IGA NEWS

Newsletter of the International Geothermal Association

Quarterly No. 85

IGA ACTIVITIES

Message from the President

Roland N. Horne

Greetings IGA Members, and I hope that those of you in the Northern Hemisphere have been enjoying your summer (and that those in the South have been enjoying your winter!) In my letter this time, I'd like to describe "how I spent my summer vacation"… My narrative is about geothermal education.

Our international geothermal community has hosted several international education programs over the years, in Kyushu (Japan), Pisa (Italy), Auckland (New Zealand), Reykjavik (Iceland), Mexicali (Mexico), and Skopje (Macedonia), as well as many other geothermal courses and programs within the world's universities. The (northern) summer of 2011 saw the inaugural class of geothermal students sitting down to work at the National Geothermal Academy (NGA) in Reno, Nevada, representing the first comprehensive geothermal education program in the US. The idea of the program came from the US Department of Energy in 2009, in response to rapid expansion of geothermal development activity in the US that was encountering difficulty hiring personnel with the appropriate geothermal skills. From that seed of an idea, the program was designed and constructed by a consortium of US universities and organizations, including my own university, Stanford, together with Cornell, Southern Methodist University, Oregon Institute of Technology, University of Utah, West Virginia University, and importantly University of Nevada at Reno. Important contributions to the program also came from industry,

Roland Horne teaching a class at the NGA

Contents

including classes in drilling taught by Lou Capuano, Jr. and Lou Capuano III, and classes in power plants by Ron DiPippo. Under the leadership of Prof. Wendy Calvin at UNR, the course was divided into eight subject modules, each taught by a professor or group of professors from the participating universities and organizations. 27 students attended the entire eight week sequence, and another 27 students sat in one or more of the individual modules.

Although this is a concept that has been applied to very good effect in other international geothermal education programs, this was a first for the US.

As reported by Wendy Calvin, a total of 54 students took advantage of the course offerings in summer 2011. More than half of those students were from industry, government or academic research positions and they were already working in the field. The numbers are shown in the following table.

Full 8 week	27	Grad	21	US	45
Ind. Module	27	Industry	17	International	9
		Academic	7		
		Government	5		
		Undergrad	4		
Total	54				

I spent a week in Reno in July, teaching the reservoir engineering module. The experience was an inspiration. The students in the program were an energetic bunch, enthusiastic about geothermal energy, and working hard (very hard) to succeed in the courses. As I have observed and experienced in other international education programs, the NGA student group was notable for its cohesiveness, and the camaraderie among its members. The friendships made within this group are, I'm sure, likely to last for a long time, especially as these inaugural class graduates will surely encounter each other again and again in the geothermal industry.

It is on this youthful community that I would like to reflect. The establishment of a new generation of geothermal experts is vital to the continuation and proliferation of our field. Geothermal energy development calls for a broad range of skills, and demands versatile and talented individuals. As more experienced experts retire, new people must be available, and willing, to take their place. The provision of a new talent pool is a rich prize for our field. The NGA, and its counterparts in the world, have been brilliantly successful in providing this opportunity to new graduates.

But skills alone are not sufficient to drive geothermal development forward. Our field is considered sufficiently "unusual" by many, so that those motivated to join it require a degree of pioneering spirit and a dose of evangelical enthusiasm. I believe that it is this combination of innovation and zest that gives our geothermal classes the personal cohesiveness that they all seem to enjoy.

With passionate groups of young people launching out from our educational programs and institutions, the future of geothermal energy is in good hands!

With Best Regards

Roland N. Horne

UPCOMING EVENTS

World Renewable Energy Congress 2011, 17-19 October, Bali, Indonesia. Website: http://wreeec2011bali.com

GRC 35th Annual Meeting, 23-26 October 2011, San Diego, CA, USA. Website: www.geothermal.org

Geothermal Power Forum and Networking Event, 9 November 2011, Calgary, Canada. Website: www.cangea.ca

9th Asian Geothermal Symposium, 7-9 November, Ibusiki, Kagoshima, Japan. Website: http://unit.aist.go.jp/georesenv/english/event-e/asia9.html

Sustainable Earth Science Conference, 8-11 November 2011, Valencia, Spain. Website: http://www.eage.org/events/index.php?eventid=551&Opendivs=s3

Der Geothermiekongress 2011, 15-17 November 2011, Bochum, Germany.
Website: www.geothermie.de

Australian Geothermal Energy Conference 2011, 16-18 November 2011, Melbourne, Australia. Website: www.ausgeothermal.com

Kenya Geothermal Conference, 21-23 November 2011, Nairobi, Kanya. Website: www.gdc.co.ke

33rd New Zealand Geothermal Workshop, 21-23 November 2011, Auckland, New Zealand. Website: www.nzgeothermal2011.org.nz

Geopower Europe 2011, 5-7 December 2011, Milan, Italy. Website: http://www2.greenpowerconferences.co.uk

37th Stanford Workshop on Geothermal Reservoir Engineering, 30 Jan-1st Feb 2012, Stanford, CA, USA. Website: http://pangea.stanford.edu/ERE/research/ geoth/conference/workshop.html

AMERICAS

Geothermal Energy Applications in the South American Mining Industry: Examples of Geologic and Financial Synergies With Global Applications

By Cully Cavness and Andrés Ruzo

Mining presents a number of appealing advantages to the geothermal industry as a potential partner and consumer of electricity. This article will explore the aspects of geology, logistics, and finance that enable valuable mining-geothermal collaborations, and will conclude with a number of examples from Argentina, Peru, and Chile.

The mining-geothermal opportunity begins with geology, and the fact that many important ore veins precipitated from ancient hydrothermal systems. For example gold lodes often precipitate as hydrofracture breccias where heated subterranean waters with concentrations of dissolved gold cool and precipitate the gold in fractures and fissures. That cooling can occur for a variety of reasons ranging from upward convection away from a heat source (short term) or changing geologic conditions causing the migration of a heat source (long term). In either the short or long-term case there is a possibility that active hydrothermal systems may still exist in the general vicinity of ancient hydrothermal systems (mineral deposits). Therein lies an opportunity. Simply put—today's mineral deposit was yesterday's geothermal system.

Logistics constitute the second major pillar of the collaboration between geothermal developers and miners. On one hand we find that there are many low and medium temperature geothermal resources that remained undeveloped because they are situated far from transmission grids, and the projects' economics do not justify transmission build out. On the other hand we find that many mines are also located in remote locations and must often import huge volumes of expensive diesel fuel to power their mining and rock crushing operations (often over 100MW of demand).

