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PROFESSIONAL EDUCATION – A KEY FOR GEOTHERMAL ENERGY DEVELOPMENT

ABSTRACT

Professional education and capacity building form key elements in successful development of renewable energy technologies, including geothermal. International geothermal schools have primarily been operated for the benefits of the developing countries and have (apart from the UNU-GTP) mainly been aimed at electricity production. There is, however, also an urgent and growing need for geothermal schools dealing with low temperature resources and the application of heat pumps. Many European countries could also reduce CO_2 emissions significantly by replacing natural gas or oil with geothermal water. Top European universities and research institutions could furthermore contribute significantly to world climate mitigation by inviting scholars from developing countries to share their knowledge and to participate in the development of clean technology for heating and cooling.

KEY WORDS

Energy supply, geothermal energy, education, developing countries, Millennium Development Goals

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INTRODUCTION

Global energy demand is expected to grow by more than one-third over the period 2010–2035 in the new policies scenario of the International Energy Agency (IEA 2012), with China, India and the Middle East accounting for 60% of the increase. Energy demand barely rises in OECD countries, although there is a pronounced shift away from oil and coal (and in some countries nuclear) towards natural gas and renewables. Despite growth in low-carbon sources of energy, fossil fuels remain dominant in the global energy mix. In 2011, fossil fuel subsidies amounted to USD 523 billion, up almost 30% since 2010 and six times more than subsidies to renewables (IEA 2012). The growth in China´s electricity demand from 2010 to 2035 is expected to be greater than the current total electricity demand in the USA and Japan. China´s coal fired output increases almost as much as its energy generation from nuclear, wind and hydropower combined (IEA 2012).

Despite progress in recent years, nearly 1.3 billion people remain without access to electricity and 2.6 billion do not have access to clean cooking facilities (IEA 2012). Ten countries (four in developing Asia and six in sub-Saharan Africa) account for two-thirds of those without electricity and just three countries (India, China, and Bangladesh) account for more than half of those without clean cooking facilities. While the Rio+20 Summit did not result in a binding commitment towards universal commitment or universal modern energy access by 2030, the UN Year of Sustainable Energy for All has generated welcome new commitments towards this goal (IEA 2012).

The total global primary energy supply in 2008 was about 492 EJ (IPCC 2012). It was mostly provided by fossil fuels (85%). The renewables collectively provided 12.9% of the primary energy, mostly in the form of traditional biomass (10.2%) and much less by hydropower (2.3%) and the "new renewables" (wind 0.2%, geothermal 0.1%, and direct solar 0.1%). Nuclear energy provided 2% of the world primary energy.

With its natural thermal storage capacity, geothermal energy generation is especially suitable for supplying base-load power. Considering its technical potential and possible deployment, geothermal energy could meet roughly 3% of global energy demand by 2050, and also has the potential to provide roughly 5% of the global demand for heating and cooling by 2050 (IPCC 2012).

The main growth in energy use will be in developing countries. It is thus very important to support developing countries with fast expanding energy markets, such as China and India, to try as much as possible to meet their growing energy demands by developing their renewable energy resources. In some countries in e.g. the East African Rift Valley (Kenya) and in Central America (Costa Rica and El Salvador), the majority of the grid connected electricity is already provided by hydro and geothermal energy (Fridleifsson et al 2008; Fridleifsson, 2013a). It is very important to assist them in developing their renewable energy resources further, rather than guiding them to meet the fast growing energy demands with fossil fuels.

International geothermal schools have primarily been operated for the benefits of the developing countries, and have (apart from the UNU-GTP in Iceland) mainly been aimed at electricity production. There is, however, also an urgent and growing need for geothermal schools dealing with low temperature resources and the application of heat pumps. Many European countries could reduce CO_2 emissions significantly by replacing natural gas or oil with geothermal water. Top European universities and research institutions could furthermore contribute significantly to world climate mitigation by inviting scholars from developing countries to share their knowledge and to participate in the development of clean technology for heating and cooling.

This paper will focus on the background and the operations of the main international geothermal schools which were established mainly in the 1970´s. The data on the individual schools is mainly obtained from papers written by directors or senior staff members of the institutions.

