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UNU-GTP AND GEOTHERMAL CAPACITY BUILDING IN AFRICA

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ABSTRACT

The United Nations University Geothermal Training Programme (UNU-GTP) is celebrating its 30th anniversary in 2008. It has operated in Iceland since 1979 offering six months annual courses for professionals from developing countries. From being one of four geothermal schools established in the 1970s the UNU-GTP is now the only international graduate school offering specialized geothermal training. The aim is to assist developing countries, with geothermal potential, in capacity building in order to make the countries self sufficient in geothermal development. The training is tailor-made to suit the needs of the home country. UNU Fellows generally receive scholarships financed mainly by the Government of Iceland. Since 2000, cooperation between the UNU-GTP and the University of Iceland (UI) has opened the possibility for few UNU Fellows to extend their studies to MSc level, with the six months training adopted as an integral part (30 out of 120 ECTS). In 2008, the cooperation has been expanded to include PhD studies, with two former UNU Fellows commencing PhD studies in 2008-2009.

As a contribution to the UN Millennium Development Goals, the UNU-GTP has expanded activities by annual workshops/short courses in Africa (started in Kenya in 2005), Central America (started in El Salvador in 2006), and Asia (started in China in May 2008). The events are set up in cooperation with local energy agencies responsible for geothermal development. A part of the objective is to increase geothermal cooperation and to reach out to countries with interest in geothermal development who have not yet received quality training.

Africa is a major cooperating partner of the UNU-GTP. Amongst the 402 UNU-GTP graduates (1979-2008), 107 or 26% have come from eleven African countries. Moreover seven out of sixteen UNU MSc graduates have come from Kenya, one from Uganda, and one from Djibouti. And an additional three UNU MSc-Fellows from Africa (Eritrea and Ethiopia) are currently pursuing MSc studies in Iceland. Also, the first two UNU PhD-Fellows are Kenyans. Kenya is currently the leading country in geothermal development in East Africa, and many of their specialists have been trained in Iceland. The UNU-GTP looks forward to see other African countries succeed in geothermal development, and is determined to provide the training opportunities that the region needs.

1. INTRODUCTION

The United Nations University (UNU) was founded in 1975 with an aim to build a global university, with special focus on assisting developing countries. Its headquarters are in Tokyo, but teaching is conducted in various centres around the world. The Geothermal Training Programme (GTP) 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.

The aim of the UNU-GTP is to assist developing countries with significant geothermal potential to establish groups of specialists in geothermal exploration and development. This has been done by offering 6 months intensive training in the various fields that are needed in exploration and development of geothermal resources. An MSc programme was initialized in 2000 in cooperation with the University of Iceland, and a PhD programme has recently begun (August 2008), also in cooperation with the University of Iceland, providing more advanced academic opportunities in geothermal sciences or engineering. And most recently one more element has been added to the training efforts, taking the training to the developing countries, through workshops/short courses hosted in cooperative countries on different continents.

The paper describes the operations of the UNU-GTP and special reference is made to the activities and needs in Africa.

2. INTERNATIONAL GEOTHERMAL SCHOOLS

It is recognized that the development of geothermal resources requires a dedicated group of skilled specialists from many disciplines of science and engineering. Because of its diversity, geothermal energy utilization is not taught separately at universities, rather it is a field where specialized theoretical work and practical training is acquired at post-graduate level. The training of geothermal specialists has mainly taken place on-the-job within companies and institutions. But especially for the benefits of the developing countries, international geothermal schools have contributed significantly in the transfer of geothermal technology from the leading geothermal countries to newcomers in the field.

In the 1970s, four international geothermal schools were established, in Italy, Japan, New Zealand and Iceland, with the support of UN institutions and the respective governments. In the early 2000s the financial support for all the programmes except the UNU-GTP, both from the international institutions and the local governments had been cut drastically leading to the closure of the schools in Italy, Japan, and New Zealand. Auckland University, New Zealand, has, however, continued to enrol students in MSc and PhD studies in geothermal as a part of its regular activities, while Kyushu University, Japan, started a new doctoral course (with Japanese government scholarships) entitled "International Special Course of Environmental Systems Engineering" in 2002. Geothermal energy is among the topics eligible for scholarships in this course (Fridleifsson and Georgsson, 2004).

