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International Experience in Geothermal Education

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ABSTRACT

Geothermal energy production and utilization is receiving ever greater recognition in today's renewable energy landscape. Academic institutions and the geothermal industry are beginning to take this into account, as shown by the increasing number of geothermally related course offerings and vocational training programs. Because the last 20 years have observed a dramatic increase in European geothermal development, there has been a resulting shortage of trained industry professionals. There is an especially great need for trained geologists, resource analysts, drillers, engineers, geothermal heat pump installers and geothermal power plant managers. It's safe to say that as the industry grows, so too will the need for geothermal education and training. A number of colleges and universities across the world are starting to offer undergraduate, graduate, and certification programs related to geothermal. This article attempts to introduce, compare, make observations and draw inferences from the last twenty years of international geothermal-education experience and practices.

1. INTRODUCTION

Due to world-wide growth in the geothermal energy sector, there is now a serious lack of trained geothermal manpower. The complexity of geothermal technology requires a wide range of experts with different levels of skills, as well as people with the multidisciplinary education and experience needed to allow for good interaction between the several disciplines represented in a typical geothermal project: geologists, drilling engineers, seismic-equipment operators, water-quality chemists, and environmental-protection specialists all have to understand each other's requirements as well as their own, to ensure a geothermal project's efficient and successful completion. Although basic training in geothermal exploration, exploitation and utilization is available throughout most of European countries, these programs are too few and not interdisciplinary enough to supply the highly skilled workforce the geothermal sector requires. Internationally, only a limited number of specific university degree programs are available. Many of them offer geothermal specialization block courses integrated into programs of Geosciences, Civil Engineering, Process and Environmental Engineering, Mechanical Engineering, Sustainable Energy and others. But these blocks of geothermal education are usually only short-time courses, often only offered as electives, and usually covering only basic skills. Some other non-university academic institutions (mostly research institutes), do however offer geothermal graduate, postgraduate and PhD programs in close cooperation with universities.

2. GEOTHERMAL AND GEOTHERMAL EDUCATION IN HUNGARY

Hungary has a long tradition of geothermal utilization. The surface manifestations of geothermal potential in Hungary have been known since ancient times, and thermal springs in Budapest were used by the Roman Empire and in the Medieval Hungarian Kingdom. Exploration for deeper thermal waters began in 1877, usually with the goal of using thermal waters for balneology (spas). During the 1950's and 1960's hundreds of geothermal wells were drilled, and many of these wells were used for agricultural purposes. At present agricultural use is still one of Hungary's more important applications for its geothermal waters. In addition, more than 40 townships with more than 9,000 apartment blocks are heated in district heating projects. Although the number of operating GSHP systems is under the European average, a slight but steady growth has been observed in this sector over the last several years. Thermal waters are also used in secondary oil production, with hot water being injected into oil reservoirs for enhanced oil recovery. Other innovative applications are also being developed, such as in heavy oil-producing fields where oil distribution pipes are heated by geothermal water to increase the flow of the often extremely viscous oil.

2.1 The State of Geothermal Education in Hungary

Geothermal education at the University of Miskolc, in Hungary, has a fairly long tradition. It was originally an offshoot of the petroleum-engineering program, which was established because of demands from Hungary's petroleum industry in the early 60s. Since that time, thousands of wells have been drilled in an unsuccessful search for hydrocarbons, but many of those wells unleashed significant sources of hot water. As a result, geothermal education has become more important for the country's energy security. The University of Miskolc currently offers geothermal-related degrees at BSc, MSc, and PhD levels. Meanwhile, professors from Miskolc University have worked on geothermal projects in cooperation with international professors and industry experts, while successfully teaching and lecturing at other institutions, both in Hungary and abroad.

One particularly important milestone for Hungarian geothermal education was the four-semester postgraduate geothermal school, initiated at the University of Miskolc in 2008. The next important milestone came in 2012, when a project co-funded by the European Union begun at the same university. This project aimed at developing a postgraduate geothermal education program in an E-learning format, and was entitled "Curriculum Development and Modernization for the Post-Graduate Training Program in Geothermal Engineering, University of Miskolc, Faculty of Earth Science and Engineering." The project had a January 2012 to January 2014 timeframe, a total budget of 600,000 Euros, and full compatibility with the Digital University educational portal. The scope of this effort was quite broad, and consisted of the following courses (credit hours given for each course are shown in parentheses): Renewable Energy, Advanced Geology, Advanced Geophysics, Fluid Dynamics, Hydrogeology, Drilling Well Design, Geothermal

Reservoir, Geothermal Water Production, Geoinformatics, Geothermal Chemistry, Geothermal Heat-Transfer Systems, Geothermal Power Production, Geothermal Direct Uses, Geothermal Heat Pump, and Geothermal Environmental Impacts. All of the curricula were created in a bilingual format, i.e., Hungarian and English.