1. EDUCATION OF PROFESSIONAL MANPOWER FOR GEOTHERMAL DEVELOPMENT – MAIN WORLD CENTRES

Geothermal research and development requires expertise from many disciplines such as geology, geophysics, geochemistry, chemical engineering, civil engineering, drilling engineering, mechanical engineering, reservoir engineering, as well as environmental science. Geothermal studies are therefore generally not taught as a separate subject at undergraduate level in universities, but rather at postgraduate level at universities and at schools and courses for professionals.

Following a recommendation of the "Meeting of Geothermal Experts on Training in Geothermal Energy" at UNESCO headquarters in 1968, two international geothermal schools were established in 1970:

- International Post-Graduate Course in Geothermics at the International Institute for Geothermal Research in Pisa (Italy),
- International Group Training Course in Geothermal Energy at Kyushu University in Fukuoka (Japan).
- Next two geothermal schools were founded in 1978:
- Geothermal Institute established at Auckland University (New Zealand),
- United Nations University Geothermal Training Programme (UNU-GTP) at the National Energy Authority (Orkustofnun) in Reykjavik (Iceland).

A brief review of the courses listed above follows.

1.1. International Post-graduate Course in Geothermics, Pisa, Italy

The Pisa School (with annual courses of 5–10 months) was established in 1970, but unfortunately closed in 1993 due to drastic cuts in government financing, but later held short courses (1–3 weeks) occasionally in developing countries (Dickson and Fanelli 1995). The course syllabus was designed to meet the needs of developing countries and covered aspects from reconnaissance to exploitation. The courses varied in length between years, with an average duration of 9 months, and were divided into two parts: lectures/conferences and project work. The two parts were broken up with a visit to Italian geothermal areas and power plants. Two hundred students received training during the 15 sessions of the course (1970–1984). Over the period 1979–1983, the courses were financed primarily by the Italian National Research Council, the Italian Ministry of Foreign Affairs, UNESCO, and by the Italo-Latin-American Institute.

The programme was reorganized in 1985 in order to create a more flexible structure capable of a wider range of operation than the preceding course (Dickson and Fanelli 1995).

The name was changed to International School of Geothermics (1985–1992). The courses lasted 8 months and the overall format was similar to that of the previous phase, i.e. theoretical lectures and practical work, separated by field trips, with the main objective focused towards geothermal exploration. The theoretical part of the courses consisted of roughly 320 hours of lectures on the following topics: introduction to geothermal energy and its uses, geology, geochemistry, hydrogeology, geophysics, drilling, reservoir physics, and case histories of Italian geothermal fields. At the end of the course, the students submitted a report on their practical work and received a Certificate of Attendance. A total of 124 students attended the 7 courses between 1985 and 1992. During this period, the Ministry of Foreign Affairs contributed to the running costs of the courses and provided 110 scholarships for participants from the developing countries. During the whole period (1970–1992), 324 students participated in the course (Dickson and Fanelli 1995).

1.2. International Geothermal Training Course, Kyushu, Japan

The Government of Japan initiated the course in 1970 in cooperation with UNESCO, as a part of Japan´s technical cooperation programmes for developing countries. Arrangements for conducting the course were at first administered by the Overseas Technical Cooperation Agency, and from 1974, the Japan International Cooperation Agency (JICA). Kyushu University was selected to hold the course due to the availability of teachers and proximity to geothermal fields in operation. The course, which came to be known as the General Course, started in 1970 as a two month course and was run every year until 1989.

The successful completion of the General Course and the growing demand of geothermal specialists in developing countries encouraged the Japanese geothermal staff at Kyushu University to continue offering geothermal education. As a result, a remodelled course, the Advanced Course, was established in 1990. The course was run until 1999, for four months each year. The goal was to enable participants to play a leading role in geothermal projects in the developing countries. More enphasis was placed on practical work than in General Course. Through its 10 years of operation, a total of 98 geothermal scientists and engineers from 16 countries completed the course.

