GEOTHERMAL TRAINING PROGRAMME

LECTURE 5

GEOTHERMAL EDUCATION IN AFRICA – PAST EXPERIENCE AND FUTURE PROSPECTS

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ABSTRACT

Group training of candidates from developing countries in geothermal technology started at the International School at Pisa (Italy) and at Kyushu University (Japan) in 1970. In 1979, training started at the Geothermal Institute (Auckland) and UNU-GTP (Iceland). Since then, 1689 scientists and engineers have been trained worldwide. As at 2004, geothermal professionals trained at Pisa – Italy, Kyushu-Japan, GI-Auckland and UNU-GTP were 322, 385, 654 and 318 respectively. Of the 1689 geothermal professionals worldwide, Africa has 282 (approx. 17%). Training of these scientists and engineers from Africa on geothermal energy development technologies at the three institutions has been very useful. Graduates trained are among the leading specialists in geothermal research and development in their countries. This will continue to be as more countries diversify their power generation mix to include geothermal as an indigenous and environmentally friendly and renewable source of energy. Some countries are already ahead of others in manpower development and thus those still behind will require training to build up the necessary human capacity. All these training needs will be realised if UNU-GTP will continue with the current training assisted by the establishment of East African Geothermal Resources Centre for shorter courses and practical field training.

1. INTRODUCTION

Training in geothermal technology that started in 1970 at the International School at Pisa (Italy) and at Kyushu University (Japan) were non-degree overview type courses. These lasted between 9 and 2 months in Pisa and 4 months in Kyushu. This decade saw a rapid expansion of geothermal projects in developing countries sponsored by international and bilateral aid. Overview teaching, however, could not cope with demand for specialized and academic type training. At the request of the UN Development Programme (UNDP) and with the support of the NZ Ministry of Foreign Affairs (MFA), the Geothermal Institute (GI) was established in 1978 at the University of Auckland (UA). Its purpose was to offer a post-graduate, 10 months academic Diploma course for earth scientists and engineers (Hochstein, 2005). After this course started in Auckland, a 6-months training course began at Reykjavik (Iceland) in 1979 as part of a United Nations University training programme (Fridleifsson, 2005).
2. WORLD GEOTHERMAL RESOURCE USE

On a global scale, geothermal resources constitute a small, yet rapidly growing, energy resource. It is a very important renewable energy source for many countries. In the year 2000, geothermal energy constituted about 0.25% of the annual worldwide energy consumption (Friðleifsson, 2001) and had been identified in more than 80 countries and utilisation of the resource had been recorded in 58 countries in the world. Geothermal energy, as natural steam and hot water, has been used for decades to generate electricity, in space heating and industrial processes. In 2005, a total of 24 countries were generating electric power from geothermal resources (Bertani, 2005) and 71 countries were using geothermal energy directly (Lund et al., 2005). The world installed electrical capacity from geothermal resources is 8,900 MWe (year 2005). In developing countries, where total installed electrical power is still small, geothermal energy still plays a significant role. Various countries have plans to increase the use of geothermal resources and by 2010, the total installed capacity is expected to reach over 10,000 MWe (Bertani, 2005). The thermal capacity of non-electrical uses (greenhouses, aquaculture, district heating and industrial processes) is 72,622 GWh/yr (year 2004, Lund et al., 2005).

2.1 Geothermal use in Africa

Among African countries, Kenya has been generating electricity since 1981 and Ethiopia started in 1998. These are the only countries in Africa producing electricity from geothermal steam. Since Kenya commissioned its first 45 MWe geothermal power plant at Olkaria East in 1981, it has been producing electricity with an availability factor of over 95%. An Independent Power Producer (IPP) commissioned an additional 12 MWe as a pilot plant for Olkaria III. Olkaria II (70 MWe) was commissioned in 2003, and the extension of Olkaria II by 35 MWe and Olkaria III by 36 MWe is expected to start soon. Oserian Development Company - a flower-growing firm, commissioned a small project with a 2.0 MW binary plant in September 2004 in Olkaria. Ethiopia commissioned its first 8.5 MWe geothermal plant in 1998 at Aluto in the Lakes District (Teklemariam et al., 2000). Exploration for high-temperature resources (for electricity production) has also been conducted in Cape Verde, Djibouti, Eritrea, Tanzania, Uganda and Zambia (Friðleifsson, 2001).

