

The UNU Geothermal Training Programme: Training Activities Offered On-Site in Developing Countries

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ABSTRACT

Since 2005 the Government of Iceland has provided core funding for the United Nations University Geothermal Training Programme (UNU-GTP) reserved for local training in developing countries. These activities, that have come to be known as the UN Millennium Short Course Series, were initiated with Workshops for Decision Makers in three continents (held in Kenya in 2005, El Salvador in 2006, and China in 2008) and continued by annual Short Courses for East Africa and Latin America. The aim is not only to increase efforts in geothermal capacity building in these regions, but also to further regional cooperation in geothermal development. Furthermore, through these short courses UNU-GTP has reached out to new countries at an early stage in the development of geothermal resources, for which these events have proved a suitable start.

In Kenya, the week-long “Workshop for Decision Makers” has been followed by annual Short Courses on Geothermal Exploration, now extending for more than 3 weeks. Close cooperation partners from the start have been the Kenya Electricity Generating Company (KenGen) and, from its foundation in 2009, the Geothermal Development Company (GDC). Almost 500 individuals from 22 countries in Africa (including Yemen) have benefitted from this training. These events have been an important contributor to the momentum that is currently being witnessed in geothermal development in Africa. In El Salvador, the series was started with a similar Workshop which has been followed by near-annual 1-2 week Short Courses on various topics in line with the needs in Latin America. Here, the cooperation partner has been LaGeo of El Salvador. By the end of 2014, 370 individuals from 14 countries of Latin America and the Caribbean, had attended the events. Conditions have not yet allowed the development of the Asian series beyond the starting Workshop in 2008, attended by almost 120 participants.

The material prepared for the UN Millennium Short Courses has also provided a platform for UNU-GTP to go one step further by offering customer-designed Short Courses and Training on contract, in line with the needs of local companies and institutions from developing countries, usually financed 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 more geothermal manpower, but also in other parts of the world, including Asia and Latin America. Courses have extended from 1 week to 3 months, and local training up to 6 months on site.

The rapidly increasing needs for geothermal know-how in Africa and Latin America is beyond what UNU-GTP can be expected to fulfil through its regular activities and finances. The next step is foreseen to be the establishment of formal regional geothermal training centres. A recently started programme of Diploma Courses in El Salvador and MSc opportunities in geothermal studies in Kenya are hopefully sprouts that soon may grow into fully fledged geothermal training centres for Latin America and East Africa.

1. INTRODUCTION

The United Nations University Geothermal Training Programme (UNU-GTP) was established in Iceland in 1978. The task of UNU-GTP is 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. Since 1979, annual six-month courses have been held in nine different lines of geothermal science and engineering for professionals from developing countries. The hallmark of UNU-GTP is to give university graduates engaged in geothermal work intensive on-the-job training in their chosen fields of specialization. The programme is hosted at Orkustofnun – The National Energy Authority of Iceland. During 1979-2014, 583 scientists and engineers from 58 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. In 2014, 40 MSc Fellows have completed their degree, with 12 pursuing their studies. Similarly, the first PhD Fellow defended her thesis in 2013, with 2 pursuing their studies in Iceland (for further information see Georgsson et al., 2015).

From 2005, funding has also been secured for additional training efforts, taking the training to the partner countries. This was Iceland's official contribution to the UN Millennium Development Goals, and has been implemented through regular workshops/short courses hosted in selected countries on different continents, in cooperation with local energy institutions/companies (Fridleifsson, 2004; Georgsson 2010a). The first phase has usually 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 is introduced and the possible role of geothermal energy in the future energy mix of the region discussed. The lectures describe state-of-the-art exploration and development, from surface exploration, through drilling, production exploration, assessment, environmental and regulatory considerations, and utilization, to project management, planning and financing. The purpose is, on one hand, 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 of the region. This is followed by specialized Short Courses for earth scientists and engineers on surface exploration, deep exploration, production exploration, drilling, resource assessment, utilization, operation and management, production monitoring, environmental issues, planning and financial aspects etc., in line with the type of geothermal activity and the needs of the respective region. These have been referred to as the “*UN Millennium Short Course Series*”. 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) (Fridleifsson, 2010; Georgsson 2010a). Specialized Short Courses have since been held annually in Africa and almost annually in Central America. Material presented and written for these events has been published on CDs and is also available on the website of UNU-GTP (www.unugtp.is) under *publications*.