The UNU Geothermal Training Programme (UNU-GTP) is thus, at present, the only international graduate school offering specialized training in all main fields of geothermal science and engineering, and has been supported strongly by the Government of Iceland with increasing contributions in recent years.

3. GEOTHERMAL TRAINING IN ICELAND

Since 1979, the UNU-GTP has held annual six month courses for professionals from developing countries. Nine specialized lines of training are offered: geological exploration, borehole geology, geophysical exploration, borehole geophysics, reservoir engineering, chemistry of thermal fluids, environmental studies, 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 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 tailor-made for the individual and the needs of his institution/country. Table 1 shows the time schedule for the training.

TABLE 1: Approximate time schedule for the six month specialized courses at UNU-GTP

UNU GEOTHERMAL TRAINING PROGRAMME IN ICELAND

Week	Geological Exploration	Borehole Geology	Geophysical Exploration	Borehole Geophysics	Reservoir Engineering	Environmental Studies	Chemistry of Thermal Fluids	Geothermal Utilization	Drilling Technology
1 2 3 4 5	Lecture course on all main aspects of geothermal energy exploration and utilization, practicals and short field excursions								
6 7 8 9 10	Field geology Maps and photos Structure analysis Hydrogeology	Drilling Petrological logging Alteration Mineralogy	Resistivity methods Thermal methods Magnetics Gravity	Course on well logging and reservoir engineering including: Logging and well testing practises Reservoir physics Reservoir simulation Tracer tests Computer programs		EIA Project planning Chemistry Physics Biology Monitoring Revegetation Health and safety	Sampling of fluids and gas Scaling and corrosion Analytical methods Thermodynamics Geothermometers	Heat transfer and fluid flow Control systems	Drilling equipment Drilling procedures Well design Safety Management Rig operations
11 12			Excursion to the main geothermal fields of Iceland						
13 14	Field work in deeply eroded strata	Aquifers Modelling	Data processing techniques	Logging methods Data evaluation	Responses to exploitation	Gas dispersion and abatement	Water rock interaction	Design of plants and systems	Cementing Completion
15 16 17 18 19 20 21 22 23 24 25 26	Project and report	Project and report	Project and report	Project and report	Project and report	Project and report	Project and report	Project and report	Project and report

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 integrated with geothermal exploration or utilization projects that are in progress in Iceland at the time of training. The project topic is always selected with respect to the status in the home country of the participant. All project reports have been published by the UNU-GTP, and since 1994, 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 titles of reports from 1979-2003 and of abstracts from 1988-1998 can be found on the home page of the UNU-GTP (*www.unugtp.is*). The complete reports from 1999 onwards can also be accessed from the home page in pdf version.

Participants for the 6 months training are selected by private interviews during site visits to country in question, where UNU-GTP representatives assess geothermal fields, research institutions and energy utilities. Participants are selected for training in specializations considered most relevant to promote geothermal development in the respective country. Candidates must have a university degree in science or engineering, a minimum of one year practical experience in geothermal work, speak English fluently, have a permanent position at a public energy company, utility, research institution, or university, and be under 40 years of age.

Participants from developing countries have received Fellowships financed by the Government of Iceland and the UNU that cover international travel, tuition fees, and per diem in Iceland. The UNDP, the International Atomic Energy Agency (IAEA) and more recently a few other institutions have also financed fellowships for several trainees through the years. Qualified participants from industrialized countries (including EU countries) can also be accepted on condition that they obtain similar scholarships from their own institutions/countries.

For a more detailed description of the operations of the UNU-GTP see e.g. Fridleifsson (2005) or the UNU-GTP webpage (*www.unugtp.is*).

Since the foundation of the UNU-GTP in 1979, 402 scientists and engineers from 43 countries have completed the annual six month specialized courses offered. Of these, 44% have come from countries in Asia, 26% from Africa, 15% from Latin America, and 15% from Central and Eastern Europe. The largest groups have come from China (70), Kenya (42), Philippines (31), El Salvador (27) and

Ethiopia (26). In many countries, UNU-GTP graduates are among the leading specialists in geothermal research and development (Table 2). Figure 1 shows the UNU Fellows of 2008, the largest group to date with 22 fellows.

