Promotion of the Geothermal Energy through Education and Training

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Abstract

After a brief overview on topics related to geothermal taught in some higher education specialisations, the paper presents the known geothermal and training possibilities organised in Europe, including some information on how these are financed. In the end, the paper identifies some topics which are missing or could be improved in the future to allow for a better promotion and development of the geothermal energy utilisation in the future, with a special focus on enhanced geothermal systems.

Keywords: geothermal training, higher education

1. INTRODUCTION

Many EU Member and Associated States, as well as other countries, more or less close to Europe, have significant geothermal resources (mainly low enthalpy), suitable for both direct heat utilisation and power generation. Properly implemented, geothermal energy is sustainable, most of it renewable, and benign for the environment. Although its advantages are well known, the present geothermal production stands far below the expectation allowed by the assessed potential, mainly in the Associated, but also in some Member States. One reason for this situation is the limited number of available specialists with the multi-disciplinary training required by the exploitation and utilisation of geothermal resources.

Most, probably all, European countries have higher education in fields and specialities related to exploration and exploitation of mineral resources, which include in their curricula courses on topics related to or useful for the exploration and exploitation of geothermal resources. As a general rule, courses Geology, Geophysics, Geochemistry, Geo-hydrology, etc. provide basic training in the respective topics, but not including specific aspects related to geothermal resources.

The situation is more or less similar in higher education institutions specialised in oil and gas, which usually have specialisations in reservoir engineering and well drilling, completion and exploitation. The courses thought in these faculties provide basic education useful in the exploitation of geothermal resources, but again in most cases specific aspects of geothermal reservoirs are not presented. Many geothermal specialist have their basic training in oil and gas, their expertise in geothermal resources being acquired later in specialised schools or on the job in research centres or commercial companies.

The situation is again similar in higher education specialisations related to the utilisation of geothermal energy: energy engineering, heat engines, civil engineering installations, district heating systems, automation, etc.

Four international geothermal schools have been established around the world in the '70s, of which two in Europe, which had funds available to offer scholarships to students from developing countries: in Pisa Italy (in 1970), in Kyushu, Japan (in 1970), in Auckland, New Zealand (in 1978), and in Reykjavik, Iceland (in 1978). Unfortunately, the Pisa school has not held its annual course since 1993 due to drastic cuts in government financing, but has occasionally held short courses (1-3 weeks) in developing countries. The International Group Training Course at Kyushu University was closed in 2001 and the Diploma course at Auckland University in 2003, also due to withdrawal of government financing. Auckland University is still admitting students to M.Sc. and Ph.D. studies in geothermal as a part of its regular activities. Kyushu University started a new doctoral course (with Japanese Government Scholarships) entitled "International Special Course of Environmental Systems Engineering" in 2002.

2. THE U.N.U. GEOTHERMAL TRAINING PROGRAM IN REYKJAVIK

The United Nations University and the Government of Iceland decided in 1978 to establish the Geothermal Training Programme (UNU-GTP) in Reykjavik. Since then, it continues to train geothermal specialists from developing countries around the world. The number of students per year increased from 2 in 1979 to 20 in 2005, all of them on full fellowships. All candidates have to have a university degree in a relevant specialisation and a minimum one year practical work experience in geothermal. Fellows are selected after an interview.

The training lasts about 6 months (26 weeks), between late April and early October. The geothermal training programme offers 9 lines of specialised training:

- **Geological exploration** offers practical training in basic geological and geothermal mapping, which is commonly the first step in the geothermal exploration of an area. Participants should have a degree in geology.
- **Borehole geology** gives training in making geological logs, 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/or interpretation of such data. Emphasis is on the application of computers in the interpretation. Participants should have a degree in physics, geophysics or engineering.
- **Borehole geophysics** covers the essentials of geophysical measurements in boreholes used for geothermal investigations, with an emphasis on temperature and pressure measurements. Participants should have a degree in physics, geophysics or engineering.
- **Reservoir engineering** covers the methodology needed to obtain information on the hydrological characteristics of geothermal reservoirs and to forecast the long term response of the reservoirs to exploitation. Participants should have a degree in engineering, physics, geophysics, mathematics or hydrogeology.
- **Environmental studies** cover environmental impact assessments (EIA), laws and policies, the planning and execution of EIA projects and environmental auditing. Scientific methods suitable for environmental monitoring are assessed and biological impact, pollution and occupational safety considered. Participants should have a degree in science or engineering.