The International Group Training Course at Kyushu University closed in 1999. A training course on Renewable Energy Resources was started in 2003 at Kyushu University (Ryuichi Itoi, personal communication 2007). This course was funded by the Japan International Cooperation Agency (JICA). The number of participants per year was limited to 2–4. This course was terminated in 2007. In addition, Kyushu University started a PhD programme in 2002, namely the International Special Course on Environmental Systems Engineering with the support of the Ministry of Education, Culture, Sports, Science and Technology. The course consisted of lectures and projects. The main objective of the course was conducting research projects for writing PhD dissertations. The Earth Resources Engineering Department of Kyushu University can award three to four government scholarships per year; commonly one or two for geothermal studies. Information on the course can be obtained at the web site www.c-shop.net/kyushu/. Participants were given lectures on basic knowledge and techniques, with one week of field work. A total of 272 scientists and engineers from 32 countries participated in the General Course (Fukuda et al 2000).

1.3. Geothermal Institute, Auckland, New Zealand

The Geothermal Institute at the University of Auckland was established in 1978 at the request of the United Nations Development Programme (UNDP), and with the support of the New Zealand Ministry of Foreign Affairs (Hochstein 2005). The Institute offered an annual Geothermal Diploma Course (about 10 months), specialized professional courses (about 3 months), research studies centred on the graduate school, and irregular short training courses in developing countries (2–4 weeks). The Diploma Course and the specialized training courses were discontinued at the end of 2002 due to a change in New Zealand aid policy (Hochstein 2005).

The Geothermal Diploma Course was held from 1979 to 2002. A total of 655 students from 36 countries attended, with 592 obtaining the Diploma in Geothermal Energy Technology after passing examinations and producing a project report. The student groups came from Indonesia and the Philippines (41%), other Asian countries (18%), Latin America (15%), Africa (15%), New Zealand (7.5%), and Europe (3.5%). About 75% of all Diploma students received fellowships to attend the course, either from the UNDP (1979–1989) or from the New Zealand government (1982–2002). The remainder had either private sponsorship or were New Zealand students with subsidized entrance.

Due to demand for shorter training for more senior professionals, 3 month courses were established in reservoir engineering and environmental studies. The former course was initiated in 1988 and was given every year until 1997, and again in 2000 and 2001. The latter was given in 1998, 1999, and 2002. A total of 119 candidates attended the courses. Most received fellowships from the New Zealand government, but the remainder was privately funded. More than half (54%) of the students came from Indonesia and the Philippines and 12% came from Europe and New Zealand.

A significant number of graduate students at the University of Auckland undertook research on geothermal topics that was supervised by the staff of the Geothermal Institute. As a result, about 100 MSc or ME degrees were awarded. The graduates came from industrialized countries (59%) and developing countries (41%). One third of them had previously attended the Diploma Course.

Newson et al. (2010) report that the University of Auckland resumed teaching postgraduate geothermal courses in 2007 with the introduction of a five month Postgraduate Certificate in Geothermal Energy Technology (www.iese.co.nz/geothermal-institute). The reason why mainly due to preceived lack of young professionals in the geothermal industry, lack of training courses worldwide, and lack of will on behalf of industry, government or eductional institutions to remedy the problem. The decision was also influenced by rising oil prices and increasing emphasis worldwidl on the use of renewable energy sources.

The course consists of 3 postgraduate level lecture courses and a short (5 week) research project. Two of the lecture courses are compulsory introductory courses, while the third is an elective course (geoscience or geothermal engineering). In the first 2 years, 16 students from 7 countries attended the programme, all funded by private companies or their employers (Newson et al 2010).

Geothermal expertise within the University of Auckland resides within the Faculty of Engineering, the Faculty of Science, and the Institute of Earth Science and Engineering (IESE 2012a). Research and instructional capacity for the geothermal sector is reported to exist across the following areas: geothermal engineering, reservoir modelling, geotechnics, geochemistry, geology, geophysics, energy economics and market modelling. Some scholarships have been available from the New Zealand Ministry of Foreign Affairs for students from eligible countries to attend the postgraduate programmes at the Geothermal Institute. Geothermal Short Courses are being offered by the Geothermal Institute and the 2013 courses, having a duration of 3–5 days (IESE 2012b).