The need for geothermal training has now grown beyond what UNU-GTP is able to fulfil and service through its regular financing from the official development assistance (ODA) of the Government of Iceland. This has led to requests for additional services, backed up by local or international financial sponsorship. To this can be added that a lot of teaching material has been prepared through the *UN Millennium Short Course Series*. Together these factors played a major role in the decision of UNU-GTP to take its training activities one step further and offer courses or training fulfilling special needs of a paying customer. A formal decision on this was taken in 2009 with the first such event held in early 2010. These services with customer-designed courses and training have been increasing with every year and are now an integral part of the operations of UNU-GTP. The content of these events has varied significantly, based on the needs of the respective client. It has covered both regular Short Courses and hands-on training, and the time frame has varied from 2 days to 6 months for individual events.

This paper describes the operations of UNU-GTP, with special reference to on-site capacity building activities in its partner countries, concluding with some scope being given to possible future development.

2. THE UN MILLENNIUM SHORT COURSE SERIES

2.1 The East African Series

2.1.1 The planning and execution of the first Workshop

The chosen region for the first event associated with Iceland’s contribution to the UN Millennium Development Goals, was East Africa with its huge, and to a large extent, unused potential for geothermal power development, and more specifically Kenya, the leading African country in geothermal development, with about 127 MWe on-line in 2004 (Mwangi, 2005). Cooperation was sought with the Kenya Electricity Generating Company (KenGen), the main authority responsible for geothermal development in Kenya at that time. UNU-GTP had also had a long and fruitful cooperation with KenGen (and its predecessors) through training of its personnel in Iceland. 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 event 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 UNU-GTP had accepted to play a leading role in guiding and implementing the capacity building component of ARGeo. The Workshop was intended to be the first step in the 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 the following 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 (Figure 1). In all, 35 participants attended, including the lecturers that were active in all phases of the Workshop (Tables 1-3). KenGen proved to be a first-class host 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 (Fridleifsson, 2010; Georgsson 2010a; 2010b).

2.1.2 The Short Courses

At the Workshop it was recommended that Short Courses focussing 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 1 gives an overview of the events, while Table 2 shows the participation from various countries, and Table 3 lists the number and background of the lecturers. The first one 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 also a forum on the status and possibilities of geothermal development in East Africa. The event started with series of scientific lectures covering the three main fields of surface exploration of geothermal resources, 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, adding also practical training including field demonstrations and practical use of computer programs (Georgsson, 2010a). The Short Course was very well received and based on the results of an assessment meeting of all participants and lecturers during the last day, it was clear that it had been a success. The basic model was one that should be repeated but suggestions were made for improvements and additions, which were realised in the next 2-3 years. 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. And in 2008, 4 days of project work were added at the end of the course, making it a 3-3½ week event. Basically, this is the model that has since been followed.

KenGen has cooperated with UNU-GTP through the series of Short Courses, and after the formation of the Geothermal Development Company (GDC) at the end of 2008, GDC came in as an additional partner in this project. This 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 UNU-GTP and the Icelandic Government, while the costs of the local Kenyan participation and some of the local arrangements are born by KenGen, and from 2009 also GDC.



Figure 1: Participants and lecturers in Workshop for Decision Makers on Geothermal Projects and their Management in Kenya in 2005.

Table 1: Workshop and Short Courses belonging to the UN Millennium Short Course Series, held in East Africa 2005-2014.

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	Naivasha	Oct. 27 – Nov. 18, 2012	23
Short Course VIII on Exploration for Geothermal Resources	Naivasha	Oct. 31 – Nov. 22, 2013	23
Short Course IX on Exploration for Geothermal Resources	Naivasha	Nov. 2 – 23, 2014	22

During the last 9 years, the annual Short Course at Naivasha has gradually developed into a general course on geothermal exploration, though still with an emphasis on surface exploration, extending for about 3½ week. The content of the Short Course has 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 4 shows the setup of “Short Course VIII on Exploration for Geothermal Resources” which was held in late 2013. Figure 2 shows the participants in the 2012 Short Course, while Figure 3 was taken during the Olkaria excursion in 2013.

