Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

UNU Geothermal Training Programme in Iceland: Sharing Geothermal Knowledge with Developing Countries for 41 Years

Lúdvík S. Georgsson, Ingimar G. Haraldsson and Málfrídur Ómarsdóttir

GRÓ Geothermal Training Programme, Orkustofnun, Grensásvegi 9, IS-108 Reykjavík, ICELAND

lsg@os.is, igh@grogtp.is, mao@grogtp.is

Keywords: Geothermal, training, capacity building, developing countries, United Nations University, Iceland

ABSTRACT

The United Nations University Geothermal Training Programme (UNU-GTP) specialized in capacity building in geothermal exploration and development for geothermal professionals since its establishment in December 1978. In the beginning of 2020, changes were made on the organization behind the programme, and with it the name changed to GRÓ Geothermal Training Programme (GRÓ GTP). The mandate of the Geothermal Training Programme (GTP) has always been to provide for capacity building in developing countries, which has been achieved through intensive hands-on training and academic studies in Iceland, as well as short courses, workshops and training in cooperation countries. The annual 6-month training in Iceland, given in 1979-2019 by UNU-GTP, is the basic operation of the Programme. As geothermal exploration and development is very much a multi-disciplinary task, the training is offered in eight lines of study. From 2015 these are: Geothermal Geology, Geophysical Exploration, Reservoir Engineering and Borehole Geophysics, Chemistry of Thermal Fluids, Environmental Science, Geothermal Utilization, Drilling Technology, and Project Management and Finances, with the fellows trained in their chosen discipline. At the end of 2019, a total of 718 scientists and engineers from 63 countries had completed the annual 6-month specialized courses. Africa has received the largest support with 39% of the UNU Fellowships, 35% have been given to countries in Asia, 15% to Latin America and the Caribbean, 10% to Central and Eastern Europe, and 1% to Oceania. Many UNU graduates have become leading specialists in geothermal research and development in their home countries. Fellowships for MSc and PhD studies have been offered to selected candidates, who have completed the 6-month training, with the aim to go one or two steps further in assisting developing countries to strengthen their geothermal research capacity and know-how. This has been done in cooperation with University of Iceland and Reykjavík University. The 6-month training is recognized to fulfil 25% of the MSc programme credit requirements (30 ECTS units) if needed. The MSc and PhD Fellowships cover the costs of studying in Iceland, while the Icelandic universities are responsible for the studies. In 2001-2019, 67 UNU Fellows completed an MSc degree in geothermal science or engineering in Iceland through the UNU-GTP MSc programme. The recipients of six, out of the first eight PhD fellowships, were Kenyans. The first one defended her PhD dissertation in 2013. By the end of 2019, three had completed their PhD studies, all from Kenya, with three more in line in near future. Most of the UNU Fellowships for training or studies in Iceland have been financed by the Icelandic Government, while some have been co-sponsored through international support, or by local companies.

The operations of UNU-GTP were not limited to Iceland. Training activities in developing countries, usually referred to as the UN Millennium Development Goals Short Course Series, were initiated in 2005, with a Workshop for Decision Makers held in Kenya. It was followed by annual Short Courses for East Africa held in Kenya from 2006. A similar series for Central America was given in El Salvador from 2006, later stretching to the whole of Latin America and the Caribbean. In both series, UNU-GTP has worked closely with the local energy companies, KenGen and GDC in Kenya, and LaGeo in El Salvador. The aim was to increase efforts in geothermal capacity building and further regional cooperation in geothermal development by taking the training to the cooperation countries. The annual series were reorganized in 2016, in line with the recent *UN Sustainable Development Goals*, with the first UN SDG-events given in 2016, both in El Salvador and in Kenya. These Short Course series have also provided a basis for UNU-GTP to offer customer-designed short courses and training in line with needs of an externally funded customer. This became an important part of UNU-GTP's operations, with 44 events given in the period from 2010 to 2019.

In April 2016, UNU-GTP signed a cooperation agreement with LaGeo – the Salvadorian geothermal company in becoming an active partner in a 5-month Diploma Course on geothermal exploration and development offered in Spanish in El Salvador for geothermal professionals from Latin America with the University of El Salvador as the third partner. An agreement was reached with the Nordic Development Fund (NDF), with the Ministry for Foreign Affairs in Iceland as an intermediary partner, to finance the programme for three years. In May 2019, the ministry agreed to support it for two more years, through 2020. In 2016-2019, 29-30 Spanish speaking students have attended the course annually, 20 on full fellowships awarded each year.

After a cooperation of over 41 years, the Government of Iceland and United Nations University (UNU) severed their connection at the end of 2019. Instead, a new Category 2 Centre under the auspices of UNESCO named GRÓ, was established in Iceland to envelope the four Icelandic former UNU programmes. With this new affiliation the programmes are expected to continue their operations in a similar way as before, whilst keeping the UN ties. Thus, the Geothermal Training Programme continues its activities as GRÓ GTP.

This paper describes the activities of the UNU Geothermal Training Programme with emphasis on its operations in Iceland but including also an outline of its foreign operations. The latter is though more thoroughly described in another paper.

1. INTRODUCTION

The United Nations University Geothermal Training Programme (UNU-GTP) was established in Iceland at the end of 1978, and celebrated its 40th anniversary in 2018 (Georgsson, 2018). The task of UNU-GTP was to help developing countries and transitional countries with geothermal potential to establish groups of specialists in geothermal exploration and development, by giving university

graduates, engaged in geothermal work, intensive training in their chosen field of specialization. Since 1979, annual 6-month courses have been held, with 8 – 9 different study lines in geothermal science and engineering on offer, for professionals from developing countries (Georgsson et al., 2015a).

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, a similar contract was signed with Reykjavík University, which consequently also joined in as a cooperation partner.

From 2005, funding was also secured for additional training efforts, taking the training to the partner countries. The funding came from the Government of Iceland, as Iceland's official contribution to the UN Millennium Development Goals and was implemented through regular Workshops/Short Course series (UN MDG Short Course Series) hosted in selected countries on different continents, in cooperation with local energy institutions / companies (Georgsson et al., 2015b; Haraldsson et al., 2021). In line with the newly established *UN Sustainable Development Goals*, the annual series were reorganized in 2016, into the UN SDG Short Course Series, given in El Salvador for Latin America and Caribbean (LAC), and Kenya for East Africa (Haraldsson, 2018; Haraldsson et al., 2021).

The need for geothermal training in developing and transitional countries was for many years well beyond what UNU-GTP was able to fulfil and service through its regular budget from the Official Development Assistance (O.D.A.) of the Government of Iceland through the Ministry for Foreign Affairs (MFA). This 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 was prepared through the MDG Short Course Series. These factors played a major role in the decision of UNU-GTP to take its training activities one step further in 2010 and offer courses or training fulfilling special needs of a sponsored customer. In recent years, this became an important part of UNU-GTP's operations (Georgsson et al., 2015b; Haraldsson, 2018; Haraldsson et al., 2021).

