there are no widely recognised national nor international standards for reporting to potential investors on geothermal resource or reserve capacities.

"Some of the leading geothermal companies in each country recognised that, without standards, this could lead to unrealistic claims being made by irresponsible promoters and a general loss of credibility for the industry. Accordingly, committees in both counties started work on drawing up appropriate Codes, in consultation with the relevant regulatory authorities.

"The Australians finished first. Their Code has now been in use for 18 months. Sensibly, the authorities running the Australian Stock Exchange recommended a trial period before making it mandatory for ASX reporting. But that does not mean it has no effect. All of the leading Australian geothermal companies have unanimously and voluntarily agreed to adopt the Code. The trial period has been very useful in terms of refining the concepts and rules and a Second Edition of the Australian Code is about to be released.

"In the meantime the IGA has reviewed the Australian code and has agreed to support it as being appropriate. It is interesting that we are starting to see projects in other countries and non-Australian companies making use of it. They clearly appreciate the credibility it brings".

Alison Thompson, Chair of CANGEA added: "With over $1 billion of geothermal power company market capitalization on the Toronto and Venture Stock Exchanges, the Geothermal Reporting Code is a long overdue measure for our industry. Leading companies using the Code recognize that the competition for equity funding is not only between geothermal businesses, but between all resource-based opportunities including oil and gas and mining. The introduction of the Reporting Code goes a long way to help investors measure risk and evaluate rewards and then choose the appropriate investment for them, be it a barrel of oil, an ounce of gold or a MW of geothermal electricity.

"While the Geothermal Reporting Code is in a trial year before it becomes mandatory for CanGEA member companies, we are extremely pleased with the rapid uptake by some of the most influential players in the industry including developers, qualified persons and investments banks."

For further information, please contact Jim Lawless: JLawless@skm.co.nz

Election of IGA Board of Directors (2010-2013)

The term of office of the current BoD expires in October 2010, so it is time to launch the election of a new BoD for the next term. This article will give members an idea of how the balloting will be carried out and also a list of candidates for you to review. The ballot and other election material will be made available through the IGA website and voting will be completed by July 26, 2010. You may vote for a maximum of 30 candidates. A personal IGA password will be provided to each member by e-mail for access to the election website. In addition to providing access to the IGA election page, the personal password can be used to access members' areas on the IGA website. Therefore, it is important that the password be preserved for future use. The following voting alternatives will be available:

1. Go to the IGA website: www.geothermal-energy.org, and choose the link to the election page. There you can use your personal password that you will receive by e-mail to access the ballot, mark your vote and submit it through the internet. This method is preferred for all those who have access to the internet.
2. Those members who do not have an e-mail address and are not able to vote through the web can request the IGA Secretariat (Tel. +354 588 4430) to send the election material to them by postal mail. The list of candidates on the opposite page can also be used as a ballot. Mark your vote on the ballot, fold it and insert it in an envelope. Write your name and address on the envelope as sender and mail it to: IGA Secretariat /Samorka, Sudurlandsbraut 48, 108 Reykjavik, Iceland. The vote will be treated as invalid if you do not write your name and address on the envelope. If you prefer, you can also send your ballot by fax (+354 588 4431) or e-mail (iga@samorka.is). In this case, you must also give your name.

Election of IGA Board of Directors (2010-2013)