1.4. UNU Geothermal Training Programme, Reykjavik, Iceland

The Government of Iceland and the United Nations University (UNU) decided in 1978 to establish the UNU Geothermal Training Programme (UNU-GTP), with Orkustofnun (the National Energy Authority of Iceland) as the host institution (www.unugtp.is). The mandate is to assist developing countries with significant geothermal potential to establish groups of specialists in geothermal exploration and development by offering six month specialized training for professionals employed in geothermal research and/or development. More recently, the UNU-GTP also offers a few succeful candidates the possibility of extending their studies to MSc or PhD degrees in geothermal sciences or engineering in cooperation with the University of Iceland. The trademark of the UNU-GTP is to give university graduates engaged in geothermal work intensive on-the-job training in their chosen fields of specialization (Fridleifsson 2010). The trainees work side by side with geothermal professionals in Iceland (the majority with ISOR–Iceland GeoSurvey (www.isor.is)). Specialized training is offered in geological exploration, borehole geology, geophysical exploration, borehole geophysics, reservoir engineering, chemistry of thermal fluids, environmental studies, geothermal utilization, and drilling technology. The operations of the UNU-GTP (including Fellowship for participants from developing countries) are financed by the Government of Iceland. During 1979–2012, 515 scientists and engineers from 53 developing countries and countries in transition have completed the annual six month courses. They have come from countries in Asia (40%), Africa (32%), Central and Eastern Europe (12%), Central America and the Caribbean (16%), and Oceania (0.4%). Since 2000, 36 have graduated with MSc, and 1 PhD. In early 2013, five are pursuing their MSc, and two their PhD studies at the University of Iceland. The UNU-GTP maintains contact with the majority of its 515 UNU Fellows. The annual Yearbook of the UNU-GTP (with research reports of Fellows of the year) is sent by mail to over 380 former UNU Fellows. Over 400 of the former

Fellows are still in active e-mail contact. The Yearbook as well as MSc and PhD theses are available on the website (www.unugtp.is). The UNU-GTP has awarded travel stipends to former Fellows to attend the World Geothermal Congresses in 1995, 2000, 2005 and 2010.

The UNU-GTP also organizes Workshops and Short Courses on geothermal development in Africa (started in 2005), Central America (started in 2006), and in Asia (in 2008). This is a contribution of the Government of Iceland to the Millennium Development Goals of the United Nations (Fridleifsson 2010). The courses/workshops are set up in cooperation with energy and earth science institutions responsible for exploration, development and operation of geothermal energy utilities in the countries/regions. A part of the objective is to increase the cooperation between specialists in neighbouring countries in the field of sustainable use of geothermal resources. The courses may in the future develop into sustainable regional geothermal training centres (Fridleifsson 2010). About 200 scientists and decision makers have participated in the workshops (1 week), and about 530 scientists and engineers have been trained at the short courses (1–3 weeks). Many former UNU Fellows are lecturers and co-organizers of the UNU-GTP Workshops and Short Courses (Georgsson 2012).

Due to ever increasing demand for capacity building in geothermal, the UNU-GTP has also in the last 3 years been contracted to give various courses and advanced training in geothermal technology in several countries, lasting from 1 week to 6 months. These courses and training have both been multi-disciplinary, or concentrated on specific scientific fields relevant for geothermal exploration and development in the respective countries/regions. This customer designed training is now a significant part of the activities of UNU-GTP.

2. PROFESSIONAL COURSES AND EDUCATION ON GEOTHERMAL ENERGY IN EUROPE

The International Geothermal Association (IGA) (www.geothermal-energy.org) has a list of Global Geothermal Courses. It is excellent that geothermal courses are presently given at 58 institutions (in Europe 31, Asia 9, Australia/Pacific 3, North America 13, and South America 2. In Europe alone there are 20 in Germany, 4 in Iceland, 2 in Poland, and 1 in each of Croatia, Hungary, Macedonia and Switzerland).

