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Geothermal Training for Africans: The Operations of the UNU-GTP in Iceland and Africa and Possible Future Development

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ABSTRACT

The United Nations University Geothermal Training Programme (UNU-GTP) in Iceland specializes in capacity building for geothermal exploration and development for professionals from developing countries. The aim is to assist countries with geothermal potential to build up expertise in geothermal exploration and development. This is achieved through training and post-graduate academic studies in Iceland and, more recently, also through short courses and workshops in the developing countries themselves. The annual 6-month training in Iceland is the core of the programme. Africa is a priority area within the UN system. With the increased geothermal development in Africa and especially in Kenya in recent years, the UNU-GTP has put more emphasis than ever on capacity building for Africa, which is manifested both in the training activities in Iceland and on-site in Africa. In 2012, 19 out of 33 6-month training UNU Fellows in Iceland came from Africa, and many courses have been given in Africa (Kenya) in the last 3 years, both through UNU-GTP's initiative or sponsored by local energy agencies. Out of 515 UNU Fellows in Iceland in the period 1979-2012, 165 or 32% have come from 15 African countries. In addition, 15 out of 33 UNU-GTP MSc-graduates to date are from 6 African countries, and the first three PhD-Fellowships have gone to Kenyans.

UNU-GTP training activities in developing countries were initiated with a series of annual workshops/short courses, starting in Africa (Kenya) in 2005 and later in Central America and Asia. These events have been organized in cooperation with established local energy agencies responsible for geothermal development. The aim has not only been to increase capacity building but also to further regional cooperation in geothermal development and to reach out to new countries with capacity and interest in geothermal development. The week-long "Workshop for Decision Makers" held in Kenya in 2005 has been followed by annual short courses, first aimed only at surface exploration but gradually extended to cover most aspects of geothermal exploration and even an introduction to development, now extending for 3½ weeks. In this, UNU-GTP has worked closely with Kenya, through KenGen, and since 2009 also GDC. Since the start in 2005, more than 360 individuals from 19 countries in Africa (including Yemen) have benefitted from this training. These series have also provided a basis that has made it possible for the UNU-GTP to go one step further by offering customer-designed short courses in line with the needs of clients from the developing countries through local or external financial sponsors. Since 2010, this has become an important part of the operations of UNU-GTP, not-least in Kenya due to its urgent need for additional geothermal manpower.

Many of Africa's leading geothermal experts have obtained their basic geothermal training in Iceland. Together with Icelandic experts, they now share their knowledge and experience with a new generation of African geoscientists and engineers. The next step in capacity building for Africa should be the establishment of a regional geothermal training centre for East Africa. The UNU-GTP wants to assist in this and create a UNU-GTP sub-centre in Kenya, preferably through cooperation with GDC and KenGen, and international sponsors. A similar set-up is now being evaluated in El Salvador for Latin America with funding already secured.

1. INTRODUCTION

The United Nations University (UNU) was founded in 1975. The aim was to build a global university network with a special focus on capacity building in developing countries. Its headquarters is in Tokyo, but teaching is conducted in various centres around the world. The Geothermal Training Programme is operated within Orkustofnun - the National Energy Authority of Iceland. Orkustofnun became an Associated Institution of the UNU in 1978 and the UNU Geothermal Training Programme (UNU-GTP) has been in operation since 1979.

Exploring and developing geothermal resources is a multi-disciplinary task, where experts of varying fields are needed. If the results of the exploration are positive, drilling of wells is usually the next step, and, still later, development of the resource for utilization, either for electrical production and/or direct-use. Geoscientists, together with environmental scientists, join in the exploration during data collection and interpretation that allows for the creation of a conceptual model of the

geothermal systems. At the drilling stage, engineers with special knowledge on drilling in geothermal fields are needed, and reservoir engineers are required for the subsurface exploration to model and simulate the behaviour of the geothermal system, as well as monitor it. And when it comes to utilization, other engineers are needed for the design of the geothermal facilities.

A country that wants to develop its geothermal resources, therefore, needs to have access to a group of experts in the various fields of geothermal science and engineering to be the project, knowledge is left behind in the country for running the installation and monitoring the geothermal system, or for further development of a similar kind.

The task of the UNU-GTP is to assist with this, to help developing countries with significant geothermal potential to establish groups of specialists in geothermal exploration and development that have the basic knowledge necessary for geothermal development. The UNU-GTP has done this by offering 6 months intensive training in Iceland in the various fields that are required in the exploration and development of geothermal resources. An MSc programme and a PhD programme ware initiated in 2000 and 2008 respectively, both in collaboration with the University of Iceland (UI), to take the training a step further and provide advanced academic opportunities in geothermal sciences or engineering. From 2005, core funding has also been secured for additional training efforts, taking the training to the developing countries. This has been Iceland's contribution to the UN Millennium Development Goals, and has been done through regular workshops/short courses hosted in selected countries on different continents, and through cooperation with their local energy institutions/companies. Consequently, the possibility of offering courses to fulfill the special needs of paying customers was formally decided on in 2009 with the first such event held in early 2010, and is now an important part of UNU-GTP´s operations.