TABLE 2: Fellows of the UNU Geothermal Training Programme in Iceland 1979-2008

FELLOWS OF THE UNU GEOTHERMAL TRAINING PROGRAMME IN ICELAND 1979-2008										
Country	Geological exploration	Borehole geology	Geophysical exploration	Borehole geophysics	Reservoir engineering	Chemistry of therm. fluids	Environmen. studies	Geothermal utilization	Drilling technology	Total
Albania								1		**1**
Algeria	1					1		1		**3**
Azerbaijan							1			**1**
Bulgaria				1	2	2				**5**
Burundi	1									**1**
China		3	1	2	24	14	9	15	2	**70**
Costa Rica	2	2	2		2	2	2	3		**15**
Djibouti		2			1					**3**
Egypt		1		1	1	1				**4**
El Salvador	1	1	2	2	5	4	3	5	4	**27**
Eritrea	2		2			2				**6**
Ethiopia		3	4	1	5	4	1	6	2	**26**
Georgia								1		**1**
Greece			1					2		**3**
Guatemala		1			1	1				**3**
Honduras		1	1							**2**
Indonesia		5	3	2	5	1	2	5	1	**24**
Iran	1	3	1	1	1	1	3	7	1	**19**
Jordan	1			1	1	2		1		**6**
Kenya	1	4	10		6	7	7	3	4	**42**
Latvia								1		**1**
Lithuania					1			1		**2**
Macedonia						1				**1**
Mexico	1		1	1	2					**5**
Mongolia	1		1		1	1		4		**8**
Nepal						1		1		**2**
Nicaragua					3	3	1			**7**
Pakistan	1	1			1	1				**4**
Philippines		4	5	4	9	6		3		**31**
Poland		1		1	5	1		6		**14**
Romania						1		4		**5**
Russia	1				2	5	1			**9**
Rwanda								1		**1**
Serbia				1	1	1				**3**
Slovakia				1	1					**2**
Tanzania	3					1				**4**
Thailand		1		2		1		1		**5**
Tunisia					1			5		**6**
Turkey		1			1	4	1	3		**10**
Uganda	4	1	1		1	3	1			**11**
Ukraine					2					**2**
Vietnam	1		1		1	1			1	**5**
Yemen	1					1				**2**
Total	**23**	**35**	**36**	**21**	**86**	**74**	**32**	**80**	**15**	**402**

FIGURE 1: UNU Fellows of 2008 enjoying life at top of Mt. Leirhnjúkur in the Krafla area, N-Iceland

4. MSC AND PHD PROGRAMME

Since 2001, sixteen former UNU Fellows (Djibouti 1, China 1, Iran 3, Jordan 1, Kenya 7, Mongolia 1, Philippines 1, and Uganda 1) have been completed an MSc degree (by September 2008) through the UNU-GTP MSc programme in geothermal science and engineering in cooperation with the University of Iceland (UI). The six months at the UNU-GTP fulfil 25% of the MSc programme credit requirements (30 of 120 ECTS). The aim of establishing the MSc programme in cooperation with the UI was to go a step further in assisting selected countries in building up their specialist groups and to increase their geothermal research capacity. The first UNU Fellow to attend the MSc programme in geothermal engineering was from Jordan (UNU Fellow 1999). He graduated in 2001. The MSc programme has gradually received more funding and in 2008 six UNU Fellows completed the MSc degree. The MSc theses have been published in the UNU-GTP publication series, and can 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.

The first three former UNU Fellows have now been admitted to commence PhD studies at the University of Iceland in the academic year 2008-2009. Two are on UNU-GTP Fellowships (both from Kenya) and one (from Djibouti) is funded through other sources.

5. MILLENIUM DEVELOPMENT SHORT COURSES

The Government of Iceland has secured core funding for the UNU-GTP to expand its capacity building activities by annual short courses/workshops in geothermal development in selected countries in Africa (started in 2005), Central America (started 2006), and in Asia (started in 2008). This is a contribution of the Government of Iceland towards the Millennium Development Goals of the UN. The courses/workshops are set up in cooperation with local energy agencies/utilities and earth science institutions responsible for exploration, development and operation of geothermal facilities in the respective countries. A part of the objective of the workshops/short courses is to increase cooperation between specialists in the region in the field of sustainable use of geothermal resources. The courses may in the future develop into sustainable regional geothermal training centres.