Papers specially written for the Short Courses have been published on CDs and the presentations distributed to participants, lecturers and others interested (Georgsson, 2010a; Georgsson et al., 2009a, 2010a; 2011a; 2012a, and 2013a; Ómarsdóttir et al., 2014). Most of the material is also available at the UNU-GTP website (www.unu-gtp.is).

An extra component in the local capacity building was the “Short Course on Geothermal Project Management and Development” (Georgsson et al., 2010a). This three day event, given in Entebbe, Uganda in November 2008, was co-organized by 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 was aimed at high-level managers / employees in ministries / energy companies / research institutions in East Africa and 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 (see also Tables 1-3).

Table 2: Participants in the Workshop and Short Courses in East Africa 2005-2014.

Country	Kenya 2005*	Kenya 2006	Kenya 2007	Kenya 2008	Uganda 2008	Kenya 2009	Kenya 2010	Kenya 2011	Kenya 2012	Kenya 2013	Kenya 2014	Total	6 mo. UNU Fellows**
Algeria			1					1				2	1
Burundi				2	1	2	2	1	2	2	1	13	1
Cameroon										1	1	2	
Comoros			2			2	3	2	1	1	2	13	1
Congo				1	1			1	3	3	2	11	
Djibouti		2	1	2	3	2	2	3	2	3	2	22	10
Egypt			1									1	1
Eritrea	2	3	2	2	1	2		2		2	1	17	4
Ethiopia	5+2	3	1	2	3	3	1	3	3	3	3	32	12
Kenya	6+9	10	13	18		21	31	30	28	32	30	228	60
Malawi							3	3	2	3	1	12	2
Morocco							1					1	1
Mozambique							1	1	2	1	1	6	
Niger										1		1	
Nigeria									2	2	1	5	
Rwanda			2	2	1	3	3	4	6	3	2	26	11
Sudan									2	3	2	7	1
Tanzania	2	2	2	2	4	3	3	2	3	2	3	28	8
Uganda	4	3	3	2	5	3	2	2	3	2	3	32	10
Zambia				2	2	2	3	2		3	1	15	1
Yemen			2	2	1	2	1	1	2	2	1	14	4
Zimbabwe											1	1	
Others					2					1		3	
Total	30	23	30	37	24	45	56	58	61	70	58	492	128

* The second number shows African lecturers, who participated fully in the Workshop;

** UNU Fellows in Iceland for 6 month training during the same period (2005-2014).

Table 3: Lecturers and supervisors in the Workshop and Short Courses in East Africa 2005-2014.

Short Course / Workshop	Home country	Neighbour. countries	Internat.	Iceland	Total	Former UNU-Fellows
Kenya 2005	9	2	1	4	16	8
Kenya 2006	11	5	0	4	20	15
Kenya 2007	16	4	0	5	25	18
Kenya 2008	19	5	0	4	28	23
Kenya 2009	27	4	0	4	35	26
Kenya 2010	27	3	0	4	34	23
Kenya 2011	27	5	0	4	36	27
Kenya 2012	40	4	0	4	48	29
Kenya 2013	40	6	0	4	50	32
Kenya 2014	46	6	0	4	56	31
Uganda 2008	1	7	2	5	15	8



Figure 2: Participants of Short Course VII on Exploration for Geothermal Resources held in November 2012 visiting Olkaria.



Figure 3: Dr. Kristjan Saemundsson explains the geology in the field excursion in Olkaria during Short Course VIII in 2013. He has been a regular lecturer from the start of the Kenyan Short Course Series, together with Dr. Halldór Ármannsson and Mr. Knútur Árnason.

Short Courses as can be seen from Table 3. In Table 3 it is also evident that most of the African lecturers / supervisors are former UNU Fellows trained in Iceland.

Table 4: The structure of “Short Course VIII on Exploration for Geothermal Resources“, held at Lake Bogoria and Lake Naivasha, Kenya, in November 2013.