The paper describes the operations of the UNU-GTP, with special reference to its capacity building activities in Africa and the needs of the continent. At the end some scope of possible future development is given.

2. GEOTHERMAL POTENTIAL OF EAST AFRICA

The East African countries have similar energy production and consumption characteristics. Traditional biomass fuels represent the largest category of energy produced, amounting to between 70% and 90% of the total primary energy production. Most of them are also dependent on fossil fuels as a primary energy source. The high usage of combustible waste and biomass causes deforestation and contributes to environmental degradation. All East African countries import petroleum products mainly for transport and electricity production. In times of environmental awareness and sky-high oil prices, development of local renewable energy sources is of importance. For the countries surrounding the Great East African Rift System with its volcano-tectonic activity, high-temperature geothermal resources have the potential of playing a large role and even becoming one of the main sources of electricity production (Teklemariam, 2008).

Kenya has been the leading African country in geothermal development, with 202 MWe on-line in Olkaria at the end of 2009 (Simiyu, 2010). In Ethiopia, the Aluto-Langano pilot power plant, built in 1998 for the production of 7.2 MWe on-line, is again in operation after difficulties for some years (Teklemariam, 2008), but only at about half its capacity due to lack of steam. Geothermal exploration and research have been undertaken in Djibouti, Eritrea, Uganda and Tanzania, and more recently in Comoros, Zambia, and Rwanda. Malawi, Mozambique and Sudan could also be included here. The potential of using geothermal energy for electricity production may be greatest in Kenya and Ethiopia, but the other countries should not be discounted. With today's technology, East Africa has the potential to generate many thousands of megawatts of electricity from geothermal power. Kenya has now decided to take a giant step into this future by declaring geothermal as its main future energy source for electricity, with the aim of adding about 1500 MW on-line by the year 2018 and producing about 5000 MW on-line in 2030 according to the Kenya Vision 2030 (Simiyu, 2010; Ofwona 2012). With this Kenya is setting an example which their neighbours will follow closely. This development will increase the demand for man power with knowledge on geothermal, and thus the need for capacity building. Furthermore, Ethiopia is now preparing to drill in Aluto-Langano, after 1½ decade of low activity, and Rwanda is also evaluating its possibilities for geothermal electricity through a fast-track programme.

3. GEOTHERMAL TRAINING IN ICELAND

Since 1979, the UNU-GTP has offered annual 6-month training for professionals from developing countries. Nine specialized lines of training in geoscience and engineering are offered: Geological Exploration, Borehole Geology, Geophysical Exploration, Borehole Geophysics, Reservoir Engineering, Chemistry of Thermal Fluids, Environmental Science, Geothermal Utilization and Drilling Technology (www.unugtp.is). Each trainee attends only one specialized line of study. The trademark of the training is to give university graduates engaged in or targeted for geothermal work, intensive on-the-job training in their chosen fields of specialization. The trainees work side by side with geothermal professionals in Iceland. The training is, as much as possible, tailor-made for the individual and the

