

Capacity Building in Geothermal: Update and Summary of UNU-GTP's Activities for Geothermal Development in Africa

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ABSTRACT

United Nations University Geothermal Training Programme (UNU-GTP) in Iceland specializes in capacity building for geothermal exploration and development for professionals from countries or regions often referred to as developing countries. This is achieved through hands-on training, post-graduate academic studies in Iceland, and through short courses, workshops and training in the relevant countries. Africa is a priority within the UN system, and with its high geothermal potential, especially in E-Africa, geothermal is already playing an important role in providing indigenous energy to an energy-starved part of the world. However, more emphasis is certainly needed, for further improving the energy situation. Here, the recent UN Sustainable Development Goals (SDGs) set targets that need to be adhered to.

From the start in 1979, the annual 6-month training in Iceland has been at the core of UNU-GTP's operations. Of 694 UNU Fellows, completing the 6-month training from 1979 to 2018, 270 or 39% have come from 17 African countries. In addition, 37 of 62 UNU-GTP MSc-graduates to date (late 2018) are from 8 African countries, and the 2 PhD graduates to date have both come from Kenya, with 3 more Africans now enrolled for PhD studies in Iceland on UNU-GTP Fellowships. Most of the UNU Fellowships for training or studies in Iceland have been financed by the Icelandic Government, while some have been sponsored through international support, or by local institutions or companies.

The UN Millennium Short Course Series for E-Africa, held annually in Kenya in 2005-2015 with 3-3½ week long short courses, was at first aimed only at surface exploration, but has gradually been extended to cover most aspects of geothermal exploration and development. Here, UNU-GTP has worked closely with Kenya, through KenGen and GDC. In 2016, the series was reorganized to focus more on the new UN SDGs. The new series were initiated in 2016, hopefully will continue for the coming years. Close to 700 participants from 23 African countries have benefitted from these two series. This effort is highlighted in a special paper.

In addition, UNU-GTP has also been able to offer customer-designed training and courses in line with the needs of clients, which have support of local or external financial mechanisms. This has become an important part of the operations of UNU-GTP in recent years, with more than 40 events of which 22 have been given in Africa, extending from 2 days up to 6 months.

Despite strong efforts over the years, the need for geothermal capacity building in Africa is as high as ever. A natural development to meet this need is the formal establishment of the African Geothermal Center of Excellence (AGCE) in Kenya, which is now in an interim phase under the guidance of UNEP in Nairobi. UNU-GTP is fully supportive of this development and hopes to see its formal establishment soon.

1. Introduction

The United Nations University Geothermal Training Programme (UNU-GTP) was established in Iceland in late 1978, and is thus celebrating its 40th anniversary this year (Georgsson, 2018; Haraldsson, 2018). The task of UNU-GTP is to help developing countries with geothermal potential to establish groups of specialists in geothermal exploration and development, by giving university graduates, engaged in geothermal work, intensive on-the-job training in their chosen field of specialization. Since 1979, annual 6-month courses have been held, with 8/9 different lines in geothermal science and engineering on offer, for professionals from developing countries.

The MSc programme, in geothermal science and engineering, was initiated in 2000 in cooperation with University of Iceland, and extended to PhD studies in late 2008. In 2013, Reykjavik University also joined in as a cooperation partner.

From 2005, funding was also 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 was implemented through regular workshops/short course series hosted in selected countries on different continents, in cooperation with local energy institutions/companies, in 2016 reorganized into the *UN SDGs Short Course Series*.

The current need for geothermal training has grown beyond what UNU-GTP is able to fulfil and service, through its regular budget from the Official Development Assistance of the Government of Iceland. This has led to requests for additional services, backed up by local or international financial sponsorships. It should also be noted that a lot of quality teaching material has been prepared through the Short Course Series. 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 sponsored customer. In recent years, this has become an important part of its operations (see Haraldsson and Georgsson, 2018).

Currently, UNU-GTP is the only international programme offering specialized training in all main fields of geothermal science and engineering. This paper describes the recent operations of UNU-GTP, with special reference to capacity building for geothermal development in Africa, concluding with some discussion on possible future development and future connection and cooperation between UNU-GTP and the scheduled African Geothermal Center of Excellence (AGCE).