The first workshop in Africa ("*Workshop for Decision Makers on Geothermal Projects and their Management*") was held in Kenya in November 2005 with 35 participants (including lecturers) from Eritrea, Ethiopia, Kenya, Tanzania and Uganda, as well as Iceland and the Philippines. The second event in Africa was a 10 day short course also held in Kenya in November 2006 ("*Short course on surface exploration for geothermal resources*"). 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. The lectures and practical exercises were mainly in the hands of Icelandic (UNU-GTP and ISOR) and Kenyan (KenGen) lecturers, with one additional lecturer coming from each of Djibouti, Eritrea, Ethiopia, Tanzania and Uganda. Most of the African lecturers were former UNU Fellows.

The short course was given in an extended format in 2007 ("*Short Course II on Surface Exploration for Geothermal Resources*"), held at Lake Bogoria and Lake Naivasha, Kenya, November 2-17, 2007. The basis of the course was the same as in 2006, but extended with additional lectures and a week of field work, which was entirely handled by KenGen staff, while the lecturers from Iceland were involved in the latter part of the course. In all, 30 trainees were invited from 10 countries in Africa plus Yemen in addition to the home country Kenya, while 25 lecturers took care of the teaching Five Icelandic lecturers and one from most of the neighbouring E-African countries that are members of ARGeo, added to those from KenGen

The plans for 2008 are continuing along the same line as for previous years, with further development of the Short Course in Kenya, "*Short Course III on Exploration for Geothermal Resources*", to be held

at Lake Bogoria and Lake Naivasha, Kenya, October 24 – November 17, 2008, adding project work and some lectures to its scope with at least 30 scheduled participants from 12 countries in East Africa (plus Yemen). The Workshop in 2005 and the Short Courses in 2006, 2007 and 2008 have been co-hosted by the UNU-GTP and Kenya Electricity Generating Co. - KenGen.

A special addition in 2008 will be the "*Short Course on Geothermal Project Management and Development*" to be held in November 20-22, prior to the ARGeo C-2 conference in Entebbe, Uganda. The short course is mainly aimed at second or third level managers/employees in ministries/energy companies/research institutions in East Africa. Participants are expected to come from about 10-12 countries in East Africa + Yemen, while the lecturers will come from Iceland, Kenya, Philippines, El Salvador, Ethiopia and Uganda. The Short Course is co-hosted by the UNU-GTP, KenGen and DGSM, Uganda.

The short courses in Kenya have certainly proven their value as a good first training opportunity for young scientists and engineers engaged in geothermal work. There are already several examples of the course leading to more advanced 6 months training in Iceland for some outstanding participants, and in one case it has even led to MSc studies in Iceland.

Reports from the annual Millennium Workshops/Short Courses of the UNU-GTP can be seen on our webpage, *www.unugtp.is*. Presentations and papers from these events are available for download.

FIGURE 2: Participants in the short course in Kenya in 2007 with some of the teachers

6. INTERNATIONAL ACTIVITY

Generally the UNU Fellows are very active internationally. The most memorable and recent participation of UNU Fellows in the international arena was the World Geothermal Congress 2005 in Turkey - WGC 2005, where the UNU-GTP was very well represented. In all, 141 papers (20% of all

papers) were authored or co-authored by 104 former UNU Fellows from 26 developing and transitional countries. The papers were divided between 23 of the 24 technical sessions of the conference. The level of activity of the UNU Fellows in the international geothermal community is well reflected in the fact that a third of the 318 graduates of the UNU-GTP from 1979-2004 were authors of or refereed papers at the congress. The papers are accessible on the webpage *www.unugtp.is*. Seventy seven former UNU Fellows from 25 countries attended the congress in Turkey. Most of their travels were funded by the UNU-GTP in Iceland and the UNU Centre in Japan. Sixty one UNU Fellows attended the WGC 2000 in Japan (out of 227 graduates), and 35 the WGC 1995 in Italy (out of 161 graduates). The UNU-GTP policy to support the participation of former UNU Fellows in the WGC every five years has made it possible for a large number of professionals from all continents to share their research results and experience with the international geothermal community (Fridleifsson 2008).

Similar stories can be told about the ARGeo C-1 and C-2 conferences where former UNU Fellows have played major roles in the organizing committees and are responsible for a large number of presentations. Meseret Teklemariam, UNU Fellow in 1985 headed the organizing committee in Ethiopia for the ARGeo C-1 conference that was held in Ethiopia in 2006, and Godfrey Bahati has been the vice chairman in the organizing committee for the ARGeo C-2 conference in Entebbe.