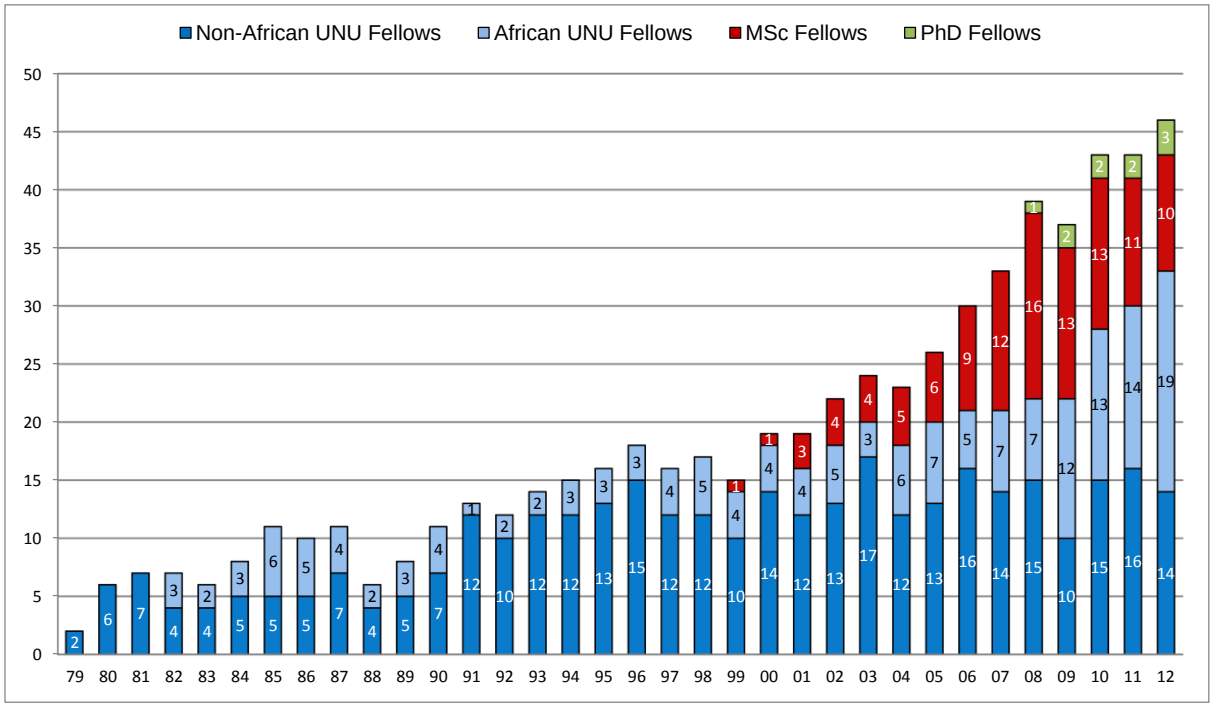

Figure 1: Number of UNU Fellows trained and doing research in Iceland 1979-2012 – the share of Africa for each year of the 6-month training is emphasized.

needs of his institution/country. Table 1 shows the time schedule for the training.

Table 1: Time schedule for the six months specialized courses at UNU-GTP.

Week	Geological Exploration	Borehole Geology	Geophysical Exploration	Borehole Geophysics	Reservoir Engineering	Chemistry of Thermal Fluids	Environmental Science	Geothermal Utilization	Drilling Technology
1	Introductory Lecture Course Main aspects of geothermal energy exploration and utilization Practicals and short field excursions								
2									
3									
4									
5									
6									
7	Field geology Lithological, tectonic & hydrothermal mapping Temperature surveying	Sample preparation Cutting analysis Petrography - Lithological & alteration logs	Thermal methods - Magnetics Gravity - Seismic methods Resistivity of rocks - Resistivity methods: DC, TEM & MT	Well logging & testing - theory & practises Logging and testing demonstrations Reservoir physics & well/reservor modelling Monitoring response to exploitation		Sampling of fluid & gas - Wet steam wells - Analytical methods Thermodynamics - Data processing and interpretation	EIA project planning Chemistry - Physics Biology - Monitoring Revegetation - Safety	Thermal design of power plants & source systems - Direct use of geothermal heat - Scientific modelling of utilization systems	Drilling equipment & procedures - Well design Rig operations - Safety Management - Cementing
8									
9									
10									
11	Excursion to some of the main geothermal fields of Iceland, geothermal power plants and direct use facilities								
12									
13	Gradient wells Remote sensing - GIS	XRD - Fluid inclusions Logging software	Processing & modelling resistivity data - GPS	Resource management & reinjection Data processing & software applications		Water-rock interaction Corrosion & scaling	Gas dispersion & abatem. Corrosion & scaling	Power plant components - Control systems - Corrosion & scaling	Completion - Testing Problems - Drilling software
14									
15	**Project and report writing**	**Project and report writing**	**Project and report writing**	**Project and report writing**	**Project and report writing**	**Project and report writing**	**Project and report writing**	**Project and report writing**	**Project and report writing**
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									

A significant part of the practical training is conducted in connection with individual research projects. In most cases the participants bring with them data from geothermal projects in their home countries, but sometimes the research projects are based on Icelandic data. All project reports have been published by the UNU-GTP, and since 1994, the reports have been collected in the annually published book "Geothermal Training in Iceland", with the international publishing code (ISBN 978-9979-68 / ISSN 1670-7400). Copies of the book can be obtained upon request. The reports are mailed regularly to former UNU Fellows and many of the leading geothermal institutions in developing countries. The complete reports can also be accessed from the home page of the UNU-GTP (www.unugtp.is) in a pdf version.

Participants for the 6-month training are usually selected by private interviews during a site visit to the country in question, where a UNU-GTP representative assesses geothermal fields, research institutions and energy utilities. A candidate must have a university degree in science or engineering and speak fluent English. Furthermore, he/she should have a minimum of one year's practical experience in geothermal work, a permanent position at a public energy

Figure 2: UNU Fellows in Iceland for the 6-month training in 2012.

company, utility, research institution or university, and be under 40 years of age. Selected participants from developing countries receive UNU Fellowships financed by the Government of Iceland that cover international travel, tuition fees, and per diem in Iceland. Other international agencies such as UNDP and the IAEA, and national institutions like the Icelandic Development Agency (ICEIDA) and BGR of Germany have also financed Fellowships for a few trainees through the years.

