The United Nations University

GEOTHERMAL TRAINING PROGRAMME
Orkustofnun, Grensásvegur 9,
IS-108 Reykjavík, Iceland

20th Anniversary Workshop
October 1998

TWENTY YEARS OF GEOTHERMAL TRAINING IN ICELAND

Ingvar Birgir Fridleifsson,
United Nations University Geothermal Training Programme,
Orkustofnun, Grensásvegur 9, Reykjavik,
ICELAND

ABSTRACT

The first official statement on establishing a geothermal institute in Iceland was made by the Icelandic ambassador to the United Nations University (UNU) in March 1975 when it had just been established. The Government of Iceland sent the first proposal on possible venues of co-operation to the UNU in Tokyo in January 1976. The UNU convened an international workshop at Laugarvatn in Iceland in July 1988 to "discuss the proposal made by the Government of Iceland to conduct, with UNU support, advanced, practical training in geothermal energy for persons from developing countries. The objective of the workshop was to determine the need for the proposed training course and ensure that it would not duplicate courses already available". The Government of Iceland decided on 31st October 1978 to ask Orkustofnun to sign an Agreement on Association with the UNU. The Agreement on the Status of Association was signed in Tokyo in December 1978 and in February 1979 in Reykjavik. The first two UNU Fellows from the Philippines arrived in Iceland in May 1978. Since then the UNU Geothermal Training Programme has held annual six month courses for professionals from developing countries. Specialized training is offered in geological exploration, borehole geology, geophysical exploration, borehole geophysics, reservoir engineering, chemistry of thermal fluids, environmental studies, geothermal utilization, and drilling technology. The trademark of the training is to give university graduates engaged in geothermal work very intensive on-the-job training in their chosen fields of specialization. The aim is to assist developing countries with significant geothermal potential to build up groups of specialists that cover most aspects of geothermal exploration and development. During 1979-1998, 213 scientists and engineers from 35 countries have completed the six month courses, and over 70 have received shorter training.

1. INTRODUCTION

The Charter of the United Nations University (UNU) was adopted by the United Nations General Assembly in 1973. In 1969, U Thant, the Secretary General of the United Nations (UN), first proposed the idea of establishing the UNU "as an international community of scholars engaged in research, postgraduate training and dissemination of knowledge in furtherance of the purposes and principles of the UN". Member countries of the UN were requested to support the establishment of the UNU. This could be in the form of contributions to the Endowment Fund of the UNU or through hosting individual

research and training programmes at Associated Institutions. The Government of Japan offered to host the headquarters of the UNU in Tokyo and several countries considered in what way they could support the UNU. The UNU commenced operations formally in September 1975 as an autonomous organ of the UN General Assembly, under the joint sponsorship of the UN and UNESCO.

The Permanent Mission of Iceland to the UN supported the idea of establishing a UN University from the beginning and considered in what way Iceland could best contribute to the work of the new university. The first official statement on establishing a UNU geothermal institute in Iceland was made by Ambassador Ingvi S. Ingvarsson in Tokyo at the Fourth Session of the UN Committee on Natural Resources on 25th March 1975. The UNU had just been established and the first rector appointed, Mr. James R. Hester from the USA. At this stage, only two governments had made pledges on financing the UNU: Japan 100 million USD and Senegal 25 thousand USD.

The following proposal was adopted on 28th March 1975 at a meeting in Tokyo: "The Committee on Natural Resources, aware of the urgency of developing alternative sources of energy; decides to request the Economic and Social Council: a) To recommend that the United Nations University consider including in its programme of priorities research in the field of geothermal and solar energy and the practical applications of these energy sources; "

This paper describes the preparations for the establishment of the UNU Geothermal Training Programme (UNU/GTP) in Iceland and summarises the activities of the first twenty years of operations.

2. PREPARATIONS FOR UNU ACTIVITIES IN ICELAND

The Government of Iceland sent the first proposal on possible venues of co-operation to the UNU in Tokyo in January 1976. UNU Vice-Rector Walter Manshard and Dr. James M. Harrison visited Iceland in June 1976 for further discussions and visited institutions which might become Associated Institutions of the UNU. Initially training programmes for both geothermal energy and fisheries technology were considered. The UNU showed preference for geothermal energy to start with. It was considered whether the geothermal training centre should be hosted by the University of Iceland or Orkustofnun - the National Energy Authority (NEA), a government research institution with a large number of geothermal specialists, excellent laboratory facilities, drill rigs and logging equipment. After evaluating the available facilities the UNU selected Orkustofnun.