7. 30TH ANNIVERSARY WORKSHOP

The year 2008 marked the 30th anniversary of the UNU-GTP. The anniversary was celebrated with a two day Anniversary Workshop at Grand Hotel in Reykjavík, on August 26-27. The Foreign Minister of Iceland, Mrs. Ingibjörg Sólrún Gísladóttir, and the Vice-Rector of the United Nations University, Dr. Janos J. Bogardi, among others gave speeches at the Opening Ceremony of the Anniversary Workshop. Thirty three former UNU Fellows from 23 countries attended the Workshop, in addition to the 22 UNU Fellows in 2008 from 15 countries and 8 MSc Fellows from 5 countries. In total 44 papers were presented at the Anniversary Workshop and an additional 3 were printed in the Proceedings (on CD) (Georgsson et al., 2008). The Proceedings are also available on our website (*www.unugtp.is*).

Amongst the papers there were papers from three continents, outlining the contribution of the UNU-GTP training to geothermal development in these continents. One of these was a paper on Africa given by Martin Mwangi from KenGen (2008). In it he concludes that "UNU-GTP training has been very useful and will continue to be useful as more countries diversify their power generation mix to include geothermal as an indigenous and environmentally friendly source of energy." and "The recent establishment of a short course based in Kenya by UNU-GTP jointly with KenGen and involving UNU Fellows from Africa is an excellent development. We propose that the UNU-GTP continues to assist in this and that it will be made a permanent school as activities in geothermal development increases in the region."

Over one hundred guests from the geothermal and academic community in Iceland, there amongst many of the teachers and supervisors as well as former staff members of the UNU-GTP, participated in the Anniversary Workshop at Grand Hotel. It was a great experience to see so many of the UNU-GTP alumni and supervisors share their research results as well as meeting with friends and colleagues from various parts of the world, reminiscing about the past, and planning for the future. These are the pillars of the network of UNU-GTP Fellows worldwide.

FIGURE 3: UNU-GTP staff and teachers with the UNU Fellows who attended the 30th Anniversary Workshop.

8. GEOTHERMAL ENERGY IN AFRICA

The East African countries have similar energy production and consumption characteristics. Most of them are dependent on fossil fuels as a primary energy source. Traditional biomass fuels represent the largest category of energy produced amounting to 70-90% of the total energy production. 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 fluctuating oil prices, local renewable energy sources should be of vital importance. For the countries surrounding the Great East African Rift System (Figure 4) with its volcano-tectonic activity,

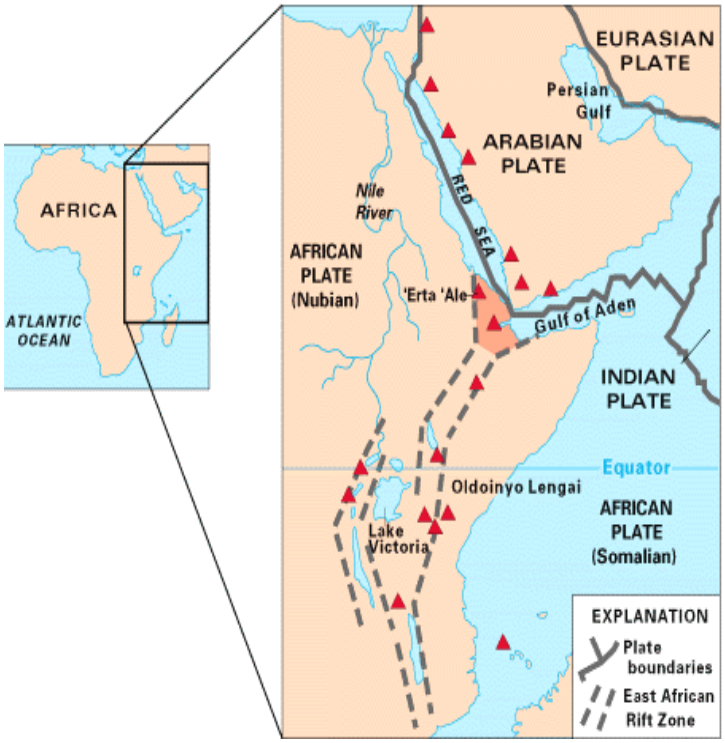

FIGURE 4: The Great East African Rift System (Teklemariam, 2008)

high-temperature geothermal resources have the potential to play a much larger role and even to be one of the most important resources for electricity production. Currently, renewable energy sources (hydro, geothermal, solar, etc.) represent only a small portion of the total energy production, averaging 2% for hydropower and solar and geothermal production combined (Teklemariam, 2008). Geothermal can also be expected to play an important role in the countries in North Africa. However, the geothermal resources in this part of Africa are of the low-temperature type, and the utilization is therefore mainly limited to direct uses, i.e. space heating, agriculture, aquaculture, recreation, etc.