2. The Organization of UNU-GTP

UNU-GTP is operated at Orkustofnun - the National Energy Authority of Iceland (www.os.is), which has been an Associated Institution of UNU since 1978. UNU-GTP is

financed through the Official Development Assistance (ODA) from the Ministry for Foreign Affairs.

UNU-GTP cooperates closely with ÍSOR – Iceland GeoSurvey, the main Icelandic geothermal research institution, where a considerable part of its teachers have a full-time employment. UNU-GTP also has a close cooperation with University of Iceland (UI), and Reykjavík University (RU), where several of its key lecturers and project supervisors are based. Similarly, many of Iceland's main engineering and energy companies have contributed significantly to teaching and supervising at UNU-GTP, not forgetting many smaller companies active in geothermal research or development.

UNU-GTP has five full time staff members employed by Orkustofnun, but lecturers and supervisors are hired or contracted from its cooperation partners, in line with the needs of the trainees and students at each given time. Every year, about 100 staff members of these institutions/companies render services to UNU-GTP under informal contracts. This gives the necessary flexibility required to provide the highly specialized training UNU-GTP is offering.

Since 2015, UNU-GTP is governed by a Board, with representatives from Orkustofnun, the Ministry for Foreign Affairs, and UNU, adding the director of UNU-GTP ex-officio. The D.G. of Orkustofnun serves as Chairman. The Board of UNU-GTP meets 2-3 times a year.

Academically, UNU-GTP is governed by a Studies Board, which is composed of high-level experts (from ÍSOR, UI and RU, etc.) responsible for each of the specialized study lines, with the Director of UNU-GTP serving as its chairman. The Studies Board meets every 3-4 months and serves an important role in setting the academic standards for the training

3. 6-Month Training in Iceland

3.1 Current Structure of the 6-Month Training

The 6-month training in Iceland was restructured in 2015, with four of the older study lines combined into two lines, and a new line on Project Management added. Furthermore, more attention was given to group work and interdisciplinary work among the UNU Fellows. The emphasis on the other study lines in geothermal science and engineering, however, remains high since these form the basis of every geothermal project in the world. Table 1 shows the detailed time schedule for the 6-month training in Iceland after the revision of 2015.

Table 1: Detailed Time Schedule of the 6-Month Training in Iceland.

	W E K	Geothermal Geology	Geophysical Exploration	Reservoir Eng. & Borehole Geoph.	Chemistry of Thermal Fluids	Environmental Science	Geothermal Utilization	Drilling Technology	Project Managm. and Finances
Group Project Work	1	Introductory Lecture Course and Group Project Work							
	2								
	3								
	4								
	5								
	6								
	7	Specialized Training: Lectures, Visits and Excursions							
	8								
	9								
	10								
	11	Main Excursion							
	12	Specialized Training cont.							
	13								
	14	Individual Project and Report Writing							
	15								
	16								

Training usually starts in late April and ends in October each year. All participants attend the introductory lecture course (6 weeks), including about 4 weeks of lectures and 2 weeks of group project and seminars, which aims to ensure good basic knowledge on most aspects of geothermal energy resources and technology, and to generate an appreciation for the

interrelationship between the various disciplines necessary in geothermal projects from the initial exploration to the stages of implementation and utilization. The introductory course is followed by lectures and practical training in the respective specialized fields (6 weeks). Excursions are also arranged to main geothermal fields under exploration and utilization in Iceland (2 weeks). In association with these, seminars are held and case histories studied. The most important part is through the execution of the final individual research project with supervision from an expert in the field of research (10-12 weeks) which is concluded with a research project report.

The main emphasis of the training is to provide the participants with sufficient understanding and practical experience to permit the independent execution of projects within a selected discipline when they return home. Eight specialized lines of training are offered (Table 1). A detailed description of the study lines can be found on the UNU-GTP web page (www.unugtp.is) They include the following:

