# Contribution of UNU/GTP training to geothermal development in Central and Eastern European countries

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**Abstract**

Geothermal energy represents the biggest potential and has in many countries the most promising prospects for development among all renewable energy sources. It is expected that its role and level of use will steadily increase, especially in light of the new challenges to be met globally, i.e. rationalization of energy use, environmental protection, and sustainable development. Successful development of geothermal use is conditioned by access to the knowledge, modern methods, best experiences, and the world's solutions. The United Nations University Geothermal Training Programme (UNU/GTP), offered in Iceland, creates unique possibilities in this respect, providing generous assistance to many developing countries, and Central and Eastern European countries in educating their own geothermal professionals.

This paper describes the contribution of the UNU/GTP in educating teams of geothermal specialists from those Central and Eastern European countries (CEE), which have significant geothermal potential. The UNU/GTP has been in existence for 25 years, from 1979 to 2003. The first European students came from Turkey in 1985, but from other CEE countries in 1989 or later. From 1985, 52 Fellows from the CEE have completed the UNU/GTP (17% of the total number of 300 graduates from all countries). The UNU/GTP has made an enormous contribution to the dissemination of information, transfer of knowledge, and best world practice. The knowledge and skills gathered by Fellows during the UNU/GTP courses result in important benefits for their countries, institutions, and individual professional development. Graduates from the CEE are actively employed in various geothermal-related fields in their home countries, and even internationally. They are involved in geothermal education, research, project preparation, implementation, and operations.

Thanks to the UNU/GTP, the process of creating teams of professionals, capable of covering the full scope of geothermal disciplines and activities is well advanced in some CEE countries. Professional knowledge, and experience in successful international co-operation gathered during the UNU/GTP in Iceland, have created new and high quality skills transferred to the home countries of the Fellows. This knowledge, practice, and experience create a strong foundation for further progress in geothermal energy development and usage in several CEE countries.

***Keywords:*** *geothermal training, Iceland, the United Nations University, international co-operation, Central and Eastern Europe.*

# 1 Introduction

Among renewable energy sources, geothermal energy represents the biggest potential and the most promising prospects for development in a number of countries all over the world. The reliability, environmental advantages, profitability and competitive character of this energy source have already been proved in over 60 countries (Lund and Freeston, 2001). Its role and level of use will certainly increase, especially in light of new challenges to be met by individual countries and globally, i.e. rationalization of energy use, environmental protection, limitation of greenhouse gases, introduction

of sustainable development practices, and preservation of natural resources of our planet for future generations.

To adequately use geothermal energy resources; countries, which possess these resources, should start by educating specialists capable of handling geothermal issues. The lack of such professional teams hampers geothermal development in many countries. In fact, successful development of geothermal energy is conditioned by access to the knowledge and applicability of new methods, best experiences, and the world's solutions. The United Nations University Geothermal Training Programme (UNU/GTP), offered in Iceland, creates very unique possibilities in this respect, giving generous assistance to many developing countries, and Central and Eastern European countries (CEE) in educating their own geothermal specialists.

The 25th Anniversary of the UNU Geothermal Training Programme, celebrated in 2003, is the ideal occasion to present the contribution and support for many countries and institutions all over the world. This paper reviews the enormous contribution the UNU/GTP has made toward geothermal development in the CEE countries; building on the foundation of their geothermal potential, present state, and prospects of implementation. It was prepared with the cooperation of several former Fellows who were fortunate to attend the UNU/GTP. They expressed their opinions on the role of the UNU/GTP in geothermal development in their respective countries, as well as their professional achievements and activities inspired by the studies in Iceland.

# 2 Europe – Geothermal resources and use

## 2.1 Geological and geothermal conditions

The European continent is composed of three main geostructural units:

- Precambrian structures (including the Precambrian platform of Northwestern Europe occupying over half the total area of the continent);
- Palaeozoic folded structures of Central and Western Europe, partly covered by the Permian-Mesozoic sediments (maximum thickness amounts to 7-12 km within the territory of Poland);
- Alpine system of Southern Europe, running from the Iberian Peninsula to the Caucasus Mountains.