Chad McConathy, President of Meridian Power LLC, a Denver-based geothermal developer, explains that "there are quite a few mines located throughout the world that have an increasing demand for power due to expansion, and have facilities often co-located with geothermal resources. In many of these expansions, the mining companies often face high costs to expand onsite utility infrastructure as they grow in these remote locations, and could overcome these challenges, both for themselves and geothermal developers if the geothermal resource was converted to electricity and sold to the mine."

The synergies don't stop there either. Mining concessions often include rights to geothermal resources (termed "subsurface vapors" in Argentina's mining leases, for example), and of course miners typically complete extensive geophysical and exploration drilling research programs before developing prospects. Further, mining companies will often have existing field offices and resources for drilling and well engineering. Accordingly, by riding on the coat tails of a mining project the savvy geothermal developer can significantly decrease upfront exploration and infrastructure costs.

Public relations and regulatory synergies abound as well. The mining industry can always benefit from a cleaner, more environmentally friendly reputation, and shifting from diesel consumption to geothermal could certainly be one effective tactic for miners to decrease pollution and improve their image. The reduced risk of fuel price fluctuation is another byproduct of this strategy.

The third tenet of geothermal-mining synergy is the critical step of finance. Geothermal promoters around the world bang their heads against walls as lender after lender recoils from the high upfront investment and delayed payback periods of their geothermal projects. Miners can provide geothermal developers with a secure and dependable PPA (because they will be the direct and singular consumer of the power), which significantly decreases the perceived risk for banks and equity investors alike. Further, large mining firms can generally help arrange project finance for geothermal developments. Remember that mines, like geothermal resources, are meant to be long-term assets, so the financing of the power plant and its consumer often aligns quite nicely.

No conversation on South American mining is complete without mentioning Peru. Peru has consistently been one of South America's (and the world's) leading mineral producing countries and is currently making its first steps into the geothermal sector.

Currently there are no working geothermal projects in Peru. However, there is much to come. As of April 2011, the first geothermal concessions came up for bid in Peru, and many project are in their exploration stage. Furthermore the "Geothermal Map of Peru" is currently under development, which, beyond yielding a heat flow map, will also quantify the total geothermal energy potential, as well as temperature-at-depth maps similar to those of the US (www.google.org/egs).

In creating the "Geothermal Map of Peru," many of the major supporters facilitating the study have been mining companies. To them, geothermal energy presents multiple opportunities. Firstly, it is a way to cut costs by offsetting expensive diesel consumption, particularly because many Andean mines are at high elevations, which can cut the efficiency of diesel engines in half. Additionally, as a green, base-load, local power source, geothermal can be used to generate social capital (i.e. pro-environment marketing) as well as provide an extra revenue stream (i.e. base-load carbon credit sales). Furthermore, as geothermal (like mining) is a geo-economic industry, it presents mining companies with the opportunity to diversify into a new market sector using the financial and technical know-how they already possess.

Miners have experience dealing with long-term project financing, high exploration risk, and finding resources in the subsurface. As a result, it is no surprise that many have now expanded to the geothermal sector. The best example of this is Ross Beaty of Pan-American Silver (involved in many of Peru's major mines), who created Alterra Power Corp. (formerly Magma Energy), a dominant player in the international geothermal market. Another success story is Tom Ogryzlo of Plata-Peru Resources, who was one of the founders of Polaris Energy (a geothermal company that is now part of Ram Power).

The list continues to Barrick Gold, Minero Andina, and Geotermia Andina, which represent just a glimpse of the geothermal-mining cooperation in planning and/or execution stages in South America. GeoThermHydro, the Icelandic geothermal consulting group based in Santiago, believes that the opportunity for geothermal energy to power new and old mines in the Chilean Andes is one of the greatest opportunities facing Chile's renewable energy industry.

All geo-economic industries (geothermal, mining, oil & gas) require long-term strategy and planning, a strong stomach for risk and high capital costs, and a mastery of producing resources from the subsurface. Project finance, PPAs, and high-level government interactions are also part of the everyday job description for a geo-economic entity. For miners, these job requirements come naturally; therefore, their natural affinity and understanding greatly lowers the barriers of entry into geothermal markets, making geothermal development a low-hanging fruit for mining companies.

Cully Cavness recently spent two months working in the Argentine and Chilean geothermal industries as part of a Thomas Watson Fellowship, and has now transitioned into a new role as Business Development Manager at Global Geothermal. Andrés Ruzo is a Ph.D. Candidate at Southern Methodist University (SMU) creating the "Geothermal Map of Peru" for his dissertation which has received grants from National Geographic and the AAPG, among others. He is currently conducting field work in Peru, where he is working closely with South American mining and hydrocarbon firms.

EUROPE

EGEC: NEWS from EUROPE

International Energy Agency Launches New Publication

May 31st, 2011

EGEC welcomes the publication of a new International Energy Agency Report dealing with Renewable Energy Technologies, which was launched on May 24th last.

For more information see here: EGEC Comments on IEA Book

New Training Course in Deep Geothermal Systems in Switzerland

June 8th, 2011

A new training course in deep geothermal systems is being organised by the Centre for Hydrogeology and Geothermics of the University of Neuchatel (Switzerland).

The course includes modules of 5 days each between November 2011 and May 2012 in Neuchatel. The participants include scientists and engineers from the fields of earth sciences and energy. The main objective of this course is to train specialists in deep geothermal systems, who will be capable afterwards in their company or public institution of planning, setting up and leading parts or the totality of geothermal projects. Participants who complete the training will receive a Certificate of Advanced Studies.

All the courses will be given in English by international experts in geothermics.

More information can be found online or please see below for additional information.

CAS Neuchatel Information Leaflet

CAS Registration Form

Newsletter from Géothermie Soultz Launched

June 14th, 2011

The team from Géothermie Soultz, the innovative deep geothermal project located at Soultz-sous-Forêts in Northern France, have just launched a newsletter packed with information on the project, and associated activities. It is available online, and subscribe to keep up-to-date!