- *Geothermal Geology* (combines the previous lines in *Geological Exploration* and *Borehole Geology*), giving practical training in basic geological and geothermal mapping, and in geological logging and analyses of drill cuttings and cores. Participants should have a degree in geology.
- *Geophysical Exploration* is practical training in conducting geophysical surveys of geothermal areas and interpretation of the data. Emphasis is on resistivity measurements, but other methods are also introduced. Participants should have a degree in geophysics, physics, mathematics or engineering.
- *Reservoir Engineering and Borehole Geophysics* (combines our previous lines in *Reservoir Engineering* and in *Borehole Geophysics*) covers the methodology needed to obtain information on the hydrological characteristics of geothermal reservoirs, and the essentials of geophysical measurements in boreholes used for geothermal research and development. Participants should have a degree in engineering, physics, geophysics, engineering mathematics or hydrogeology.
- *Chemistry of Thermal Fluids* gives a practical basis for thermal fluid chemistry in geothermal exploration and exploitation, together with water-rock interaction. Participants should have a degree in chemistry, geochemistry or chemical engineering.
- *Environmental Science* covers Environmental Impact Assessments (EIA), laws and policies, the planning and execution of environmental monitoring and projects and environmental auditing. Participants should have a degree in environmental science but general degrees in science or engineering can also be acceptable.
- *Geothermal Utilization* deals with design of power plants and systems, and corrosion and scaling. Direct utilization is also given due scope as well as scientific modelling of utilization systems. Participants should have a degree in engineering.
- *Drilling Technology* provides engineers with the information and on-site training necessary to prepare them for the work of drilling engineers or supervisors. The course includes selection of drilling equipment, well design, casing programmes, cementing techniques, cleaning and repairs of production wells, etc. Participants should have a degree in mechanical engineering or related engineering degrees.
- *Project Management and Finances* which was opened in 2015, provides participants with a solid knowledge in management of geothermal projects and their financial and financing implications. Participants should have a degree in science, engineering or financing, and have some experience in managing geothermal projects. They have a possibility to be certified by the IPMA (International Project Management Association), with D or even C certification.

The final research project topic is always selected with respect to the conditions of the home country of the participant. Whenever possible or practical, the participants bring data from geothermal projects in their home countries to use as a basis for the project. In 2017, 19 of the 23 projects dealt, at least partially, with geothermal areas in the home countries of the Fellows.

An important part in the 6-month training is also the visit of the UNU Visiting Lecturer, who gives a week long lecture series and has topical discussions with the UNU Fellows.

Since 1994, all project reports have been published by UNU-GTP in the annual book *Geothermal training in Iceland* (ISBN 978-9979-68). Printed copies can be obtained upon request. The books are mailed to the libraries of universities and leading geothermal research institutions in over 50 countries. All research reports from 1979 to 2017 are also available online at the UNU-GTP website (www.unugtp.is).

From 1979-2018, of the 694 scientists and engineers from 61 countries completing the 6-month courses, 270 are Africans or 39%, which is the biggest share of any continent, with Asia the only comparable continent with 35%. In 2018, 24 UNU Fellows enrolled for the training. Figure 1 shows the annual number of UNU Fellows in Iceland completing the 6-month training in Iceland, with African participation shown in light blue, including also those studying for MSc and PhD.