Many African countries have made some direct uses of their geothermal resources. These countries are Algeria, Egypt, Ethiopia, Kenya, Tunisia, and Zambia. Tunisia, which is one of the world leaders in the use of geothermal energy for greenhouse heating and irrigation, is currently leading in Africa with about 110 hectares of greenhouses being heated with geothermal. This development has mainly taken place in oases (Kebili, Tozeur and Gabes) in the Sahara desert (Mohamed, 2005). In Kenya, Oserian Development Company, a flower-growing firm utilizes a steam well leased from KenGen, on the Olkaria field. A heating system was installed in May 2003 and carbon dioxide from the well is also used for the flowers photosynthesis. The system started off by heating 3 hectares, was expanded to 30 hectares and is now being expanded to 40 hectares. Greenhouse heating amounts to 79.1 TJ/yr and a capacity of 10 MWt. (Lund et al., 2005). Hot springs have also been identified in Burundi, Zambia, Cape Verde, Madagascar, Malawi, Mozambique, Uganda, and Zimbabwe (Friðleifsson, 2001).

3. WORLD TRAINING IN GEOTHERMAL ENERGY DEVELOPMENT

In order to realise faster development in geothermal resource utilization, Africa requires trained manpower. The main institutions that have taken a leading role in geothermal technology training are the UNU/GTP in Iceland, the Geothermal Institute at the University of Auckland in New Zealand, the International Institute for Geothermal Research in Pisa, Italy, and Kyushu University - Japan. By 1992, the school at Pisa had trained a total of 324 students from 68 countries in various courses. Of this total, there were 43 Africans, 117 Latin Americans, 113 Asians, and 49 Europeans (Hochstein, 2005). On the other hand, the Geothermal Institute at University of Auckland had trained 96 Africans.
out of a total of 638 by the year 2002. Similarly, 61 Africans (16%) out of a total of 385 had been trained in Japan by the year 2001. Of the 318 students trained by UNU-GTP by 2004, there were 140 Asians, 45 Latin Americans, 82 African and 51 European (Table 1.) Except for the Iceland training, all the other three have now been discontinued.

From Table 1, expansion in Total Geothermal Installed Generating Capacity over the years relates directly to geothermal human capacity that has been developed over the years. For Africa, geothermal installed capacity vis-à-vis human capacity expansion over the years has not been proportional due to lack and/or limited funding towards geothermal development. Asia is at the top in terms of geothermal installed capacity and trained geothermal professionals. It thus becomes a very good example when planning capacity building activities for geothermal professionals in the developing countries. This direct connection between increase in installed capacity and trained manpower is an excellent example of the impact of capacity building in geothermal energy technology on geothermal development.

**TABLE 1:** Student population at international geothermal training courses and total installed capacity (MW)

<table>
<thead>
<tr>
<th>Institution</th>
<th>Continents</th>
<th>Asia</th>
<th>Latin America</th>
<th>Africa</th>
<th>Europe</th>
<th>Total</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyushu, Japan (1970-2001)</td>
<td></td>
<td>165</td>
<td>120</td>
<td>61</td>
<td>39</td>
<td>385</td>
<td>1</td>
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<tr>
<td>Pisa, Italy (1970-1992)</td>
<td></td>
<td>113</td>
<td>117</td>
<td>43</td>
<td>49</td>
<td>322</td>
<td>1</td>
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<tr>
<td>Auckland (GI), New Zealand (1979-2002)</td>
<td></td>
<td>443</td>
<td>103</td>
<td>96</td>
<td>22</td>
<td>644</td>
<td>1</td>
</tr>
<tr>
<td>UNU-GTP, Iceland (1979-2004)</td>
<td></td>
<td>140</td>
<td>45</td>
<td>81</td>
<td>51</td>
<td>317</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>961</strong></td>
<td><strong>385</strong></td>
<td>281</td>
<td><strong>161</strong></td>
<td><strong>921.2</strong></td>
<td><strong>1688</strong></td>
<td>3</td>
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<tr>
<td><strong>Tot. inst. capacity by 2005 (MW)</strong></td>
<td><strong>3291.3</strong></td>
<td><strong>1377</strong></td>
<td><strong>134</strong></td>
<td><strong>5723.5</strong></td>
<td><strong>3</strong></td>
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</table>

