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UNU Geothermal Training Programme - Taking the Training to the Developing Countries

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ABSTRACT

As its contribution towards the Millennium Development Goals of the UN the Government of Iceland has provided funding for the United Nations University Geothermal Training Programme (UNU-GTP) to give annual short courses/workshops in geothermal exploration and development in the different continents. The series includes the following: To begin a workshop is hosted for decision makers in energy ministries/utilities and earth science institutions in the region, intended to increase awareness of the benefits of geothermal energy among these and to further cooperation and contacts between different agencies and individuals in the respective countries. The series is then continued through annual 1-3 week Short Courses in geothermal sciences or engineering with subjects in line with the needs of the region. The Short Courses include active field work, lectures and project work. Participation is by invitation, and the target trainees are young scientists and engineers who are active or potential participants in geothermal work in the region. A cooperation partner is selected with reference to potential and possibilities in hosting such events and overseeing local management. Lecturers are from the UNU-GTP in Iceland and the local partner, usually former UNU Fellows trained in Iceland, and to some extent the neighbouring countries, but renowned international lecturers are brought in if necessary.

The first series started in Kenya in 2005 in cooperation with KenGen targeting the East African countries and focussing on exploration of high-temperature resources. A similar series started in El Salvador in 2006 for Central America in cooperation with LaGeo, so far focussing on exploration and environmental implications of high-temperature geothermal development, and in China in 2008, focussing on direct use of geothermal resources. These series have already proven their value as a basis of future cooperation between countries and individuals, and as a first training opportunity for young scientists and engineers engaged in geothermal work. To date about 200 leaders have participated in the three workshops and about 160 scientists or engineers have been trained through the Short Courses, including countries that so far had not qualified for conventional 6 months training in Iceland. Thus, the UNU-GTP has been able to reach a much larger audience. This has also led to a significant increase in cooperation between the respective countries both in active project work and in sharing of technical and human resources. Most of the material presented, and associated written papers, have been published on CDs and in some cases also in printed proceedings, but it is also all available at the UNU-GTP web site (*www.unu.is*). The structure and content of the Workshops and Short Courses is described and their possible future development is discussed in this paper.

1. INTRODUCTION

The United Nations University Geothermal Training Programme (UNU-GTP) was established in Iceland in 1978. Since 1979, it has held annual six-month courses in nine different lines of geothermal science and engineering for professionals from the developing countries. The trademark of the UNU-GTP is to give university graduates engaged in geothermal work intensive on-the-job training in their chosen fields of specialization. The aim is to assist developing countries with significant geothermal potential in building up groups of specialists that cover most aspects of geothermal exploration and development. The programme is hosted at Orkustofnun – The National Energy Authority of Iceland. During 1979-2009, 424 scientists and engineers from 44 countries have completed the six month course. An MSc programme in geothermal science and engineering was started in 2000 in cooperation with the University of Iceland, and a PhD programme in late 2008. Twenty UNU-GTP MSc Fellows have completed their degree (Fridleifsson, 2008 and 2010), with nine pursuing their studies, and the first two UNU-GTP PhD Fellows are now (in August 2009) pursuing their studies in Iceland.

At the UN Summit Meeting on Sustainable Development in Johannesburg in 2002, the Icelandic Government announced that its contribution to the goals of the conference would be to finance increased operations of the UNU-GTP to enhance the use of geothermal resources for power production, thus, allowing the UNU-GTP to expand its capacity building activities, through workshops and short courses in geothermal exploration and development in selected developing countries. At the International Conference for Renewable Energies in Bonn in 2004, this contribution to the UN Millennium Development Goals was outlined further, and targeted to comprise annual workshops / short courses in East Africa to start in 2005, in Central America to start in 2006, and in Asia to start later (Fridleifsson, 2004). From the year 2005, the Government of Iceland has secured the necessary core funding for the UNU-GTP to put these plans into operation.

The courses/workshops are set up in a selected country in the target region through cooperation with local energy agencies / utilities and earth science institutions, responsible for exploration, development and operation of geothermal facilities in the respective countries. The courses may in the future develop into sustainable regional geothermal training centres.