EGEC's Reaction to the IEA Geothermal Technology Roadmap

June 14th, 2011

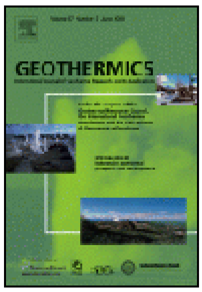
EGEC welcomes the International Energy Agency having launched its Technology Roadmap for Geothermal Heat and Power, which outlines the key actions that need to be undertaken globally to further develop geothermal heat and power. EGEC's reaction to the Roadmap outlines our key positions and responses.

The report itself can be downloaded from the IEA website.

ITA Group & Terna Energy Win Concessions for Geothermal Exploration in Greece

June 27th, 2011

A consortium of ITA Group S.A and Terna Energy S.A have been announced as winners of Greece's call for tenders and owners of the geothermal concessions of South Chios, Samothraki, Evros Basin and Nestos Basin –



Xanthi – Porto Lagos for geothermal exploration during the next 5 years.

Under the terms of their agreement with the Ministry of Energy, they must invest 95 million euros in geothermal exploration in the next 2 years.

German Parliament Adopts New FiT for Geothermal

July 8th, 2011

Amendment of the Renewable Electricity Law in Germany (Feed-in Tariff). The new tariff for geothermal power is given in § 28:

- 0.25 Euro per kWh for all geothermal power (no further limitation)
- 0.05 Euro per kWh additional price for EGS (after German petrathermal definition)

The start of annual reduction of 5 % (for new plants going on the grid) has been postponed to 2018.

After the last reading and final decision on the law in the Parliament (Bundestag), the 2nd chamber (Bundesrat, delegates of the Laender) today passed the law without objection. The new values will take effect from 1 January 2012.

AFRICA

Kenya

Tapping Into the Geothermal Energy to Power the East African Region Beyond the Nation

Ministers and technical experts in Ministries of Energy and/ or Mines from the member countries of the African Rift Geothermal Development Facility (ARGeo), met at the Headquarters of the United Nations Environment Program in Nairobi, Kenya, on 2 September 2011 for a High Level Geothermal Meeting. The UNEP issued the following press release:

" The two-day meeting organized by UNEP in collaboration with the Government of Kenya, Geothermal Development Company (GDC), and Kenya Electricity Generating Company (KenGen) is expected to raise awareness and sensitize high level decision makers about the unique development opportunities that geothermal energy presents and how member countries can benefit from ARGeo's support services, to accelerate the development of their geothermal resources.

" Kenya is a concrete example of a country making a transition to a low carbon, resource efficient Green Economy. Using Kenya as an illustrative geothermal success story, the ARGeo high level meeting discussed, among other issues, challenges and opportunities for development of geothermal resource in the East African Rift region, strategic approaches in development of geothermal resources, responses of various geothermal programmes to develop geothermal energy, country support for resource mobilization and financing of geothermal projects as well as best practices and lessons to be learnt.

" Geothermal energy accounts for about 15% of Kenya's current power generation in operation, with an estimated potential of 4,000 MW. Preliminary estimates along the whole African Rift indicate that there might be some 6 GW or more of geothermal potential in this region

" The ARGeo project was proposed with a view to accelerating the development of this large untapped geothermal resource potential in the East African Rift region.

" The meeting will lead to a common understanding of the objectives and outcomes of the ARGeo project and to the development of strategic partnerships and synergies with the other major geothermal support programmes in the region.

" As one of its key outcomes, the meeting is expected to result in transfer of adequate knowledge about the objectives and outcomes of the ARGeo project, and development of a strategic framework for ARGeo projects in line with requirements of the other geothermal support programmes in the region. "

The meeting included field visits for the High level officials from ARGeo member countries to the Olkaria geothermal power plant, and to Menengai geothermal fields for the technical experts. The press release went on to explain that Olkaria is the first geothermal field in Africa where geothermal energy resource was utilized for electricity power generation. It has an estimated geothermal potential of more than 1,000 MWe. At present, the current installed capacity is about 209 MWe. 240MWe power development is in progress at Olkaria I and IV due for commissioning in 2013 and a further 50MW at Olkaria III to be commissioned in 2014. Menengai is the second geothermal field outside of Olkaria. Geothermal Development Company (GDC) has completed drilling of two wells and drilling is in progress for two others. The first well is currently under discharge test with output of about 10MW while the second well is heating. It is anticipated that a 5-10MW power plant will be operational at Menengai by 2012.

The press release also noted that the ARGeo project is supported by GEF with co-funding from the Icelandic International Development Agency (ICEIDA), the German Federal Institute of Geosciences and Natural Resources (BGR), the United Nations University-Geothermal Training Programme (UNU-GTP), and the International Atomic Energy Agency (IAEA).

ASIA

China

3rd China GSHP Trade High Level Forum held in Xi'an, China

Keyan Zheng, GCES, China

The 3rd China GSHP Trade High Level Forum was held successfully on 27-28 August 2011 in Xi'an, China. The Geothermal Council of China Energy Society (GCES) and the China Committee of the International Ground Source Heat Pump Association (IGSHPA-China) jointly hosted the activities. The Periodical Office of "Ground Source Heat Pump" and the China Web of GSHP http://www.dyrbw.com organized the events. A total of 340 participants from all over China attended the forum activities.

The representative of the Ministry of Land and Resources (MLR) gave a speech. MLR has put national resources into carrying out a survey and assessment for shallow geothermal energy resources in key cities, as a public contribution to showing geological conditions for the feasibility of GSHP. The representative from the Ministry of Housing and Urban-Rural Development (MOHURD) also gave a speech, introducing the status of GSHP applications and growth trends in China. Speakers from the cities and provinces of Beijing, Shenyang, Hubei, Hebei, Jiangsu, Chongqing and Henan, etc., reported on local progress. Representatives of industry described their experience in research and production. Such dialogue between experts and participants is welcome, and 50 papers were selected from the proceedings of the forum for further widespread exchange.

An Award ceremony was held during the activities. The Chinese ground source heat pump industry organized public appraisal activities for "Ten Strong Enterprises of Chinese Ground Source Heat Pump Trade" in the year of 2009 and 2010. They were classified into two types: heat

The rostrum platform of the 3rd China GSHP Trade High Level Forum

Participants visit the GSHP system in the Urban Gate project

pump products and system integration. This activity established standards and examples for the ground source heat pump industry in China.