Since the foundation of the UNU-GTP in 1979, 515 scientists and engineers from 53 countries have completed the annual six months specialized courses offered (Figure 1). Of these, 40% have come from countries in Asia, 32% from Africa, 16% from Latin America, 12% from Central and Eastern Europe. The first two from Oceania (Papua New Guinea) were trained in 2012. The largest groups have come from China (80), Kenya (72), El Salvador (34), Philippines (33) and Ethiopia (30). In many countries, UNU-GTP graduates are among the leading specialists in geothermal research and development.

At the start of this century, regular funding of the UNU-GTP financed the 6-month training of 16 UNU Fellows per year, gradually growing to between 20 and 22 at the end of the decade, while 1-3 extra UNU Fellows were being financed in some years through other sources, at least partially. However, the last three years have seen a dramatic increase in this. Improved set-up and new facilities in Iceland, and better access to good teachers have made it possible for UNU-GTP to accept additional fellows if financed through external sources. African institutions are given the first priority to benefit from this increased scope of training. This is reflected in the large groups in the period 2010-2012 (Figure 1), with the largest group to date trained in 2012, including 33 UNU Fellows, 11 of whom (8 Kenyans, 2 Philippinos and 1 Nicaraguan) are mainly financed through other agencies. Our statistics show that the participation of African Fellows has gradually grown and has reached 40% in the past 10 years (2003-2012), and half of those participating in the last 3 years have come from Africa (see Figure 1). This reflects the high priority given to Africa currently at UNU-GTP, as in the UN system in general. Figure 2 shows the group of UNU Fellows trained for 6 months in Iceland in 2012, 19 of whom come from Africa.

The aim of establishing an MSc programme in cooperation with the University of Iceland (UI) was to go a step further in assisting selected countries to strengthen their specialist groups more and increase their geothermal research capacity, through admission to and support for postgraduate academic studies. The 6-month training at the UNU-GTP fulfils 25% of the MSc programme credit requirements (30 of 120 ECTS). Since 2001, 33 former UNU Fellows (China 2, Costa Rica 1, Djibouti 1, El Salvador 3, Eritrea 2, Ethiopia 2, Indonesia 4, Iran 3, Jordan 1, Kenya 8, Mongolia 1, Philippines 2, Rwanda 1 and Uganda 1) have completed an MSc degree in geothermal science and engineering through the UNU-GTP MSc programme, i.e. 15 or 45% coming from Africa. The MSc theses have been published in the UNU-GTP publication series (ISBN 978-9979-68 / ISSN 1670-7427) and can also be obtained from the UNU-GTP webpage (www.unugtp.is). All of the MSc Fellows have been on UNU-GTP Fellowships funded by

the Government of Iceland. Furthermore, five former UNU Fellows, all coming from Africa, have now been admitted to PhD studies at the University of Iceland, with the first two admitted in the academic year 2008/2009. Three of them are on UNU-GTP Fellowships (all from Kenya) while the other two (from Djibouti and Eritrea) have been funded through other sources in Iceland. The first PhD Fellow is scheduled to defend his PhD thesis in the second half of 2012.

For a more detailed description of the general operations of the UNU-GTP, see Fridleifsson (2010) or visit the UNU-GTP webpage - www.unugtp.is.

4. TRAINING ACTIVITIES IN AFRICA

4.1 Local Training in Developing Countries

At the UN Summit Meeting on Sustainable Development held in Johannesburg in 2002, the Icelandic Government announced that its contribution to the goals of the conference would be the financing of increased operations of the UNU-GTP to enhance the use of geothermal resources for power production. This would allow the UNU-GTP to expand its capacity building activities in geothermal exploration and development in special target regions in the third world where geothermal could be foreseen to make a considerable impact, e.g. as a replacement for biomass and fossil fuel in energy production. At the International Conference for Renewable Energies held 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 starting from 2005, in Central America starting from 2006 and later on in Asia (Fridleifsson, 2004). From the year 2005, the Government of Iceland has secured the necessary core funding for the UNU-GTP to carry out these plans in East Africa and Central America.

The courses/workshops are set up in a selected country in the target region through close cooperation with local energy agencies/utilities and/or earth science institutions, responsible for exploration and development of geothermal and/or operation of geothermal facilities in the respective countries. In terms of implementation, the first phase has been a workshop during which decision makers in energy and environmental matters in the target regions have met for a week with leading local geothermal experts and specially invited international experts. The status of geothermal exploration and development has been presented in addition to discussing the current role of geothermal energy in the energy mix of the regions, and its possible future development. The purpose has been, on one hand, to get decision makers in the energy market of the regions together and to present to them and educate them about the possibilities of geothermal energy and, thus, increase their awareness of the necessity for more effort in the education of geothermal scientists and engineers in the region. On the other hand, it has been to further the cooperation between specialists and decision makers within the different countries, and between countries. The workshop is followed by "annual" specialized short courses for earth scientists and engineers in surface exploration, deep exploration, production exploration, environmental studies, production monitoring etc., in line with the needs for geothermal development in the respective regions.