With the technology of today, East Africa has the potential to generate 2,500-6,500 MWe of energy from geothermal power (GEA, 1999). Despite that, Kenya is now the only country harnessing this resource in a quantity to speak of. Since the early 1980's, Kenya has been increasing their total geothermal power generation from 15 MWe to 130 MWe at the Olkaria geothermal field near Lake Naivasha. Also, Kenya has recently put forward very ambitious plans to add a total of at least 1260 MW of geothermal power in the next 10 years (Simiyu, 2008). It should also be mentioned that in Kenya geothermal water and carbon dioxide from geothermal fluids are used in an extensive complex of greenhouses for growing roses. Rose exports from that farm have totalled USD 300 million per year (Mwangi, 2005). Kenya is an example for the other East African nations to follow.

In Ethiopia, the Aluto-Langano pilot power plant, built in 1998 for producing 7.2 MWe on-line, has only partially been in operation since its opening about 10 years ago, with mechanical problems in the plant and limited steam supply being difficult problems to overcome. This has lead to no or low production for long periods of time. After restoration, the plant is now producing 3 MWe (Teklemariam, 2008). Geothermal exploration and research have been undertaken in Djibouti, Eritrea, Uganda, Tanzania, Zambia, Malawi, and most recently in Rwanda. The potential to use geothermal energy for electricity production may be greatest in Kenya, Djibouti and Ethiopia, but countries like Eritrea, Uganda, Tanzania and probably also Rwanda should not be discounted here. Ambitious exploration projects, including in some cases exploration drilling, are now in their initial stages in several countries, like Djibouti, Ethiopia and Eritrea, in cooperation with foreign research groups and/or investors. Reykjavik Energy Invest has expressed interest to cooperate with Djibouti and Ethiopia in developing some of their geothermal fields. The Geological Survey of Germany (BGR) must also be mentioned, having been very active in the area in recent years promoting geothermal exploration through its Geotherm programme. This effort got geothermal exploration going in some countries where not much had been done for long periods of time, such as in Tanzania, Rwanda and Yemen, not forgetting the BGR projects in e.g. Uganda. The same can be said about the Icelandic Development Agency - ICEIDA on its project in Uganda and an upcoming project in Eritrea.

The status of exploration and utilization of geothermal energy resources in the East African region for the last three decades has been summarized by Teklemariam (2008):

- The region has a large untapped geothermal resource potential;
- The geothermal resources are an indigenous, reliable, environmentally clean and economically viable, renewable energy resource;
- Development of geothermal resources are constrained by
    i. the risks that are associated with resource exploration and development;
    ii. the financial risks that are associated with investment in power development projects; and
    iii. lack of appropriate investment and institutional settings in many East African countries;
- Diversified use of geothermal energy augments energy supply from hydro power plants and improves the generation mix. It avoids vulnerability to drought and oil price fluctuations.

To light up East Africa by geothermal electricity, investors and financial assistance from international agencies are a necessity, and the human capacity to deal with the exploration and development needs to be built up.

In North Africa, low-temperature waters for direct use have been utilized very successfully in Tunisia where hot water intended for irrigation is cooled down in greenhouses thus allowing production of quality products, such as cucumbers and melons, mainly for export to Europe. In 2008, the total area heated in geothermal greenhouses in Tunisia reached 147 ha, making it one of the largest producers in the world from geothermally heated greenhouses. To this, extensive use of geothermal water for bathing can be added as an important cultural habit with roots stretching back some thousands years. Tunisia provides an example for other countries of North Africa to follow (Ben Mohamed, 2008).