Shaanxi Sijichun Central Air Conditioning Co. Ltd and Hundred Group enterprises sponsored the forum activities. More than 30 companies and manufacturers concerned with heat pumps, air conditioning and accessories attended the exhibition. Participants visited two demonstration GSHP projects in the city. The Urban Gate project is a group of international modernization buildings with a total construction area of over 100,000 m^2. It used GSHP for space heating and cooling to meet 60% of base load, with peak load met by other sources from the city heating supply and a LiBr refrigerator respectively. The 41st World Gardening Expo 2011, which was held in Xi'an, used ground source heat pumps in the Changan Pagoda, the Hall of Nature and the Gate.

GSHP utilization has reached 150 million m^2 of area in China, putting it second in the world. The 3rd China GSHP Trade High Level Forum was a success. It has well promoted exchange and growth for the GSHP business in China. Many participants said that they would like to attend the annual forum next year.

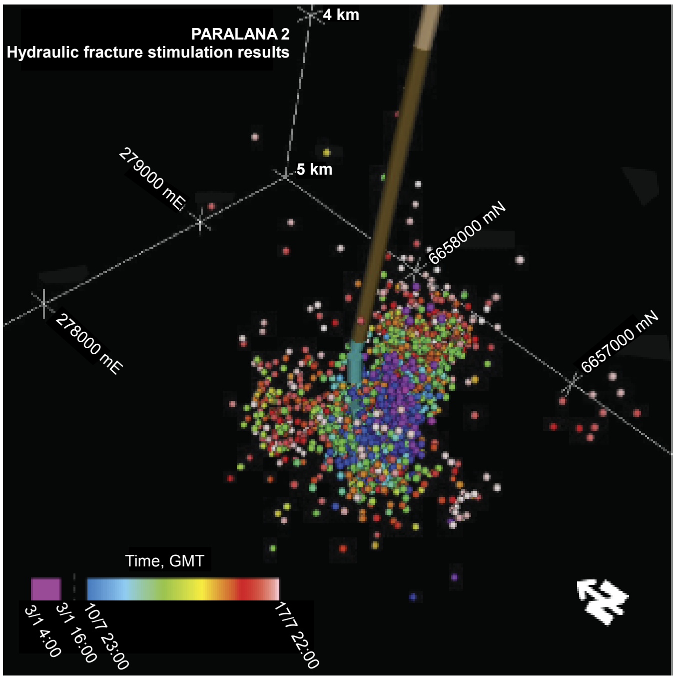
OCEANIA

Australia

Update from Australia

Graeme Beardsmore, Hot Dry Rocks Pty Ltd

Petratherm Limited (PTR) has become the second Australian company to develop an underground stimulated fracture system for an Engineered Geothermal System (EGS). PTR carried out hydraulic fracture stimulation in its 4,000 m deep Paralana 2 well in South Australia during the period of 11th to 15th July, injecting a total of 3.1 million litres of water at pressures up to 9,000 psi (62 MPa) and



sustained pump rates up to 27 L/s. PTR's seismic monitoring array detected more than 4,000 micro-seismic events during the stimulation, the largest being magnitude M2.6. A preliminary interpretation of 'located' events suggests that the stimulation program enhanced a zone extending about 900 m east of Paralana 2, over a depth interval 3,700–4,000 m. PTR expects an average reservoir temperature >180°C over this depth interval. Wellhead pressure of 3,940 psi (27MPa) suggests that the reservoir is over-pressured.

Also in July, the Australian Government issued some major announcements around proposed legislation for a 'Carbon Tax'. The proposal includes the introduction of a tax on 1 July 2012 at a starting price of $23 per tonne of CO_2. The price is to increase annually and eventually transition into a 'Carbon Trading Scheme.' The Government will also mandate a target of 80% renewable energy for Australia by 2050. Associated with the introduction of the tax and renewable energy target, the Government also proposes to set up two new agencies. The Australian Renewable Energy Agency (ARENA) will oversee A$3.2 billion (~US$3.4 billion) worth of existing Government renewable energy programs. The Clean Energy Finance Corporation will manage a A$10 billion (~US$10.7 billion) fund to stimulate renewable energy developments through mechanisms such as investments, loan guarantees or grants. While the news is undoubtedly positive for the continued development of a geothermal energy industry in Australia, the legislation has not yet passed through Parliament and the Government has only a narrow grip on power. The Opposition does not support the proposal.

New Zealand

Note from the editor: The following contributions are from the current NZGA newsletter which illustrates the very active situation over there. Our thanks go to the NZ Geothermal Association for permission to reproduce these extracts (compiled jointly by Brian White, Spence McClintock, Colin Harvey and Connie Crookshanks).

Geothermal gives NZ the Edge on Data Centre Location?

Centrally placed between the USA and Asia, and viewed as a "politically safe and neutral" location, New Zealand's geothermal resources might just prove attractive to several global companies like Google, Facebook and Amazon keen to use renewable energy, as cooling is one of the largest cost items in operation costs. Geothermal power as a power source for data centers is being discussed in Iceland too. Over the last couple of years, Iceland has been working on attracting data centers to the country. Geothermal energy as a source of power for attracting energy intensive industries and companies, such as data centers clearly is interesting. Find out more here and here.

Ngatamariki gets Green Light for MRP

In June this year Mighty River Power Ltd. announced commitment to the 82 MW plant costing $466 million to be built at Ngatamariki, north of Taupo. Ormat Technologies was announced as the winner of the EPC contract. The completion of this power plant will bring the total installed capacity of Ormat's technology in New Zealand to approximately 350 MW in 14 plants. It will lift total geothermal generation under MRP's operation to 460 MW and mean that more than 40% of MRP's electricity generation output (by ownership interest) is from geothermal sources.The new power plant will be comprised of four air-cooled Ormat Energy Converters and will allow 100 % geothermal fluid reinjection, which serves both to sustain the reservoir and to produce electrical power with virtually no environmental impact. The modular nature of the Ormat plant will allow further similar units to be installed later. The construction of the power plant is expected to be completed within 24 months from the contract date. Initial site works have already started. Further details here.

Drilling is expected to commence shortly as a new rig arrives from Iceland, along with up to 40 staff members. MRP entered into a two-year US$25 million contract with the Iceland Drilling Company (also known as Jardboranir) for the provision of a drilling rig. The type of drilling rig that will be used is a significant step forward in drilling technology and is the first of its type to be used in New

Trailer-mounted, higly automated DrillMec HH300.

Zealand. It is the company's largest land rig and is a trailer-mounted highly automated DrillMec HH300.