From the very outset, both students and those working in the geothermal industry expressed a high level of interest in this new postgraduate geothermal program. Students typically enrolled in the program after receiving their BSc or MSc degree from a Hungarian university, and after finding employment in either the petroleum industry or in the financial sector, where geothermal projects represented a good investment possibility. International professors and experts from Europe, the US and elsewhere were invited to give classes or seminars. Although the program had an online orientation, many in-person field trips were organized for the purpose of exploring the more practical aspect of such important topics as drilling, district heating systems and greenhouse development.

After a few years, however, interest in Hungary's geothermal programs declined, despite the high potential demand domestically and despite generous support for geothermal education from the European Union. The reasons for this decline in interest are varied, but can't be explained fully without becoming involved in a political discussion which is outside the scope of this paper.

Another impediment is that the economic situation of the University of Miskolc does not permit it to effectively maintain, modernize and invest in the university's educational programs. One frequent and unfortunate result of this underinvestment is that when foreign (non-Hungarian) engineering students enroll in the University of Miskolc to learn geothermal engineering – having been attracted to the university by the Stipendium Hungaricum scholarship organization – they are often taught by people who don't speak English, don't know where to find English-language teaching materials and know less about geothermal than the students themselves.

The final nail in Hungary's geothermal coffin is the Hungarian Chamber of Engineers (HCE), the nationwide professional licensing organization for Hungarian engineers. The HCE could have helped the geothermal industry by providing a valid, internationally recognized set of regulations to determine who is officially qualified to design a new geothermal system or modify an existing one. Such regulations would allow it to offer a valid geothermal-design certificate to engineers, as is for example available in Germany. But because the HCE refuses to recognize geothermal as a separate engineering topic, and refuses to provide a geothermal-engineering certificate, it becomes much more difficult to establish the well-defined training that would furnish the Hungarian geothermal field with enough trained engineers and technicians. This in turn makes it difficult for geothermal investors, who can't find enough well-trained manpower.

Figure 1: Field trip to Szentes greenhouse

Figure 2: Classroom course in Miskolc

2.2 Short Courses and Training Programs in Hungary

As in other developed countries, these kinds of courses fall under the aegis of the HCA. It's generally understood that HCA's role is to assess the professional level of its members while enforcing professional and ethical standards. HCE expects that engineers keep their knowledge up-to-date by means of regular license renewal programs. In the geothermal field these include such topics as Advanced Geology, Fluid Dynamics, Drilling Well Design, Geothermal Water Production, Direct Uses, Green Houses, Ground Source Heat Pumps, and Geothermal Environmental Impact. They are offered by a variety of subcontracting geothermal experts and professors. Interest in these training courses remains high, and they nowadays seem like Hungary's most well-accepted and viable geothermal training.. In this regard, the European Geothermal Council's (EGEC) also plays a very important role. EGEC continually offers a wide selection of geothermal courses and training programs, such as Geothermal District Heating, Drilling, Reservoir engineering, Underground Heat Storage, and Ground Source Heat Pumps (GSHP). Best of all, many of these courses are completely free for HCA members.

3. GEOTHERMAL EDUCATION OPPORTUNITIES OUTSIDE HUNGARY

Over the last twenty years, more and different opportunities for geothermal education have evolved, some designed for students, others for professors. One of the most significant and successful of these is the United Nations University Geothermal Training Programme (UNU-GTP), established in 1978 in Iceland. Since 1979, UNU-GTP has held annual six-month courses for professionals from the developing countries, concentrating on nine different facets of geothermal science and engineering. Another important source of international geothermal education is the National Geothermal Academy (NGA), sponsored by the U.S. Department of Energy Geothermal Technologies Office. NGA offers courses on such important topics as geothermal geostatistics and geothermal reservoir engineering. Lastly, occasional free online courses are offered, such as the geothermal exploration course offered through the Schlumberger company, and the open courses offered by Stanford, Yale and MIT.