- **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 and the interpretation of results. Participants should have a degree in chemistry, geochemistry or chemical engineering.
- **Geothermal utilization** deals with the civil, mechanical and chemical engineering aspects of geothermal fluids in pipes, equipment and plants. The feasibility of projects and environmental factors are also considered. 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 deals with the selection of drilling equipment, well design and casing programs, cementing techniques, and the cleaning and repairs of production wells. Participants should have a degree in engineering.

All participants attend an introductory lecture course (5 weeks) which aims to provide background knowledge on most aspects of geothermal energy resources and technology, and to generate an appreciation for the interrelationship between the various disciplines necessary in geothermal projects from the initial exploration to the stages of implementation and utilization. Participants have to take two written tests during the introductory lecture course. The lecture course is followed by lectures and practical training in the respective specialized fields (7 weeks), and the execution of a research project (12 weeks) which is concluded with an extensive research project report. Excursions are also arranged to the main geothermal fields under exploration and utilization in Iceland, the main one lasting 2 weeks (11 and 12). Seminars are held and case histories studied on each of the fields.

The aim of the UNU-GTP is to assist developing countries and Central and Eastern European (CEE) countries with significant geothermal potential to build up groups of specialists that cover most aspects of geothermal exploration and sustainable development. Until now, 340 fellows from 39 countries have completed the 6 months training, about 17% of them coming form Central and Eastern European countries.

Since 2000, a cooperation agreement was signed between the UNU-GTP and the University of Iceland on M.Sc. studies in geothermal science and engineering. This is designed for UNU Fellows who have already completed the six month courses at the UNU-GTP, which constitute 25% of the M.Sc. program credit requirements.

The activities of the UNU-GTP are funded by the Government of Iceland(80-90%) and the United Nations University. International agencies (e.g. UNDP and IAEA) have also financed fellowships for several trainees through the years in connection with their geothermal projects. These have both been for six months and shorter periods of time. Fellowships awarded by Iceland and UNU have been restricted to six months training and M.Sc. studies.

More details on the UNU-GTP have been presented by Invar B. Fridleifsson at the World Geothermal Congress 2005 in Antalya, Turkey.

3. THE INTERNATIONAL SCHOOL OF GEOTHERMICS IN PISA

The International School of Geothermics has been operative since 1970. It evolved from an agreement signed in 1969 between UNESCO, the Italian Ministry of Foreign Affairs, and the National Research Council of Italy (CNR). The School is a branch of the former International

Institute for Geothermal Research, which became an integral part of the Institute for Geosciences and Earth Resources (CNR) in 2002.

During its 35 years of activity, the School has organised 22 long-term courses in Italy (lasting 5 - 10 months), attended by 324 graduates from 22 countries; it has also organised short courses in Europe, Africa, Latin America and Asia, as well as congresses and conferences all over the world. The School was responsible for preparing and organising the specialized courses associated with the Geothermal World Congresses held in Italy (1995) and Japan (2000). The School also has the mission of disseminating geothermal information worldwide, which takes the form of drafting, editing, and disseminating technical and scientific publications.

The short courses, like all the geothermal training organised by the School, are held under the auspices of UNESCO, and have formed part of the routine activity of the School for the last 20 years. These courses, lasting 1 – 3 weeks, are organised in agreement with host organisations in geothermal countries. During the last 10 years, the School has held courses of this type in El Salvador (1995), Eritrea (1997), Ethiopia (1997), Argentina (1998), India (1999), Chile (2000), Costa Rica (2002), North Korea (2002), Yemen (2002), Tunisia (2003), and Ecuador (2004). A total of 532 participants have attended these short courses since 1985.

The financial resources required by the School for its geothermal training activity come from the National Research Council and UNESCO. More details can be obtained from Marnell Dickson, who kindly offered all this information on the International School of Geothermics.

4. THE INTERNATIONAL GEOTHERMAL ASSOCIATION

The International Geothermal Association (IGA), founded in 1988, is a scientific, educational and cultural organization established to operate worldwide. It has more than 2000 members in 65 countries. The IGA is a non-political, non-profit, non-governmental organization in special consultative status with the Economic and Social Council of the United Nations, and Partner of the European Union for the Campaign for Take Off (CTO) the Renewable Energy.

As stated in Article 2 of the IGA By-Laws: “The Association is a tax-exempt, non-profit organization, presently chartered as International Geothermal Association, Inc., under the laws of New Zealand. Its registered office is at present at the Geothermal Institute of the University of Auckland, New Zealand”.

The objectives of the IGA are: to encourage research, development and utilization of geothermal resources worldwide through the compilation, publication and dissemination of scientific and technical data and information, both within the community of geothermal specialists and between geothermal specialists and the general public. In this respect, one of the most important activity of the IGA is to organise, every five years, the World Geothermal Congress.