After a cooperation of over 41 years, the Government of Iceland, through the MFA, and UNU decided to sever their cooperation from the end of 2019. This change of status had to do with policy decisions at UNU which were incompatible with the vision of the MFA in Iceland, which financed the four Icelandic UNU programmes. Instead, MFA sought cooperation with UNESCO. This led to the formation of the new Category 2 Centre named *GRÓ – International Centre for Capacity Development, Sustainable Use of Natural Resources and Societal Change*, which operates under the auspices of UNESCO. GRÓ was established on January 1, 2020 and acts as an umbrella over the four programmes. Besides UNU-GTP these were UNU-FTP, UNU-LRT and UNU-GEST, which all are operated in Iceland and all have now adopted the prefix GRÓ. Thus, from the beginning of 2020, UNU-GTP became GRÓ GTP, and under this new affiliation it is expected to continue its operations in a similar way as before. GRÓ GTP is currently the only international programme offering specialized postgraduate training in all main fields of geothermal science and engineering.

In this paper, the operations of UNU-GTP from 1979-2019 are described, with special reference to capacity building for geothermal development in developing and transitional countries.

2. GENERAL ORGANIZATION OF UNU-GTP

UNU-GTP was operated at Orkustofnun (OS) – National Energy Authority of Iceland, which was an Associated Institution of UNU since 1978. UNU-GTP was primarily financed through Official Development Assistance (O.D.A.) from the MFA. In recent years, UNU-GTP had five permanent staff members (employed by OS), but lecturers, supervisors and support staff were hired through short-term contracts from ÍSOR – Iceland GeoSurvey, University of Iceland (UI), Reykjavik University (RU), and other geothermal and engineering agencies/companies, in line with the needs of the trainees and students at each given time. Every year, about 100 staff members of these institutions/companies rendered services to UNU-GTP. This gave the necessary flexibility to provide the highly specialized training in the eight lines of specialization on offer. UNU-GTP cooperated closely with ÍSOR, the main Icelandic geothermal research institution, where a considerable number of its teachers had full-time employment. UNU-GTP also had a close cooperation with UI and RU where many of its lecturers and project supervisors are based. Similarly, staff members of many of Iceland's main engineering and energy companies contributed significantly to the teaching at UNU-GTP, not forgetting smaller companies active in geothermal research or development. Dr Ingvar Birgir Fridleifsson was the founding Director of UNU-GTP and served as such until his retirement in 2013. Mr Lúdvík S. Georgsson became the Deputy Director of UNU-GTP in 1990, and in Mid-2013, he took over as Director, holding the position to the end of 2019, when he retired. Other recent staff members are Mr Ingimar G. Haraldsson, Deputy Director since 2013, Ms Málfrídur Ómarsdóttir, Environmental Scientist, Dr Vigdís Hardardóttir, who replaced Ms Thórhildur Ísberg in mid-2019 as School Manager, and Mr Markús A.G. Wilde, Service Manager.

Since 2015, UNU-GTP was governed by a Board, with Dr Gudni Jóhannesson, Director General of OS as its chairman. Other board members have included Amb. María Erla Marelsdóttir, Director General of Directorate for International Development Cooperation, representing the Ministry for Foreign Affairs, Dr Jakob Rhyner, Vice Rector of UNU for Europe, representing UNU, and Mr Lúdvík S. Georgsson, Director of UNU-GTP, ex officio. In late 2018, Mr Sebastian von Einsiedel, new Vice Rector of UNU for Europe, replaced Dr Rhyner, and in Mid-2019, Mr Jón Erlingur Jónasson, Director at the Directorate of International and Security Affairs, MFA, took over from Amb. Marelsdóttir. The Board of UNU-GTP met two times a year from its establishment.

UNU-GTP was academically governed by a Studies Board, composed of high-level geothermal experts responsible for each of the specialized lines of study which were on offer in the 6-month training in recent years. The Director of UNU-GTP was the chairman of the Studies Board. Members of the Studies Board in 2019 are listed below:

Chairman: Lúdvík S. Georgsson, Director UNU-GTP
Geothermal Geology: Ms Anette K. Mortensen (Landsvirkjun)
Borehole Geology: Dr Hjalti Franzson (ÍSOR)
Geophysical Exploration: Mr Gylfi Páll Hersir (ÍSOR)
Borehole Geophysics: Mr Benedikt Steingrímsson (ÍSOR)
Reservoir Engineering: Dr Gudni Axelsson (ÍSOR)
substituting for Ms Saeunn Halldórsdóttir (ÍSOR) on leave
Chemistry of Thermal Fluids: Mr Finnbogi Óskarsson (ÍSOR)
Environmental Science: Prof. Brynhildur Davídsdóttir (UI)
Geothermal Utilization: Dr Páll Valdimarsson (pvald ehf.)
Drilling Technology: Mr Kristinn Ingason (Mannvit Eng.)
Project Management and Finances: Prof. Helgi Thór Ingason (RU)

The Studies Board met 3-4 times a year. It set the academic standards for the training and designed training schedules for the different study lines and each UNU Fellow. The generous work of the members of the Studies Board through the years is gratefully acknowledged.

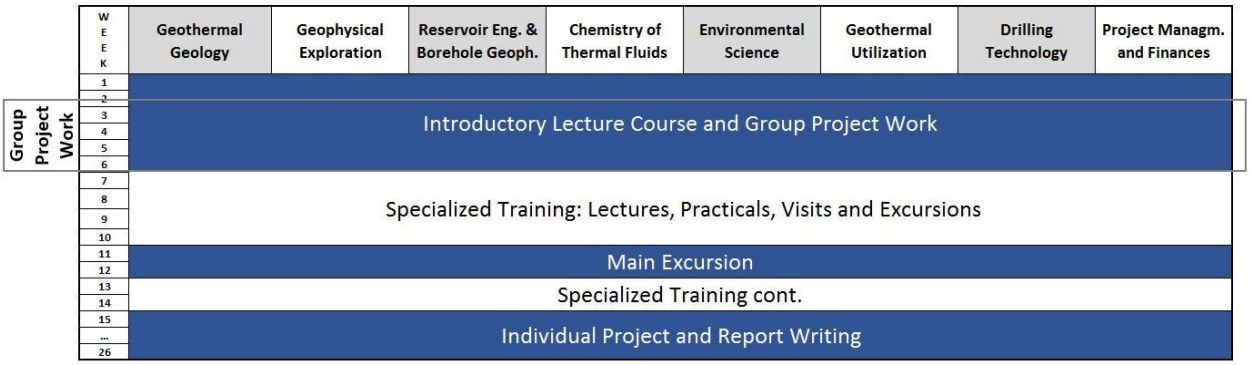
3. THE 6-MONTH TRAINING IN ICELAND

3.1 The structure of the 6-month training

The organization of the 6-month training goes back to the establishment of the programme. At that time, it was decided to offer the training in eight study lines in geoscience and engineering, with the addition of a ninth study line in environmental science in 1997. The training was also divided into 4 main phases. All participants started by attending the introductory lecture course (6 weeks, usually with three lectures in the morning and practical work in the afternoon), which aimed at giving background knowledge on most aspects of geothermal energy resources and technology, and to generate an appreciation for the interrelationship between the various disciplines necessary to develop geothermal projects, from the initial exploration to the stages of implementation and utilization. Participants took two written tests during the course. The introductory course was followed by lectures and practical training in the respective specialized fields (6 weeks), in some cases with a test at the end. In addition, excursions were arranged to many main geothermal fields under exploration and utilization in Iceland with seminars held and case histories studied on each field (2 weeks in total). The most important part was though the execution of an individual research project with supervision from experts in the project topics (11-12 weeks), concluded with an extensive research project report. Fellows were encouraged to use data from their home countries to enhance their skills and enable their training to be a contribution towards their home institution. The training usually started in late April, ending in October each year. This study line setup remained unchanged until 2015.