Dates	Programme	No. lectures	Practicals	Lecturer/Supervisor		
				Local	Neighbour	Iceland
Oct. 31	Arrival at Lake Bogoria Hotel					
Nov. 1	Introductory lectures	8		8		
Nov. 2-5	Site visits to geothermal areas and geothermal field work		X	11		
Nov. 6	Site visit Menengai, drive to Naivasha		X	2		
Nov. 7	Geothermal energy, systems & hydrology - Lectures	6		2	1	3
Nov. 8	Geothermal & geological mapping - Lectures & practicals	6	X	3		1
Nov. 9-10	Geophysics – Lectures & practicals on interpret.	14	X	4		2
Nov. 11	Chemistry of thermal fluids – Lectures & interpret.	7	X	3		1
Nov. 12	Drilling, resource assessment & well logging – Lectures Practical sessions in geophysics and geological laborat.	5	X	6		
Nov. 13	Environmental science and monitoring – Lectures & Practical, including chemical laborat.	5	X	6		1
Nov. 14	Power plants, direct use & mapping resources – Lectures	10		6		1
Nov. 15	Excursion – Olkaria geothermal field, power plants and drilling rigs		X	2		3
Nov. 16-17	Status of geothermal in E-Africa – GIS – Lectures & practs.	20	X	2	6 (+12)*	1
Nov. 18	Planning projects and case examples	9	X	4		3
Nov. 19-21	Project work in groups		X	8		1
Nov. 22	Project present, course review, closing ceremony	(10)		8		1
Nov. 23	Departure participants – Instructors assessment meeting					

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

2.1.3 Results of the African 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, 492 Africans (including Yemen) have participated in the events during 2005-2014. During the same period 128 UNU Fellows from the region have been trained in Iceland. It is clear that with the Short Courses the UNU-GTP has been able to reach a far larger number of geoscientists and engineers in East Africa than through its conventional training in Iceland, and, thus, it has been possible to spread geothermal knowledge to a wider region and audience, and contribute to potential geothermal development in new countries.

The Short Courses have also been an important element in catalysing increased cooperation between the countries in East Africa. In that case Kenyans have, to a large extent, been in 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 the ICEIDA, e.g. in Djibouti and Eritrea, have been carried out partly with a multinational group including qualified experts from the neighbouring countries who have been trained by UNU-GTP earlier in their career. For a further description of the Workshops / Short Courses of UNU-GTP in Africa see Georgsson (2010; 2012; 2014) or the UNU-GTP webpage (www.unugtp.is).

2.2 The Central American Series

2.2.1 The Starting Workshop in 2006

Similar to East Africa, in Central America geothermal resources are now playing an increasing role in the power production of countries like El Salvador, Costa Rica, Nicaragua, and Guatemala, with considerable untapped potential. Additionally, Mexico has certainly been one of the world's largest producers of geothermal electricity for many years. UNU-GTP has since its early years supported this region through training of many staff members of geothermal institutions, especially in El Salvador and Costa Rica. Hence, Central America was selected as the region for the second Series of Millennium Short Courses, with LaGeo S.A de C.V. in El Salvador chosen as a cooperation partner for this task. 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 of courses, which it has certainly proven to be.

The “Workshop for Decision Makers on Geothermal Projects in Central America” was held in San Salvador in late November 2006 (Fridleifsson and Henriquez, 2006). The fifty participants in the six day event were mainly from the four countries in Central America most active in geothermal development, i.e. Costa Rica, El Salvador, Guatemala, and Nicaragua, and some of them were from the highest level of governance. Lectures were mainly presented in English but with simultaneous translation into Spanish, which has been the norm for the Series. The Workshop was a sound success. In its conclusions, it was said that “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.”

2.2.2 The Short Courses

With geothermal development in Central America at a more advanced stage compared to East Africa, it has not been necessary to put the same emphasis on surface exploration in the Short Courses. The topics have therefore differed from one event to another (Table 5). The first one was devoted to resource assessment and environmental management, a week-long event held in El Salvador in late November 2007 (Fridleifsson et al., 2007).

Table 5: Workshop and Short Courses belonging to the UN Millennium Short Course Series, held in Central America 2006-2014.