As implemented, the first phase has been a week long workshop during which decision makers in energy and environmental matters in the target region have met with the leading local geothermal experts and specially invited international experts. The status of geothermal exploration and development has been introduced and the possible role of geothermal energy in the future energy mix of the region discussed. The lectures have described state-of-the-art exploration and development, from surface exploration,

through drilling, production exploration, assessment, project management, planning and financing, to development. The purpose has, on the one hand, been to educate key decision makers in the energy market of the respective region about the possibilities of geothermal energy and increase the awareness of the necessity for more effort in the education of geothermal scientists in the region, and, on the other hand, to further the cooperation between specialists in the different countries. This is then followed by specialized short courses for earth scientists and engineers in surface exploration, deep exploration, production exploration, environmental studies and production monitoring etc., in line with the type of geothermal activity and the needs of the respective region.

Presently, workshops for decision makers have been held for East Africa (in Kenya 2005), for Central America (in El Salvador 2006) and for Asia (in China in 2008). Specialized Short Courses have since been held annually in Africa and in 2007 in Central America, with additional courses to be held in Africa and Central America in late 2009. Material presented and written for these events has been published on CDs and is also available on the website of the UNU-GTP (*www.unugtp.is*) under *workshops/short courses.* This paper describes these Workshops and Short Courses, their structure and development and their role in the geothermal capacity building in the different regions.

2. THE SHORT COURSES IN AFRICA

During the planning of the first workshop, the priority region was East Africa with its huge and to a large extent unused potential for geothermal power development. Here, it was decided to seek cooperation with the Kenya Electricity Generating Company – KenGen. Kenya has been the leading African country in geothermal development, with about 166 MWe on-line at the end of 2008 (Silas Simiyu, pers. comm.), and KenGen has been the main authority in charge of that development. The UNU-GTP has also had a long and fruitful cooperation with KenGen through training of its personnel in Iceland. Hence, it was clear that KenGen had the knowledge and capability to act as a strong and active partner in this project. A cooperation contract was signed in early 2005. The Lake Naivasha area in the southern part of the Kenyan rift was chosen as the main site for the Short Courses, due to the presence of the active Olkaria high-temperature geothermal system and its geothermal power plants in the vicinity.

The first course in Africa ("*Workshop for Decision Makers on Geothermal Projects and their Management*") was held in Kenya November, 14-18, 2005 in cooperation not only with KenGen, but also ICEIDA (Icelandic International Development Agency) and UNEP (United Nations Environment Programme). The Workshop was held after six nations in East Africa with good geothermal potential had decided to join forces and increase their cooperation in geothermal research and development within the so-called African Rift Geothermal Facility (ARGeo). Here the UNU-GTP had accepted to play a leading role in guiding and implementing the capacity building component of ARGeo. This Workshop was intended to be the first step in that capacity building process.

The aim of the Workshop was to make high-level decision makers from the respective energy ministries, national electric power companies, geological surveys, and finance ministries, better informed about the main phases of geothermal development and what kind of manpower, equipment, and financing is needed for each phase, and what was available in the region. Participation was by invitation only, as has been for all other events. High-level decision makers from five of the six ARGeo countries (Eritrea, Ethiopia, Kenya, Tanzania, and Uganda) attended the Workshop (with Djibouti not being able to attend), plus lecturers from Ethiopia, Iceland, Kenya and The Philippines. In all, 35 participants attended, including the lecturers that were active in all phases of the Workshop (Tables 1 and 2, Figure 1). The travel and hotel cost of all invited foreign participants and lecturers were covered by the UNU-GTP, the Icelandic Government and ICEIDA, while the cost of the local Kenyan participation was borne by KenGen. KenGen proved to be first-class hosts and made excellent arrangements for the Workshop.

From the great attention of the participants and their active participation in the discussion, it was clear that the Workshop achieved its aim, and that there was indeed need for increased capacity building in the region. Sixteen papers were written, presented and distributed as conference proceedings and on a CD-ROM (Fridleifsson et al. 2005).

Table 1. Participants in the Workshop and Short Courses in East Africa.