In years when no World Geothermal Congress is organised, the IGA can offer financial support for courses and conferences of up to USD 5,000 per event. The organisers submit a formal application to the IGA Education Committee, which makes a recommendation to the IGA Board of Directors. The grant is subject to approval by the IGA BoD, which also sets the amount of the actual financial support based on the number of applications received for that year and available funds (usually limited).

The IGA also compiled a Roster of Available Lecturers. The roster a number of experts, the specific topics these are willing to lecture on, as well as their requirements, if any.

4.1 The World Geothermal Congress and Associated Short Courses

The first World Geothermal Congress was held in 1995 in Florence, Italy, and was attended by 1,451 participants. The Short Courses organized in connection to the WGC 1995 were:

1. Environmental Aspects of Geothermal Development
2. Data Management and Related Software in Geothermal Application
3. Drafting a Geothermal Project for Funding
4. Injection technology

The second World Geothermal Congress was held in 2000 in Beppu and Morioka, Japan, and was attended by 1,800 participants. The Short Courses connected to the WGC 2000 were:

1. Environmental Safety and Health Issues in Geothermal Development
2. Heating with Geothermal Energy: Conventional and New Schemes
3. Long Term Monitoring of High and Low-enthalpy Fields under Exploitation
4. Project Management and Financing

The most recent World Geothermal Congress was held in 2005 in Antalya, Turkey, and attended by 1,301 participants. The Short Courses connected to the WGC2005 were:

1. Power Generation
2. Integrated Use of Geothermal Energy
3. Environmental Advantages of Geothermal Energy
4. Developing Geothermal Projects

The minimum number of participants in order to organise a Short Course is about 20. In some cases, depending on the available facilities and preferences of the lecturers, there is also an upper limit of about 60 participants which can be accepted at a course.

The funds needed to organise the Congresses and the associated Short Courses are usually coming from participation fees, exhibition fees, advertising, donations from Governmental entities in the host country, grants from international entities (usually US DoE, UN, EC), donations from commercial companies, and the IGA. Unfortunately, EC support could not be obtained in 2005.

For all 3 Congresses organised until now, and important financial support was offered by the UNU-GTP in Reykjavik and the UNU Rectorate in Tokyo, the funds being used to award full fellowships to selected former UNU-GTP Fellows who presented papers at the Congress and wished to attend a Short Course.

4.2 The International Summer School for the Direct Application of Geothermal Energy

The International Summer School for the Direct Application of Geothermal Energy (ISS) has been established in 1989 and is registered in Skopje, Macedonia. In 1999 the IGA Board of Directors officially approved that ISS activities form an integral part of the IGA Education Committee activities, and a formal contract has been signed in this respect.

The International Summer School on Direct Application of Geothermal Energy organizes international courses and workshops, usually one event per year (except WGC years), and each year in a different country interested in a wider utilisation of geothermal energy.

Up to now, the ISS organised 14 events (including courses, seminars and workshops) in 10 countries: Macedonia and Greece (1990), Macedonia (1992), Bulgaria (1993), Romania (1994), Slovenia (1994 and 1995), Turkey (1996, 1997, and 2003), Portugal (1998), Oregon, USA (1999), Germany (2001), Greece (2002), Poland (2004).

Attendance to the courses has been in average between 40 and 50 (some up to 60), and to the workshops and seminars between 60 and 70. When some of the events have been organized together in the frame of "International Geothermal Days", common attendance has been between 100 and 130.

The ISS events are always organised in collaboration with a local entity (university, National Geothermal Association, etc.). The local organisers are usually defining the topics of the course, seminar and workshop based on the specific fields of interest in each country or region, and are also responsible to provide a suitable venue, as well as most of the funds necessary to organise the event. The ISS provides its organisational experience, the best available lecturers for the specific topics, and up to USD 5,000 for fellowships for participants from developing countries (from the IGA, subject to its BoD approval). Another source of financial support is the GeoFund program of the World Bank, which is still not fully operational yet.

More information on the ISS is available from Prof. Kiril Popovski.

5. THE UNIVERSITY OF ORADEA

The University of Oradea is a state university established with this name in 1990, based on other higher education institutions, which functioned, under different names, for more than a century before. It has at present almost 2,000 employees, and about 20,000 undergraduate, graduate and postgraduate students in 18 faculties and 4 colleges, and a number of entities (groups, teams, centres) active in some specific research fields.