In late 2014, UNU-GTP set into motion a revision of its activities. Four of the nine study lines on offer were combined into 2, and a new study line added, with the 6-month training thus again reorganized into 8 lines, run for the first time in the present format in 2015. Furthermore, a group-project assignment was added into the study schedule parallel with introductory lectures, where the UNU Fellows work together as a team with real data from geothermal systems. Thus, they participate in lectures and excursions through the first half of the programme and work on individual projects and research in their chosen field of expertise for the second half of the programme as shown in Table 1. By offering these different study lines, UNU-GTP was able to create a sound basis for geothermal capacity building in its partner countries. Each participant only followed one line of training, but within each line there was some flexibility. The programme itself, as well as its close connection to research fields of geothermal energy, was an essential contribution to geothermal research worldwide through the research projects of the UNU Fellows. The main emphasis of the training was to provide the participants with sufficient understanding and practical experience to permit the independent execution of projects within a selected discipline, on return home. The eight specialized lines of training on offer are presented in Table 1, with the following description giving some detail. A more detailed description is found on the GTP web page (now: *www.grogtp.is*), as GRÓ GTP follows the same structure in its 6-month training:

Table 1: Time schedule and basic content of the 6-month training in Iceland.



- *Geothermal Geology* (combines the previous lines in Geological Exploration and Borehole Geology), giving practical training in basic geological and geothermal mapping, and in borehole geology through geological logging, and analyses of drill cuttings and cores. The identification of alteration minerals (microscope and x-ray diffraction) and the interpretation of the alteration mineralogy forms an integral part of the course. 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 insight also given into thermal, magnetic, gravity and seismic methods. Participants should have a degree in geophysics, physics, mathematics, or engineering.
- *Reservoir Engineering and Borehole Geophysics* (combining the previous lines in Reservoir Engineering and in Borehole Geophysics) covers the essentials of geophysical measurements in boreholes used for geothermal investigations, with an emphasis on temperature and pressure measurements, and the methodology needed to obtain information on the hydrological characteristics of geothermal reservoirs, including reservoir physics, well and reservoir modelling, resource assessment and monitoring responses. Participants should have a degree in engineering, physics, geophysics, mathematics, or hydrogeology.
- *Chemistry of Thermal Fluids* gives an insight into the role of thermal fluid chemistry in geothermal exploration and exploitation, including sampling, analysis of major constituents, thermodynamics, water-rock interaction and interpretation of results and monitoring responses. 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. Scientific methods suitable for environmental monitoring

are assessed and ecological impact, pollution, mitigation measures, and occupational safety considered. Participants should have a degree in environmental science or engineering, but general degrees in science or engineering can also be acceptable.

- *Geothermal Utilization* deals with thermal design of power plants and systems, power plant components, control systems, and corrosion and scaling. Direct use is also given due scope with a good overview of its possibilities as indicated by the Líndal Diagram including district heating, swimming pools / spas, greenhouses, aquaculture, drying, use of ground source heat pumps, etc., 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 with the aim to strengthen the management side of geothermal projects, which has often been underestimated, provides participants with a solid knowledge in management of geothermal projects and their financial and financing implications. Some financial tools to assist in this are introduced with emphasis on geothermal aspects. Participants should have a degree in science, engineering, or economics, and have some experience in managing geothermal projects. They have a possibility to be certified by the International Project Management Association (IPMA), with D or even C certification.

One guest lecturer with a strong international reputation was invited every year as a UNU Visiting Lecturer to give a lecture series on geothermal and to lead discussions with the UNU Fellows. Usually, they lectured for a week in Reykjavík. Table 2 lists the UNU Visiting Lecturers since 2000. Papers related to many of the lectures of the UNU Visiting Lecturers have been published and are available on request in printed format, and online on the GTP website (now: *www.grogtp.is*) under Publications.

Table 2: UNU Visiting Lecturers 2000-2019.

2000	Trevor Hunt	New Zealand	2010	Roland N. Horne	USA
2001	Hilel Legman	Israel	2011	Ernst Huenges	Germany
2002	Karsten Pruess	USA	2012	Cornel O. Ofwona *UNU Fellow 1996*	Kenya
2003	Beata Kepinska *UNU Fellow 1994*	Poland	2013	Kevin Brown	New Zealand
2004	Peter Seibt	Germany	2014	Malcolm Grant	New Zealand
2005	Martin Mwangi *UNU Fellow 1982*	Kenya	2015	Meseret Teklemariam *UNU Fellow 1985*	Ethiopia
2006	Hagen Hole	New Zealand	2016	James Koenig	USA
2007	José Antonio Rodriguez	El Salvador	2017	Juliet Newson	New Zealand
2008	Wang Kun *UNU Fellow 1998*	China	2018	William Cumming	USA
2009	Wilfred Elders	USA	2019	Alper Baba *UNU Fellow 2003*	Turkey

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 the recent study line of Project Management and Finances is mostly aimed at individuals with experience in management, the age limit is somewhat laxer.

Much care has been taken in selecting the participants, with personal interviews playing an important role. The traditional selection procedure is through site visits, which have been 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 important to promote geothermal development in the respective country. All qualified candidates have been interviewed personally by a 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 MDG/SDG Short Course Series in East Africa and Central America have also served as important 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 a possibility to be selected for the training in Iceland. The Short Course Series reduced considerably the need for conventional site visits. In a few cases, on-line video interviews have also been carried out.

Participants from developing countries normally receive UNU Fellowships financed by the Government of Iceland which cover international travel, tuition fees and per diem in Iceland. In earlier years, UNU also contributed to this. In recent years (2010-2019), almost a third of the fellowships have been funded by institutions in partner countries, either directly or through international or bilateral agencies, such as the EEA-grants or the World Bank.

3.3 Participation in the 6-month training from the start

Of the 718 scientists and engineers from 63 countries completing the 6-month courses in 1979-2019, 281 or 39% are Africans, 250 or 35% come from Asia, 107 or 15% come from Latin America and the Caribbean, 75 or 10% are Europeans from transitional countries, and finally only 5 or 1% come from Oceania. The largest groups of UNU Fellows have come from Kenya (134), China (90), Ethiopia (45), the Philippines (43), El Salvador (42), Indonesia (38) and Iran (25). Nine other countries have sent 10-20 participants. Table 3 lists the countries and number of UNU Fellows, and their lines of study in Iceland in 1979-2019, while Figure 1 shows a world map with the origin of the 6-month UNU Fellows. Figure 2 shows the annual number of UNU Fellows completing the 6-month training in Iceland, including also those studying for MSc and PhD. The largest groups of UNU Fellows were in Iceland in 2013 and 2016, 34. However, in 2013, 5 additional Kenyans received an advanced 6-month training in Borehole Geology in Kenya.