List of candidates

Name	Country	Name	Country
Miklos A. Antics *	Romania	Bjarni Pálsson #	Iceland
Nilgun Bakir #	Turkey	György Pátzay #	Hungary
Graeme Beardsmore *	Australia	Fernando S. Penarroyo #	Philippines
Christian Boissavy *	France	Sanja Popovska V. *	Macedonia
D. Chandrasekharam &	India	Paul Quinlivan #	New Zealand
Surya Darma *	Indonesia	Árni Ragnarsson &	Iceland
Luis C. A. Gutiérrez-Negrín #	Mexico	Paolo Romagnoli #	Italy
Marek Hajto #	Poland	Horst Rüter *	Germany
Valiya Hamza &	Brazil	Ladislaus Rybach *	Switzerland
Colin Harvey *	New Zealand	Burkhard Sanner #	Germany
Paul Hirtz *	USA	Silas Simiyu &	Kenya
Roland Horne *	USA	Yoonho Song &	S. Korea
Herman Darnel Ibrahim #	Indonesia	Benedikt Steingrímsson *	Iceland
Eduardo Iglesias &	Mexico	Valentina Svalova #	Russia
Ryszard Henryk Kozlowski #	Poland	Gábor Szita #	Hungary
Horst Kreuter *	Germany	Koichi Tagomori #	Japan
Zbigniew Malolepszy @	Poland	Richard B. Tantoco #	Philippines
George Melikadze #	Georgia	Meseret Teklemariam #	Ethiopia
Francisco E. Montalvo *	El Salvador	Roland Wyss #	Switzerland
Juliet Newson #	New Zealand	Kasumi Yasukawa *	Japan
Zhonghe Pang #	China	Feliksas Zinevicius #	Lithuania

* Current member of the Board re-nominated by the Nominating Committee

\# Nominated by an affiliated organization

@ Candidate by petition

& Candidate from Nominating Committee

EUROPE

TRANSENERGY: TRANSBOUNDARY GEOTHERMAL ENERGY RESOURCES OF SLOVENIA, AUSTRIA, HUNGARY AND SLOVAKIA

PROJECT BASIC INFORMATION

Central Europe Programme, Application Round 2, Priority 3: Using our environment responsibly

Duration: 01.04.2010 - 31.03.2013

Partners: National Geological Surveys of Hungary (MÁFI), Austria (GBA), Slovakia (SGUDS) and Slovenia (Geo-ZS)

Lead partner: MÁFI, project leader: Dr. Annamária Nádor (nador@mafi.hu)

INTRODUCTION

The project "TRANSENERGY – Transboundary Geothermal Energy Resources of Slovenia, Austria, Hungary and Slovakia" aims to provide implementation tools based on a firm geoscientific basis for enhanced and sustainable use of geothermal resources in the western part of the Pannonian basin (Fig. 1)

The project addresses the key problem of using in a sustainable way natural resources that are shared by different countries. Natural resources such as geothermal energy, whose main carrying media are deep groundwaters along regional flow paths, are strongly linked to geological structures that do not stop at state borders, i.e. integral parts of the entire flow system encompass vast areas (recharge areas lie in mountain regions while waters discharge from the deeply buried basement structures of intramountain basins). Therefore only a transboundary approach and the establishment of a joint, multi-national management system may handle the assessment of geothermal energy and the limits of use in a region, irrespective of political state borders.

The responsible use of natural resources is an important issue when possible national interventions may cause unfavourable effects in a neighbouring country. This is especially true for transboundary aquifers, where water extraction at a national level without cross-border harmonized management strategies may cause negative impacts (depletion, or overexploitation) leading to unnecessary economic and political tensions between countries. The need for complex assessment in transboundary regions is in line with water protection policy and rational water use as set up in the Water Framework Directive (2000/60/EC).

Geothermal energy is strongly restricted to areas with appropriate geological makeup (high geothermal gradient, favourable reservoir rocks and sufficient transporting media - geothermal fluids). In this respect the target area of the project has outstanding opportunities. Due to the thin lithosphere, the geothermal gradient is above the world average in the Pannonian Basin. The project region is divided by state borders into four independent Member States (Austria, Slovakia, Slovenia, Hungary), but geologically the area is composed of interconnected structures of the Eastern Alps, Western Carpathians and different sub-basins of the Pannonian Basin, with vast amounts of transboundary geothermal resources.