Event	Main site	Dates	Duration (days)
Workshop for Decision Makers on Geothermal Projects in Central America	Santa Tecla	Nov. 27 – Dec. 2, 2006	6
Short Course on Geothermal Development in Central America: Resources Assessment and Environmental Management	Santa Tecla	Nov. 15 – Dec. 1, 2007	7
Short Course on Surface Exploration for Geothermal Resources	Santa Tecla	Oct. 17 – 30, 2009	14
Short Course on Geothermal Drilling, Resource Development & Power Plants	Santa Tecla	Jan. 16 – 22, 2011	7
Short Course IV on Geothermal Development and Geothermal Wells	Santa Tecla	Mar. 11 – 17, 2012	7
Short Course V on Conceptual Modelling of Geothermal Systems	Santa Tecla	Feb. 24 – Mar. 2, 2013	7
Short Course VI on Utilization of Low- and Medium-Enthalpy Geothermal Resources and Financial Aspects of Utilization	Santa Tecla	Mar. 23 - 29, 2014	7

The third event in Central America was delayed to 2009. The two week long “Short Course on Surface Exploration for Geothermal Resources” was held in October 2009 in El Salvador. It was a shorter version of the courses that had been held in East Africa in 2007-2009, with the main emphasis on geophysics and chemistry of thermal fluids, and aimed at young earth scientists in the region (Georgsson et al., 2009b). The last day consisted of participation in the “Central American Geothermal Workshop”, a cooperative event between LaGeo, the International Geothermal Association (IGA) and UNU-GTP, intended to highlight geothermal development in Central America. The Short Course reached a broader audience than the first two with participation from the East Caribbean Region (Table 6).

The third Short Course was the “Short Course on Geothermal Drilling, Resource Development, and Power Plants“, a week long course given in January 2011. There, UNU-GTP reached for the first time to countries in South America (Georgsson et al., 2011b). The topic also proved to be interesting to many private companies in the geothermal business in the region, reflected in their increased participation, at their own cost. This is a trend which has continued in the following events, the one week long “Short Course IV on Geothermal Development and Geothermal Wells” in March 2012 (Georgsson et al., 2012b), “Short Course V on Conceptual Modelling of Geothermal Systems” in February 2013 (Georgsson et al., 2013b), and “Short Course VI on Utilization of Low- and Medium-Enthalpy Geothermal Resources and Financial Aspects of Utilization” in March 2014 (Haraldsson et al., 2014). Tables 6 and 7 show the number of participants and lecturers. Figure 4 shows the participants of the Short Course in 2012.

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. And in the last 3-4 years the target area has expanded to the whole of Latin America and the Caribbean, as shown in Table 6. A continued need is foreseen for alternating Short Courses covering a range of topics from surface exploration to development, field management, production monitoring, environmental

aspects, drilling, utilization and more, as the events so far give a good indication of. As participation can be expected to cover a wider geographical area than in the early years of the series, reaching countries where geothermal resources have not been developed to the same extent as in Central America and Mexico, the focus may shift somewhat towards a greater emphasis on exploration. Many of the small nations of the Eastern Caribbean region have important geothermal resources to be developed. Participation from this region can be expected to become a significant factor for the Short Courses in the near future. Similarly, participation from South America is also expected to increase, as interest grows in the development of the significant high-temperature resources associated with the Andes Mountain range.

Table 6: Participants in the Millennium Short Course Series in Central America 2007-2014.

Country	WS 2006	SC 2007	SC 2009	SC 2011	SC 2012	SC 2013	SC 2014	Total
Bolivia					1			1
Chile					5	5	4	14
Colombia				5	2	4	2	13
Costa Rica	X	6	7	6	1	2	3	25+
Dominica			2	2	2	1	1	8
El Salvador	X	22	9	23	28	18	26	126+
Ecuador				1	2	3	2	8
Guatemala	X	1	1	2	1	2	2	9+
Honduras		2	2	5	2	4	1	16
Mexico		1		3	6	6	3	19
Montserrat							1	1
Nevis			2	2	1	2	2	9
Nicaragua	X	13	7	13	11	11	5	60+
Peru						3	1	4
Others			2		3		2	7
Total	50	45	32	62	65	61	55	370



Figure 4: Participants of Short Course on Geothermal Development and Geothermal Wells held in Santa Tecla, March 2012.

Table 7: Lecturers in the Millennium Workshop and Short Courses in El Salvador in 2006-2014.