It has to be pointed out that the International Summer School on Direct Application of Geothermal Energy of IGA under the excellent leadership of Prof. Kiril Popovski in Skopje, Macedonia, made a big contribution to geothermal education in Europe with the courses as well as the textbooks, handbooks and guidelines, which were published in advance of the courses (1990–2009). Since 2011 it has been continued as International Summer School (ISS) on Geothermal Energy of IGA European Regional Branch. Geothermal courses, workshops and seminars organized by the ISS of IGA / IGA ERB in cooperation with several other associations and institutions are also listed as follows on the IGA website (http://www.geothermal-energy.org/; March 2013):

1. International Course on Direct Application of Geothermal Energy, Macedonia and Greece, 1990.

2. International Course on Engineering Aspects of Geothermal Use in Agriculture, Macedonia, 1992.

3. International Course on Geothermal Energy, Technology, Ecology, and International Workshop on Geothermal Energy for Greenhouses and Aquaculture in CEE countries, Bulgaria, 1993.

4. International Course on Direct Application of Geothermal Energy in Industry and for District Heating, and International Workshop on Geothermal Energy for Industry in CEE countries, Romania, 1994.

5. First Meeting of the INTERGEO – International Collaboration Network of Central/East European Countries on Direct Application of Geothermal Energy, Romania, 1994.

6. International Seminar of the INTERGEO: Geothermal School, Slovenia, 1994.

7. International Course on Reservoir Engineering and Balneology, and International Workshop on Strategy of Geothermal Development in Europe at the End of XX Century, Slovenia, 1995.

8. International Seminar of IGA European Branch: Geothermal Energy, Turkey, 1996.

9. International Course on Geothermal District Heating Schemes, and International Workshop on Strategy of Geothermal Development in Agriculture in Europe at the End of XXth Century, Turkey, 1997.

10. International Workshop on Heating Greenhouses with Geothermal Energy; International Seminar on Electricity Production from Geothermal Energy, and International Course on Economy of Integrated Geothermal Projects, Portugal, 1998.

11. International Course on Direct Utilization of Geothermal Energy: International Workshop on Small Scale Electric Power Generation, and International Seminar on Geothermal Heat Pumps, USA (Klamath Falls OR), 1999.

12. International Workshop on Geothermal Energy Application for Balneology and Water Tourist Centres; International Course on Geothermal Heat Pumps, and International Seminar on Hot Dry Rock Technology, Germany, 2001.

13. International Course on District Heating, Agricultural and Agroindustrial Uses of Geothermal Energy; International Workshop on Possibilities of Geothermal Development of Aegean Islands, and International Guided Tour Volcanology of Santorini Island, Greece, 2002.

14. International Summer School on Geothermal Geochemistry, Turkey, 2003.

15. International Course on Low Enthalpy Geothermal Resources, Exploitation and Development, and International Workshop on Geothermal Energy Resources in CEE Countries; IGD, Poland, 2004.

16. Pre- and Post-Conference Short Courses for WGC 2005: Integrated Use of Geothermal Energy; Power Generation; and Environmental Advantages of Geothermal Energy, Turkey, 2005.

17. International Workshop on National Development of Geothermal Energy Use, and International Course on Organisation of a Successful Development of a Geothermal Projects, IGD, Slovakia 2009.

18. International Workshop on Ground Source Heat Pumps and International Course on "Drilling, completion and testing of geothermal wells, IGD, Romania 2012.

Most recently, two educational events were organised by ISS on Geothermal Energy of IGA ERB in frame of the European Geothermal Congress 2013, Pisa, Italy.

19. International Short Course on "Drilling and completion of geothermal wells". EGC 2013, Italy 2013.

20. International Short Course on "Ground Source Heat Pumps". EGC 2013, Italy 2013.

Each of the listed events were attended by 50–100 participants from all over Europe and even the world (geologists, hydrologists, mechanical engineers, technologists, agricultural engineers, economists, etc.).

To attend the events of ISS of IGA / IGA ERB, some fellowships were offered thanks to grants from the IGA Education Committee with some contributions from other companies and institutions (GPC IP, EGEC).