Country	Kenya 2005*	Kenya 2006	Kenya 2007	Kenya 2008	Uganda 2008	Total
Algeria			1			**1**
Burundi				2	1	**3**
Congo				1	1	**2**
Djibouti		2	1	2	3	**8**
Egypt			1			**1**
Eritrea	2	3	2	2	1	**10**
Ethiopia	5+2	3	1	2	3	**16**
Kenya	6+9	10	13	18		**56**
Rwanda			2	2	1	**5**
Tanzania	2	2	2	2	4	**12**
The Comoros			2			**2**
Uganda	4	3	3	2	5	**17**
Zambia				2	2	**4**
Yemen			2	2	1	**5**
Others					2	**2**
Total	**30**	**23**	**30**	**37**	**24**	**143**

* The second number shows lecturers, most of whom also participated in other parts of the workshop

Table 2. Lecturers in the UNU-GTP Millennium Workshops and Short Courses.

Short Course / Workshop	Total	Home country	Neighbour. countries	Internat.	Iceland	UNU-Fellows
Kenya 2005	14	7	2	1	4	8
Kenya 2006	20	11	5	0	4	15
Kenya 2007	25	16	4	0	5	18
Kenya 2008	28	19	5	0	4	23
Uganda 2008	15	1	7	2	5	8
El Salvador 2006	25	8	9	5	3	9
El Salvador 2007	16	3	5	3	5	7
China 2008	32	16	6	4	6	11

Figure 1: Participants in the Workshop in Kenya in 2005, including the lecturers

One of the results of the Workshop was that the first Short Courses should focus on surface exploration which was the field acutely needed for most countries in the region. Hence, the second event in Africa was the 10 day "*Short Course on Surface Exploration for Geothermal Resources*" held in Naivasha, 13-22 November, 2006. The purpose was to give "a state of the art" overview of the possibilities and status of surface geothermal exploration in East Africa. In all, 33 trainees attended from Kenya, Djibouti, Eritrea, Ethiopia, Tanzania and Uganda, i.e. the six ARGeo countries (Table 1). The lectures and practical exercises were mainly in the hands of Icelandic (UNU-GTP and ISOR – Iceland GeoSurvey) and Kenyan (KenGen) lecturers, with one additional lecturer coming from each of the other participating countries (Table 2). Most of the African lecturers were former UNU Fellows. The Short Course consisted of two main parts, a scientific part with lectures covering the three important fields of surface exploration of geothermal resources, i.e. geology, geophysics and chemistry of thermal fluids, including many case examples, during the first half. The second half continued with presentations and discussions on the status of exploration in the different countries and practical training including field demonstrations and use of computer programmes (Georgsson and Simiyu, 2006). The Short Course was very well received and from the results of an assessment meeting of all participants during the last day, it was clear that the Short Course had been a success. The basic model was one that should be repeated but suggestions were made of improvements and considerable additions.

The "*Short Course II on Surface Exploration for Geothermal Resources*" was held at Lake Bogoria and Lake Naivasha, Kenya, 2-17 November, 2007. The basis was the same as in 2006, but it was extended with additional lectures. The first week was now spent on field work and was entirely handled by the KenGen staff, while lecturers from Iceland and neighbouring countries were involved in the second part of the course. In all, 30 trainees were invited from 10 countries in Africa plus Yemen (Table 1, Figure 2). New countries included Algeria, Egypt, The Comoros, Rwanda, and Yemen, the latter three participating in a UNU-GTP event for the first time. Yemen was included despite being on the other side of the Red Sea and thus in Asia, as it has common geological features with East Africa. The teaching was shared by 25 lecturers, five from Iceland and one from the five neighbouring E-African countries that were member countries of ARGeo facility, plus the local lecturers from KenGen (Table 2). All except two of the African instructors were former UNU Fellows.

Figure 2: Participants and some of the lecturers in the 2007 Kenyan Short Course

The first week of the Short Course comprised field excursions and demonstrations and was located at Lake Bogoria in the Central Kenyan rift, whereas the second part of the course, comprised a series of lectures, demonstrations of computer programs and case examples, and visits to the Olkaria power plants, and was again located at Lake Naivasha (Georgsson et al., 2007). This extended course reached its purpose, as could be noted from enthusiastic and active trainees, who wanted to extend the course even more, mainly pointing at practical project work as missing, but even asking for a broader scientific background, e.g. by adding lectures on environmental science, reservoir assessment and drilling to give some insight into all aspects of exploration for geothermal resources.