STAKEHOLDERS AND THEIR EXPECTED NEEDS

The project intends to supply the needs of users for simple, transparent, interoperable and harmonized data and geoscientific information for their everyday work. Stakeholders of the project comprise a wide range of decision-making bodies (ministries, local and regional governmental authorities, municipalities), water management and environmental protection authorities, development agencies, land-use planning organizations, thermal water users (spas, health centres, heating systems), potential investors for energy production, other organizations (scientific associations, non-profit agencies, clusters, consulting agencies, universities, research companies, drilling companies, etc. dealing with geothermal utilization). The main aim is to assemble a stakeholder panel and prioritize data and service types based on their demand.

The project is designed to involve stakeholders directly in the project as observers/beneficiaries, and/or members of the External Evaluation Board (see project management). Stakeholders will be reached through media and non-media communication tools (website and promotional materials, press-releases, events at local and transnational levels, workshops, etc.).

PROJECT MANAGEMENT ORGANISATION

A Strategic Management Board (= Steering Committee) was set up at the beginning of the project, consisting of the Project Manager (PM), Financial Manager (FM), Communication Manager (CM), Work Package leaders and the project co-ordinators of the partner organizations (PPC) (Fig. 2). It is responsible for implementing project work and making all major operational decisions.

An External Evaluation Board (EEB) of key-stakeholders will be set up, representing equally each country: one national and one local governmental representative, one current and one potential user as well as a maximum of 3 people from international agencies. This Board will be set up during the first 7 months period