The drilling programme consists of four monitoring wells and four or five main wells. In addition to the Ngatamariki wells, the rig will be available for exploration drilling at new prospects and the drilling of replacement wells on existing fields.8

The project is part of MRP's pipeline of geothermal projects, following the 100 MW Kawerau plant brought into production in 2008 and the 140 MW Nga Awa Purua station on-line last year, in a $1 billion plan to build up to 400MW of new geothermal production. This investment is complemented by a further US$250 million program of international investment through GeoGlobal LLC. Specific projects include the 50 MW Hudson Ranch project in California, a geothermal exploration project in Tolhuaca in Chile, and opportunities in Bavaria in Germany

Te Ahi O Maui - New Geothermal Development Option for Eastland Group

Eastland Group announced in June that it had signed an exclusive deal to be part of a three-way venture of a ground-breaking international indigenous people's project. The project name draws together Maori and Hawaiian concepts of the "fire of Maui" and source of geothermal heat.

It is part of the group's energy development plans, and involves the exclusive development right for 170 hectares in Kawerau on a Maori trust block belonging to the Kawerau A8D Ahuwhenua Trust.

There is an existing commercially viable geothermal well on the land known as KA22 well, and the initial 10 MW to 15 MW development costing up to $60 million will be based around this. But Eastland Group chief executive Matt Todd says an assessment of the entire area has shown a significant additional resource underneath the A8D block (possibly up to 50 MW). The other company involved in the deal is the Hawaiian-owned Innovations Development Group (IDG), and this project has allowed them to successfully create the world's first Native to Native trade deal. Native to Native Trade has been established to help indigenous peoples who want to develop their lands and resources, but need assistance to see that realised. Such trade encourages ownership in projects, shared profits and socially, environmentally and culturally appropriate practices. Further details here.

Eastland is developing the project as part of a strategy aimed at using its balance sheet and engineering expertise to develop a fleet of smaller-scale renewable generators. It already owns the 5 MW Waihi hydro project inland from Wairoa and last year bought the 9 MW Geothermal Developments Ltd (KA 24) plant at Kawerau.

Tikitere Geothermal Plant Announcement

A Rotorua Maori trust is set to become a major player in electricity supply with plans to build a $140 million geothermal power station near Tikitere.

The initial 45 MW development could employ up to 20 local people in the first six months during the initial investigation and development phase, with more job opportunities in the future.

The Tiki Tere Trust (also known as the Whaka-pounakau 24 Trust) partnered with the neighbouring Paehinahina Mourea Trust and the Manupirua Ahu Whenua Baths Trust in 2008 to investigate the possibility of developing a geothermal power station on their lands. Jim Gray is a key figure in this development, and he will be known to many people in the geothermal community through his long term attendance at the Geothermal Workshops and the NZGA Annual General Meetings. The Trust has undertaken a six months long international process seeking expressions of interest. At the end of this process, Ormat Technologies was contracted to carry out the exploration, construction and development of the proposed geothermal development on a Build Operate Transfer (BOT) basis. The plant would be transferred to Tikitere Geothermal Power after 14 years of operation. This is the first time that this sort of arrangement has been used for geothermal projects in New Zealand.

In terms of timing, Jim has said that exploration drilling is at least 6 months away, consents still need to be obtained, so that operation is unlikely before 2015.

The Tikitere field may have potential to generate up to 200 MW of electricity, but Jim has said the overall project would be developed in stages to avoid effects on surface geothermal features such as Hell's Gate (the prime asset of the Tiki Tere Trust) and Manupirua Springs. Further details here.

International

Global and regional geothermal potentials

Luis C.A. Gutiérrez-Negrín

Mexican Geothermal Association

The last issue of IGA News (No. 84, April-June 2011, pp. 11-12) mentioned the publication of the Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN), produced by Working Group III of the UN's Intergovernmental Panel on Climate Change (IPCC). Chapter 4 of this SRREN is devoted to geothermal energy and was prepared by an international team headed by Barry Goldstein (Australia) and Gerardo Hiriart (Mexico). The full reference of this chapter is:

Goldstein, B., G. Hiriart, R. Bertani, C. Bromley, L. Gutiérrez-Negrín, E. Huenges, H. Muraoka, A. Ragnarsson, J. Tester, V. Zui, 2011: Geothermal Energy. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. v. Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

One of the main sections of chapter 4 concerns geothermal potentials. As this is of interest to readers of IGA News, an excerpt from subsection 4.2 (Resource Potential) is reproduced below. In this excerpt, technical potential is defined in the SRREN's glossary (mentioned in footnote 1) as: "the amount of RE (Renewable Energy) output obtainable by full implementation of demonstrated and likely to develop technologies or practices. No explicit reference to costs, barriers or policies is made. In the literature, analysts often adopt practical constraints; in that context they implicitly take into account for instance socio-geographical and socio-political considerations." Capacity Factor is also defined in the glossary (see footnote 2) as: "the ratio of the actual output of a generating unit over a period of time (typically a year) to the theoretical output that would be produced if the unit were operating uninterruptedly at its nameplate capacity during the same period of time."

4.2 Resource Potential

The total thermal energy contained in the Earth is of the order of 12.6 x 10^{12} EJ and that of the crust of the order of 5.4 x 10^{9} EJ to depths of up to 50 km (Dickson and Fanelli, 2003). The main sources of this energy are the heat flow from the Earth's core and mantle, and that generated by the continuous decay of radioactive isotopes in the crust itself. Heat is transferred from the interior towards the surface, mostly by conduction, at an average of 65 mW/m^2 on continents and 101 mW/m^2 through the ocean floor. The result is a global terrestrial heat flow rate of around 1,400 EJ/yr. Continents cover ~30% of the Earth's surface and their terrestrial heat flow has been estimated at 315 EJ/yr (Stefansson, 2005).

Stored thermal energy down to 3 km depth on continents was estimated to be 42.67 x 10^6 EJ by EPRI (1978), consisting of 34.14 x 10^6 EJ (80%) from hot dry rocks (or EGS resources) and 8.53 x 10^6 EJ (20%) from hydrothermal resources. Within 10 km depth, Rowley (1982) estimated the continental stored heat to be 403 x 10^6 EJ, with no distinction between hot dry rock and hydrothermal resources, and Tester et al. (2005) estimated it to be 110.4 x 10^6 EJ from hot dry rocks and only 0.14 x 10^6 EJ from hydrothermal resources. A linear interpolation between the EPRI (1978) values for 3 km depth and the values from Rowley (1982) results in 139.5 x 10^6 EJ down to 5 km depth, while linear interpolation between the EPRI (1978) values and those from Tester et al. (2005) only for EGS resources results in 55.9 x 10^6 EJ down to 5 km depth (see second column of Table 4.2). Based on these estimates, the theoretical potential is clearly not a limiting factor for global geothermal deployment.