Short course / Workshop	Home country	Neighb. countries	Intern.	Iceland	Total	UNU-Fellows
El Salvador WS 2006	8	9	5	3	25	9
El Salvador SC 2007	3	5	3	5	16	7
El Salvador SC 2009	12	4	0	5	19	11
El Salvador SC 2011	12	6	1	6	25	14
El Salvador SC 2012	10	8	3	5	26	11
El Salvador SC V 2013	10	7	1	5	23	14
El Salvador SC VI 2014	12	11	2	4	29	9

2.3 UN Millennium Events in Asia

The first UN 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 energy 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 Bureau of Geology and Minerals Exploration and Development (TBGMED) (Fridleifsson et al., 2008).

Countries with a need for space heating for at least a few months of the year and known geothermal resources near densely populated areas (towns, villages), were invited. In addition to China, participants, including important decision makers in ministries, energy companies and large municipalities, came from India, Iran, Jordan, Mongolia, the Democratic People's Republic of Korea, and the Republic of Korea. A large majority of the participants came from China, with 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 (Figure 5). In total, 52 lectures presented in English, with simultaneous translation into Chinese, and slides were shown both in English and Chinese. The workshop was very well received. (Fridleifsson, 2010, Georgsson, 2010a).



Figure 5: Participants in the Workshop for Decision Makers on Direct Use of Geothermal Resources in Asia, held in China in May 2008.

The Workshop in Tianjin was 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. This did not materialize for various reasons, the most important being the financial crisis that hit Iceland in late 2008, which led to reduced funding for the UNU Geothermal Training Programme in the aftermath of this serious event for Iceland's economy.

Preliminary discussions were also held with representatives of PT. Pertamina G.E. 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 small Pacific island nations. However, in the difficult financial climate after 2008, these plans had also to be postponed, at least for the time being.

2.4 Some additional positive consequences

From a more general perspective, the *UN Millennium Short Course Series* have become a new channel to the more advanced training in Iceland, giving the strongest participants the chance to show their ability and strength, and consequently opening the possibility to be selected for training in Iceland. Thus, the series have to some extent reduced the need for conventional site visits to partner countries. There are now many examples of good participants in the Short Courses being selected for the 6 month training in Iceland. And in a few cases, this has led to MSc studies in Iceland, with the first degree being awarded in April 2010. The Short Courses have also become an important element in catalysing increased cooperation between the countries within the region.

Finally, the availability of the papers and presentations prepared for these events, not only on CDs but as open-file material on the internet has really proven important as can be seen from the high number of downloads of papers published for some of these events counted in hundreds of thousands per year for the most popular ones (Georgsson et al., 2015).

3. SPONSORED CUSTOMER DESIGNED TRAINING ACTIVITIES

The latest capacity building service of UNU-GTP is the customer-designed Short Courses or Training in developing countries, given for the first time in 2010. This new service was triggered by the urgent need for training in countries planning fast-tracking of geothermal development, while it has also been an offspring of the regular training and Short Courses, and the material prepared there (see e.g. Simiyu, 2010 and Teklemariam, 2008). This has proven a good opportunity for some countries/institutions in need of

a rapid capacity building process, beyond what UNU-GTP can service under its conventional operations, and which have themselves the strength or the support of external sources (e.g. multilateral or bilateral aid agencies) to finance such events. The paying customer defines the outline of the Short Course, while UNU-GTP is a guarantee of the quality of the contents.

In 2010-2014, 20 events, Short Courses or Advanced Training, have been held for eight different customers in four continents. The contents have varied from general geoscientific courses to more specialized ones, such as on geothermal drilling, as well as scaling and corrosion in geothermal installations. Similarly, the length has varied from a few days to 6 months, based on the need and goals. Table 8 lists examples of these events, which have benefitted about 400 individuals in all.

Table 8: Examples of customer-designed Workshops, Short Courses and Training given by UNU-GTP for different customers in 2010-2014.