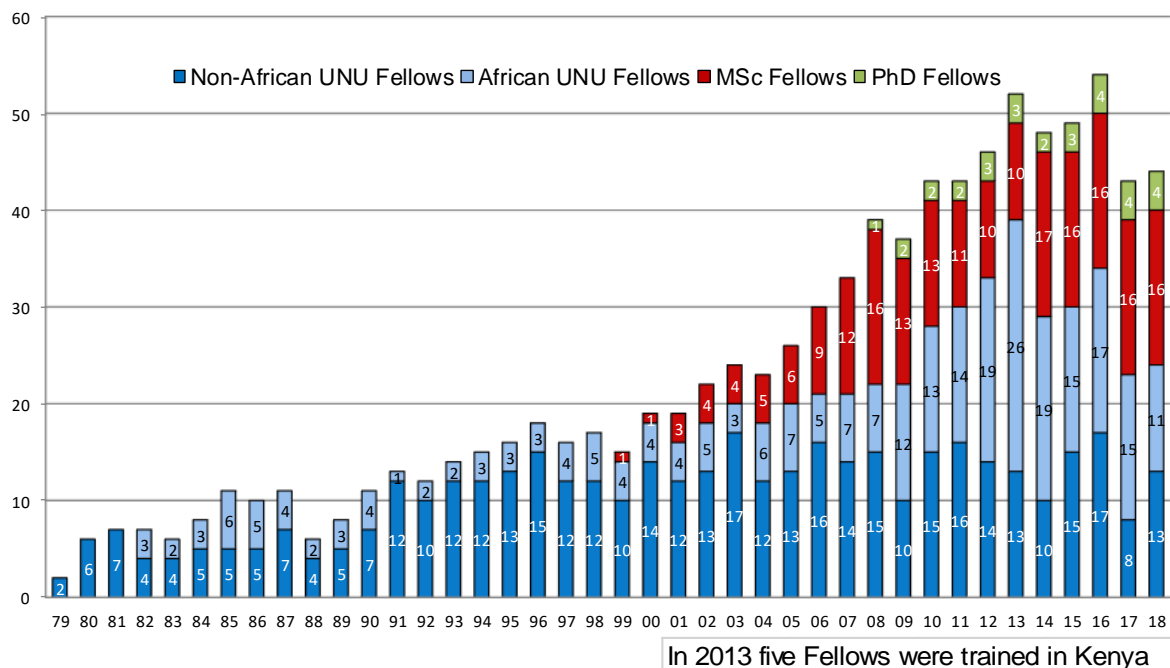


Figure 1: UNU Fellows completing the 6-month training and studying for MSc and PhD in Iceland in 1979-2018.

Figure 2 shows the participants' countries of origin who completed 6-month training during 1979-2018. The largest groups of Fellows have come from Kenya (129), China (89), Ethiopia (43), El Salvador and the Philippines (41), Indonesia (35) and Iran (25). Nine other countries have sent 10-20 participants, four of them are in Africa.

Regular contact has been held with former UNU Fellows by sending them an informal annual newsletter. A good majority of the Fellows keeps in contact with UNU-GTP and each other through e-mail correspondence, Facebook and other digital media platforms.

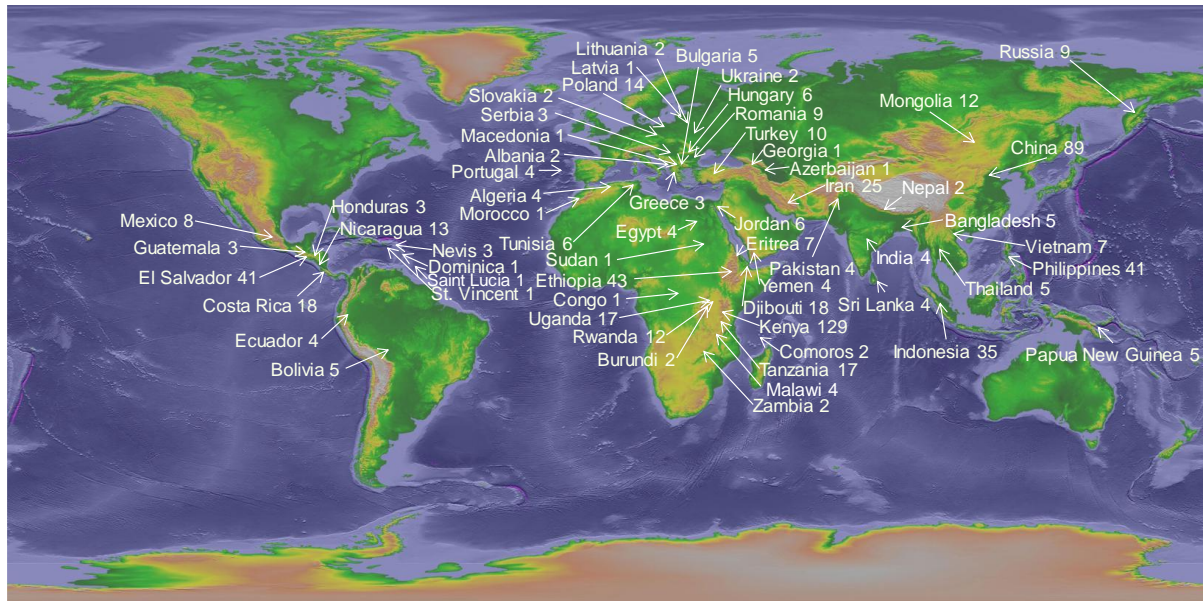


Figure 2: World map showing the origin of UNU Fellows trained in Iceland in 1979-1918.