9. TRAINING OF AFRICANS AT UNU-GTP

Amongst the 402 graduates of the UNU-GTP (1979-2008), 107 have come from eleven African countries (Table 3). Eight of these countries are within or border the East African Rift Valley, while the rest are located in North Africa. One additional country is given in Table 3, Yemen. Bordering the East African rift at its northern end, Yemen has, at least partly, similar geological background as East Africa, and can thus geologically be said to belong to the same group. The largest number of Fellows (42) has come from Kenya, followed by Ethiopia (26), Uganda (11), and Tunisia and Eritrea (6 each). Former UNU Fellows lead the geothermal research and development in all of these countries.

In the MSc programme, 9 of the 16 who have completed the MSc degree have come from Africa, with additional 3 now pursuing their studies in Iceland. Finally, the first to enrol under the new PhD programme is a Kenyan, and the second Kenyan PhD Fellow is scheduled to begin in early 2009. All the MSc and PhD Fellows have been on scholarships provided to the UNU-GTP by the Government of Iceland. With more advanced training at MSc and PhD level the UNU-GTP is assisting Africa, amongst others, in bringing geothermal research to a still higher level.

The majority of the African geothermal professionals trained at the UNU-GTP are still pursuing geothermal work, at least part-time, or are available for geothermal work on request. About a quarter of the alumni have either retired, have left the geothermal sector, have migrated to other countries and discontinued in geothermal or have passed away. This is most notable in Ethiopia where more than 40% of the trained professionals have left geothermal, most through emigration to other countries during periods of unrest (Table 3).

TABLE 3: UNU Fellows from Africa and Yemen trained in Iceland and their current status (information from UNU-GTP archive and Mwangi, 2008)

Country	6-months training			MSc programme		PhD pro.
	No. trained	Retired or not active	Available	Graduated	Studying	Studying
Algeria	3	3	0			
Burundi	1	1	0			
Djibouti	3	1	2	1		
Egypt	4		4			
Eritrea	6	2	4		1	
Ethiopia	26	11	15		2	
Kenya	42	7	35	7		1
Rwanda	1		1			
Tanzania	4	1	3			
Tunisia	6		6			
Uganda	11	2	9	1		
Total	**107**	**27**	**80**	**9**	**3**	**1**
Yemen	2		2			

The aim of the UNU-GTP is to concentrate its training efforts to assist in building up multidisciplinary groups of geothermal specialists in selected countries. Priority for training is given to candidates from carefully selected institutions where geothermal exploration and development is already under way. The limiting factor is, in some cases, the availability of sufficiently qualified staff in the recipient institutions. KenGen in Kenya is a shining example of capacity building, but other fine multi-disciplinary good groups have been established at the Geological Survey of Ethiopia and at the Department of Geological Survey and Mines in Uganda. We foresee a similar development in other countries of East Africa, e.g. Eritrea and Tanzania, in line with the needs of the countries.

Already, the annual short courses given in Kenya have proven a valuable addition to the training capacity of the UNU-GTP. They have given an increasing number of young Africans an introduction to state of the art exploration techniques for geothermal resources and to the possible development of this valuable renewable energy sources. Furthermore, it has become a new channel for opening possibilities of more advanced training in Iceland for the most promising candidates. We foresee further development of the short course in the near future, and hope that the courses may develop into a permanent school for geothermal training run by KenGen under the umbrella of the UNU-GTP.

10. THE NEXT STEPS

Geothermal energy is now on the threshold of becoming recognized in East Africa as a sustainable energy resource for electricity production. Kenya has set very ambitious goals for the coming decade by declaring that geothermal is to become their main source for additional electricity in the near future. Their plans are to install additional 1260 MW on-line by 2018 from geothermal. Other countries in the region are following in their footsteps. Ethiopia, Eritrea, Djibouti and Uganda are also taking large steps in exploring their resources, partially in cooperation with foreign research groups or investors, hopefully leading to development of their geothermal resources in the near future. Countries like Tanzania and Rwanda are a step behind but they have ambitious exploration programmes, providing positive results that are the key for a geothermal future. In North Africa geothermal heating of greenhouses exemplified by Tunisia has a great untapped potential.

It is of importance for the geothermal countries in Africa that necessary training opportunities are provided in line with the development. The UNU-GTP looks forward to see other African countries follow in the footsteps of Kenya, and is determined to provide the training opportunities that the region needs, both in Iceland and through courses in Africa; hopefully through a future UNU-GTP/KenGen training centre. The economic outlook in the world may not be bright at the moment but the future of local renewable and environmentally friendly energy sources at competitive prices carries the potential to light up Africa.

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