They are also included in Figure 2, bringing the total number for that year to 39. Figure 3 shows the group of UNU Fellows in Iceland in 2019.

Table 3: Fellows of UNU Geothermal Training Programme 1979-2019.

Country	Geothemal Geology[1]	Geophysical Exploration	Reservoir Engineering & Borehole Geophysics[2]	Chemistry of Thermal Fluids	Environmen. Science[3]	Geothermal Utilization	Drilling Technology	Project Managem. & Finances[4]	Total
Albania						2			**2**
Algeria	1	1		1		1			**4**
Azerbaijan					1				**1**
Bangladesh	1	1	2	1					**5**
Bolivia			1	2			2		**5**
Bulgaria			3	2					**5**
Burundi	1					1			**2**
China	3	2	40	16	10	16	3		**90**
Comoros		2							**2**
Costa Rica	4	3	2	3	2	4			**18**
Djibouti	5	1	4	3	1	2	3		**19**
Dominica				1	1				**2**
D.R. Congo	1								**1**
Ecuador	1		1			1		2	**5**
Egypt	1		2	1					**4**
El Salvador	3	2	8	9	5	11	4		**42**
Eritrea	2	2	1	2					**7**
Ethiopia	7	8	9	6	2	8	3	2	**45**
Georgia						1			**1**
Greece		1				2			**3**
Guatemala	1		1	1					**3**
Honduras	1	1				1			**3**
Hungary		1	2			2		1	**6**
India				1		3		1	**5**
Indonesia	6	3	10	2	3	11	1	2	**38**
Iran	5	1	3	2	4	9	1		**25**
Jordan	1		2	2		1			**6**
Kenya	25	16	14	19	12	18	23	7	**134**
Latvia						1			**1**
Lithuania			1			1			**2**
Macedonia				1					**1**
Malawi	1			1		2			**4**
Mexico	1	1	5			1			**8**
Mongolia	1	2	1	2		5	1		**12**
Montserrat						1			**1**
Morocco		1							**1**
Nepal				1		1			**2**
Nicaragua	1		5	5	2				**13**
Nigeria			1						**1**
Pakistan	2		1	1					**4**
Papua N.G.	2	1	1		1				**5**
Philippines	4	8	19	6		6			**43**
Poland	1		6	1		6			**14**
Portugal	1		1			1	1		**4**
Romania	1		1	1		4	1	1	**9**
Russia	1		2	5	1				**9**
Rwanda	2	2	2	1	2	2	1		**12**
Serbia			2	1					**3**
Slovakia			2						**2**
Sri Lanka	1	2	1						**4**
St.Kitts & Nevis			1			1		1	**3**
St. Lucia					1			1	**2**
St.Vinc. & Gre.	1		1						**2**
Sudan						1			**1**
Tanzania	6	2	1	3	3	2	1	1	**19**
Thailand	1		2	1		1			**5**
Tunisia			1			5			**6**
Turkey	1		1	4	1	3			**10**
Uganda	7	3	1	5	1				**17**
Ukraine			2						**2**
Vietnam	2	1	1	2			1		**7**
Yemen	3			1					**4**
Zambia						1		1	**2**
Total	**109**	**68**	**167**	**116**	**53**	**139**	**46**	**20**	**718**

[1] **Geological Exploration** and **Borehole Geology** combined into **Geothermal Geology** from 2015

[2] **Reservoir Engineering** and **Borehole Geophysics** combined into one line from 2015

[3] **Environmental Science** opened in 1997

[4] **Project Management & Finance**s opened in 2015

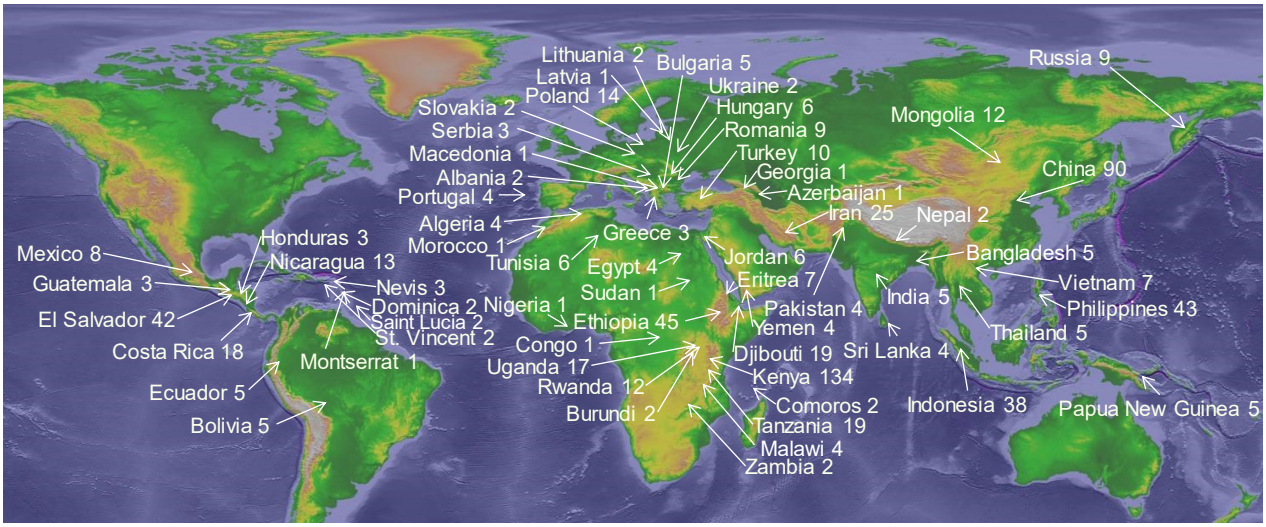


Figure 1: World map showing the origin of 6-month UNU Fellows trained in Iceland in 1979-2019.