The southern part of the continent shows temporary seismic activity (the Mediterranean and Balkan countries) while active volcanism is known mostly from Italy.

In general, Europe is characterized by low-to-moderate heat flow values (Čermak and Kučerova, 1993). This parameter ranges from 30-40 $mW/m^2$ within the oldest part of the continent (the Precambrian platform) to 60-80 $mW/m^2$ within the Alpine system. Relatively high values of 80-100 $mW/m^2$ occur within seismically and tectonically active southern areas of Europe. Similar values are reported from some other regions, i.e. the Pannonian Basin and the Upper Rhein Graben. For comparison, the highest European heat flow, up to 150-200 $mW/m^2$, is known from Iceland, a hot spot of the Middle Atlantic rift zone.

Thermal regime and geological conditions imply that Europe possesses mostly low-temperature resources, predominantly connected with sedimentary formations. However, at attainable depths in several regions, high-enthalpy resources are also found, as in Georgia, Greece, Italy and Turkey. Abundant high-enthalpy fields are also found in the far eastern region of Russia (Kamchatka); on European islands

(Iceland, Azores, Mediterranean islands); and certain overseas territories of France (Guadeloupe), and Spain (the Canary Islands). Presently, the main European geothermal fields under exploitation are the Larderello region (Italy), the Paris Basin (France), and the fields in certain CEE countries such as the Pannonian Basin (Hungary, Macedonia, Serbia, Slovakia, Romania), the Palaeogene troughs system of the Inner Carpathians (Poland, Slovakia) and other Alpine structures of Southern Europe (Bulgaria, Romania, Turkey).

Geothermal bathing and balneotherapy have ancient, or at least a long historical tradition, in Europe (Cataldi et al., 1999) e.g. Bulgaria, Macedonia, Turkey, Poland, Romania, and Slovakia. In the 14$^{th}$ century, France began implementation of geothermal energy for house heating. However, the first municipal district heating system was initiated in Reykjavik, Iceland in the 1930's. In 1904, the first geothermal power plant in the world was launched in Larderello, Italy.

The CEE countries are generally characterized by large, low-enthalpy geothermal potential, which appears to be significant also on a European scale. Geothermal systems are predominantly associated with sedimentary formations (carbonates, sandstones). They often belong to the aforementioned extensive geostructural units spreading over several neighboring countries. As an example one can name some particular units of the Alpine system known from Slovakia, Poland, Ukraine, Macedonia, Serbia, Bulgaria, Romania, Greece, Turkey, and Georgia.

## 2.2 Geothermal uses – current state and future prospects

As was already mentioned, many of the CEE countries of UNU/GTP graduates belong to those CEE countries in Europe where geothermal bathing and balneotherapy have old roots. On the other hand, geothermal uses for heating-oriented purposes are much younger; at the earliest they were initiated in the 1950's–1960's (Bulgaria, Romania), and most recently in 2000–2001 (Ukraine; pilot installations). There is also one country, Latvia, with no geothermal implementation yet, being at the stage of feasibility study and project preparation.

In CEE countries, geothermal energy is regarded as a local energy source, similar to other countries of continental Europe. It is expected that geothermal energy can, and should, achieve a significant share in many local energy markets. In Europe, climate, market demand, reservoir conditions and ecological reasons favor the application of geothermal energy mainly to space heating; heating greenhouses; aquaculture; industrial uses; bathing and balneotherapy. In some CEE countries, several specific geothermal direct uses are implemented e.g. for the cultivation of microalgae for pharmaceutical, cosmetic and food industries (Bulgaria); or dry ice and liquid $CO_2$ production (Turkey).