Event	Location	Dates	Customer	Duration
Course on Geothermal Drilling	Indonesia	Jan. 25 – Feb. 19, 2010	SenterNovem, Bappenas, & PT. Pertamina G.E	4 weeks
Training Course on Exploration for Geothermal Resources	Silali, Kenya	May 17 – Jun. 12, 2010	GDC, Kenya	4 weeks
Course on Geothermal Exploration and Development	El Salvador	Nov. 7 – 12, 2011	Organization of American States - OAS	1 week
Course on Geothermal Technology	Naivasha, Kenya	Apr. 16 – Jul. 14, 2012	KenGen, Kenya	13 weeks
Advanced Training in Borehole Geology	Naivasha, Kenya	Jul. 16 – Dec. 16, 2012, Jan. 7 – Feb. 2, 2013	KenGen, Kenya	6 months
Training in Drilling Supervision	Karisimbi & Kigali	Jul. 1, 2013 – Feb. 8, 2014	ICEIDA & EWSA	10 weeks
Training in TFT-Measurements of Two-Phase Flow	Naivasha, Kenya	Mar. 31 – Apr. 12, 2014	KenGen, Kenya	2 weeks
Short Course for Decision Makers on Geothermal Development	Naivasha, Kenya	Sept. 24 – 28, 2013	ICEIDA	5 days
Workshop for Geothermal Development Donors	Iceland	May 27 – 28, 2014	ICEIDA, African Union	2 days
Short Course on Geothermal Exploration	Los Azufrez, Mexico	Nov. 24 – 29, 2014	CeMIE-Geo, Mexico	6 days

A good example is the week long “Short Course on Geothermal Exploration and Development” held in El Salvador in November 2011. The Short Course was sponsored by the Organization of American States (OAS) for the benefit of three South-American countries, Ecuador, Colombia and Peru, all of which have since been invited to send participants to the UNU-GTP Millennium Short Courses. Figure 6 shows the participants in the Short Course.



Figure 6: Participants and some of the instructors in the Short Course on Geothermal Exploration and Development held for OAS in El Salvador in November, 2011; the San Vicente volcano and geothermal field seen in the background.

It should also be mentioned here that five geologists, who completed the 3 month “Course on Geothermal Technology”, and continued for the 6 month “Advanced Training in Borehole Geology”, were assessed to have completed a similar programme as the 6 month training in Iceland, and consequently given a similar status in the UNU-GTP system.

4. REGIONAL GEOTHERMAL CENTRES

4.1 African Centre of Excellence for Geothermal Capacity Building

The increased emphasis on development of geothermal resources, currently experienced in East Africa, and especially in Kenya in association with the goals set forward in Vision Kenya 2030 (e.g. Simiyu, 2010; Ngugi, 2012), has created an overwhelming demand, which the current capacity building activities on offer, through UNU-GTP in Iceland, Auckland University in New Zealand, and local universities have had difficulty in meeting. To keep the momentum of development going and meet this demand, it is therefore extremely urgent to take the local training to a new level. For some time it has been discussed that the next step should be the establishment of a Regional Geothermal Training Centre for East Africa, located in Kenya, which UNU-GTP has voiced its support for.

In early 2014, GDC received the support of the Kenyan Government for establishing a centre of excellence in geothermal capacity building. ICEIDA and the Nordic Development Fund (NDF) are now (late 2014) ready to step in to secure the financial background for the centre. The African Union has also emphasized its support for such a centre in collaboration with regional and international stakeholders. UNU-GTP is expected to be a part of this project, and it would also be important to have the cooperation of a Kenyan University to strengthen the academic background. This centre of excellence is expected to offer various types of short courses up to 3 months in length, thus creating something complimentary to the training on offer in Iceland. The development of curricula is of paramount importance to the success of the centre and UNU-GTP is ready to assist. The linking of the UN Millennium Short Course Series to the centre could also be a possibility.

4.2 The Geothermal Diploma Course in El Salvador for the Latin American Region

In Central America, a special diploma course has been given at the University of El Salvador for few years. The first two courses were financed by the Italian Development Cooperation and run in 2010 and 2012. The students (36 in the former year and 23 in the latter) were mainly from El Salvador with a few also coming from the neighbouring countries. The Italian funding, however, only sufficed for these two courses (Caprai et al., 2012; de Velis and Montalvo, 2011).