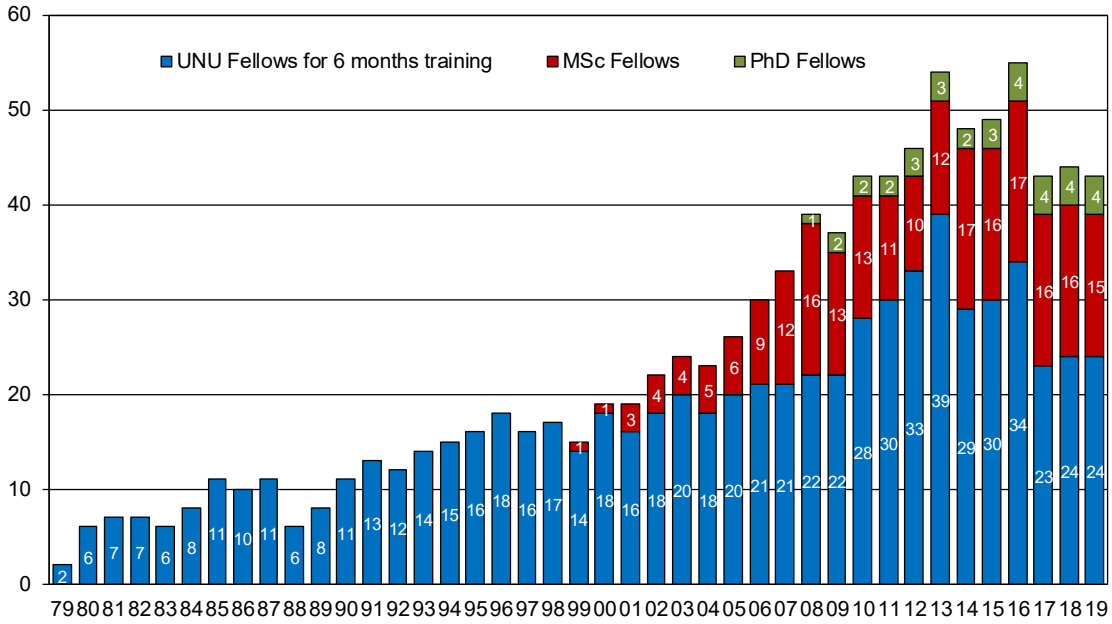


Figure 2: Number of UNU Fellows annually completing the 6-month training in the years 1979-2019, and fellows studying for MSc and PhD in Iceland in 1999-2019, including 5 Kenyans trained for 6 months in Kenya in 2013.

3.4 Evaluation of the 6-month training

The number of UNU Fellows in the 6-month training gradually increased from the modest number of 2 in 1979 (Figure 2), mainly controlled by available financing from the Government of Iceland. In the early 2000s this funding had reached a level usually being 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, 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 the period 2010-2016. 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. The last three years have again seen a minor reduction in external funding, with 24 taking part in the 6-month training on average.

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 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, in the past, mainly took the form of interviews with former trainees and their directors during site visits or in connection with international geothermal conferences. Some changes were 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 were 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. were also requested. Finally, *Anniversary Workshops* were used to evaluate the contribution of UNU-GTP to the partner countries, through papers presented, with a very positive response.



Figure 3: The 2019 UNU Fellows in Iceland in Ásbyrgi NE-Iceland.

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 at the request of the Ministry for Foreign Affairs and supported by UNU, carried out by the Swedish firm *Nirás indevelop,* which specializes in such evaluations. 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 tailor the training 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 was normally greater than the number of scholarships available. Records indicate that 70-80% of all the trainees continued working in the geothermal sector for more than five years, and for the majority working in geothermal or at least in renewable energy development became 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 (later extended to a PhD programme) in cooperation with UI and RU was to go further in assisting the partner countries to strengthen their specialist groups and increase their geothermal research capacity. The 6-month training at UNU-GTP can fulfil 25% of the MSc programme credit requirements (30 of 120 ECTS) at UI and RU. In 2001-2019, 67 UNU Fellows completed an MSc degree in geothermal science or engineering through the UNU-GTP MSc programme, in cooperation with UI and RU. To date only 12 are women (18%), which is rather low, but the last few years have seen a considerable improvement on that in line with increased emphasis on gender equality. In total, 60 have received their degree from UI, the first one in 2001, while 7 have received it from RU, the first one in 2016. Figure 4 shows a world map with the origin of all the MSc and PhD UNU Fellows. All 67 of those who completed MSc studies received UNU-GTP Fellowships funded by the Government of Iceland, but 2 were co-sponsored by the home-country. At the start of 2020, ten additional UNU Fellows were pursuing their MSc studies in Iceland; 5 started in August 2018 and 5 in August 2019. The MSc theses have been published in the UNU-GTP publication series and can also be obtained from the webpage of GTP (now: *www.grogtp.is*).

In addition, 8 UNU Fellows, all but one coming from Africa, have been admitted to the PhD programme at UI (7) and RU (1) on UNU-GTP Fellowships. All of these have been sponsored by the Government of Iceland. The first two started in the academic year 2008-2009. On February 15, 2013, a milestone was reached when the first one defended her PhD dissertation. The second defended her dissertation in 2016 and the third one in December 2019. All come from Kenya. Currently, five are pursuing their PhD studies. Of these, three are from Kenya, while one each comes from China and Tanzania.

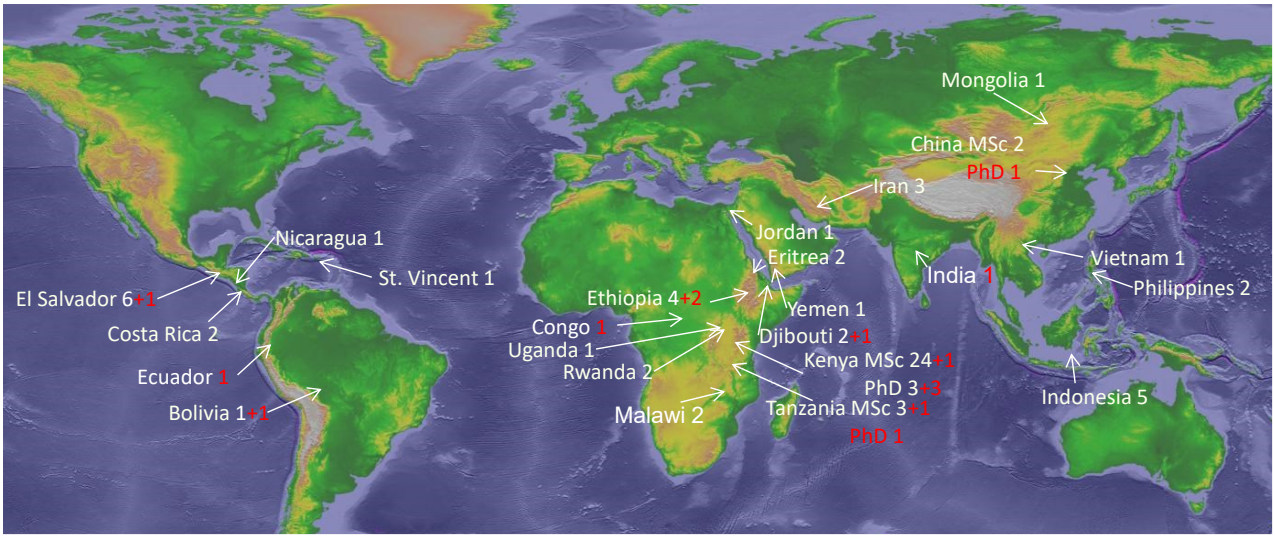


FIGURE 4: World map showing the origin of the MSc and PhD UNU-GTP Fellows in Iceland – red numbers show studies in progress in late 2019.