3. GEOTHERMAL EDUCATION FOR DEVELOPING COUNTRIES – A CASE OF AFRICA

Almost 70% of the countries in the world with quantified records of geothermal utilisation are categorised as developing and transitional countries. Geothermal energy already contributes significantly to the electricity production of several countries in Central America, Asia and Africa. The direct use of geothermal resources can also replace fossil fuels significantly in densely populated areas where space heating or cooling is needed.

A significant part of the population in many of these countries suffers shortage of energy supplies or has no access to it. Lack of energy supplies at affordable prices means the lack of possibilities and/or great constraints for development. These facts , among others, form the background for the Millennium Development Goals (MDGs) of the United Nations. They provide concrete, time-bound objectives for dramatically reducing extreme poverty in its many dimensions by 2015 – income poverty, hunger, disease, exclusion, and lack of infrastructure and shelter – while promoting gender equality, education, health, and environmental sustainability. Most of the implementation of the MDGs will be in the developing and transitional countries, but with the support of the industrialised countries and the international community. The eight Millennium Development Goals are:

1. Eradicate extreme poverty and hunger.
2. Achieve universal primary education.
3. Promote gender equality and empower women.
4. Reduce child mortality.
5. Improve maternal health.

6. Combat HIV/AIDS, malaria and other diseases.
7. Ensure environmental sustainability.
8. Develop a global partnership for development.

Even though no MDG refers to energy explicitly, improved energy services – including modern cooking fuels, improved cook stoves, increased sustainable biomass production, and expanded access to electricity and mechanical power – are necessary for meeting the goals (Modi 2005).

„Access to modern energy services is key to economic development and progress towards the MDGs. Climate change presents significant threats to the achievement of the MDGs. To achieve the objectives of the MDGs and climate change strategies (mitigation and adaptation), low carbon energy resources such as geothermal energy are required". These are the opening lines in a PhD thesis of Pacifica F.A. Ogola from Kenya, which she defended at the University of Iceland (Ogola 2013). Her study focused on the possible contribution of geothermal energy in providing energy services and creating sustainable livelihoods, while meeting the objectives of the MDGs and climate change adaptation in the eastern Baringo lowlands, within the Marigat and East Pokot districts, located in Kenya´s north rift. The thesis is based on three published papers (Ogola et al. 2011, 2012, 2012a). In the papers, there is a wealth of information on the geothermal development in Kenya and the East African Rift Valley and on how geothermal development can assist in meeting MDGs.

The geothermal potential in Africa is mainly in the East African Rift Valley States (EARS) covering countries from Eritrea in the north to Mozambique in the south, with some unproven potential in other parts of the continent, e.g. in countries such as Cameroon. The total geothermal potential in this area is not known, but estimates point to figures up to 14,000 MWe and possibly beyond. The countries are at very different stages in their geothermal development. Some, like Kenya, are already operating geothermal power plants while most of the countries are only in the surface exploration stage, and a few have not yet conducted comprehensive reconnaissance of likely geothermal locations. Most of the EARS countries lack detailed knowledge of the geothermal resources. Specialized training of professionals from the countries in the main geothermal disciplines is important so that they can act as counterparts to foreign consultants and gradually take over the geothermal exploration and development.

Geothermal resources within the Great East African Rift Valley have the potential to provide East Africa with a considerable amount of the energy it needs for development, and even become one of the main resources for electricity production.

In Kenya alone, the target is to increase the geothermal capacity from the current 202 MWe of electricity to 1,600 MWe by 2020. The long term plans are to reach 5,000 MWe by 2030 (Republic of Kenya 2011).

The demand for electricity in East Africa is assumed to grow rapidly in the coming years and decades, as these countries develop further. The countries in the East African Rift Valley have a total population of about 340 million. The present electricity consumption corresponds to around 6,600 MWe, whereof only 216 MWe is currently met by geothermal energy.

A reasonable estimate of the total future need for electricity when these countries have reached developed country income levels, some decades from now, could be in the order of 340,000 MWe.

Many of Africa's leading geothermal experts have obtained their basic geothermal training in Iceland. Together with Icelandic experts, they now share their knowledge and experience with a new generation of African geoscientists and engineers. Altogether, the 165 graduates from 15 African countries (mostly from geothermally-prospective Eastern African Rift area; fig. 1, tab. 1) completed the six months specialized UNU-GTP courses. The biggest number came from Kenya (72 prs), Ethiopia (30 prs), and Uganda (15 prs).