In the "*Short Course III on Exploration for Geothermal Resources*" notice had been taken of the recommendations, adding project work and a few lectures of varying topics to its scope. The now more than three week long course was held at Lake Bogoria and Lake Naivasha in Kenya October 24 – November 17, 2008. As before, the event was co-organized by the UNU-GTP and KenGen. The 37 participants came from 11 countries of East Africa (plus Yemen) (Table 1). For the first time Zambia and DR Congo participated in events organized by the UNU-GTP. The teaching was in the hands of experts from Iceland (UNU-GTP and ISOR – Iceland GeoSurvey), Kenya (KenGen), all except one former UNU Fellows in Iceland, and five experts and former UNU Fellows from the neighbouring ARGeo countries, in all 28 lecturers (Table 2).

The structure of the Short Course is shown in Table 3. The first week consisted of field work in the Lake Bogoria region under the guidance of KenGen instructors. The second part consisted of lectures and project work at Lake Naivasha from October 31 till November 17. The lectures (8 days) covered the classical surface exploration fields, geology, geophysics, chemistry of thermal fluids and environmental science, together with an introduction to reservoir assessment and geothermal drilling, all demonstrated by numerous field examples and through practicals (Georgsson et al., 2008a). After a one-day excursion in the Olkaria area visiting the geothermal field and the power plants (Figure 3), three days were devoted to the status of geothermal exploration and development in the East African region and planning of geothermal projects. The last phase was 4 days of project work under the supervision of KenGen experts during which the participants were given data from Kenyan geothermal fields to deal with and interpret.

The assessment of the participants and lecturers was unanimous in, that with this Short Course a model had been developed that should be followed in the near future.. The importance of the project part of the course was specially noted.

The "*Short Course IV on Exploration for Geothermal Resources*" has now been announced (August 2009), and like the others is scheduled to be held, at Lake Bogoria and Lake Naivasha, November 1-22, 2009. The model is similar to that in 2008, with a few lectures added and a modest tightening of the programme. At the time of writing it is already clear that the demand for participation is definitely not going down, and a similar course can be seen to continue in the near future.

Table 3. The Structure of the "Short Course III on Exploration for Geothermal Resources " Held in Kenya, 2008.

Dates	Programme	No. lectures	Prac-ticals	Lecturer/Supervisor		
				Local	Neighb.	Iceland
24. Oct.	Arrival at Lake Bogoria					
25. Oct.	Introductory lectures	6		6		
26.-29. Oct.	Site visits to geothermal areas and geothermal field work		X	6		
30. Oct.	Site visit and drive to Lake Naivasha		X			
31. Oct.	Status of geothermal – Lectures	5		3		2
1. Nov.	Geology – Lectures and mapping	5	X	2		1
2. Nov.	Drilling and gradient wells - Lectures	2		1		1
2.-3. Nov.	Chemistry of thermal fluids – Lectures, analysis and interpretation	8	X	3		1
4.-6. Nov.	Geophysics – lectures and interpretation	14	X	3		2
6. Nov.	Resource assessment and measurement methods	2		2		
7. Nov.	Environmental sciences – lectures and measurements	3	X	2		1
8. Nov.	Excursion – Olkaria geothermal field, power plant and drilling			3		4
9.-10. Nov.	Status of geothermal in E-Africa	13		2	5 (+ 5)*	
11. Nov.	Case examples and geol. laboratory	3	X	1		2
12. Nov.	Geothermal project planning	4	X	2		2
13.-16. Nov.	Project work in groups		X	6		2
17. Nov.	Course review, discussion, closing cerem.	2	X	2		2
18. Nov.	Departure					

* Trainees from countries outside ARGeo gave lectures on their countries, shown in parentheses

Figure 3: Site visit at the Olkaria II power plant in Olkaria geothermal area during the 2007 Short Course in Kenya

An addition in 2008 was the "*Short Course on Geothermal Project Management and Development*" held November 20-22. This special three day event was co-organized by the UNU-GTP, KenGen and the Ministry of Energy and Mineral Development (DGSM) in Uganda. The timing of the Short Course was scheduled prior to the ARGeo C-2 conference held in Entebbe, Uganda November 24-28 to strengthen this event. The ARGeo facility and conferences are the main cooperation partnerships of the East African countries with regard to geothermal development. ARGeo may not have developed into the forum it was scheduled to become but the biannual conferences have become very important venues for cooperation and exchange of ideas and information for the geothermal experts in East Africa, and are worthy of good support. The Short Course was mainly aimed at high level managers/employees in ministries/energy companies/ research institutions in East Africa. The 22 African participants came from 10 countries in East Africa and Yemen, with two European participants added (Table 1). Teaching and organization was in the hands of 5 experts from Iceland (UNU-GTP, ISOR – Iceland GeoSurvey, and Reykjavik Geothermal), 6 experts from Kenya and one from each of Ethiopia and Uganda, all former UNU Fellows, and two international experts in geothermal utilization and development from El Salvador and the Philippines who gave lectures on their special fields of expertise (Table 2). The lectures (Georgsson et al., 2008b) and project work covered the status of geothermal