The University of Oradea has a 25 years experience in geothermal research and a 10 years experience in specialised geothermal high-level training. Its departments related to geothermal training and research are: the National Geothermal Research Centre, the International Geothermal Training Centre, and mainly the Faculty of Energy Engineering, which offers B.Sc. specialisation in Thermal Energy Engineering which is strongly oriented to renewable energy sources, and M.Sc. training in Geothermal and Solar Energy Utilisation (available in both Romanian and English). Other faculties also have, among their activities, training and/or research addressing different topics related to geothermal resources and their utilisation, such as the Faculty of Electrical Engineering and Information Technology, the Faculty of Environment Protection, and the Faculty of Medical Sciences.

Taking into consideration the present and especially the forthcoming demand of specialists in the field of exploitation and use of geothermal resources, both in Romania and in other Central and East European countries, the University of Oradea decided to create an international centre for geothermal instruction (The International Geothermal Training Centre). This centre offers specialized training on several levels and for various lengths of

time, in accordance with the candidates' demands and potential requirements. Instruction is offered by members of the University of Oradea academic staff, as well as by well-known Romanian and foreign professors and specialists, invited based on the recommendation of the International Geothermal Association (I.G.A) and its European Branch.

The official inauguration of the Centre took place in April 1997, at the International Seminar for Geothermal Instruction, an event organized under the auspices of the International Geothermal Association in conjunction with the 25th meeting of its Board of Directors.

The mission of the International Geothermal Training Centre, as stated by Dr. Ingvar B. Fridleifsson (Director of the United Nations University Geothermal Training Programme in Reykjavik, Iceland, and President of the IGA at the time), is to pursue the establishment of an organized skill-training and skill-improvement system for developing the labour force needed within the context of growth of geothermal as an alternative energy source in Central and East Europe.

Considering the previously identified needs, training is offered in five specializations, at different levels of education, and being addressed to different types of trainees, as follows:

No.	Specialization	Program duration (weeks)	To whom it is addressed	Level of education	Period
1.	Energy Engineering of Geothermal Resources	28	Experts, Consultants, Researchers, Designers	In-depth studies (M.Sc.)	Oct - July
2.	SCADA operators	2	Technicians and Operators	Intermediate	Sept - Oct; June - July
3.	Management of Geothermal Systems	1	Management and Decision-taking personnel in Administrative, Legislative, and Economic sectors	Post-Graduate	Sept - Oct; June - July
4.	Automation of Geothermal Heating Systems	6	Engineers, Designers and Specialists in Exploitation	Post-Graduate	Sept - Oct, June - July
5.	Exploitation of Geothermal Reservoirs	6	Engineers, Designers and Specialists in Exploitation	Post-Graduate	Sept - Oct, June - July

Courses in any of the above mentioned specialisations can only be organised if there is a large enough number of candidates who can pay the tuition fees, which are set annually by the University Senate (still in the range of hundreds of euros).

The International Geothermal Training Centre can also organise short courses on different topics, with local or invited lecturers, in case financing, at least partial, is available from other sources. An example is the European Summer School on Geothermal Energy Applications (acronym ESGEA), organised in 2001 with partial financial support from the EC. The summer school was attended by 42 students from 7 countries, and lectures were given by 18 specialists from 10 countries.

More information was presented at the European Geothermal Conference 2003.

6. CONCLUSIONS

In the economic environment prevailing in most European states, the profitability of geothermal projects is rather limited, and requires carefully selected cost-effective technical solutions, some of them known by experienced specialists, other still waiting to be discovered or improved. Therefore, on the job training is difficult, although it seems to still be the most common way to train new specialists in many countries.

The current trend of fossil fuel prices is making renewable energies, including geothermal, more attractive not only due to their lower impact on the environment, but also due to a better economic and financial feasibility. Therefore, the geothermal business is expected to grow in the near future. This will require an increasing number of specialists with a solid training in all specialties related to exploration, exploitation and utilisation of geothermal resources.

A first action that should be taken is to identify the European universities which offer training in specialisations related to geothermal resources, contact those that already have at least some interest, or even better some experience, in geothermal training, and convince them to include in their regular graduate course certain specific topics.

A second action would be to check the possibilities and the feasibility of starting new M.Sc. programs in specific specialisations related to geothermal energy, preferably in some of the universities identified during the first action mentioned above. An important part of this action would be to define at least a basic curriculum for each proposed specialisation.

An important aspect of geothermal projects is that their success largely depends on the good collaboration between specialists in many different fields of science and technology. Therefore, each member of a successful team has to be able to communicate with many other members of that team, so that everybody needs to have some basic knowledge a number of topics not directly related to their basic training. For this reason, probably the best option would be to make use of the geothermal training experience gained in certain organisations, mainly those mentioned above and any others that could be identified and are not mentioned here.

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