1 - Hochstein, 2005; 2 - Fridleifsson, 2004; 3 - Bertani, 2005

### 3.1 Specialized geothermal training in Iceland

The Geothermal Training Programme of the United Nations University (UNU-GTP) was established in Iceland in 1978 when Orkustofnun (the National Energy Authority) became an Associated Institution of the UNU (United Nations University, 1979; Fridleifsson, 2003). Since 1979, a group of professional scientists and engineers from the developing and transitional countries have spent six months in highly specialized studies, research, and on-the-job training in geothermal science and engineering. Since the foundation of the UNU-GTP, 317 scientists and engineers from 39 countries have completed the annual six month specialized courses offered. Of these, 26% have come from Africa. In Africa UNU-GTP graduates are among the leading specialists in geothermal research and development.

Other international institutions that offered geothermal training to professionals from Africa include three international geothermal schools, which were established in Italy (Pisa in 1970), Japan (Kyushu in 1970), and New Zealand (Auckland in 1978). 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 due to withdrawal of government financing (see Fridleifsson, 2005, Hochstein, 2005). Auckland University will, however, continue admitting students to MSc and PhD studies in geothermal as part of its regular activities. Kyushu

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*a* Asia - China, Indonesia, Japan, Philippines & Thailand  
*b* Latin America - Costa Rica, El Salvador, Guatemala, Mexico & Nicaragua  
*c* Africa – Kenya & Ethiopia  
*d* Europe – Austria, France, Germany, Italy, Portugal, Russia & Turkey
University started a new doctoral course (with Japanese Government Scholarships) entitled “International Special Course of Environmental Systems Engineering” in 2002 (Fridleifsson, 2005). The UNU-GTP is thus at present the only international graduate school offering specialized training in all the main fields of geothermal science and engineering.

During the 25-year period 1979-2004, 317 scientists and engineers from 39 countries have completed the six-month programme in Iceland (Fridleifsson, 2004). Of these, 44% are from Asia, 26% from Africa, 14% from Latin America, and 16% from Central and Eastern Europe. Among the 317 graduates of the UNU/GTP, by 2004, eighty one (81) of the Fellows came from ten African countries (Table 2). These are from Algeria (3), Burundi (1), Djibouti (1), Egypt (3), Eritrea (3), Ethiopia (22), Kenya (35), Tanzania (1), Tunisia (6), and Uganda (6). Most of the participants have been on fellowships from the UNU and the Government of Iceland, but some have studied on fellowships from UNDP and the International Atomic Energy Agency (IAEA).

They have had specialized training in the following fields:

- **Geological exploration**: Practical training in basic geological and geothermal mapping, which is commonly the first step in the geothermal exploration of an area.
- **Borehole geology**: 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 form an integral part of the course.
- **Geophysical exploration**: Practical training in conducting geophysical surveys of geothermal areas and interpretation of such data. Emphasis is on the application of computers in the interpretation.
- **Borehole geophysics**: Essentials of geophysical measurements in boreholes used for geothermal investigations, with an emphasis on temperature and pressure measurements.
- **Reservoir engineering**: Methodology needed to obtain information on the hydrological characteristics of geothermal reservoirs and to forecast the long-term response of the reservoirs to exploitation.
- **Environmental studies**: 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.
- **Chemistry of thermal fluids**: The role of thermal fluid chemistry in geothermal exploration and exploitation, including sampling, analysis of major constituents and the interpretation of results.
- **Geothermal utilization**: Civil, mechanical and chemical engineering aspects of geothermal fluids in pipes, equipment and plants. The feasibility of projects and environmental factors are also considered.
- **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.