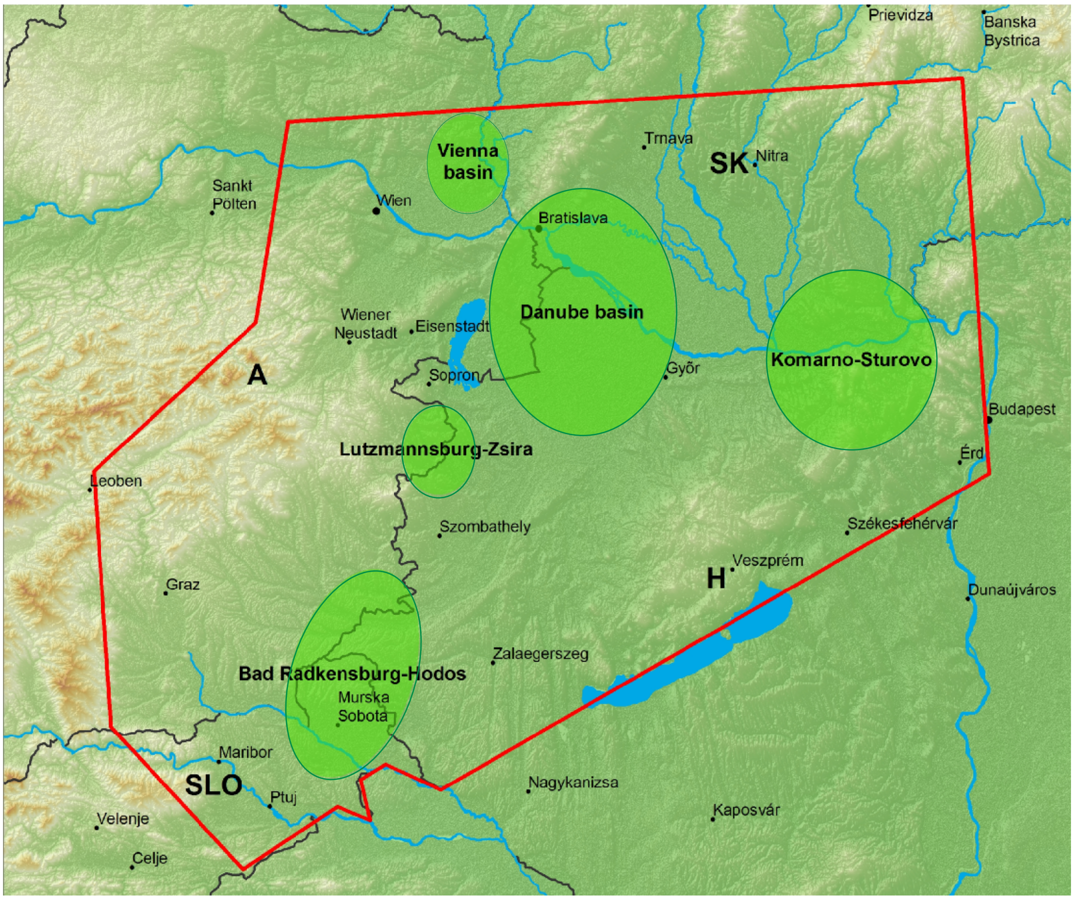


Fig. 1 Transenergy project area. Within the "supra-regional" area (red line) the project focuses on some representative regions along the borders (thermal karst of the Komarno-Sturovo area (H-SK), Pannonian Central Depression of the Danube basin (A-SK-H), Lutzmannsburg – Zsira area (A-H), Vienna basin (SK-A) and Bad Radkersburg – Hodoš area (A-SLO-H)

and will evaluate project performance via questionnaires, assessments and reporting, thus providing an independent appraisal. Participation in the EEB will be without payment, except for travel costs if this is necessary. The members of EEB will be stimulated into active participation by getting ideas for solutions to similar questions they perceive during their everyday work related to geothermal resource management.

SUMMARY OF THE WORK TO BE IMPLEMENTED

The project website (http://transenergy-eu.geologie.ac.at) will be the central information medium that will inform stakeholders and the public about the progress of the work and results.

The project aims to transfer expert know-how about geothermal resources and sustainable reservoir management to quite heterogeneous target groups (governmental authorities, experts, private investors). For that purpose, as a final outcome of the project, a web-based geothermal resource information tool will be established, which is intended to act as a decision support tool for future geothermal exploration and exploitation. It will show all relevant information on the potential, vulnerability and sustainability of the geothermal system in the investigated transboundary regions with different extraction scenarios of thermal water/heat, based on a simplified reservoir simulator. Workshops on the usage of this web-based information tool, which will serve as a planning tool for decision makers and investors, will be organized for stakeholders in each country.

In order to provide a comprehensive strategy on future geothermal exploitation, a strategy paper will also be compiled at the end of the project which will comprise a) a ranking list of potential geothermal reservoirs in the project area, b) a list of current deficiencies in the legal framework and funding strategies, c) a comprehensive catalogue of best practice methods for monitoring of geothermal utilizations to reduce environmental and technical risks, and d) a general scheme of a potential demonstration plant including technical concepts.

These two major outputs (web-based tool and strategy paper) will be established on the basis of a wide range of activities performed during the course of the project, which is summarized briefly below.

Common data sets and a joint database with harmonized data that are comparable between the countries are crucial for successful completion of the project. Rich geological data exist in the partner Geological Surveys, but data are diverse and of low uniformity (different formats, scales, projections, origins, etc.). Data relevant to the project include various types of geological maps and cross-sections, geophysical profiles, borehole data (lithostratigraphy, well-logs, production parameters, thermal data), hydrogeological parameters of thermal waters (e.g. geochemical composition), etc. Partners will provide their national data and will integrate them into a joint multi-lingual database in a common format. Based on the evaluation of datasets, additional measurements and sampling on near-border non-data areas will also be done. A common multi-lingual database with harmonized datasets will be a core output to which the different stakeholders will have access through the project website, where three levels of publicity will be set up (expert, stakeholder, public).

Harmonized datasets are basic requirements for different geoscientific models. These 3D geological, hydrogeological, hydrogeochemical and thermal models cover the whole area ("supra-regional models"), as well as detailed models for some representative regions along the borders (thermal karst of the Komarno-Sturovo area (H-SK), Pannonian Central Depression of the Danube basin (A-SK-H), Lutzmannsburg – Zsira area (A-H), Vienna basin (SK-A) and Bad Radkersburg- Hodoš area (A-SLO-H) (Fig. 1). These regions were selected because of their extreme sensitivity to any further intervention by different management policies in the neighbouring countries.