3.2 Selection of UNU Fellows

Candidates for participation in the 6-month training in Iceland must have a relevant university degree for their study line, and be fluent in English. Furthermore, they should have a minimum of one year's practical experience in geothermal work, be under 40 years of age, and have a permanent position in geothermal energy at a non-private energy company/utility, research institution, or university in their home country. However, as our recent study line of *Project Management and Finances* is mostly aimed at individuals with experience in management, here the age limit is freely implemented.

Much care is taken in selecting the participants, with personal interviews playing a key role. The traditional selection procedure is through site visits, which are conducted by representatives of UNU-GTP to the countries requesting training. The potential role of geothermal energy within the energy plans of the respective country is assessed, and an evaluation made of the institutional capacities in the field of geothermal research and utilization. Based on this, the training needs of the country are assessed and recipient institutions selected. The directors of the selected institutions are invited to nominate candidates for training in the specialized fields that are considered relevant to promote geothermal development in the respective country. All qualified candidates are interviewed personally by an UNU-GTP staff member or a representative.

The site visits have played a very significant part in the work and the success of UNU-GTP. In recent years, the UN MDGs/SDGs Short Course Series in East Africa and Central America have also served as venues for selection of candidates for the more advanced training in Iceland. The courses enable the participants to show their ability and strength and thus they may get an opportunity for an interview, which consequently opens for the possibility to be selected for the training in Iceland. The Short Course Series, have reduced considerably the need for conventional site visits. In a few cases, online video interviews have also been carried out.

Participants from developing countries normally receive Fellowships financed by the Government of Iceland that cover international travel, tuition fees and per diem in Iceland. In earlier years UNU also contributed to this. In recent years (2010-2018), almost a third of the

Fellowships have been funded by partner countries institutions of UNU-GTP, either directly or through international or bilateral agencies, such as the EFTA-funds or the World Bank.

3.3 Evaluation

The number of UNU Fellows has gradually increased (Figure 1), mainly controlled by available financing from the Government of Iceland, which in the early 2000s was on-average sufficient to cover the costs of about 20 annual UNU Fellowships, with perhaps 1-2 additional UNU Fellowships funded through other financial mechanisms. A significant change was seen in 2010-2018, with an increased number of UNU Fellowships funded through other financial mechanisms, allowing the number of available UNU Fellowships to grow to 30 on average for this period. It is a clear recognition of the quality of the training offered at UNU-GTP, when institutions/companies in countries like Kenya and the Philippines are ready to finance UNU Fellowships in Iceland.

UNU-GTP was evaluated twice as a part of the UNU system – in 1996, when a detailed account was given within an assessment report on UNU training and fellowship activities and in 1998, when a brief description was given in a report on the 20-year review and evaluation of the UNU. Both evaluations were favourable to UNU-GTP.

Internal assessments of the training have, in the past, mainly taken the form of interviews with former trainees and their directors during site visits or in connection with international geothermal conferences. Some changes have been made in the detailed contents of some of the specialized courses, based on the feedback from the trainees and their institutions. During the training, anonymous questionnaires are also used to obtain the Fellows' opinion on the content of the lectures and the performance of the lecturers. Opinions on the individual phases of the training and research activities, as well as on the general support and guidance from UNU-GTP staff, working conditions at the UNU-GTP office, the attitude and support of the staff of Orkustofnun and ÍSOR, arrangements of accommodation, daily allowance, etc. is also requested. Finally, anniversary workshops have been used to evaluate the contribution of UNU-GTP in their partner countries, through papers presented, with a very positive response.

In 2017, the four UNU sister programmes in Iceland (UNU-GTP, UNU-FTP, UNU-LRT and UNU-GEST) went through a very detailed and comprehensive evaluation process, carried out by the Swedish firm *Nirás indevelop*, which specializes in evaluations like this, at the request of the Ministry for Foreign Affairs and supported by UNU. The evaluation was commissioned to enhance accountability and learning, based on an assessment of the processes and achievements of the four programmes. Among the results the following can as an example be quoted from the executive summary: *The UNU programmes in Iceland provide training that is of high quality. Theory, professional skills training and project work are combined, which gives fellows a unique edge. Overall the four programmes have managed to achieve a relevant balance between theory and practice that maximises the usefulness of the programmes to the fellows. Moreover, the programmes take advantage from the Icelandic context and have catered to the practical and social needs of the fellows in a way that fellows have described as welcoming, caring and generally, very efficient. With regards to cost efficiency it says: ...the cost comparison with other capacity development efforts in developed countries shows that the cost per fellow and day of the UNU Iceland programmes is at a reasonable and generally competitive level* (Nirás indevelop, 2017).