Presently, Workshops for Decision Makers have been held in East Africa (Kenya, 2005), Central America (El Salvador, 2006) and Asia (China, 2008) (Fridleifsson, 2010). Short courses have since been held annually in Africa and almost annually in Central America, with the next courses in Africa and Central America scheduled for November 2012 and early 2013, respectively. Table 2 shows an overview of the events in East Africa. Material presented and written for these events has been published on CDs and is also available on the UNU-GTP website (*www.unugtp.is*).

Table 2: UNU-GTP Workshops and Short Courses held in East Africa 2005-2012 as a part of the UN Millennium Development goals.

Event	Main site	Dates	Duration (days)
Workshop for Decision Makers on Geothermal Projects & their Manag.	Naivasha	Nov. 14-18, 2005	5
Short Course on Surface Exploration for Geothermal Resources	Naivasha	Nov. 13-22, 2006	10
Short Course II on Surface Exploration for Geothermal Resources	Naivasha	Nov. 2-17, 2007	16
Short Course III on Exploration for Geothermal Resources	Naivasha	Oct. 24 - Nov. 17, 2008	25
Short Course on Geothermal Project Management & Development	Entebbe	Nov. 20-22, 2008	3
Short Course IV on Exploration for Geothermal Resources	Naivasha	Nov. 1-22, 2009	22
Short Course V on Exploration for Geothermal Resources	Naivasha	Oct. 29 - Nov. 19, 2010	22
Short Course VI on Exploration for Geothermal Resources	Naivasha	Oct. 27 - Nov. 18, 2011	23
Short Course VII on Exploration for Geothermal Resources (scheduled)	Naivasha	Oct. 27 - Nov. 18, 2012	23

4.2 The East African Series of Short Courses

During the planning of the first workshop the selected region was East Africa, due to its huge but to a large extent undeveloped potential for geothermal power production and its urgent need for further development. Kenya had for long been the leading producer of geothermal electricity in East Africa. Hence, cooperation was sought with the Kenya

Electricity Generating Company – KenGen, which (with its predecessors) had been the long-term main authority incharge of geothermal development in Kenya. The UNU-GTP had also had a long and fruitful cooperation with KenGen in its training activities. Many of its scientists and leaders had also received geothermal training in Iceland, and thus KenGen was known to have 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, being close to the active Olkaria high-temperature geothermal system and its geothermal power plants. In 2009, the newly formed Geothermal Development Company (GDC) which took over some of the tasks of KenGen as well as some of its former staff members became an additional cooperation partner. The cooperation has generally meant that the costs of all invited foreign participants (travel and accommodation) and non-local lecturers (salaries, travel and accommodation) are covered by the UNU-GTP and the Icelandic Government, while the costs of the local Kenyan participants and some of the local arrangements are borne by KenGen, and from 2009 also by GDC. KenGen and GDC have proven to be first-class hosts and cooperation partners and have made excellent arrangements for the workshops and short courses, and the contribution of their scientists in lecturing and supervising are one of the cornerstones of these events.

The "Workshop for Decision Makers on Geothermal Projects and their Management" was held in Kenya in November 2005 in cooperation not only with KenGen, but also ICEIDA (Icelandic International Development Agency). The five-day workshop brought together high-level decision makers from the energy companies/institutions in the region for information sharing and discussions on the main phases of geothermal development, including manpower, equipment, financing needed for each phase, and analyses on what was available in the region. Participation was by invitation only, as has been the case for all the events. The workshop had 30 participants from five of the six so-called ARGeo countries (Eritrea, Ethiopia, Kenya, Tanzania, and Uganda, with Djibouti missing), including the local lecturers that were active in all phases of the workshop, and the international lecturers at the event, 4 from Iceland and 1 from the Philippines. Figure 3 shows the participants and lecturers. The workshop was quite successful and it was concluded that there was indeed a serious need for increased capacity building in the region. Sixteen papers were written, presented and distributed as conference proceedings on a CD-ROM (Fridleifsson et al., 2005; www.unugtp.is).

Table 3: Participants in the UNU-GTP Workshop and Short Courses in East Africa 2005-2012.

Country	Kenya 2005*	Kenya 2006	Kenya 2007	Kenya 2008	Uganda 2008	Kenya 2009	Kenya 2010	Kenya 2011	Kenya 2012**	Total	6 mo. UNU Fellows***
Algeria			1					1		**2**	**1**
Burundi				2	1	2	2	1	2	**10**	
Comoros			2			2	3	2	2	**11**	**1**
Congo				1	1			1	3	**6**	
Djibouti		2	1	2	3	2	2	3	3	**18**	**6**
Egypt			1							**1**	**1**
Eritrea	2	3	2	2	1	2		2		**14**	**4**
Ethiopia	5+2	3	1	2	3	3	1	3	3	**26**	**8**

Figure 3: Participants in the "Workshop for Decision Makers on Geothermal Projects and their Management" held at Naivasha, Kenya, November 14-18, 2005.