The 3D geological model will outline the spatial distribution of various rock bodies with similar lithologies that determine hydrostatigraphic units; these are the basic inputs for the hydrogeological models. The regional hydrogeological models will show the quantitative status of the major thermal water flow systems (major path lines of groundwater flows, thermal and cold water budgets and their exchange at state borders, etc.). Hydrogeochemical properties will be used for calibration and validation of the flow model.

A key element is thermal modelling with heat-flow density calculations and a quantitative status assessment of the region. The results will be used to assess the geothermal potential [heat in place] as well as the geothermal resources [extractable heat in place]. Based on the steady state thermal model, time-dependent scenario-modelling will be also carried out assuming different virtual heat extractions. This will show the changes in reservoir pressure and temperature as a function of time for different production scenarios, and will describe the geothermal exploitation capacity of the region.

These models will help the decision makers and authorities both in their daily work of preserving and ensuring sustainable utilization, as well as in negotiations concerning transboundary thermal groundwaters/ geothermal resources.

Actions covering the utilization aspects of geothermal resources will focus on different authorities and users. Data collection by questionnaires will gather available information on current and planned future utilization of geothermal waters in the project area, and thereby will already provide preliminary information on continuous or even enhanced exploitation. It will also bring to the surface legal and exploitation management problems that different target groups face. Special emphasis will be given to the mitigation of possible negative environmental effects, covering also practical and legislative aspects of reinjection.

Joint transboundary utilization maps will be produced, as core outputs, based on evaluation of database information and their analysis, and will result in a series of maps with transboundary aquifers and their current exploitation rates and production parameters. Decision makers could use these maps as background information for enhancing spatial planning actions as well as for identification of problematical areas. Development agencies, potential investors and present thermal water users will be able to identify their advantages and disadvantages in comparison to other regions/users and gain more sensible information on possible future development of selected sites.

A methodology for joint groundwater management will consist of recommendations and practical guidelines for effective joint transboundary management, including a transnational monitoring system.

OTHER

New book on geothermal energy

Luis C.A. Gutiérrez Negrín, Mexican Geothermal Association

April 2010 saw the publication of a new book dealing with geothermal energy, specifically with numeric modeling of geothermal (and groundwater) systems. The title is "Introduction to the numerical modeling of groundwater and geothermal systems" and it is described as presenting the "fundamentals of mass, energy and solute transport in poro-elastic rocks". The authors are J. Bundschuh and M.C. Suárez-Arriaga, and it is published in The Netherlands by CRC Press, a division of Taylor and Francis Group, as a part of its Multiphysics Modeling series. The ISBN code is 978-0-415-40167-8.

Jochen Bundschuh is a German researcher at the Karlsruhe University of Applied Sciences, Institute of Applied Research in Karlsruhe, Germany, and the Royal Institute of Technology (KTH) in Stockholm, Sweden. He has written a couple of books dealing with geothermal, co-authored with D. Chandrasekharam, one of which was reviewed by R. Cataldi (IGA News 76, April-June 2009, pp. 6-8). Mario C. Suárez-Arriaga is a Mexican researcher at the Department of Applied Mathematics and Earth Sciences of the Faculty of Physics and Mathematics of the Michoacán University, in Morelia, Mexico. Suárez-Arriaga is also one of the founder members of the Mexican Geothermal Association (AGM: Asociación Geotérmica Mexicana) and a well-known expert in geothermal modeling.

The book offers an introduction to the basics of geothermal and groundwater systems. The different problems concerning energy and water contained in deformable porous rocks are explained from a simple and didactic point of view. The book also presents the mathematical and numerical tools, and the theories behind them, currently used to model and solve those problems. In this way, the reader is provided with a comprehensive understanding of the physical laws of fluid flow in rocks presenting a thermo-poro-elastic behavior, as well as the partial differential equations that represent those laws and the main numerical methods. This allows the reader to find the approximate solutions of the related mathematical models.