According to data presented at the 2000 World Geothermal Congress in Japan, direct geothermal use in Europe amounts to 5,714 $MW_t$ of installed capacity and 18,905 GWh/a of produced energy, i.e. 35% of the world total (Lund and Freeston, 2001; Table 1). The CEE's contribution to the given figures was 2,077 $MW_t$ and 10,823 GWh/a. With the exception of China, industrial scale usage of geothermal energy is primarily found in Europe (Table 1, Table 2). The list of top countries worldwide includes Iceland (4), as well as several other European states, including the CEE: Turkey (5), Georgia (7), Russia (8), France (9), Hungary (10), Sweden (11), Italy (13), Romania (14) and Switzerland (15) (Lund and Freeston, 2000). Since the 2000 World Geothermal Congress, data concerning the CEE countries have not changed considerably, except for Poland and Turkey where new geothermal capacities and heat production were initiated. On an experimental scale, this was done

also in Ukraine (co-generation units). In contrast, electricity generation by geothermal energy in Europe contributes only 10% of total world production (Table 1) and takes place in Italy, Iceland, Azores, and in two CEE countries, i.e. Turkey and Russia (Huttrer, 2001).

**Table 1: Summary of geothermal energy use by continent in the year 2000, showing the contribution of Europe (in: Fridleifsson, 2002, based on Huttrer, 2001; and Lund and Freeston, 2001).**

| Continent | Direct uses | | | Electricity generation | | |
|---|---|---|---|---|---|---|
| | Installed capacity $MW_t$ | Total production | | Installed capacity $MW_e$ | Total production | |
| | | GWh/a | % | | GWh/a | % |
| Africa | 125 | 504 | 1 | 54 | 397 | 1 |
| America | 4355 | 7270 | 14 | 3390 | 23,342 | 47 |
| Asia | 4608 | 24,235 | 46 | 3095 | 17,510 | 35 |
| **Europe** | **5714** | **18,905** | **35** | **998** | **5745** | **12** |
| Oceania | 342 | 2065 | 4 | 437 | 2269 | 5 |
| TOTAL | 15,144 | 52,979 | 100 | 7974 | 49,263 | 100 |

**Table 2: Geothermal energy use in the Central and Eastern European countries of the UNU/GTP Fellows in the year 2000, shown against the figures for the whole of Europe and the world (compiled from Lund and Freeston, 2000; and Fridleifsson, 2002)*.**

| Country | Direct uses | | Electricity generation | |
|---|---|---|---|---|
| | Installed capacity $MW_t$ | Total production GWh/a | Installed capacity $MW_e$ | Total production GWh/a |
| Bulgaria | 107.2 | 455 | - | - |
| Georgia | 250 | 1752 | - | - |
| Greece | 57.1 | 107 | - | - |
| Latvia | - | - | - | - |
| Lithuania | 21.0 | 166 | - | - |
| Macedonia | 81.2 | 142 | - | - |
| Poland | 68.5 | 76 | - | - |
| Romania | 152.4 | 797 | - | - |
| Russia | 307.0 | 1703 | 23.0 | 85 |
| Serbia | 80.0 | 660 | - | - |
| Slovakia | 132.3 | 588 | - | - |
| Turkey | 820.0 | 4377 | 20.4 | 119.73 |
| Ukraine | - | - | - | - |
| **Subtotal, CEE** | **2076.7** | **10,823** | **43.4** | **204.73** |
| Europe total | 5714 | 18,905 | 998 | 5745 |
| World – Grand Total | 15,144 | 52,979 | 7974 | 49,263 |

* In the cases of Poland, Turkey, and the Ukraine, the figures presented have increased since 2000 as new installations were put into operation.

Energy plans and development strategies of geothermal energy in the European countries (including the CEE countries) are treated as one of the components of the renewable energy resources mix, along with wind, solar, hydro and biomass. However, fossil fuels (plus nuclear in some cases) will still play the main role. In CEE countries, the share of renewable energy sources (including geothermal) in total primary energy production is projected to reach a level from ca. 2% (Bulgaria) to ca. 7.5% (Poland) in the years 2005–2010, and 12–15% by 2020. Although increasing, geothermal energy development in a number of countries fails to be adequate with respect to total resource reserves. For the sake of comparison, the share of renewables

in the European Union countries is predicted to reach 12% in 2010 and 20% in 2020. In the long run, forecasts for the world energy mix predict the share of renewables to increase to 30-80% by 2100 (Fridleifsson, 2000b).

Apart from the conventional uses of hydrothermal resources, the low-temperature resources (shallow water, ground, and rock formations) being extracted through heat pumps are also available. Moreover, R&D work on binary power plants is of great interest. The use of cascaded, multi-purpose, as well as integrated and distributed systems, are more and more frequently considered. New geothermal branches are gradually being developed, e.g. R&D work on heat extraction from underground mines.