energy in the world, with emphasis on East Africa, phases of geothermal development, resource assessment and geothermal project planning and management. The aim was to promote and improve focus in planning of geothermal projects in the region to move the development of geothermal resources into the production stage. The course was well received and seemed to add an important piece to the capacity building in the region.

The Short Courses in East Africa have certainly proved to be a valuable addition to the capacity building activities of the UNU-GTP as a good first training opportunity for young scientists and engineers engaged in geothermal work. They have given an increasing number of young Africans an introduction to state-of-the-art exploration techniques for geothermal resources and the possible development of this valuable renewable energy source. As an example, 90 Africans participated in the Short Courses during 2006-2008 compared to a total of 22 UNU Fellows from Africa being trained for 6 months in Iceland during the same period. Furthermore, it has become a new channel for the more advanced training in Iceland for the most promising candidates. Already there are several examples of good participants in the Short Courses being selected for the more advanced 6-month training in Iceland, and in two cases it has even led to MSc studies in Iceland (Georgsson et al., 2008c; Fridleifsson and Georgsson, 2009).

The Short Courses have also been an important element in increased cooperation between the countries in East Africa. Here, Kenyans have mainly been in the role of the donor, while countries like Rwanda, The Comoros and Zambia, have utilized their knowledge and contracted them for local research projects. Similarly, geothermal exploration projects financed by ICEIDA, e.g. in Djibouti and Eritrea, have been carried out partly with the assistance of multinational expertise from their neighbouring countries.

The UNU-GTP foresees a further development of the Short Courses in Africa, and hopes that in the near future they may develop into a permanent school for geothermal training. Additional countries may also get entrance to the courses though most countries in East Africa which have considerable geothermal potential are already participants.

3. SHORT COURSES IN CENTRAL AMERICA

In Central America geothermal resources play an important role in the power production of countries like El Salvador, Costa Rica, Nicaragua and Guatemala with considerable untapped potential in several of the countries. The UNU-GTP has since its early years supported this region through training of many staff members of its geothermal institutions, especially in El Salvador and Costa Rica. Hence, Central America was selected as the region for the second Millennium Series of Short Courses. Two partners for cooperation could be foreseen, ICE in Costa Rica and LaGeo S.A de C.V. in El Salvador, with the latter chosen for this task. A MoU on the cooperation was signed in Mid 2006. LaGeo (with its predecessors) has been responsible for geothermal development in El Salvador since the 1970s and has all the know-how necessary to be an active and strong partner in hosting this series. The "*Workshop for Decision Makers on Geothermal Projects in Central America*" was held in San Salvador from November 26 to December 2, 2006.

The aim of the Workshop was to give high level decision makers from the respective energy and environmental ministries, leading geothermal agencies, and electric utilities in the region an overview of some of the key issues of geothermal development, with a special focus on environmental issues. The fifty participants were mainly from the four countries in Central America active in geothermal development, i.e. Costa Rica, El Salvador, Guatemala and Nicaragua and some of them were from the highest level, including three ministers (Figure 4).

Thirty six papers (Fridleifsson and Henriquez, 2006) were presented by 25 lecturers from the four Central American countries as well as Iceland, Italy, Kenya, Mexico, Philippines and the USA (Table 2). Among the lecturers were 9 former UNU-GTP Fellows. Presentation was in English but simultaneous Spanish translation offered. The Workshop was a sound success. In its conclusions *the importance of local geothermal energy resources and their possible potential in increased power production in the region is emphasized, along with the minimal environmental impact of geothermal, and the need for increased training and regional technical cooperation in this field.* The cooperation with LaGeo was smooth and they presented a reliable high-class partner.