Additional quotes could be taken, but in general it must be said that the results were positive for the four programmes. At the end of the report recommendations are made on possible improvement and enhancement to keep their strong status.

Generally speaking, the effort to have the training tailor-made to the abilities of the individual and the needs of the recipient country/institution have been successful. The number of fully qualified applicants each year is normally greater than the number of scholarships available. Our records indicate that 80% of all our trainees have continued working in the geothermal sector for five years or more, and for most of them working in geothermal or at least in renewable energy development becomes the career of a lifetime. In many countries in Africa, Asia, Central America and Central and Eastern Europe, UNU-GTP graduates are among the leading specialists in geothermal research and development. They have been very successful, and have contributed significantly to energy development in their parts of the world.

4. Academic Studies in Iceland

The aim of establishing an MSc programme in cooperation with UI and RU was to go further in assisting our partner countries to strengthen their specialist groups and increase their geothermal research capacity. The 6-month training at UNU-GTP fulfils 25% of the MSc programme credit requirements (30 of 120 ECTS) at UI and RU. Since 2001, 62 UNU Fellows have completed an MSc degree in geothermal science or engineering through the UNU-GTP MSc programme, in cooperation with the UI and RU. The MSc graduates come from Bolivia 1, China 2, Costa Rica 1, Djibouti 2, El Salvador 6, Eritrea 2, Ethiopia 3, Indonesia 5, Iran 3, Jordan 1, Kenya 23, Malawi 2, Mongolia 1, Nicaragua 1, Philippines 2, Rwanda 2, St. Vincent and the Grenadines 1, Tanzania 2, Uganda 1 and Yemen 1. All of the MSc Fellows have received UNU-GTP Fellowships funded by the Government of Iceland, but 3 Fellowships have been co-sponsored by the home-country. Now, in late 2018, 10 additional former UNU Fellows are pursuing their MSc studies in Iceland. The MSc theses have been published in the UNU-GTP publication series, and can also be obtained from the UNU-GTP webpage (www.unugtp.is).

In addition, seven former UNU Fellows, all but one coming from Africa, have been admitted to the PhD programme at UI and RU on UNU-GTP Fellowships, with the first two starting in the academic year 2008-2009. On February 15, 2013 a milestone was reached when the first of these defended her PhD thesis, with the second defending her PhD thesis in 2016. Both come from Kenya. Currently, four are pursuing their PhD studies.

5. The UN Millennium and SDGs Short Course Series

The *UN Millennium Short Course series* in 2005-2015, succeeded since 2016 by the *UN SDGs Short Course Series* were a very important addition to the activities of UNU-GTP, allowing it to bring considerable part of the training to our partner regions in East Africa and Latin America, in cooperation with local energy institutions/companies (Fridleifsson, 2004; Georgsson et al., 2015). The original series saw annual events / short courses held in Kenya from 2005 to 2015, and for Central America – later extended to Latin America and the Caribbean Islands (LAC) – in El Salvador, from 2006 to 2015. A lot of material presented and papers written for these events were published on CDs and is also available on the website of UNU-GTP (www.unugtp.is).

In line with the new goals set forward by UN through the *SDGs*, two new series of annual short courses were introduced in late 2016, held in Kenya and El Salvador, respectively, replacing the old series, and taking their inspiration from the *SDGs*. To date, two events have been run within both series. In Africa, almost 680 participants have had the opportunity to attend events of these two series since their start in 2005.

With the Short Courses 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.

A detailed description of the *UN Millennium Short Course Series* is given in Georgsson and Haraldsson (2016), and of the succeeding series, the *UN SDGs Short Course Series* in Haraldsson and Georgsson (2018). Thus these will not be discussed further here.

6. Sponsored Customer-Designed Short Courses and Training Activities

The possibility for customer-designed short courses or training offered to partner countries was opened in 2010. This 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 the Millennium Short Course Series and the material prepared there. This has proven a good opportunity for some countries/institutions in need of a rapid capacity building process, 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 responsible for the quality of the contents. In 2010-2018, more than 40 different events have been given for various customers, with 22 of these held in Africa. For further information, see Haraldsson and Georgsson (2018) and Haraldsson (2018).