Kenya	6+9	10	13	18		21	31	30	26	**164**	**37**
Malawi							3	3	3	**9**	**1**
Morocco							1			**1**	**1**
Mozambique							1	1	1	**3**	
Nigeria									2	**2**	
Rwanda			2	2	1	3	3	4	6	**21**	**7**
Sudan									2	**2**	
Tanzania	2	2	2	2	4	3	3	2	3	**23**	**7**
Uganda	4	3	3	2	5	3	2	2	3	**27**	**9**
Zambia				2	2	2	3	2	2	**13**	**1**
Yemen			2	2	1	2	1	1	2	**11**	***4***
Others					2					**2**	
Total	**30**	**23**	**30**	**37**	**24**	**45**	**56**	**58**	**63**	**366**	**88**

* The second number shows African lecturers who participated fully in the workshop;
** Numbers for 2012 are based on scheduled attendance based on invitations;
*** UNU Fellows in Iceland for 6-month training during the same period (2005-2012).

At the workshop it was recommended that short courses focusing on surface exploration - the field of study acutely needed for most countries in the region - would follow the workshop. These short courses have been given annually in Kenya since 2006. Table 2 gives an overview of the events, while Table 3 shows the participation from various countries, and Table 4 lists the number and background of the lecturers. The first was the ten-day "Short Course on Surface Exploration for Geothermal Resources" held in November, 2006. The intention was to give "a state of the art" overview of the methods used in surface geothermal exploration, including a forum on the status and possibilities of geothermal development in East Africa. The event started with a series of scientific lectures covering the three main fields of surface exploration of geothermal resource, i.e. geology, geophysics and chemistry of thermal fluids, including many case examples, while the latter part consisted of presentations and discussions on the status of exploration in the different countries, in addidtion to practical training which included field demonstrations and practical use of computer programs. The short course was very well received and based on the results of an assessment meeting for all participants and lecturers during the last day, it was clear that the short course had been a success. It was suggested that the basic model should be repeated but suggestions were made for improvements and additions.

During the last 6 years, the annual short course at Naivasha has gradually developed into a more general course on geothermal exploration. In 2007, a few extra days of field work and demonstrations were added at the start of the course. This part has been held at Lake Bogoria in the Central Kenyan rift and entirely conducted by KenGen/GDC staff. In 2008, 4 days of project work were added at the end of the course, which at that time had become 3½ week long. This model has since been followed. Furthermore, the content of the short courses has also gradually been broadened by adding new topics, such as lectures on environmental science, resource assessment, project planning, drilling technology, well logging, well siting and most recently, an introduction to geothermal power plants. As an example, Table 5 shows the setup of "*Short Course VI on Exploration for Geothermal Resources"*which was held in late 2011. Figure 4 shows the participants in the 2011 short course.

Presentations and papers specially written for the short courses have been published on CDs and distributed to participants, lecturers and other interested persons (Georgsson and Simiyu, 2006; Georgsson et al., 2007; Georgsson et al., 2008a; Georgsson et al., 2009; Georgsson et al., 2010; Georgsson et al., 2011). Most of them are also available at our website (*www.unutp.is*).

Table 4: Lecturers in the UNU-GTP Workshop and Short Coursesin East Africa 2005-2011.

Short Course / Workshop	**Total**	**Home country**	**Neighbour. countries**	**Internat.**	**Iceland**	**Former UNU-Fellows**
Kenya 2005	**16**	9	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*
Kenya 2009	**35**	27	4	0	4	*26*
Kenya 2010	**34**	27	3	0	4	*23*
Kenya 2011	**36**	27	5	0	4	*27*
Uganda 2008	**15**	1	7	2	5	*8*

Table 5: The structure of "Short Course VI on Exploration for Geothermal Resources" held at Lake Bogoria and Naivasha, Kenya, November 2011.

Dates	Programme	No. lectures	Prac-ticals	Lecturer/Supervisor		
				Local	Neighbou.	Iceland
Oct. 27	Arrival at Lake Bogoria					
Oct. 28	Introductory lectures	7		7		
Oct.29-Nov. 1	Site visits to geothermal areas and geothermal field work		X	7		
Nov. 2	Site visit Menengai, drive to Naivasha		X			
Nov. 3	Geothermal energy and drilling, etc. - Lectures	6		3		2
Nov. 4	Geothermal & geological mapping, GIS - Lectures & practicals	5	X	3		1
Nov. 7-8	Geophysics – Lectures &practicals on interpret.	14	X	3		2
Nov. 7	Chemistry of thermal fluids – Lectures & interpret.	7	X	3		1
Nov. 8	Resource assessment & well logging– Lectures Practical sessions in geophysics and chemistry	5	X	6		1
Nov. 9	Environmental science and mapping resources – Lectures & Practicals	7	X	5		2
Nov. 10	Power plants & direct use – Lectures Practical session on environmental monitoring	5	X	5		
Nov. 11	Excursion – Olkaria geothermal field, power plant and drilling rigs, Oserian flower farm		X	2		2
Nov.12-13	Status of geothermal in E-Africa – Planning projects – Lectures & practicals	18	X	2	4 (+9)*	
Nov.14	Case examples	5		1		3
Nov. 15-17	Project work in groups		X	8		
Nov. 18	Project present, course review, closing ceremony	(8)	X	2		1
Nov. 19	Departure participants – Instructors assessm. Meet.					