5. THE UN MILLENNIUM AND SDG SHORT COURSE SERIES

The UN Millennium Short Course series in 2005-2015, succeeded since 2016 by the *UN SDG Short Course Series,* were a very important addition to the activities of UNU-GTP, allowing it to bring considerable part of the training to the main partners in East Africa and Latin America, in cooperation with local energy institutions/companies (Fridleifsson, 2004; Georgsson et al., 2015b). The original series saw annual events / short courses held in Kenya from 2005 to 2015, and semi-annual for Central America – later extended to the whole of Latin America and the Caribbean Islands (LAC) – held in El Salvador, from 2006 to 2015. A lot of material presented, and papers written for these events were published on CDs and are also available on the website of GTP (*www.grogtp.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, replacing the old series, and taking their inspiration from the *UN Sustainable Development Goals*. To date, four events have been run in the East African Series in Kenya and three in the LAC series in El Salvador. In Africa (also including Yemen), about 745 participants have had the opportunity to attend events of these series since their start in 2005, while 622 have attended the LAC events, starting in 2006. 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 strongly to potential geothermal development in new countries. The Short Courses have also been an important catalyser in increased cooperation between the countries in East Africa.

A detailed description of the UN Millennium Short Course Series is given in Georgsson et al. (2015b) and Haraldsson (2018), and of the succeeding UN SDG Short Course Series in Haraldsson et al. (2021).

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 was also an offspring of the regular training, and the Millennium Short Course Series and the material prepared there. This proved 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 event, while UNU-GTP is responsible for the details and quality of the contents. In 2010-2019, 44 different events were given for various customers, with 23 of these held in Africa. For further information, see Haraldsson (2018) and Haraldsson et al. (2021).

7. GENDER EQUALITY

Gender equality and gender politics 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 promoted gender equality, through 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 (UNU-GTP, 2016). The disadvantage is that energy related research and development is still quite male dominated, not least in the developing part of the world. Hence the limited nomination of female candidates is a challenge to reach the gender balance UNU-GTP seeks. This is well reflected in the statistics, as through the 41 years of 6-month training at UNU-GTP in Iceland, only 24% of the UNU Fellows were women. The ratio is, however, improving, with the recent emphasis on gender equality, and has grown to 33% for the 2010s and 41% in the last 4 years (Figure 5 shows some of the female participants in 2019 during a site visit to the recent Theistareykir power plant). Here, continued improvement is needed in numbers – i.e., to reach equality in the coming years. The aim is clear, the share of women selected for training, studies, and teaching, will continue to be increased with the ultimate goal to reach gender equality in the activities in support of SDG 5: *Achieve gender equality and empower all women and girls.*

8. FINANCIAL BASIS

The primary source of funding for UNU-GTP has come from the budget of the Icelandic Government – Ministry for Foreign Affairs (MFA). The four UNU programmes in Iceland have generally enjoyed strong support from the Government, which has identified them as key implementing entities in its development cooperation agenda. Annual contributions from the MFA used to be close to 200 M ISK, influenced to some extent by a fluctuating exchange rate of the Icelandic krona (ISK), especially in the times of the financial crisis of 2008. The last few years saw annual contributions of about 215 M ISK with increases to 245-251 M ISK in 2018 and 2019.

Prior to 2010, only minor additional funding came from other sources, such as UNDP and IAEA or bilateral agencies (ICEIDA) financing a few UNU Fellowships through the years. The last 10 years have, however, seen quite a big change in this, which in the early 2010s to some extent counteracted the effect of the financial crisis in Iceland on the programme. Foreign funding has come in, not only through the customer designed short courses and training (Section 6), but also with an increasing number of UNU Fellowships for 6-month training financed by partner countries, sometimes with assistance from multilateral or bilateral aid agencies. In total, about 30-40% of the finances of UNU-GTP in 2011-2016 came from these sources, on average about 140 M ISK annually, and 15-20% in the years 2017-2019. This has been very positive for UNU-GTP as well as its partner institutions in Iceland, from which teachers and supervisors have been contracted. This applied specially to the period following the financial crisis (after 2008), a difficult period for the geothermal industry in Iceland when local geothermal projects were scarce.



Figure 5: UNU Fellows visiting the Theistareykir power plant, N-Iceland, which went on-line in 2017-2018.

Finally, it is important to underline the importance of the contribution from the Icelandic Government. It is the basis for conventional operations of UNU-GTP, through which it can meet the requests of partner nations for capacity building in geothermal energy development.

9. THE UNU-GTP WEBSITE

Open publication has always been the motto of UNU-GTP, which is in line with the general policies of the United Nations University, supporting free access to scientific material for developing nations. The project reports and post-graduate theses of the UNU Fellows in Iceland have been distributed free of charge to geothermal institutions worldwide, and the same applies to publications of study material. With the internet becoming more and more important in spreading information, since the early 2000s, the reports have also been published in a pdf-version on the UNU-GTP website. Older reports have also been made available there. The same applies to the UNU-GTP Workshops and Short Courses, and the UNU-GTP Anniversary Publications. Papers written for these events and published in books and/or on CDs are also all available in open and accessible publications on the GTP website (now *www.grogtp.is*).

It is safe to say that with all the material now accessible on its website, UNU-GTP has created one of the largest open databases in the world on geothermal exploration, development, and utilization. This is easy to verify by searching for material on geothermal on the internet, through one of the large search engines, with material published by UNU-GTP inevitably reaching high view scores. It is also interesting to look at some statistics. Table 4 shows the most viewed publications in 2019 and their number of views. The Millennium Short Course Series are obviously attracting much attention as papers presented there are in 3 of 5 top seats. The number of views can also be considered very high for such specialized literature.

Table 4: Most viewed online publications of UNU-GTP for the year 2019.

No.	No. views	Title and author of publication	Publication year and type/event
1	170,287	*Directional well design, trajectory and survey calc...*, by Farah Omar Farah	2013 – *Report 27*
2	140,590	*Piping design: the fundamentals* by José Luis Henríquez and Luis A. Aguirre	2011 – *ES SCIII*
3	81,350	*Introduction to types and classification of rocks* by Geoffrey Mibei	2014 – *K SCIX*
4	39,267	*Design and selection of deep well pumps for geoth. wells* by Udom Kunaruk	1991 – *Report 8*
5	39,130	*Environmental impact assessment general procedures* by Pacifica.F.A. Ogola	2007 – *K SCII*

10. SUPPORT TO GEOTHERMAL TRAINING CENTRES IN THE DEVELOPING COUNTRIES

10.1 The Geothermal Diploma Course for Latin America in El Salvador

Since the start of the UN MDG Workshops/Short Courses in 2005/6, the long-term aim was for the courses to develop into sustainable regional geothermal training centres. A Specialized Geothermal Diploma Course on geothermal energy was run in El Salvador in 2010 and 2012 with Italian support, and through cooperation with LaGeo S.A. de C.V. (LaGeo), the main local geothermal company, and University of El Salvador (UES). At the request of the Nordic Development Fund (NDF) partnering with the Inter-American

Development Bank (IDB), UNU-GTP, following a mission and a thorough review, produced a report with recommendations for improvements and a possible future direction of the diploma course (Haraldsson et al., 2013). These recommendations were largely taken into account for a continued implementation of the Diploma Course, with NDF and IDB securing the financial basis for the period 2013-2015. During this period, UNU-GTP took part in the Academic Committee of the programme and made annual evaluations and recommendations for improvement (Haraldsson et al., 2021).