One of the topics that were discussed during the Workshop was that environmental legislation and development of National Parks covering many of the volcanic systems and thus geothermal systems could be a barrier to further development of this environmentally benign and renewable energy resource. Thus the first Short Course was on one hand aimed at this problem and on the other to project management. The "*Short Course on Geothermal Development in Central America: Resource Assessment and Environmental Management*" was a week long event, and held in Santa Tecla, El Salvador, November 25 – December 2, 2007. In addition to lectures (Fridleifsson et al. 2007) and discussions of the subjects, there were practical exercises on reservoir resource assessment of geothermal fields in several countries, and in environmental management planning for specific geothermal fields. Participants (45 + 8 lecturers) came from Costa Rica (6+4), El Salvador (22+3), Guatemala (1), Honduras (2), Mexico (1) and Nicaragua (13+1). International lecturers came from Iceland 3, Kenya 1, and the Philippines 2 (Table 2). The success of the Short Course was well measured from the lively discussions of the attendees after each lecture round, offering their points of view, thoughts and questions, and the stimulating project work. Figure 5 shows some of the participants visiting the Berlín geothermal power plant.

For various reasons, the third event in Central America was delayed to 2009. The "*Short Course on Surface Exploration for Geothermal Resources*" has now (August, 2009) been announced to be held October 17-30 in El Salvador. It is scheduled to be a shorter version of the courses that have been held in East Africa 2007-2008, with the main emphasis on geophysics and chemistry of thermal fluids. This two week event, which is aimed at young earth scientists in the region, will include one week of field work and excursions in the Ahuachapan area and a second week of lectures held in Santa Tecla, focussing on scientific lectures mixed with case examples and use of computer programs for interpretation etc. The last day will be participation in the "Central American Geothermal Workshop", a cooperative event between LaGeo, IGA and UNU-GTP, intended to highlight geothermal development in Central America. It is already foreseen that this Short Course will reach a broader audience than the first two with participation from the East Caribbean Region where high-temperature geothermal systems associated with active volcanic system are found.

Figure 4: From the opening of the Workshop for Decision Makers in El Salvador in 2006

Figure 5: Participants in the 2007 Short Course in El Salvador on a tour of the Berlín geothermal power plant

The Short Courses in El Salvador have brought new and important components to geothermal development in Central America. They have not only increased the available training capacity for the region, but also furthered cooperation between the countries of the region in geothermal development. The geothermal development in Central America is on average at a higher level than in East Africa, which means that the future need in capacity building is more varied. We foresee the need for Short Courses covering topics ranging from surface exploration to development. However, participation can also be expected to cover a wider area where geothermal resources have not been developed to the same extent. Many of the small nations of the Eastern Caribbean region have important geothermal resources to be developed. Participants from this region can become a significant factor in the Short Courses in the near future. Similarly, participation from South America can also be expected to these Short Courses, as interest in the development of the high-temperature resources in this part of the world grows.

4. SHORT COURSES IN ASIA

The first UNU-GTP millennium event in Asia was the "*Workshop for Decision Makers on Direct Use of Geothermal Resources in Asia*" held in Tianjin, China, May 11-18 2008. China is the leading country in direct use of geothermal in the world, so site selection was easy after it had been decided that the third UNU-GTP Millennium Series of Short Courses should be in Asia and focus on direct heating use of geothermal energy. The Workshop was organized in cooperation with the Ministry of Land and Resources and the Municipality of Tianjin. The cooperative institutions were the Tianjin Bureau of Land Resources and Real Estate Management (TBLRREM), and the Tianjin

Figure 6: Participants in the Workshop for Decision Makers in China in 2008

Bureau of Geology and Minerals Exploration and Development (TBGMED).

The criteria for a country to be invited was a need for space heating for at least a few months of the year, and that there are known geothermal resources near densely populated areas (towns, villages). In addition to China, participants came from India, Iran, Jordan, Mongolia, the Democratic People´s Republic of Korea, and the Republic of Korea. The aim was to reach the important decision makers in ministries, energy companies and large municipalities, a goal that was reached. A large majority of the participants came from China, with e.g. most of the provinces sending directors from their planning agencies. In all, 118 participants took part in the Workshop making it the best attended UNU-GTP millennium event. This included 32 lecturers of which 16 came from China, 6 from the other participating developing countries, 6 from Iceland and 4 additional international lecturers (Table 2). The 52 lectures (Fridleifsson et al., 2008) were presented in English, with simultaneous translation into Chinese, and slides were shown both in English and Chinese. The workshop was very well received.