In practice geothermal plants can only utilize a portion of the stored thermal energy due to limitations in drilling technology and rock permeability. Commercial utilization to date has concentrated on areas in which geological conditions create convective hydrothermal reservoirs where drilling to depths up to 4 km can access fluids at temperatures of 180°C to more than 350°C.

4.2.1 Global technical potential

Regarding geothermal technical potentials[1], one recent and comprehensive estimate for conventional hydrothermal resources in the world was presented by Stefansson (2005). For electric generation, he calculated the global geothermal technical potential for identified hydrothermal resources as 200 GWe (equivalent to 5.7 EJ/yr with a capacity factor (CF)[2] of 90%), with a lower limit of 50 GWe (1.4 EJ/yr). He assumed that unidentified, hidden resources are 5 to 10 times more abundant than the identified ones and then estimated the upper limit for the worldwide geothermal technical potential as between 1,000 and 2,000 GWe (28.4 and 56.8 EJ/yr at 90% CF), with a mean value of 1,500 GWe (~42.6 EJ/yr). Mainly based on those numbers, Krewitt et al. (2009) estimated geothermal technical potential for 2050 at 45 EJ/yr, largely considering only hydrothermal resources.

No similar recent calculation of global technical potential for conductive (EGS) geothermal resources has been published, although the study by EPRI (1978) included some estimates, as did others (Armstead and

[1]Definition of technical potential is included in the Glossary (Annex I).

[2]Capacity factor (CF) definition is included in the Glossary (Annex I).

Tester, 1987). Estimating the technical potential of EGS is complicated due to the lack of commercial experience to date. EGS field demonstrations must achieve sufficient reservoir productivity and lifetime to prove both the viability of stimulation methods and the scalability of the technology. Once these features have been demonstrated at several locations, it will be possible to develop better assessments of technical potential, and it is possible that EGS will become a leading geothermal option for electricity and direct use globally because of its widespread availability and lower exploration risk relative to hydrothermal systems.

More recently, Tester et al. (2006; see their Table 1.1) estimated the accessible conductive resources in the USA (excluding Alaska, Hawaii and Yellowstone National Park), and calculated that the stored heat at depths less than 10 km is 13.4 x 10^6 EJ (in conduction-dominated EGS of crystalline basement and sedimentary rock formations). Assuming that 2% of the heat is recoverable, that average temperatures would drop 10°C below initial conditions during exploitation, and taking into account all losses in the conversion of recoverable heat into electricity over a lifespan of 30 years, electrical generating capacity from EGS in the USA was estimated at 1,249 GWe, corresponding to 35.4 EJ/yr of electricity at a CF of 90% (Tester et al., 2006; see their Table 3.3). Based on the same assumptions as for the USA[3], estimates for the global technical potential of EGS-based energy supply can be derived from estimates of the heat stored in the Earth's crust that is both accessible and recoverable (see Table 4.2, fourth column).

Therefore, the global technical potential of geothermal resources for electricity generation can be estimated as the sum of the upper (56.8 EJ/yr) and lower (28.4 EJ/yr) of Stefansson's estimate for hydrothermal resources (identified and hidden) and the EGS technical potentials of Table 4.2 (fourth column), obtaining a lower value of 117.5 EJ/yr (down to 3 km depth) to a maximum of 1,108.6 EJ/yr down to 10 km depth (Figure 4.2). It is important to note that the heat extracted to achieve these technical potentials can be fully or partially replenished over the long term by the continental terrestrial heat flow of 315 EJ/yr (Stefansson, 2005) at an average flux of 65 mW/m^2. Although hydrothermal resources are only a negligible fraction of the total theoretical potential given in Tester et al. (2005), their contribution to technical potential might be considerably higher than implied by the conversion from theoretical potential data to technical potential data. This is the rationale for considering the Rowley (1982) estimate for EGS technical potential only and adding the estimate for hydrothermal technical potential from Stefansson (2005).

For hydrothermal submarine vents, an estimate of >100 GWe (>2.8 EJ/yr) offshore technical potential has been made (Hiriart et al., 2010). This is based on the 3,900 km of ocean ridges confirmed as having hydrothermal vents[4], with the assumption that only 1% could be developed for electricity production using a recovery factor of 4%. This assumption is based on capturing part of the heat from the flowing submarine vent without any drilling but, allowing for offshore drilling, a technical potential of 1,000 GWe (28.4 EJ/yr) from hydrothermal vents may be possible. However, the technical potential of these resources is still highly uncertain, and is therefore not included in Figure 4.2.

For geothermal direct uses, Stefansson (2005) estimated 4,400 GWth from hydrothermal systems as the world geothermal technical potential from resources <130°C, with a minimum of 1,000 GWth and a maximum, considering hidden resources, of 22,000 to 44,000 GWth. Taking a worldwide average CF for direct uses of 30%, the geothermal technical potential for heat can be estimated to be 41.6 EJ/yr with a lower value of 9.5 EJ/yr and an upper value of 312.2 EJ/yr (equivalent to 33,000 GWth of installed capacity) (Figure 4.2). Krewitt et al. (2009) used the same values estimated by Stefansson (2005) in GWth, but a CF of 100% was assumed when converted into EJ/r, leading to an average upper limit of 33,000 GWth, or 1,040 EJ/yr.