The financial situation changed again in 2016, with NDF continuing to finance the Diploma Course, but now with the Icelandic Ministry for Foreign Affairs (MFA) as a partner. At the same time, UNU-GTP assumed a direct role in the management of the programme, in cooperation with the local partners, LaGeo and UES, with a cooperation agreement signed in April 2016 valid for 3 years. As a result, the UN SDG Short Course Series in El Salvador also became an integral part of the Diploma Course, and, additionally, 2-3 experts from Iceland came in on an annual basis as guest lecturers to strengthen its lecture series (Haraldsson et al., 2021).

The Geothermal Diploma Course in El Salvador offered new possibilities for aspiring geothermal experts in Latin America, as the programme is conducted in Spanish and in a cultural environment that in many respects is similar to that of the participants' home countries. Fellowships, covering all basic costs, have been awarded to participants from the Latin American Region, which means that about a third of the participants are foreigners while others are Salvadorians. In 2016-2019, 20 full fellowships have been awarded each year, 10 of which were intended for participants outside El Salvador. With up to 10 additional participants financed independently, this has meant annual participation of 29-30 Spanish speaking students of geothermal. 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 4-6 weeklong project work. The success of the Diploma Course programme through the years has rested on the strong expertise found within LaGeo. The strong ties between UNU-GTP and LaGeo have further served to increase its quality and success.

In January 2019, NDF decided to discontinue its cooperation in this project due to changed emphasis and a focus on larger projects. However, a two-year additional agreement was reached with MFA to continue the project, confirmed, and signed in May 2019. To reach financial balance, some sacrifices had to be made, and it was decided that for this two-year period the UN SDG Short Courses in El Salvador would only be given once, in 2020, with the funding for the other year used directly for the Diploma Course. This means that in 2019, there was no UN SDG Short Course for the LAC region.

10.2 African Geothermal 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. Omenda et al., 2021), has created a high demand on the current capacity building activities on offer by various training institutions, such as UNU-GTP in Iceland, Auckland University in New Zealand, US Power Africa / USAID, JICA of Japan, and local universities, leading to challenges in meeting these needs. To keep the momentum of development going and meet this demand, it is 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.

In early 2014, GDC received the support of the Kenyan Government for establishing a centre of excellence for geothermal capacity building. The African Union also emphasized its support for such a centre in collaboration with regional and international stakeholders. The same could be said about UNU-GTP, and several other stakeholders. The question has been about the finances; can they be covered in a sustainable way? NDF and MFA have expressed a will to support. UNU-GTP also expressed its will to be a part of this project and suggested that the UN SDG Short Course Series in Africa could become an integral part of the set-up, e.g. 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. The agenda of the Short Course needs to be reviewed to agree with the Curriculum of the Introductory Course. Finally, it would be important to have the cooperation of a major Kenyan University to strengthen the academic background of such a centre.

The formal establishment of the African Geothermal Center of Excellence (AGCE) in Kenya is now in an interim phase under the guidance of UNEP in Nairobi. MFA and NDF have declared that they could be 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. The same could be said about UNU-GTP and its successor GRÓ GTP, and several other stakeholders. The programme now prepared for implementation is to offer courses at 3-4 different levels, and of varying time-lengths at a postgraduate level.

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

10.3 Sino Icelandic Geothermal Training Program

In recent years, plans on geothermal training in China in cooperation with UNU-GTP have been discussed on and off without it leading to conclusive results. In late 2019, new plans were put forward. Behind it was Sinopec Green Energy Company, which has been given the task to lead development of new major geothermal district heating projects in China. The first step here was a 5-week Short Course on Geothermal Exploration and Development, for 40 participants, held in Beijing in November – December 2019. Teaching and supervision was shared between Icelandic experts and Chinese experts, many of whom are former UNU Fellows in Iceland. Hopefully, this will lead to a fruitful future cooperation between the Geothermal Training Programme and Chinese partners in geothermal capacity building. With the large projects planned in China, the expected need for geothermal expertise in China is very high.

11. IMPACT OF THE UNU GEOTHERMAL TRAINING PROGRAMME

11.1 Important partner countries

In recent years the focus of UNU-GTP was on Africa – the continent which really needs more energy. Most of the countries in Sub-Saharan Africa acutely need to develop their indigenous energy sources and replace expensive fossil fuel with green energy. Here, the geothermal resources of the East African Rift System (EARS) are very important, and Kenya is leading the way. According to Kenya Vision 2030, geothermal is expected provide 5000 MWe of electricity on-line by 2030. This is probably an overly optimistic goal, but with the enlargement of OrPower 4 (to 139 MWe), and Olkaria IAU (by 83 MWe), and the new Olkaria V power plant (160 MWe) coming on-line, Kenya reached 865 MWe in late 2019 (Omenda et al., 2021). With further geothermal power units scheduled on-line in 2021 and onwards, geothermal certainly has a bright future in Kenya. This has also been seen in the large effort Kenya has put into geothermal capacity building, e.g., by sending 5-12 trainees annually to Iceland in the last 10 years, adding also many local short courses and training activities conducted by UNU-GTP. At the end of 2019, 134 Kenyans had completed the 6-month training at UNU-GTP. Kenya itself partially financed about half of these. This is by far the highest number of UNU Fellows for any country. Other E-African countries also enjoyed a good share of UNU Fellowships, such as Ethiopia (45), Djibouti (19) and Tanzania (19) (Table 3), all of which are pushing hard to put geothermal electricity on-line (Georgsson et al., 2018; Haraldsson and Georgsson, 2018).

In Asia, China traditionally was UNU-GTP's most important partner country with its strong commitment to low-temperature geothermal development. It used to be the country with most UNU Fellows, until Kenya passed it in 2013. In all, 90 Chinese UNU Fellows were trained at UNU-GTP (Table 3), many of whom are among China's leading experts in exploration and development of its geothermal resources. It is difficult to classify China as a developing country today, but due to its strong commitment and future plans for major geothermal development GTP wants to keep good connections with China and support it along the way. Other strong partners in Asia where the focus is on high-temperature development must be mentioned, such as the Philippines (43 UNU Fellows) and Indonesia (38), both of which are among world leaders in geothermal electricity production, as well as Iran (25) where the first geothermal pilot plant has been in the pipelines for some years.

Last but not least, are Central America and the Caribbean. Here, El Salvador (with 42 UNU Fellows) has been a key partner of UNU-GTP for decades, through many activities, while Costa Rica (18) and Nicaragua (13) should also be named. In all three countries geothermal plays a significant role in the local electricity production. Here the Caribbean Islands must also be mentioned. Support for Small Island Developing States (S.I.D.S.) is important in Iceland's foreign policy, and UNU-GTP has increased its support here in recent years, as can be seen with 4 UNU Fellows coming from the small Caribbean Islands in 2019.

11.2 Creating opportunities

The Icelandic geothermal industry has certainly benefitted from UNU-GTP. Jobs have been created through the teaching and supervision of UNU Fellows in Iceland. This was especially important in the aftermath of 2008 – keeping the foundation for several jobs, which would probably have been lost if not for UNU-GTP. Furthermore, the UNU-GTP network has created connections around the world for the Icelandic geothermal industry. Some have been forged through the personal contacts made between a teacher and a trainee while in Iceland, while in other cases the general knowledge acquired in Iceland about Iceland's strong focus on geothermal solutions has paved the way.