The increased use of renewables, including geothermal, will be conditioned by ecological factors, and the movement to reduce greenhouse gas emissions (initiated by international agreements, European Union directives, etc.); as well as the competitive character with respect to fossil fuel carriers, quality, and accessibility of geothermal resources. Finally, the incremental uses of geothermal energy are conditioned by the presence of specialists capable of conducting such development. Professional education is a field in which many CEE countries have received fundamental aid and support from the UNU Geothermal Training Programme in Iceland (Fridleifsson, 2002).

# 3 Share of the UNU Geothermal Training Programme in geothermal development in Central and Eastern Europe

## 3.1 Participation of Fellows from CEE countries in the UNU/GTP, 1985 – 2003

The UNU Geothermal Training Programme has been in operation since 1979, and the first students from CEE countries began attending the UNU/GTP in 1985. In the years 1985–2003, the number of CEE students totalled 52, constituting 17% of all 300 graduates (Figure 1, Table 3). They have represented 13 European countries, e.g. Bulgaria (5), Georgia (1), Greece (3), Latvia (1), Lithuania (2), Macedonia (1), Poland (14), Romania (5), Russia (4), Serbia (3), Slovakia (2), Turkey (9), and Ukraine (2). The UNU/GTP Fellows came from universities, energy research institutions and agencies in their home countries. Since 1989, the mentioned CEE countries, except Greece and Turkey, have been in political and economic transition towards democracy and market economies. Some of them will join the European Union in 2004, and some will be candidates in the near future.

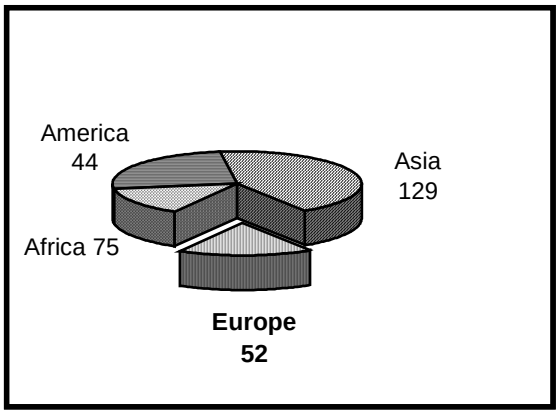


**Figure 1: Number of Fellows from the different continents, completing the UNU/GTP training in Iceland, 1979-2003.**

**Table 3: Participation of Fellows from Central and Eastern European countries in the UNU/GTP in Iceland, 1979-2003 (source: UNU GTP data files).**

| Country | Geological exploration | Borehole geology | Geophysical exploration | Borehole geophysics | Reservoir engineering | Chemistry of thermal fluids | Environmental studies | Geothermal utilization | Drilling technology | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Bulgaria | - | - | - | 1 | 2 | 2 | - | | - | 5 |
| Georgia | - | - | - | - | - | - | - | 1 | - | 1 |
| Greece | - | - | 1 | - | - | - | - | 2 | - | 3 |
| Latvia | - | - | - | - | - | | - | 1 | - | 1 |
| Lithuania | - | - | - | - | 1 | - | - | 1 | - | 2 |
| Macedonia | - | - | - | - | - | 1 | - | | - | 1 |
| Poland | - | 1 | - | 1 | 5 | 1 | - | 6 | - | 14 |
| Romania | - | - | - | - | - | - | - | 5 | - | 5 |
| Russia | - | - | - | 1 | 1 | 2 | - | | - | 4 |
| Serbia | - | - | - | 1 | 1 | 1 | - | | - | 3 |
| Slovakia | - | - | - | 1 | 1 | - | - | | - | 2 |
| Turkey | - | 1 | - | - | 1 | 3 | 1 | 3 | - | 9 |
| Ukraine | - | - | | - | 2 | - | - | | - | 2 |
| **Subtotal, CEE** | **0** | **2** | **1** | **5** | **14** | **10** | **1** | **19** | **0** | **52** |
| Other | 13 | 29 | 29 | 15 | 59 | 42 | 14 | 35 | 12 | 248 |
| GRAND TOTAL | 13 | 31 | 30 | 20 | 73 | 52 | 15 | 54 | 12 | 300 |