In comparison, the IPCC Fourth Assessment Report (AR4) estimated an available energy resource for geothermal (including potential reserves) of 5,000 EJ/yr (Sims et al., 2007; see their Table 4.2). This amount cannot be properly considered as technical potential and looks overestimated compared with the geothermal technical potentials presented in Figure 4.2. It is important to note,

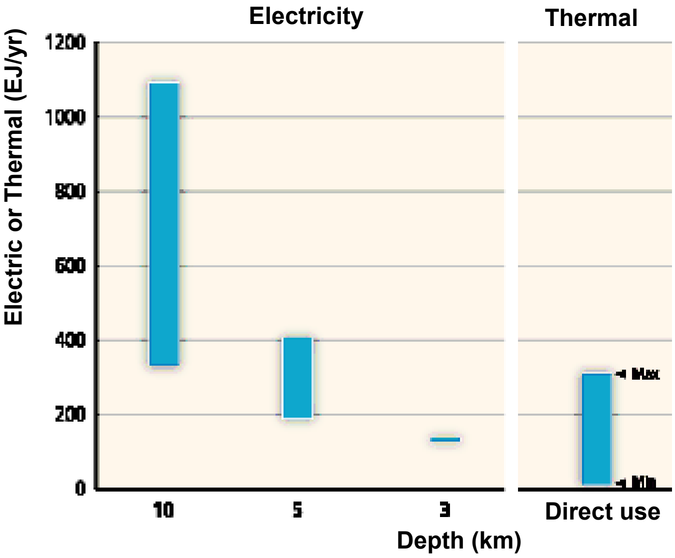


Figure 4.2 Geothermal technical potentials for electricity and direct uses (heat). Direct uses do not require development to depths greater than approximately 3 km (Prepared with data from Table 4.2 and Stefansson, 2005).

[3]1 x 10^6 EJ stored heat equals approximately 2.61 EJ/yr of technical potential for electricity at a 90% CF for 30 years.

[4]Some discharge thermal energy of up to 60 MWth (Lupton, 1995) but there are other submarine vents, such as the one known as 'Rainbow', with an estimated output of 1 to 5 GWth (German et al., 1996).

Table 4.2 Global continental stored heat and EGS technical potentials for electricity.

Depth range (km)	Technically accessible stored heat from EGS		Estimated technical potential (electric) for EGS (EJ/yr)
	(10^6 EJ)	Source	
0–10	403	Rowley, 1982	1051.8
0–10	110.4	Tester et al., 2005	288.1
0–5	139.5	Interpolation between values from Rowley (1982) and EPRI (1978)	364.2
0–5	55.9	Interpolation between values from Tester et al. (2005) and EPRI (1978)	145.9
0–3	34.1	EPRI, 1978	89.1

however, that technical potentials tend to increase as technology progresses and overcomes some of the technical constraints of accessing theoretically available resources.

4.2.2 Regional technical potential

The assessed geothermal technical potentials included in Table 4.2 and Figure 4.2 are presented on a regional basis in Table 4.3. The regional breakdown in Table 4.3 is based on the methodology applied by EPRI (1978) to estimate theoretical geothermal potentials for each country, and then countries were grouped into the IEA regions. Thus, the present disaggregation of the global technical potentials is based on factors accounting for regional variations in the average geothermal gradient and the presence of either a diffuse geothermal anomaly or a high-temperature region, associated with volcanism or plate boundaries as estimated by EPRI (1978). Applying these factors to the global technical potentials listed in Table 4.2 gives the values stated in Table 4.3. The separation into electric and thermal (direct uses) technical potentials is somewhat arbitrary in that most higher-temperature resources could be used for either or both in combined heat and power applications depending on local market conditions and the distance between geothermal facilities and the consuming centres. Technical potentials for direct uses include only identified and hidden hydrothermal systems as estimated by Stefansson (2005), and are presented independently from depth since direct uses of geothermal energy usually do not require developments over 3 km in depth.

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Table 4.3 Geothermal technical potentials on continents for the International Energy Agency (IEA) regions (prepared with data from EPRI (1978) and global technical potentials described in section 4.2.1).

REGION*	Electric technical potential in EJ/yr at depths to:						Technical potentials (EJ/yr) for direct uses	
	3 km		5 km		10 km			
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
OECD North America	25.6	31.8	38	91.9	69.3	241.9	2.1	68.1
Latin America	15.5	19.3	23	55.7	42	146.5	1.3	41.3
OECD Europe	6	7.5	8.9	21.6	16.3	56.8	0.5	16
Africa	16.8	20.8	24.8	60	45.3	158	1.4	44.5
Transition Economies	19.5	24.3	29	70	52.8	184.4	1.6	51.9
Middle East	3.7	4.6	5.5	13.4	10.1	35.2	0.3	9.9
Developing Asia	22.9	28.5	34.2	82.4	62.1	216.9	1.8	61
OECD Pacific	7.3	9.1	10.8	26.2	19.7	68.9	0.6	19.4
Total	**117.5**	**145.9**	**174.3**	**421**	**317.5**	**1108.6**	**9.5**	**312.2**

*Note: * For regional definitions and country groupings see Annex II.*

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Geothermal in International Energy Strategy Papers

Marietta Sander, IGA Executive Director

In early summer 2011 three energy strategies were launched by leading international energy organisations. In the following I would like to inform you about their main contents and implications for the geothermal sector:

1. Technology Roadmap - Geothermal Heat and Power, International Energy Agency (IEA)
2. Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN), Intergovernmental Panel on Climate Change (IPCC)
3. Renewables 2011 Global Status Report, REN21

1.) Technology Roadmap – Geothermal Heat and Power, International Energy Agency (IEA)

The "Technology Roadmap - Geothermal Heat and Power" was recently launched by the IEA on the occasion of the EURELECTRIC annual conference in June 2011 in Stockholm. The IEA was founded in 1974 as an autonomous organisation, in order to safeguard energy security in its 24 member states and additional countries. The IEA aims to promote sustainable energy strategies, transparency and international cooperation in order to identify solutions for global energy challenges.

With the series Technology Roadmaps the IEA formulated a targeted guideline for governments, industry and research institutes in order to propose specific measures and milestones which are necessary to increase the use of renewable energies (RE). A clear target for geothermal energy use globally is to increase the percentage of geothermal in the mix of global power generation from 0.3% currently to 3.5% by 2050. Similarly, the use of geothermal heat should be increased from the current level of 0.3% to 3.9% by 2050. Geothermal heat pumps are omitted from the study.

The study emphasises the necessary measures to take geothermal a step forward:

1. Further development of geothermal sites of high enthalpy reservoirs with increasing subsequent use of geothermal heat through binary power plants (ORC, Kalina).
2. Increasing efforts in Research and Development (R&D) and demonstration projects of submarine resources, supercritical resources, mine waters, drilling technology and Enhanced Geothermal Systems (EGS). An increase of the EGS projects from the current 20 (also in planning stage) to 50 by 2050 is necessary. Accordingly, EGS systems should be deployed

sustainably, widely and in a cost-efficient manner by 2030.