12. GRÓ GTP and COVID 19

At the start of 2020, the connection of the four training programmes in Iceland with UNU in Tokyo was severed. As outlined in the introduction, they were united under the umbrella of *GRÓ*, operating within the MFA, and GRÓ accepted as a *Category 2 Centre under the auspices of UNESCO*. With this new affiliation the Icelandic programmes are expected to continue their operations in a similar way as before and are also able to keep their ties to the UN system. The MFA is fully committed to the future support of GRÓ GTP, which currently is the only international programme offering specialized postgraduate training in all main fields of geothermal science and engineering. The director of the new GRÓ GTP is the reservoir physicist, Dr Gudni Axelsson.

GRÓ GTP certainly has had a testing first year of operations, with the COVID 19 pandemic dominating world events from early March 2020. All international activities have been difficult in operation, with travelling between countries more or less closed down. This has of course hampered the activities of GRÓ GTP, as with other institutions dealing with international cooperation. Eventually, the 6-month training in 2020 was cancelled. The same applied to the UN SDG Short Course in Kenya, scheduled for November, as well as the Geothermal Diploma Course in El Salvador, and the associated short course. On the positive side was the possibility to keep the academic programme running as scheduled. GRÓ GTP is determined as possible to make up for this interruption, when the world has seen the end of the COVID 19 pandemic, starting hopefully in 2021.

13. FOCUSSING ON A GEOTHERMAL FUTURE

The *UN Sustainable Development Goals* are a roadmap for the world to follow in the coming years, and the Geothermal Training Programme (GTP) must make a serious effort, aiming at harmonizing 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 the programme's activities; not forgetting *Goal 5: Achieve gender equality and empower all women and girls*. Utilization of indigenous renewable energy resources as a replacement for fossil fuels is a must in a world where increasing emission of greenhouse gasses associated with global warming is one of the greatest threats to mankind. This is what makes geothermal resources so valuable today. Here, the restructuring of the two annual Short Course series for E-Africa, and for Latin America and the Caribbean, was important putting a strong focus on the *UN Sustainable Development Goals.*

With the continued support of the Government of Iceland, the Geothermal Training Programme expects to continue its efforts to build capacity in developing countries around the world, endowed with geothermal potential which is worth realising for development. The ties with UNU may have been severed at the end of 2019, but the Government of Iceland is strongly committed to continue its support to the Programme through GRÓ. The continued UN connection through UNESCO will certainly be helpful for that.



Figure 6: UNU Fellows learning about the industry of making geothermal bread during a geothermal excursion to the Hengill area, SW-Iceland, in 2013.

GTP's core activity has been the 6-month training (Figure 6) and it is expected to continue to be so. In 2019, 24 UNU Fellows completed the training, taking the number to 718 UNU Fellows. A similar number is expected to be trained annually in the coming years. Increasing the number of fellowships in Iceland for MSc studies (currently 5 new are awarded annually) and PhD studies (currently one new is awarded annually) is a feasible path for improvement.

In UNU-GTP's strategic plan for 2016-2019, a yearly research grant was proposed for a renowned geothermal expert, linked with UNU-GTP, aimed at a research-topic of significance for developing countries with geothermal potential and the geothermal industry in general. The financial support is still lacking to carry this out to date, but it is definitely a goal to aim at realising for GRÓ GTP.

The same applies for support for regional centres in the developing countries. Active participation in the running of the 5-month Geothermal Diploma Course at UES in cooperation with LaGeo of El Salvador certainly strengthened UNU-GTP's status in the Spanish speaking part of world. This is a possible future model for the AGCE – the African Geothermal Center of Excellence. The Geothermal Training Programme looks forward cooperating with UNEP, GDC, KenGen, and other serious stakeholders on its academic development, and the African Union, NDF, MFA and other stakeholders on the financial aspects.

Capacity building and transfer of technology are key issues in the sustainable development of geothermal resources. The Geothermal Training Programme expects to continue to successfully support geothermal development in the world through its activities.

REFERENCES

Fridleifsson I.B.: Geothermal energy training in Iceland of professionals from developing countries. *Presented at the International Conference for Renewable Energies, plenary session "Best-Practice Examples and Success Stories", Bonn, Germany*, (2004), 4 pp.

Georgsson, L.S.: Forty years of geothermal training in Iceland - History, status and future direction. *Papers written for the 40th Anniversary Workshop of the United Nations University Geothermal Training Programme, organized by UNU-GTP, Reykjavík* (2018), 18 pp.

Georgsson, L.S., Fridleifsson, I.B., Haraldsson, I.G., Ómarsdóttir, M., Ísberg, Th., Gudjónsdóttir, M.S.: UNU Geothermal Training Programme in Iceland: Capacity building for geothermal energy development for 35 years. *Proceedings of the Word Geothermal Congress 2015, Melbourne, Australia* (2015a), 11 pp.

Georgsson, L.S., Haraldsson, I.G., Ómarsdóttir, M.: Capacity building in geothermal: update and summary of UNU-GTP's activities for geothermal development in Africa. *Proceedings of the ARGeo-C7, 7th African Rift Geothermal Conference, Kigali, Rwanda* (2018), 13 pp.

Georgsson, L.S., Haraldsson, I.G., Ómarsdóttir, M., Ísberg, Th.: The UNU Geothermal Training Programme: training activities offered on-site in developing countries. *Proceedings of the Word Geothermal Congress 2015, Melbourne, Australia* (2015b), 12 pp.

Haraldsson, I.G.: *UNU-GTP activities abroad 2005-2017*. UNU-GTP, Iceland, report 7 (2018), 50 pp.

Haraldsson, I.G., Axelsson, G., Ragnarsson, Á., Fridriksson, Th., Franzson, H., Fridleifsson, I.B., and Georgsson, L.S.: *El Salvador geothermal regional training program – Final report*. Prepared for the Inter-American Development Bank, UNU-GTP, report UNU-GTP/CR-1302 (2013), 156 pp.

Haraldsson, I.G., and Georgsson, L.S.: UNU Geothermal Training Programme in Africa: Short courses held in support of the UN Sustainable Development Goals and the ICEIDA/NDF Geothermal Exploration Project. *Proceedings of the ARGeo-C7, 7th African Rift Geothermal Conference, Kigali, Rwanda* (2018), 15 pp.

Haraldsson, I.G., Georgsson, L.S., and Ómarsdóttir, M.: United Nations University Geothermal Training Programme in Iceland: Training activities abroad. *Proceedings of the World Geothermal Congress 2020+1, Reykjavík, Iceland* (2021), 16 pp.

Nirás indevelop: *Evaluation of the UNU programmes in Iceland. Final report*. Nirás indevelop, Stockholm, Sweden, report (2017), 123+76 pp.

Omenda, P., Mangi, P., Ofwona, C., and Mwangi, M.: Country update report for Kenya 2015-2019. *Proceedings of the World Geothermal Congress 2020+1, virtual event, Reykjavík, Iceland,* (2021), 16 pp.

UNU-GTP: *UNU Geothermal Training Programme strategic plan for 2016-2019*. UNU-GTP, Iceland, publication (2016), 18 pp.