## 3.2 Main UNU/GTP Specialized Lines of Training Chosen by Fellows from the CEE

The CEE countries from which the UNU/GTP Fellows come, have been generally well recognized in aspects of geology, geophysics, and hydrogeology. However, in the past, the exploration, analyses, and databases were used for purposes other than geothermal development. A majority of these countries supplied suitable education, and good teams of specialists in these "classic", non-geothermal branches were created. This built a strong foundation for furthering geothermal development in many CEE countries. First, it was necessary to educate professionals in the full range of research and activities oriented to geothermal resource development in their home countries. The substantial task was to provide them with comprehensive knowledge and skills in several specific fields essential for properly conducting geothermally oriented activities, and in which they had little or no experience during their previous work. Considering these circumstances and needs, after completion of the Introductory Lecture Course - a first part of the UNU Geothermal Training Programme - the Fellows from CEE countries have mainly participated in three out of nine specializations: Reservoir Engineering (14 persons), Geothermal Utilization (19 persons), and Chemistry of Geothermal Fluids (10 persons). A total of 9 Fellows chose specializations in Borehole Geology, Geophysical Exploration, Borehole Geophysics and Environmental Studies (Table 3). The low-enthalpy resources prevailing in the CEE home countries of the UNU/GTP Fellows has been emphasized as a subject within the chosen specializations. The Fellows' project work, supervised by Icelandic teachers, is a substantial part of the UNU/GTP and often relates to the existing and planned geothermal issues in the Fellow's home country. The final reports are prepared applying modern methods of research, modeling, and interpretation. The Fellows have often developed the topics initiated during the stay in

Iceland after returning to their home countries, and the results were used in the conducted works.

# 4 Current activities of the UNU/GTP graduates

Professional knowledge and skills gathered by Fellows during the UNU/GTP courses bring about important benefits for their countries, institutions and individual professional development.

Work undertaken by the Fellows often continues in their home countries resulting in numerous pioneer PhD theses, and receipt of higher scientific degrees. UNU/GTP graduates play an important role as members of teams working on geothermal research and development, project implementation, and operations. Some occupy managerial positions in geothermal projects, e.g. in the geothermal space heating project in Poland (one of the biggest in Europe).

Fellows initiate and carry out innovative projects for the utilization of geothermal energy, e.g. R&D aimed at potential assessment and extraction from underground mines – an issue of interest in several countries in Europe and on other continents. Some Fellows work in state institutions dealing with energy and environmental issues. Being geothermal professionals, they create a positive atmosphere for promotion of geothermal resource utilization, and attempt to introduce this into the mainstream of their projects and activities.

Many Fellows working at universities and in research institutions have shared and disseminated the knowledge gathered in Iceland among wide circles of society and professionals within their countries. They promote geothermal energy among students and co-workers by delivering lectures and seminars, and supervise MSc and PhD theses on geothermal-related topics. They make use of the above activities to announce the contribution and impact of the United Nations University, and the Government of Iceland through the UNU/GTP. Some graduates are active members of the *International Geothermal Association,* and two of them are also members of the IGA Board of Directors, 2001-2004. Fellows participate on the boards of scientific and popular-science journals on geothermal issues, other renewables, ecology and sustainable development. Two Fellows were co-authors of chapters in '*Stories from a heated earth. Our geothermal heritage*' (Cataldi et al., 1999); the first, unique book on relationships between geothermal energy and human civilization. Recently, some Fellows contributed to a new edition of "Geothermal Atlas of Europe" published in 2002 (Hurter and Haenel [eds.], 2002).

One of the greatest achievements of the former UNU/GTP Fellows from the CEE was their contribution in establishing the International Geothermal Training Centre at the University of Oradea, Romania headed by a 1993 UNU/GTP Fellow. This was accomplished with the participation of all Romanian graduates, and with cooperation and significant contribution from the UNU/GTP. The most important event organized by the Centre, and supported by the European Union and International Geothermal Association, was the European Summer School in 2001.