In 2012, financial basis was secured by the NDF and the Inter-American Development Bank (IDB) to run the course for additional three years, with the goal of reaching financial sustainability in the period after 2015. As the first phase of the project, UNU-GTP was contracted to perform an assessment of the courses run in 2010 and 2012 and to provide recommendations for an improved curriculum (Haraldsson et al., 2013). The University of El Salvador (UES) and LaGeo under the management of Consejo Nacional de Energía (CNE) joined in creating the foundation for the current Diploma Course, which was given at the UES for the first time in late 2013, and again in 2014, taking into consideration many of UNU-GTP's recommendations. Fellowships have been awarded to participants from the whole Latin American Region, which meant that close to half of the participants were foreigners and the rest Salvadorians. UNU-GTP is represented in the Program Committee of the Diploma Course and continues to play an advisory role in the development of the program. The second phase of the project was scheduled to be carried out from late 2013 to late 2014, with the goal of assuring self-sustainability of the future operation of the program. This work is carried out by the International Geothermal Center (GZB) and the International Geothermal Association Service Company (IGA Service GmbH) (de Velis, 2014).

5. THE STATUS AND THE WAY FORWARD

5.1 The Progress so far

With the Millennium Workshops and Short Courses, UNU-GTP has reached a much wider audience than before. More than 490 African scientists and engineers (including Yemen) have participated from 2005 to 2014 and close to 60 individuals from the region have lectured in these events. This can be compared with the 124 UNU Fellows from Africa and 4 from Yemen (Table 2) trained for 6 months in Iceland during the same period. It can be argued that the Short Courses are really creating a critical mass to seriously further geothermal development in the region. Similar things can be said about Central America.

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, the Short Courses have also created bonds and friendship between individuals with different backgrounds and across national boundaries, which can only help the development of geothermal in the region.

The effect of the Millennium Short Courses is also reaching well beyond East Africa, with new countries being added every year, the most recent additions from Central and West Africa, as Nigeria, Niger and Cameroon have vouched for. Even though geothermal energy will hardly be a major player in the energy spectrum for these countries, at least based on the current technology, it can still play an important role in some regions as a good renewable alternative to fossil fuels and biomass.

The customer-designed short courses, which UNU-GTP started offering in 2010, have also proven to be a good opportunity for countries that are fast-tracking geothermal development, and have themselves the financial capacity or the support of external mechanisms to finance it. The first such courses were held in 2010 for four different customers, having since increased in number and become an integral part of UNU-GTP's operations. About 400 individuals have benefitted from these activities during this period (to end of 2014). This is foreseen to continue in the near future, as need demands.

5.2 Looking into the Future

The 6 months training 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 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 is expected to be slow, except through external financing as has been seen in the last four years, which has contributed to the rise in the number of

UNU Fellows in Iceland, from 20-22 in 2004-2009 to 34 in 2013. This has meant, however, that UNU-GTP is currently close to the practical capacity limit that the 6 month training in Iceland can be expected to reach, at least through the current institutional set-up.

The two Series of the UN Millennium Short Courses have developed into a new pillar in the operations of UNU-GTP. This is expected to continue, with East Africa having some priority. New countries may still get entrance to the Short Courses in Africa, although most countries in East Africa blessed with considerable geothermal potential have participated in the events already. However, the future is likely to see some further important development. The idea of the Series developing into a sustainable regional geothermal centre has been discussed informally and external financing partners are now showing interest in participating in turning this into reality. This has also been presented and accepted at the UNU headquarters in Tokyo. The financial crisis may have delayed the action, but now the opportunity is there for rapid development.

In Central America, the financial basis for the establishment of such a centre was already secured in 2012 for 3 years, by NDF and IDB. The University of El Salvador (UES) and LaGeo, under the management of CNE, joined in creating the basis for the current Diploma Course given at the UES with Fellowships given to participants from the whole Latin American Region. UNU-GTP was in the advisory position, assessing the set-up and advising on contents of the course. Work is now on-going on strengthening its background, in order to make it sustainable.

UNU-GTP foresees a similar development in the near future in East Africa. With plans of fast-tracking geothermal in the region, it is now becoming urgent to get a regional geothermal centre established, so capacity building in the region can keep up with the ambitious plans of geothermal development. GDC has the support of the Kenyan Government for establishing a centre of excellence in geothermal capacity building. The African Union has also emphasized its support for such a centre in collaboration with regional and international stakeholders. With ICEIDA and NDF ready to step in with GDC in securing the financial background and UNU-GTP ready to assist in developing the curricula for the planned courses, development should be expected in 2014-2015. Additionally, the UN Millennium Short Course Series could be linked to this planned centre of excellence.

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