Figure 3. GRC field trip in Imperial Valley

Figure 4. EGC field trip in Soultz-sous-Forêts

3.1 Courses Offered at International Conferences

The biggest and most important geothermal conference is the World Geothermal Congress (WGC), offered every five years (the next one will be in Reykjavik, Iceland, in April 2020). This conference and others like it offer an invaluable chance to learn about the latest developments in geothermal through special seminars and field trips. They are therefore an important consideration when discussing geothermal education. Some of the most relevant and important WGC conference seminars offered in recent years were: Geothermal Direct-Heat Utilization, Power Generation, Environmental Advantages of Geothermal, Electricity Generation, Geothermal Well Drilling, Reducing Drilling Risks, Reservoir Engineering, and Scaling and Corrosion. The other notable geothermal conferences are the Geothermal Research Council (GRC) annual meetings and the International Geological Congress (IGC). Both offer geothermal short courses and relevant training sessions to complement the presentations which make up the bulk of their content.

3.2 Summer Geothermal Courses at the University of Colorado, Boulder

A geothermal summer course was introduced at CU, Boulder, for the first time in 2014 August. Since then four successful courses have been held, entitled: "The Heat Beneath Your Feet: An Introduction to Geothermal Energy." Held at the College of Engineering and Applied Science under the auspices of the College of Continuing Education, this introductory graduate-level course covers the natural conditions, production, utilization, and environmental impact of geothermal energy. The purpose of this course is to give both beginners and more advanced engineering students a broad understanding of geothermal topics and their history -- something which might prove useful in other courses, in individual research, in reading and understanding the relevant literature, as well as in beginning a successful engineering practice. Information from this class can also be applied to the prospecting and design of geothermal production technology and assembling the equipment needed for a geothermal system's surface facilities. Naturally, field trips are organized to show the practical side of drilling practices and show how heat pump installations work in real life.

Figure 5. CU, Denver field trip in to learn about drilling rigs

Figure 6. CU, Boulder heat-pump field trip

The course is based primarily on lectures and teamwork, meant to develop students' understanding of core geothermal principles. The students are expected to read and think about material outside class, and to take part actively in class discussions. These discussions enhance the learning process, allow a sharing of experience, and of course make this course more interesting. The course topics are: What is Geothermal Energy at all; Geological Background; Natural and Artificial (EGS) Geothermal Reservoirs; Flow and Heat Transfer in geothermal reservoirs, in wells and in pipelines; Geothermal power plants; Geothermal direct (thermal water)

uses – bathing, green houses, heating, cooling, industrial; Ground Source Heat Pumps for heating and cooling; Sustainability; and Environmental Impact. This course is tailor-made, meaning that it can be modified to meet the needs of the participating students.

CONCLUSION

Given the variety of jobs required for a productive geothermal workforce, there are a number of suitable educational paths for students and industrial professional to consider. For undergraduate, graduate and post graduate students, following the opportunities suited for a future career in the geothermal industry mean going into civil and environmental engineering, chemical engineering, geology, geological engineering, geophysics, hydrology, mechanical engineering, and petroleum engineering. Generally, a background in physical sciences or engineering would benefit students entering the geothermal industry or pursuing more advanced degrees suited for geothermal. After 20 years' experience in geothermal education, the author can confidently state the following:

Online courses can be very efficient, as they are convenient, flexible and use resources which are available anywhere and at any time. Everyone, from full-time students to part-time students working full time, can take advantage of web-based learning. With 24/7 internet access, discussion fora and chat sessions, participants can interact with everyone online and clear up any doubts about their work. The downside is that all that is mostly theoretical, fairly non-specific and not always practical – for a full understanding of geothermal, field trips and outdoor training sessions are essential. Ideally, geothermal e-learning and personal, in-situ training in the field would complement each other to give a more complete educational experience.

Undergraduate and graduate programs are important, but there will always be an important role for special short courses and specific vocational/technical courses of limited duration. These courses and subjects can be efficiently tailored to match the educational level and interest of their geothermal students. Primarily, these would be given at a quite basic level (101, 201 levels), using jargon-free terms that non-professionals could understand. Typical participants could range at the upper end from graduate students, hydrologist and engineers to – at the beginner level – government officials, potential private investors (focused on ROI more than science), or simply those intellectually curious private citizens who are concerned about the possible adverse effects a geothermal project could have on their lives or property.. One way to determine the success of a teaching session is by the number of intelligent questions posed by the audience.

The author's own, perhaps biased opinion is that in an age when we must fairly evaluate all environmentally safe means of producing energy/heat/cooling, geothermal education is a critical part of the mix. There's no reason geothermal education shouldn't begin in elementary school and continue through undergraduate and graduate institutions. In this way we may finally elevate the general level of geothermal comprehension to a reasonable level. Obviously, this requires that we focus equally on both men and women, of every ethnic and socio-economic background, and as part of local science programs all over the country.

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