* Trainees gave lectures on geothermal in their countries, shown in parentheses

An extra component in the local capacity building was the "*Short Course on Geothermal Project Management and Development*". This three-day event, which took place in Entebbe, Uganda in November 2008, was co-organized by the UNU-GTP, KenGen and the Ministry of Energy and Mineral Development (DGSM) in Uganda. The timing and location of the short course was scheduled prior to the ARGeo C-2 conference to strengthen that event. The short course targeted high-level managers/employees in ministries/energy companies/research institutions in East Africa. The lectures (Georgsson et al., 2008b) and practicals covered the status of geothermal energy in the world with an emphasis on East Africa, introduction to the phases of geothermal development, resource assessment and geothermal project planning and management. The purpose was to promote and improve focus in planning of geothermal projects in the region to assist in moving the development of geothermal resources into the production stage. The course (see also Tables 2-4) was well received and added an important piece to the capacity building in the region.

Participation in the short courses in Kenya has increased every year, with the highest number of participants in a

Figure 4: Participants in the 2011 Short Course in Kenya.

single event being 58 for the 2011 Short Course, which will probably be exceeded at the 2012 event. Here a significant factor has been the pressure to increase training opportunities in Kenya itself, needed for its on-going fast-tracking of geothermal development. Many new countries have also been added to those invited in the first year (Table 3). The Comoros, Malawi, Rwanda and Zambia were participating for the first time in any UNU-GTP events and have subsequently been invited to send candidates for the 6-month training programme in Iceland.

The additions in 2012 are Sudan and Nigeria. Yemen has been included despite being on the other side of the Red Sea and thus in Asia, as some of its geological features relate to the East African Rift Region. The total number of participants is now beyond 360 persons (Table 3). The number of lecturers has also increased with the length of the short courses as can be seen from Table 4. The table also shows that most of the African lecturers/supervisors are former UNU Fellows trained in Iceland.

4.3 Results of the Short Courses

The short courses in East Africa have certainly proven to be a valuable addition to the capacity building activities of the UNU-GTP in Africa. They have now become well established as a good initial training opportunity for young East African scientists and engineers engaged in geothermal work. The participants are given a solid introduction to state-of-the-art techniques used in the exploration for geothermal resources and the possible development of this valuable renewable energy source. In total, 364 Africans (including Yemen) have participated in the short courses during the period 2006-2012 (number for 2012 assessed). During the same period 88 African (including Yemen) UNU Fellows have been trained in Iceland. It is clearly seen that through the short courses the UNU-GTP has been able to reach a far larger number of geoscientists and engineers in East Africa than it has through its conventional training in Iceland. It has thus, been able to spread geothermal knowledge to a much wider region and audience, and consequently open up for possible geothermal development in new countries. Furthermore, the short courses have become a new channel for the more advanced training in Iceland. For the trainees that use this opportunity to show their ability, skills and ambitions it can open the door to their selection for training in Iceland. Many examples now exist of strong participants in the short courses being selected for the 6-month training in Iceland. In a few cases it has already led to MSc studies in Iceland, with the first of these completing the MSc degree in April 2010.

The short courses have also been an important element towards increased cooperation between the countries in East Africa. Here Kenyans have, to a large extent, played the role of the donor, while countries like Rwanda, Comoros, Zambia and most recently Sudan have utilized their knowledge and contracted Kenyan experts for local exploration projects. Similarly, geothermal exploration projects financed by ICEIDA, e.g. in Djibouti and Eritrea, have been carried out partly with a multinational group which include qualified experts from the neighbouring countries who have been trained by the UNU-GTP earlier in their career.

For a further description of the workshops/short courses of the UNU-GTP see Georgsson (2010a and b; 2011) or the UNU-GTP webpage (www.unugtp.is).