3. Establishing clear geothermal and investor-friendly framework conditions (concessions, feed-in-tariffs, Power Purchase Agreements, tax holidays, national energy masterplans).

According to the study necessary prerequisites for the above proposed action items are financial incentives like risk mitigations funds or insurances, strategic advice to decision-makers, databases and technical guidelines.

The Technology Roadmap provides clear, but rather general advice for the measures to be taken. It becomes clear that significant R&D funds are available in industrialised countries. Hopefully, this will lead to a closer cooperation of industrialised countries with developing countries. The Technology Roadmap also incorporates information on the different geothermal resources, technologies, power plant technology and economics, and presents case studies from Indonesia. In addition, country-specific risk mitigation schemes are presented and advice given to the involved stakeholders. Hints on how to obtain the necessary financial resources for developments are not yet included in the roadmap.

Document download at: http://www.iea.org /papers /2011/Geothermal_Roadmap.pdf

2.) Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN), Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO) in 1988 to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts.

Since April 2008 a group of 120 leading experts compiled the SRREN with the aim of presenting the role of renewable energies for climate change mitigation. The report provides clear guidelines on how 80% of energy supply could be provided through RE resources by 2050. Besides a summary for policymakers and chapters with integrated topics the six RE technologies bioenergy, geothermal, solar energy, ocean energy, hydropower and wind energy are presented in detail.

The SRREN shows that investor-friendly political and legal framework conditions like national energy strategies and clear licensing procedures would play a vital role in achieving the 80% RE target by 2050.

It is inspiring to see that 50% of the global RE resources would be deployed in developing countries. Similar to the IEA Roadmap the target group of the SRREN are decision-makers in governments, industry, the financial sector and academia.

For geothermal the authors estimate an increase to 140-160 GWel by 2050 from the current level of 11 GWe. The installed direct use capacity is estimated to reach 800 GWth. The geothermal chapter provides a good overview of the global and regional resource potential, GHG emissions in the whole project cycle (Life Cycle Analysis), emission during operation, economics (Figure 1) and required research and optimisation approaches.

Document download at: http://srren.ipcc-wg3.de/

3.) Renewables 2011 Global Status Report, REN21

The REN21 was founded subsequent to the International Conference for Renewable Energies – Renewables 2004 which took place in Bonn, Germany. REN21 promotes RE to meet the needs of both industrialised and developing countries that are driven by climate change,

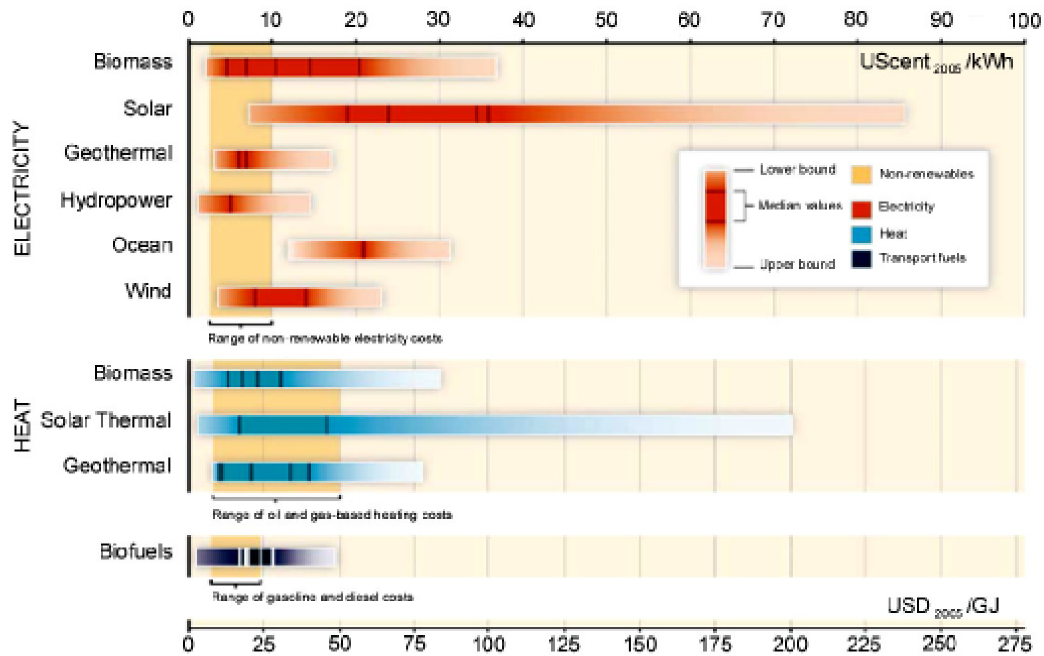

Fig. 1: Range in levelised cost of energy (IPCC SRREN 2011)

energy security, development and poverty alleviation. Herein three action areas are promoted: Policy, Advocacy, and Exchange.

The Global Status Report 2011 focuses on regulatory and investor-friendly framework conditions and provides information on market trends and investment developments. Up to now RE enabling policies have already been established in 119 countries.

Regarding geothermal the latest data on global applications are provided, the largest equipment suppliers mentioned and the Renewable Heat Incentive of the United Kingdom is presented. This incentive provides subsidies to house owners for the installation of heating and cooling systems in buildings.

Document download at: http://www.ren21.net/Portals/97/documents/GSR/REN21_GSR2011.pdf

Conclusion:

All three recently published strategy documents reflect that groundbreaking steps are necessary in order to increase the use of geothermal resources. Significant tasks are required in the following fields:

1. Creation of RE-friendly regulatory legal and institutional framework conditions (policy) and investor-friendly incentive schemes.
2. R&D and technology optimization for EGS, drilling projects, exploratory methods, supercritical and submarine reservoirs, binary power plant technology.
3. Advocacy and policy dialogue on geothermal.

The proposed action items of the examined energy strategies correspond with the insight I gained while working on an international technical assistance project in countries adjacent to the East African Rift System over the past 3 years.

During the last geothermal workshop in East Africa in December 2010 (see Figure 3) the following action items were identified:

(1) Financing; (2) Optimisation of national regulatory framework conditions; (3) Advisory to policy makers; and (4) Capacity building.

The German government supports the geothermal sector in East Africa through the Geothermal Facility for Eastern Africa which was developed by the KfW (German Development Bank).

Fig. 3: Participants of the Geothermal Policy Workshop, Rwanda, Dec. 2010

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