Fellows have co-organized, and have been active participants in national and international geothermal conferences, e.g. the European Geothermal Conferences of 1999 and 2003 in Basel (Switzerland), and Szeged (Hungary), respectively. CEE Fellows were invited to be speakers and lecturers during several courses of the International Summer School on Direct Application of Geothermal Energy. More recently, one graduate delivered a lecture at the Short Course co-organized by the UNU/GTP preceding the International Geothermal Conference in Iceland, 2003. One should also point out that four graduates from Europe were invited to participate and

deliver lectures at the 20th Anniversary Workshop of the UNU Geothermal training Programme 1998 in Reykjavik (Georgsson, 1998).

UNU/GTP Fellows from CEE countries also participated in the World Geothermal Congresses, in 1995 and 2000, the most important events for the international geothermal community. In 1995, several graduates from Europe attended the Congress in Florence, Italy, while Fellows from Poland and Slovakia were also involved in organization of the pre-Congress field trip to Slovakia and Poland. And finally, 15 UNU/GTP graduates from CEE countries participated in the 2000 World Geothermal Congress in Japan. They came from Bulgaria, Lithuania, Macedonia, Poland, Romania, Serbia, Slovakia and Turkey. Each Fellow from the CEE was either author or co-author of at least one of the 88 papers presented by all former UNU/GTP graduates. Their participation was possible thanks to the great financial support and management of the UNU/GTP, and the UNU headquarters.

In several cases, contacts between the UNU/GTP Fellows and their supervisors and other experts from Iceland have been maintained in the framework of projects on the use of special methods and computer programmes taught during the UNU/GTP. In the last few years, Fellows from various countries, in conjunction with Icelandic lecturers, were involved in the preparation of joint project proposals submitted for funding to the European Commission. In addition, numerous international conferences and workshops give teachers, supervisors, and Fellows the opportunity to meet and discuss on-going issues. Graduates are regularly updated on the state of research and projects in Iceland and other countries via the annual UNU/GTP reports and other publications.

Participation in international events provides UNU/GTP graduates important opportunities to be on-line with the current state of geothermal research and use worldwide. However, this is frequently hindered by high costs of participation and the lack of financial support from their institutions (financed by governmental sources mostly). Therefore, Fellows appreciate the enormous help in this respect granted by the UNU headquarters and the International Geothermal Association.

A number of Fellows maintain personal contact via the Internet and mail. Some of them visit one another, thus maintaining and developing professional contacts and personal friendships. As an example of co-operation of former Fellows, one can mention a field trip of several Polish students and their supervisor (UNU/GTP graduate) to main geothermal sites in Turkey, which was arranged thanks to the assistance of a Turkish UNU/GTP graduate.

Referring to respective CEE countries, the jobs and positions the former UNU/GTP Fellows are filling in society can be summarized as follows (according to the most recent information gained in May, 2003):

- **Bulgaria:** From the total number of five graduates, two Fellows hold positions as associate professors working as geothermal specialists at the Bulgarian Academy of Sciences. One of them is also working as a university lecturer. One graduate is working for the Ministry of Regional Development and Public Works, being involved, among other things, in international cooperation and EU-programmes. Two former Fellows have moved to other professional activities and currently are not involved in geothermal activity.
- **Georgia:** The first Fellow graduated in 2002. He is working for the Georgian Geothermal Co., looking at feasibility of energy projects, including geothermal.
- **Greece:** Three Fellows from Greece graduated in 1996 on special scholarships from Brussels (Financial Mechanism of the European

Economic Area). They were mainly working in municipal institutions. All of them have now left geothermal work and moved to other activities.