7. Gender Equality

Gender equality and gender issues are a key element in Icelandic foreign policy and for the United Nations. Gender equality is also an important part of the *UN Sustainable Development Goals*. In line with its Strategic Plan for 2016-2019, UNU-GTP actively promotes Gender Equality, by a gender balanced candidate selection, cooperating with UNU-GEST on special gender and energy lectures, as well as increasing the share of women lecturers in its programmes. The disadvantage is that energy related research and development is still quite male dominated, not least in the developing part of the world. Hence selection of female candidates is sometimes difficult. This is well reflected in our statistics, as through the 40 years of 6-month training at UNU-GTP in Iceland, only 22% of the UNU Fellows have been women. The ratio is though improving and has grown to 31% for the 2010s and 37% in the last 3 years. If we look specially at how this looks with regards to African participation, the numbers are even more discouraging, with only 18% of African candidates being female. Looking at the 2010s, the numbers are improving slightly with 23% female participation and 28% in the last 3 years. Here, we need to see improved numbers – i.e. more equality in the coming years. The aim of UNU-GTP is clear, it will continue to increase the share of women selected for training, studies, and teaching, with the ultimate goal to reach full gender equality in our activities as soon as possible in support of SDG 5: *Achieve gender equality and empower all women and girls*.

8. Support to Geothermal Training Centres in the Developing Countries

8.1 The Geothermal Diploma Course in El Salvador for the LAC region

There is a substantial demand for geothermal training in the world and the capacity building activities of UNU-GTP can only meet a part of it. UNU-GTP has therefore supported newly established geothermal training centres in developing countries. The cooperation with LaGeo

and the University of El Salvador in the past few years is the best example of this. UNU-GTP was approached by the Nordic Development Fund (NDF) and the Inter-American Development Bank (IDB) in 2012, with the request to evaluate a geothermal diploma course that had been run with Italian support at the University of El Salvador in 2010 and 2012 (Caprai et al., 2012). After a mission and a thorough review, UNU-GTP produced a report with recommendations for improvements and a possible future direction of the programme (Haraldsson et al., 2013). These recommendations were largely taken into account and implemented during the next three times the diploma course was given (2013-2015), which were financed by NDF and IDB (de Velis, 2014). During this period, UNU-GTP took part in the Academic Committee of the programme and made annual evaluations and recommendations for improvement. In 2016, UNU-GTP assumed a direct role in the management of the programme, which now was funded solely by NDF, and implementing partners' contributions. With this agreement, the UN SDGs Short Course Series in El Salvador also became an integral part of the Diploma Course, and additionally, 2-3 experts from Iceland also came in as guest lecturers to strengthen its lecture part.

The geothermal diploma course in El Salvador offers new possibilities for aspiring geothermal experts in Latin America, as the program is conducted in Spanish and in a cultural environment that in many respects is similar to that in the participants' home countries. Fellowships, covering all basic costs, have been awarded to participants from the Latin American Region, which means that close to half of the participants are foreigners while the rest is Salvadorians. The courses, which have lasted 4-5 months, are rather general in scope and have not offered specializations in a particular geothermal discipline, except through the one-month project work. The success of the diploma course programme through the years has rested on the strong expertise found within LaGeo, the state-owned geothermal exploration and electricity generation company in El Salvador. The strong ties between UNU-GTP and LaGeo have further served to increase its quality and success.

In 2016-2017, the financial need of the Diploma course was secured by NDF with MFA/ICEIDA in Iceland as an intermediary partner towards UNU-GTP. This allowed the running of a course for 30 Spanish speaking geothermal students, with 20 full Fellowships awarded each year – 10 of which were intended for participants outside El Salvador. This agreement was prolonged for 2018. A 5-year additional agreement is now in the pipelines.