4.4 Short Courses Designed for a Special Customer

The latest capacity building service of the UNU-GTP has been to offer customer-designed short courses in developing countries, which were conducted for the first time in 2010. This new service provided by the UNU-GTP was triggered by an urgent need for training in countries at the starting stage of fast geothermal development, such as Indonesia and Kenya. The provision of this service has been made possible through the existing material prepared for the training in Iceland and even more so for the regular short courses. This has proven a good opportunity where there is a need for a fast-tracking programme in capacity building beyond what UNU-GTP can service within its conventional operations. The paying customer defines the outline of the short course or the expected outcome, while the detailed contents are designed by UNU-GTP, with its name providing the guarantee for the quality of the contents. The first such courses were held in 2010 for four different customers in 2 continents (Asia and Africa). The years 2011 and 2012 have seen a continuation and escalation of these operations. The contents have varied from general geoscientific courses to more specific ones such as geothermal drilling, as well as scaling and corrosion in geothermal installation. The length has varied from 1 week to 3 months. A variant of this has been hands-on-training of a group of specialist in a selected field, for shorter or longer time periods.

5. THE STATUS AND THE WAY FORWARD

5.1 The Progress so Far

Since its establishment in 1979, the UNU-GTP has to date given 165 Africans the opportunity to attend an intensive 6-month training in Iceland in geothermal sciences or engineering. In recent years, with larger groups and higher priority given to Africa, its share has risen to 32% of the total. However, in an even shorter term, during the last 3 years more than half of the UNU Fellows have come from Africa (46 out of 91), with some financed through external sources. A very positive aspect is that majority of the UNU Fellows from Africa are still active in geothermal exploration and development.

High priority has also been given to Africa in the selection of candidates for MSc and PhD studies in Iceland on UNU-GTP Fellowships. To date, 33 MSc Fellows have completed their studies at the University of Iceland, of whom 15 (45%) are African. The first 3 PhD Fellows are all Kenyans, with the first one scheduled to defend his thesis in the second half of 2012. Two additional former UNU Fellows from Africa

(from Djibouti and Eritrea) have also been doing their PhD studies at the University of Iceland, both funded through Icelandic sources.

With the Millennium Workshops and Short Courses, the UNU-GTP has reached a much wider audience than before. More than 360 African scientists and engineers (including Yemen) have participated (or will) during the period 2005-2012 and close to 50 individuals from the region have lectured in these events. This can be compared to the 84 UNU Fellows from Africa and 4 from Yemen trained in the 6-month programme in Iceland during the same period. It can be argued that with this, the short courses are really creating a critical mass to seriously further geothermal development in the region.

The short courses have also opened up new connections. In East Africa, key geothermal scientists are lecturing and supervising a new generation of young and promising scientists. This way the geothermal know-how is being transferred from one generation to the next. Similar to the 6-month training programme, the short courses have also created bonds and friendship between individuals from different backgrounds and across national boundaries, which can only help the development of geothermal in the region.
The customer-designed short courses, which the UNU-GTP started offering in 2010, have also proven to be a good opportunity for countries that are in a fast-track developing mode of geothermal, and which have themselves the financial strength for this or the support of external mechanisms to finance it. The first such courses were conducted in 2010 for four different customers. This has since escalated and become an important part of UNU-GTP's operations. This is foreseen to continue in the near future, as need demands.

5.2 Looking into the Future

The 6-month training programme in Iceland has been the cornerstone of the UNU-GTP operations and will continue to be so. Similarly, the academic studies in Iceland for an MSc or a PhD degree will also be given their due importance. The financial climate in Iceland has been difficult after the crisis that struck the country in late 2008. Therefore, expansion in these regular operations was hardly seen in the framework until the economic climate had improved. However, a remarkable development has now been seen in the last three years, through external financing, with the number of UNU Fellows in Iceland having risen from between 20 and 22 in 2004-2009, to the current group of 33. Here though, the UNU-GTP is close to the practical capacity limit that the 6-month training programme in Iceland can handle, at least through the current institutional set-up.

The two Series of the UN Millennium Short Courses have developed into new pillars in the operations of UNU-GTP and will be continued, with East Africa having a priority. We may still see new countries gaining entrance to the short courses though most countries in East Africa blessed with considerable geothermal potential have already sent some participants to the short courses. However, the future is likely to see some important development here. The idea of these developing into a sustainable regional geothermal centre has been discussed informally and external financing partners have shown interest in participating and turning this into a reality. This has also been presented and accepted at UNU headquarters in Tokyo. The financial crisis may have delayed action, but hopefully this will now soon turn into a reality. In Central America, formal preparations have already started with the financial basis for the establishment of such a centre already secured for approximately the next 3 years by the Inter-American Development Bank (IDB) and the Nordic Development Fund (NDF). Preparations are now underway.

The UNU-GTP foresees a similar development in the near future for the short courses in East Africa, aiming at developing these into a permanent school for geothermal training under the umbrella of the UNU-GTP, or through some other formal cooperation. With the fast-tracking plans of geothermal in the region, it is now becoming urgent to get this started so that capacity building in the region can keep up with the ambitious plans of geothermal development. The time has now come for the main players in this field to stand up and join hand to make this a reality.

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