Since 2000, MSc degree courses were introduced in cooperation with the University of Iceland. These are geothermal professionals who had attended the six month course. Four Kenyans have already completed their MSc course in reservoir engineer, geology, geochemistry and environmental science. In 2004, an environmental scientist from Uganda started his MSc studies. In 2005, two more scientists from Kenya started their MSc studies majoring in geochemistry and environmental science.
3.2 Geothermal training for African professionals

Kenya is the leading country in geothermal research and development in Africa. Most of the geothermal specialists in the country have been trained in Iceland. With the advanced training of the MSc students (Table 2), the UNU-GTP is assisting Kenya in bringing geothermal research to a higher level. It is hoped that, in the future, Kenya will be in a position to assist neighbouring countries by training some of their scientists and engineers. At present, Kenya obtains about 10% of its electricity from geothermal energy. The government plans to increase this figure to 20-25%. The UNU-GTP will support this aim (Fridleifsson, 2005).

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<tbody>
<tr>
<td>Algeria</td>
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<tr>
<td>Burundi</td>
<td>1</td>
<td></td>
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<tr>
<td>Djibouti</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Egypt</td>
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<td></td>
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<tr>
<td>Eritrea</td>
<td>3</td>
<td></td>
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<tr>
<td>Ethiopia</td>
<td>22</td>
<td></td>
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<tr>
<td>Kenya</td>
<td>35</td>
<td>4</td>
<td>27</td>
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<td>1</td>
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<tr>
<td>Tanzania</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Tunisia</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Uganda</td>
<td>6</td>
<td>1</td>
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<tr>
<td>Total</td>
<td>81</td>
<td>5</td>
<td>96</td>
<td>43</td>
<td>61</td>
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4. FUTURE PROSPECTS

The three international geothermal schools have played a major role in geothermal manpower development for third world countries especially Africa. Countries like Kenya and Ethiopia now have the capacity to carry out surface geothermal exploration, drilling and reservoir monitoring, and environmental impact assessments. Other countries like Uganda, Eritrea, and Tanzania have not yet attained the capacity to carry out exploratory work.

4.1 United Nations University - GTP

The only remaining geothermal training institution – UNU-GTP would therefore continue to play a major role in assisting such countries attain the necessary capacity. With an assurance of UNU-GTP continuation with its core activity i.e. specialized six month training, more geothermal professionals from African countries will be trained. After 25 years of UNU-GTP operations, their experience strongly suggests that to make technology transfer successful and sustainable, it is necessary to build core group of at least ten geothermal specialists in a given country (see Fridleifsson, 2005). This gives further chance to expand Africa’s geothermal specialist. Suggestions of starting regional geothermal resources facilities such as the East African Geothermal Resources Centre (training centre) in Kenya have been there. The proposed centre would be used for training people from the region, archiving important documents/data, and acting as a coordination centre for geothermal activities in the region (see Mwangi, 2003).

The Government of Iceland made a further commitment at the International Conference for Renewable Energies (in Bonn, June 2004) to provide the core funding for short specialized courses in geothermal development conducted in selected countries in Africa, Asia, and Central America. The
courses will be set up by the UNU-GTP in cooperation with the local organizations. These are energy agencies/utilities and earth science institutions responsible for the exploration, development and operation of geothermal energy power stations. With longer term goals of the United Nations University and the UNU-GTP being to assist in the establishment of formal training centres with former UNU Fellows as main teachers in countries like China, El Salvador, Kenya, and Philippines; geothermal training in Africa stand to benefit immensely (see Fridleifsson, 2005).