This book explains how specific useful models can be generated and solved. Its introductory character comes from the fact that it explains the basic aspects of geothermal and groundwater systems in three main fields: mathematics, physics and engineering. The laws and equations presented throughout the book have been carefully formulated based on fundamental principles of physics, and thus the reader is able to understand the importance of mathematics applied to the different subjects.

Simple models are presented and solved as the book progresses, together with several examples. Numerical techniques to be used in more sophisticated and advanced models are also described in a careful way. In both cases, the physical interpretation of equations and mathematical results is emphasized.

Parameters and coefficients appearing in aquifers of isothermal and geothermal types are presented, based on well-developed explanations and documented results of experiments. When the book deals with natural reservoirs formed by poro-elastic rocks under changes of pressure and temperature, it gradually introduces the laws of mass, momentum and energy conservation, particularly the two thermodynamic laws.

Coefficients that support theoretical considerations, obtained from experimental results, are also presented from a practical viewpoint, including short descriptions about how these coefficients are measured in the laboratory.

The book introduces some relatively new ideas, among them:

- The formulation in four dimensions of the linear poro-elastic theory.
- The deduction of thermo-poro-elastic matrix equations in four dimensions by using the Gibbs and Helmholtz potentials.
- A model to estimate the collapse of fractures and faults in rocks.
- Direct examples of the thermodynamics of porous rocks.
- Numerical values and relationships of poro-elastic coefficients.
- Practical correlations for low enthalpy aquifers and two-phase hydrothermal reservoirs.
- A graphical presentation of the properties of water and some examples of models of groundwater and geothermal systems.

This book is intended to be a synoptic compendium of the fundamentals of transport of fluids, solutes and heat, applicable to all types of underground systems from shallow aquifers to deep hydrothermal reservoirs. As such, it will surely be a useful textbook for senior undergraduate and graduate students, postgraduates, geologists, hydro-geologists, geophysicists, engineers, mathematicians, and other professionals involved in the important fields of groundwater and geothermal resources.

The general content of the book is as follows:

1. Introduction: The water and energy problems, the vision of the Intergovernmental Panel on Climate Change (IPCC), mutiphysics modeling, modeling needs in the socio-economic context, the importance of numerical modeling.
2. Rock and fluid properties: Properties of porous rocks, linear thermo-poro-elastic deformation including the Biot-Willis coefficient, properties of water.
3. Special properties of heterogeneous aquifers: The concept of multiple porosity, the concept of triple porosity-permeability in geothermal systems, average parameters, general models of mixtures, applications to field-data, discontinuity of parameters at interfaces, petrophysical properties of Mexican geothermal fields (Los Azufres, Los Humeros and Cerritos Colorados) as examples of heterogeneous non-isothermal aquifers.
4. Fluid flow, heat and solute transport: Fluid mass conservation, the Navier-Stokes equations, Darcy's law, flow to wells in homogeneous aquifers, fundamentals of pump-tests, equations for heat transport, flow in two-phase reservoirs, equations for solute transport.
5. Principal numerical methods: Finite difference method, finite element method (FEM) including the linear Lagrange interpolation polynomials, the Poisson equation and the Galerkin method, finite volume method (FVM), boundary element method for elliptic problems including the Dirac distribution.
6. Procedure of a numerical method elaboration: Objectives of numerical methods, conceptual models, types and the field-data required to construct them, numerical formulation, parameter estimation, selection of model type and code (including the ASM, SUTRA, TOUGH2, COMSOL Multiphysics, NODFLOW and STAR methods), analysis of calibration and sensitivity, numerical simulations, assessment of uncertainties, misuses and mistakes, example of model construction.