- **Latvia:** One Fellow has graduated from the UNU/GTP thus far. Currently, she is working on her PhD thesis concerning balneological properties and the use of geothermal waters in Latvia.
- **Lithuania:** Two Fellows have graduated from the UNU/GTP so far. Currently, one of them is working as a commissioner appointed by the President of Lithuania at the National Commission for Prices and Energy. He deals with regulation and control policy implementation in the energy sector of Lithuania, including regulation of renewable energy sources. He is also working as an associate professor at the Kaunas University of Technology, giving lectures on thermal engineering. The other is pursuing his career at the Institute of Geology in Vilnius and dealing with geothermal projects.
- **Macedonia:** The only UNU/GTP Fellow (from 1989) was Prof. Mirjana Gorgieva. She was working at the University in Skopje, and was actively participating in international geothermal meetings and events. She passed away in 2002.
- **Poland:** From the total number of fourteen Fellows (including two persons attending the 2003 UNU/GTP), one graduate holds a position of general director and president of the management board of the company conducting the largest geothermal space heating project in Poland (Podhale region); eight persons are working at universities; two Fellows are employed at the Polish Academy of Sciences; and one person is working for a company designing and manufacturing heat pumps. Five Fellows are board members of various scientific and popular journals on geothermal energy and other renewables. Seven graduates have a PhD degree, while five are working on their PhD theses.
- **Romania:** All five Fellows from this country came from the University of Oradea. Four of them are working there and all have PhD degree, but the fifth is doing her PhD thesis in USA. Three are working as readers, and one person holds a professorship position. This strong and very active team was involved in the establishment of the International Geothermal Training Centre at the Oradea University.
- **Russia:** Four UNU/GTP Fellows have come from Russia, the first one in 1994 and the last one in 2003. All have been involved in geothermal exploration and assessment in the Kamchatka Peninsula, especially the Mutnovsky high-temperature field, and still are with the exception of the first Fellow, who is now working in the oil industry.
- **Serbia:** Three Fellows attended the UNU/GTP in the early nineties. Soon after, with the civil war and UN ban on Yugoslavia, their position became very difficult. One of them has though been very active, working at the Laboratory of Geothermal Energy at the Institute of Hydrogeology and writing several papers on geothermal exploration. One moved to Canada in the mid-nineties.

- **Slovakia:** Two Fellows attended the UNU/GTP. One Fellow from the Geological Institute in Bratislava is working in the private sector now. The other one came from the Geological Institute in Bratislava (at present the Geological Survey of Slovak Republik). After coming back from Iceland, he completed his PhD degree, then was in a position as the head of the Applied Geology Department (1994), and vice-director (1995) of the Institute. Now in 2003, he is working as a project manager for the two projects evaluating geothermal energy in prospective geothermal areas of the Slovak Republic. He is also giving lectures on geothermal energy as an associate professor at the Comenius University in Bratislava.
- **Turkey:** The nine Fellows from Turkey have come in two groups. The first three were in Iceland in the mid-eighties. All of them are still involved with geothermal work. One is a professor at the Middle East Technical University, while the other two work as geothermal consultants having retired from official positions. The remaining six were trained in the last 5 years. Three of them come from Izmir in W-Turkey, but the others from various parts of W-Turkey. All are very active in geothermal research.
- **Ukraine:** Two Fellows have completed their PhD dissertations after coming back from the UNU/GTP in Iceland. They are involved in geothermal research and activities in their country, in association with the Institute of Engineering Thermo-Physics in Kiev.

# 5 Room for improvement

Despite the successes listed above, in the opinion of many Fellows themselves, there is room to more intensely and effectively use Fellows' potential through involving them in more initiatives and projects connected with geothermal energy development, which are or will be conducted in their home countries. This should be done to significantly increase the professionalism of teams working on geothermal issues; to provide a better framework for more efficient development methods and operations of the projects; reduce errors; limit hazards; and make optimum use of financial resources (especially those that have limited availability as a rule in CEE countries).

There is still much to be done in this respect by the institutions employing Fellows, geothermal communities and respective governments, so that countries can more substantially benefit from the generous support and contribution of the UNU, and the Government of Iceland. The UNU and the Government of Iceland might play a more substantial role in this respect, by contacting national and governmental bodies in the respective CEE countries on a high diplomatic level to inform directly about the scope and amounts of permanent aid available for the education of geothermal professionals. Governments should realize, better than they now do, their own highly professional human resources, which have to be used for further geothermal development in line with the ideas promoted by the UNU and affiliated governments and organizations.