The next step in capacity building for Africa might be the establishment of a regional geothermal training centre for East Africa. The UNU-GTP wants to assist in this and create

Fig. 1. Geographical distribution of UNU-GTP Fellows from Africa completing the six month Training Programme 1979–2012 (the location of the Great Rift Valley can clearly be seen in the eastern part of the continent. Of the 515 scientists and engineers who have graduated from the UNU-GTP in Iceland, 165 (32%) came from Africa)

Rys. 1. Rozmieszczenie geograficzne krajów afrykańskich, z których pochodzili stypendyści Programu Szkolenia Geotermalnego Uniwersytetu ONZ w latach 1979–2012 (we wschodniej części kontynentu zaznacza się Wielki Rów Afrykański. Spośród 515 naukowców i inżynierów, którzy ukończyli szkolenie na Islandii, 165 osób (32%) pochodziło z Afryki)

Table 1

Number of geothermal professionals from Africa, trained in each UNU Geothermal Training Programme specialised course, Iceland

Tabela 1

Liczba specjalistów z Afryki przeszkolonych w ramach poszczególnych kursów specjalistycznych Programu Szkolenia Geotermalnego Uniwersytetu ONZ na Islandii, 1979–2012

	Geological Exploration	Borehole Geology	Geophysical Exploration	Reservoir Engineering	Environmental Science	Chemistry	Geothermal Utilization	Drilling Technology	Total
Algeria	1		1			1	1		4
Burundi	1								1
Comoros			1						1
Djibouti		2		2		1	2		7
Egypt		1		1		1	1		4
Eritrea	2		2	1		2			7
Ethiopia		5	5	5	1	4	7	3	30
Kenya	2	12	13	10	10	11	6	8	72
Malawi	1								1
Morocco			1						1
Rwanda	1	1	2	1	1		1		7
Tanzania	3	1	1	1	1	1			8
Tunisia				1			5		6
Uganda	4	2	3	1	1	4			15
Zambia							1		1
Total	15	24	29	23	14	25	24	11	165

a UNU-GTP sub-centre in Kenya, preferably through cooperation with the Kenya Electricity Generating Company (KenGen) and the Geothermal Development Company (GDC) and international sponsors. A similar set-up is now being evaluated in El Salvador for Latin America with involvement of UNU-GTP and financing from the Nordic Development Fund (NDF) and the Inter-American Development Bank.

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KSZTAŁCENIE ZAWODOWE – KLUCZ DO ROZWOJU ENERGETYKI GEOTERMALNEJ

STRESZCZENIE

Kształcenie na poziomie profesjonalnym i rozwijanie odpowiednich umiejętności należą do kluczowych czynników, które mają wpływ na pomyślny rozwój technologii i wykorzystanie odnawialnych źródeł energii, również energii geotermalnej. W tym zakresie działalność międzynarodowych szkół z zakresu geotermii była początkowo ukierunkowana przede wszystkim na kraje rozwijające się i dotyczyła głównie (poza Kursami Szkolenia Geotermalnego ONZ) produkcji energii elektrycznej. Istnieje jednakże równie pilne i rosnące zapotrzebowanie na szkolenia i szkoły geotermalne dotyczące niskotemperaturowych zasobów geotermalnych i zastosowania pomp ciepła tym bardziej, że także wiele krajów europejskich może zmniejszyć emisję CO_2 zastępując węgiel, gaz ziemny lub ropę naftową energią wód geotermalnych. Najlepsze europejskie uniwersytety i instytuty badawcze mogą ponadto przyczynić się w znacznym stopniu do ograniczenia zmian klimatu na świecie, zapraszając uczonych z krajów rozwijających się do dzielenia się wiedzą i uczestniczyć w rozwoju czystych technologii do ogrzewania i chłodzenia.

SŁOWA KLUCZOWE

Dostawy energii, energia geotermalna, edukacja, kraje rozwijające się, Milenijne Cele Rozwoju