7. Parameter identification and inverse problems (chapter written by Ángel Pérez and Longina Castellanos): Ill-posed examples of the inverse problem, linear least-squares (LLS), non-linear least squares (NLS), application examples.
8. Groundwater modeling application examples: Groundwater extraction, water exchange by leakage, modeling scenario of multi-layer aquifers, point source contamination and remediation, boron contamination, annual temperature oscillations in a shallow stratified aquifer.
9. Geothermal systems modeling examples: Geothermal energy and characteristics of Mexican geothermal reservoirs, transient radial-vertical heat conduction in wells, Avdonin model, geothermal brine in oil reservoirs, modeling submarine geothermal systems and potentials, modeling processes in fractured geothermal systems, including simple, double and triple-porosity models.

Mathematical appendixes: Karl Weierstrass approximation theorem, Lagrange interpolation polynomials, Stokes integral theorem, Riemann's theorem, Green's first and second identity, divergence theorem, Dirac distribution, Jochen's table.

More information about this book is available by clicking the following link:

http://www.crcpress.com/product/isbn/9780415401678

IGA News

IGA News is published quarterly by the International Geothermal Association. The function of IGA News is to disseminate timely information about geothermal activities throughout the world. To this end, a group of correspondents has agreed to supply news for each issue. The core of this group consists of the IGA Information Committee:

The members of this group submit geothermal news from their parts of the world, or relevant to their areas of specialization. If you have some news, a report, or an article for IGA News, you can send it to any of the above individuals, or directly to the IGA Secretariat, whatever is most convenient. Please help us to become essential reading for anyone seeking the latest information on geothermal worldwide.

Send IGA News contributions to:
IGA Secretariat, c/o Samorka
Sudurlandsbraut 48, 108 Reykjavík, Iceland
fax: +354-588-4431
e-mail: iga@samorka.is

This issue of IGA News was edited by Eduardo Iglesias. John Garnish proofread the articles. Produced by Gestur Gíslason for the IGA Secretariat. Design layout by François Vuataz.

Application for membership

Please complete the following form and return it with payment to:

International Geothermal Association Secretariat
c/o Samorka
Sudurlandsbraut 48, 108 Reykjavik, Iceland
tel: +354-588-4437; fax: +354-588-4431;
e-mail: iga@samorka.is
IGA Home Page: www.geothermal-energy.org

Membership

☐ Enrol me as a new member of IGA
☐ Renew my membership to IGA

Dr Mr Mrs Ms (circle)
Family name ______________________
First name ______________________
Profession ______________________
Organization ______________________
Address ☐ Work ☐ Home
____
____

Phone (area code) ______________________
Fax (area code) ______________________
e-mail ______________________

Note: The information you provide will be held on the IGA database. It will be used to update you on the activities of the Association, and may be changed or cancelled at any time upon your request. It will be included in the IGA Directory, which may be circulated in printed or electronic form to IGA members only. If you do not wish your details to be used for this purpose, please tick the box (in which case your name will not be printed in the IGA Directory) ☐

Membership category

☐ Individual - USD 30
☐ Student - USD 5
☐ Corporate - USD 300
☐ Institutional - USD 750
☐ Sustaining: individual - USD 100
☐ Sustaining: corporate - USD 1000

Representatives of Corporate and Institutional members:
Contact person ______________________
Second person ______________________
Third person ______________________

Payment

There are three ways to make payment to IGA:

1. International Wire Transfer in USD

Please notify the Secretariat by fax or e-mail when you wire funds.

Bank: Kaupthing Banki
Branch 0301
Address: Laugavegur 120
105 Reykjavik
Iceland
Account # 0338-38-100551
SWIFT: ESJA IS RE
IBAN: IS 410338381005516301079620

2. Bank draft, company or personal check in USD.

3. Credit card

☐ Master Card
☐ American Express
☐ Visa

Card # ______________________
Expiration date ______________________
Signature ______________________
Date of signature ______________________
2008 dues USD ______________________
2009 dues USD ______________________
2010 dues USD ______________________
2011 dues USD ______________________
Contribution USD ______________________
TOTAL USD ______________________

These financial data will not be stored on a database, and will not be recorded in any electronic form.