# 6 The role of the UNU Geothermal Training Programme in geothermal development in the CEE countries

The UNU Geothermal Training Programme provides significant and exceptional assistance and support for CEE countries in educating teams of professionals capable of conducting versatile activities aimed at geothermal use and development. The

UNU/GTP has made an enormous contribution in the dissemination of knowledge; promotion of geothermal resource utilization; and the transfer of knowledge, know-how, experience and best practice at the global level.

UNU/GTP Fellows have been fortunate to have a special occasion to study and cooperate with high-level, scientific and intellectual elite. They have gathered very broad knowledge in a number of key branches of geothermal utilization, to be employed in their home countries. The UNU/GTP Fellows have had a chance to observe and follow methods employed by professionals in world-renowned centres, e.g. Orkustofnun, and the University of Iceland and had access to the Orkustofnun Library, abounding in the world's geothermal literature.

The culture and organization of every-day work and life of the Icelandic people – a perfect example to follow, have impressed UNU/GTP Fellows. Iceland - this unique natural 'geothermal laboratory' – has exceptional conditions for geothermal study and research. The UNU/GTP has given Fellows the opportunity to work with high-ranking specialists, have the opportunities to present individual achievements, and discuss the problems encountered in Fellows' home countries.

A number of permanent contacts between UNU/GTP Fellows, Icelandic, and international experts have been started, and now they are further realized in the form of co-operation, consultations or partnerships on joint projects. The friendships born in Iceland have been proved in difficult life situations, when former Fellows experienced help and support provided by UNU/GTP lecturers and friends. They turned out to be reliable and compassionate friends to many of us.

UNU/GTP Fellows have learned how to feel the need and purposefulness of efforts aimed at increasing geothermal energy use, and promoting the usage as benign for the environment. A popular Icelandic saying "Orka til heilla" or energy for benefits expresses this admirably. It can also be implemented in the CEE countries, thanks to the persistent work reinforced by knowledge and enthusiasm brought from Iceland.

Considerable numbers of Fellows have been educated during the UNU/GTP, therefore the process of creating teams of specialists dealing with a full scope of geothermal activities in their own countries seems to be quite advanced. Geothermal development is guaranteed by the possession of know-how, good practice and experience in successful international co-operation gathered during the UNU/GTP. These are new and permanent qualities transferred to the home countries of the Fellows. Many of the CEE countries soon will bring their experiences to the united Europe and the European Research Area. UNU/GTP Fellows have been prepared for running a vast range of research projects, and work on geothermal energy management in their home countries. We hope the results of the UNU/GTP will be fully utilized for the benefit of individual CEE countries, Europe and the world.

The UNU/GTP can be perceived as building interpersonal, and international relationships with people trying to achieve universal targets, and who feel responsible for rational management of the Earth, its resources and preservation for future generations.

## Acknowledgements

On the 25th Anniversary of the UNU Geothermal Training Programme, all graduates from the Central and Eastern European countries are pleased to congratulate the Director, Dr. Ingvar B. Fridleifsson, Deputy Director Dr. Ludvik S. Georgsson, all technical assistants, members of the Studies Board, lecturers, supervisors and all persons involved. We are very grateful for the knowledge and skills mastered under

your vigilant eyes, and for making us so enthusiastic about geothermal energy and its development in our home countries.

We would like to extend our sincere thanks to the Government of Iceland and the United Nations University authorities for generous support for our countries in creating teams of highly professional geothermal experts, who are involved in making progress in the use of this environment-friendly source of energy, and who are committed to the realization of the ideal of sustainable development. Our best wishes are extended to Prof. Hans van Ginkel, the UNU Rector, for his kind interest in the activity of the UNU/GTP and the support given to the graduates.

The knowledge and skills mastered during the UNU/GTP will remain our very precious abilities, and create a source of inspiration for further work in our lives. We wish all UNU/GTP staff further successes and satisfaction in educating geothermal specialists from Europe and the world.

And finally, please accept our wishes of success to all the members of the international family of the UNU/GTP Fellows and their institutions in the world. We are fully convinced that all of you will keep in your kind memory the time spent studying and working, the field trips and social meetings, friendships and the feeling of unity of purpose in the geothermal community, which was born among special people and in a special place – Iceland.

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