4.2 Geothermal training under ARGeo

Among the planned new activities for UNU-GTP (2005-2008) will be to conduct short courses in Africa (Kenya, Ethiopia, Uganda) under the Renewable Energy Efficiency Partnership -REEEP initiative (established after the Johannesburg Summit in 2002) (Fridleifsson, 2005, Fridleifsson, 2003). The first course is to be held in Kenya in 2005 in collaboration with Kenya Electricity Generating Company (KenGen) and the UNEP/GEF African Rift Geothermal project (ARGeo) with participants from Kenya and neighbouring countries with geothermal resources. The teaching will be in the hands of former UNU Fellows in Kenya and the regular teachers of the UNU-GTP, but there will also be lectures by specialists from GEF and UNEP. Funding is partly provided by the Government of Iceland, but co-financing will be sought with energy utilities in the region as well as international development agencies (Fridleifsson, 2005).

The first short course in Africa is to be held at Lake Naivasha Simba Lodge in Kenya 12-18th November 2005 in collaboration with KenGen and the African Rift Geothermal Facility (ARGeo). ARGeo has recently been established by the United Nations Environment Programme (UNEP), the Global Environment Facility (GEF), several African countries, and aid agencies from several countries. Participants in the course will come from Kenya and neighbouring countries with geothermal resources suitable for electricity production (e.g. Djibouti, Eritrea, Ethiopia, Tanzania, and Uganda). A part of the objective of the course is to increase the cooperation between specialists in the respective African countries in the field of sustainable development and use of geothermal resources.

The first course in Kenya will be planned as an opening course in an ARgeo course series. The tentative title of the course is ‘Short Course for Decision Makers on Geothermal Projects and their Management’. It is obvious that many decision makers in the region are not aware of what geothermal resources can do for their respective countries. These decision makers therefore assign very little human and financial resources to geothermal development. This opening course will be aimed primarily at these potential prime movers of geothermal project activities in the ARgeo countries. The course will give an overview of the planning, financing and execution of geothermal projects. The course will include; preparation of documents needed for proposals for financing of geothermal projects at different stages of development, and the requirements and preparation of data for the leasing of geothermal fields to private investors.

4.3 Geothermal training centre in Kenya

There have been suggestions of starting regional geothermal resources facilities such as the Geothermal Training Centre in Kenya. The proposed centre would be used for training people from the region, archiving important documents/data, and acting as a coordination centre for geothermal activities in the region. It is suggested that this sort of centre can be started as part of the UNU under the UNU/GTP curriculum, and with Iceland’s support, to increase the yearly total number of trainees while cutting down on the travel costs. This can be done by the UNU providing the expertise, with additional assistance of available experts in the region. This would help in developing further the expertise in the region, and would provide training to the locals in their surrounding environment. This has the advantage of developing home-based solutions to problems. Olkaria in Kenya has been identified as the ideal site for a regional geothermal training centre in East Africa because KenGen has
the basic manpower and facilities to provide hands-on training in all phases of geothermal development from geothermal exploration to operation of geothermal power plants. The training centre will initially start with short courses with emphasis on the practical training on i) field data collection and processing, ii) equipment repair and maintenance iii) laboratory sample handling and analysis, iv) providing graduates from neighbouring countries field experience and data in preparation for the 6 months UNU-GTC training in Iceland. KenGen has thus drafted a plan for a geothermal training centre at Olkaria with six weeks annual training courses. It is hoped that some of the trainees from this school would go to the UNU-GTP for advance training.

In addition to the formal training, three geothermal conferences have been held in Nairobi. During the last conference in 2004, it was agreed that the Nairobi conference be called Eastern Africa Conference and to be held in different countries in the region so as to reach many different participants. The next conference will be held in Addis Ababa, Ethiopia in November 2006.

5. CONCLUSIONS

Training of scientists, engineers and technicians from Africa in the field of geothermal energy development technologies has been very useful and will continue to be useful as more countries diversify their power generation mix to include geothermal as an indigenous and environmentally friendly source of energy. Some countries are already ahead of others in manpower development thus those still behind will require training to build up the necessary manpower. All these training needs will be realised if UNU-GTP will strive to attain its target of ten trained geothermal experts per country, continued UNU funded training in specialised areas for countries ahead in man power and the establishment of the East African Geothermal Resources Centre under ARGeo, which has recently been established by the United Nations Environment Programme (UNEP).

REFERENCES