8.2 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; Omenda and Mangi, 2016), has created an overwhelming demand for the current capacity building activities on offer by various training institutions, such as UNU-GTP in Iceland, Auckland University in New Zealand, and local universities, leading to challenges in meeting these needs. To keep the momentum of development going and meet this demand, it is therefore 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 NDF declared that they would be ready to step in to secure the financial background for the centre. The African Union also emphasized its support for such a centre in collaboration with regional and international

stakeholders. The same can be said about UNU-GTP, and several other stakeholders. The formal establishment of the African Geothermal Center of Excellence (AGCE) in Kenya is now finally in an interim phase under the guidance of UNEP in Nairobi. The programme now prepared for implementation is to offer courses at 3-4 different levels, and of varying time-lengths at a postgraduate level, as follows:

- A. A 3-week introductory course for scientists and engineers, with an award of certificate
- B. A 3½ week course in 2-3 subjects, on Geothermal Geoscience, and on Geothermal Engineering, and possibly on Environmental Sciences, with an award of certificate.
- C. A 6½ week course in 8-10 different lines involved in geothermal exploration and development, including e.g. Geology, Geophysics, Chemistry, Reservoir Engineering, Drilling Technology and Utilization etc., with an award of certificate.
- D. Additional courses tailor-made for special needs of the country/-ies.

This general programme looks sound, with some details needing to be finalised. A participant completing courses at levels A, B and C has completed a 3-month training, including some specialization. If possible academically, this should be rewarded with a diploma.

The question is about the finances; can they be covered in a sustainable way. NDF and MFF/ICEIDA have expressed a will to support, but the scheduled costs are important, and they are not clear yet. UNU-GTP has also expressed its will to be a part of this project and it is suggested that the UN SDGs Short Courses will become an integral part of the set-up, taking over the role of the Introductory Course on Geothermal Science and Technology. But for that to be implemented, an agreement on this must be reached with both KenGen and GDC, as both companies are important partners here, and the curricula needs to be reviewed to agree with the Introductory Course. Finally, it would be important to have the cooperation of a major Kenyan University to strengthen the academic background.

For various reasons, the African Geothermal Center of Excellence has taken longer time to materialize than expected. But now it seems to be heading towards a realistic solution. The question is whether the financial barriers can be overcome, but with the support of different stakeholders there is every reason to believe that. UNU-GTP fully supports this. If this hurdle is cleared, the road towards success looks clear.

9. Focussing on a Geothermal Future

9.1 Summarizing UNU-GTP Support to Africa

Africa has certainly enjoyed its share in the 6-month training at UNU-GTP, which has always been at the core of its activities. During the 40 years of operation, 39% of the UNU Fellows have come from 17 African countries. In addition, 60% of the UNU-GTP MSc graduates are from 8 African countries, and the 2 PhD graduates to date are both from Kenya, with 3 more Africans now enrolled on PhD UNU-GTP Fellowships. Our main concern here is to reach a better gender balance with regards to African participation in the near future.

With the UN MDGs and UN SDGs Short Course Series, UNU-GTP has reached a much wider audience than before. Close to 680 African geoscientists and engineers have participated in these and many individuals from the region have also lectured in these events. It can be argued that these series are 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. In this way, the geothermal know-how is being transferred from one

generation to the next. Similarly, it can be said that the customer-designed short courses have 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, with 22 events given in Africa during 2010-2018.

9.2 Looking to the Future

With the support of the Government of Iceland, UNU-GTP hopes to be able to continue its efforts to strengthen African geothermal capacity for geothermal development. Our intention is to continue along a similar line as before, perhaps with some slight changes in emphasis, such as increasing the number of fellowships for MSc studies and PhD studies in Iceland.

The African Geothermal Center of Excellence – AGCE seems finally to be finding its feet under the interim coordination of UNEP in Nairobi. We look forward to cooperate with UNEP, GDC, KenGen, and other serious stakeholders, on its academic development, and the African Union, NDF, MFA/ICEIDA and other stakeholders on the financial aspects.

The UN Sustainable Development Goals are a roadmap for the world to follow in the coming years, and UNU-GTP must make a serious effort, aiming to harmonize its operations better with these. Goal 7: *Ensure access to affordable, reliable, sustainable and modern energy for all*; and Goal 13: *Take urgent action to combat climate change and its impacts*, should be at the heart of all our activities; not forgetting Goal 5: *Achieve gender equality and empower all women and girls*.

Capacity building, transfer of technology and increased emphasis on policy making are key issues in the sustainable development of geothermal resources. The UNU Geothermal Training Programme expects to continue to successfully support geothermal development in the world through its capacity building activities.

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