With the increased economical development in the countries of Asia, more demand is made on heating and cooling. It is therefore of the greatest importance to educate these populous countries on how existing geothermal resources can used for heating and even for cooling and thus play an important role in the reduction of emission of greenhouse gasses, as geothermal heating systems usually replace coal heated systems. For example, about 1 million people in the Tianjin region (out of 11 million) live in houses heated by geothermal water, and another 4 million enjoy geothermally heated hot tap water in their apartments. Many of the key geothermal specialists there were trained in Iceland.

The Workshop in Tianjin is expected to be followed by annual courses in China in specific aspects of direct utilization of geothermal energy for space heating, bathing and other purposes, starting in 2010. The UNU-GTP and the Tianjin Bureau of Geology and Minerals Exploration and Development (TBGMED) in 2006 also signed a Letter of Agreement on discussing preliminary plans prepared by the TBGMED for establishing a geothermal sub-centre of the UNU-GTP in Tianjin.

Preliminary discussions have also been held with representatives of Pertamina in Indonesia to cooperate on the organization of a Workshop and Short Courses for the Asian countries in the exploration and development of high-temperature geothermal systems for electricity production. The Philippines and Indonesia are among the leaders on the list of countries producing electricity from geothermal fields, and the potential for increased production is immense in Indonesia. Several other countries in Asia and the Pacific area have considerable potential for power production, such as China, Iran, Papua New Guinea and Thailand, and many of the Pacific island nations. However, with the financial crisis in Iceland these plans probably need to be postponed for a while.

5. THE FUTURE OF THE UNU-GTP MILLENNIUM SERIES

With the Millennium Workshops and Short Courses, the UNU-GTP has reached a much wider audience than before. In Africa more than 140 Africans have participated in the UNU-GTP Millennium Series (Table 1) during 2005-2008, and between 30 and 40 additional individuals from the region have lectured in the events. This can be compared with the 28 UNU Fellows from Africa (and Yemen) that have been trained in Iceland during the same period. If participants in the other Millennium events are added, the UNU-GTP capacity building through the Millennium events has reached about 350 individuals during these four years.

The Short Courses haven created new bonds and opened new ways of cooperation. In East Africa key geothermal scientists in the region are lecturing and supervising the young and promising scientists, with the knowledge thus being transferred from one generation to the next. Similarly, this has created bonds and friendship between individuals with different background and across boundaries. This can only help the development of geothermal in the region.

The financial crisis in the world has hit Iceland badly. The operations of the UNU-GTP are almost solely financed by

the Government of Iceland (>90%). Even though the Government has emphasized that development aid through UNU-GTP has a high priority, some cut-downs are foreseen, which may affect the operations of the UNU-GTP to some extent in the near future, after a long period of continuous expansion. The UNU-GTP Millennium Series will though certainly get their fair share, and will be continued as possible. Expansion is though hardly in the framework until the financial climate has improved. This means that the Short Courses in Africa and Central America will be continued. The same will hopefully apply for the scheduled Short Courses in China in direct use of low-temperature resources.

An important part of the development of these Series is also how they can act as a channel for more advanced training in Iceland for the best candidates. This has been very successful in East Africa where many good African trainees have later come for 6-month training in Iceland and even continued for MSc studies after doing well in a Short Course in Kenya.

Most importantly is though that these Series can be expected to develop into sustainable regional geothermal centres under the umbrella of the UNU-GTP. Requests for this have already been discussed. The idea has also been presented at the headquarters of the United Nations University in Tokyo and the reception was good. Here the financial crisis has also delayed action but hopefully this can be turned into reality in the next future.

CONCLUSIONS

With the Millennium Series of Workshops and Short Courses on the exploration and development of high-temperature resources given in East Africa and El Salvador and the recently started Series in China for Asia on the use of low-temperature resources the UNU-GTP has managed to reach far greater number of geothermal scientists and engineers, than through the conventional 6-month training in Iceland. The Series have been a real success story, and serious expectations are now based on their continuation in the respective countries. Many former UNU Fellows from these regions have been key members of the planning and execution of the events, as lecturers, supervisors or managers. Despite a financial crisis it is very important that this momentum in the geothermal capacity building in the developing countries is kept and many countries rely on Iceland to do that.

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