A committee was appointed by the government in 1978 to prepare a proposal to the UNU. Members of the committee were Mr. Árni Gunnarsson, chairman, (Ministry of Culture and Education), Mr. Ólafur Egilsson (Foreign Ministry), Mr. Kristmundur Halldórsson (Ministry of Industry), Rector Gudlaugur Thorvaldsson (University of Iceland), Dr. Gudmundur Pálmason (Orkustofnun), Dr. Ingvar Birgir Fridleifsson (Orkustofnun), Prof. Thorbjörn Karlsson (University of Iceland), Prof. Sveinbjörn Björnsson (University of Iceland), Prof. Andri Ísaksson (UNESCO Committee of Iceland), and Prof. Sigmundur Gudbjarnarson (National Research Council). A working group consisting of specialists from the Geothermal Division of Orkustofnun and the University of Iceland prepared a draft syllabus for the geothermal training programme which formed the core of the formal proposal. The people most active in this work later became members of the first Studies Board of the Training Programme.

A proposal to the UNU for the establishment of the Geothermal Training Programme in Iceland was adopted by the Government of Iceland on 21st March 1978 and submitted to the UNU in Tokyo. The UNU convened an international workshop at Laugarvatn in Iceland in July 1988 to "discuss the proposal made by the Government of Iceland to conduct, with UNU support, advanced, practical training in geothermal energy for persons from developing countries. The objective of the workshop was to determine the need for the proposed training course and ensure that it would not duplicate courses already available. For this purpose, invitations were sent to experts in geothermal energy who were

knowledgeable about current training facilities and development activities, to individuals from selected developing countries that are developing their geothermal energy resources, and to representatives of the UN agencies that sponsor training course. Participants also included staff members of Orkustofnun, which was the host organization, representatives of the University of Iceland and many interested observers from the government of the host country", as it says in the UNU report on the workshop (United Nations University, 1979).

The workshop concluded that "After consideration of the existing courses and that proposed by Iceland, it is concluded that they cover reasonably well the diversity of general and specialized requirements for training at the professional level. The Iceland course is regarded as an important addition to the existing programmes. It is urged, especially by participants from recipient coutries, that the Iceland training programme for individuals be as short and flexible as possible while still adequately improving the knowledge and the skills of trainees. It is felt that preference should be given to candidates from those developing countries where geothermal exploration or development is under way, and to those who already have some practical experience in their own discipline" (United Nations University, 1979).

Representatives of the UNU at the workshop were Prof. Walther Manshard (Vice Rector of the UNU), Dr. James M. Harrison (Consultant of the UNU), and Dr. Walter Shearer (Programme Officer of the UNU). There were three representatives of UN agencies and geothermal specialists from El Salvador, Germany, Hungary, Iceland, India, Italy, Japan, Kenya, New Zealand, Philippines and USA. The workshop was organized under the leadership of Dr. Gudmundur Pálmason, director of the Geothermal Division of Orkustofnun.

The Government of Iceland decided on 31st October 1978 to ask Orkustofnun to sign an Agreement on Association with the UNU. The Agreement on the Status of Association was signed in Tokyo on 27th December 1978 and on 13th February 1979 in Reykjavik. The first two UNU Fellows from the Philippines arrived in Iceland in May 1979.

3. GEOTHERMAL TRAINING IN ICELAND

The first annual training session started in May 1979 with two UNU Fellows from the Philippines. Since then, a group of scientists and engineers from energy agencies and research organizations, and universities in the developing countries, have come to Iceland every spring to spend six months in highly specialized studies, research, and on the job training in geothermal science and engineering. All of them are university graduates with practical experience in geothermal work in their home countries. The training is tailor-made to the individual and the needs of his institution/country. In all, 213 participants from 35 countries completed the six month courses during 1979-1998. They have come from Asia 45%, Africa 26%, Latin America 15% and Central & Eastern Europe 14%. Table 1 shows the number of participants per country and the specialized courses they have taken.

The Geothermal Training Programme operates within Orkustofnun - the National Energy Authority of Iceland. It is academically governed by a Studies Board, which is composed of experts responsible for each of the specialized courses that are offered, and a chairman who is the director of the Training Programme. The members of the first Studies Board in 1979 were Dr Ingvar Birgir Fridleifsson (chairman), Dr. Haukur Jóhannesson (Geological Exploration), Dr. Hrefna Kristmannsdóttir (Borehole Geology), Prof. Sveinbjörn Björnsson (Geophysical Exploration), Dr. Valgardur Stefánsson (Borehole Geophysics), Dr. Jónas Elíasson (Reservoir Engineering), Prof. Stefán Arnórsson (Chemistry of Thermal Fluids), Dr. Jón Steinar Gudmundsson (Geothermal Utilization), Prof. Valdimar K. Jónsson (Geothermal Utilization), and Mr. Ísleifur Jónsson (Drilling Technology).

In addition to the eight specialized courses offered from 1979, a new course in Environmental Studies has been operated since 1997. The present members of the Studies Board are Dr. Ingvar Birgir

Fridleifsson (chairman), Dr. Kristján Saemundsson (Geological Exploration), Dr. Hjalti Franzson (Borehole Geology), Dr. Knútur Árnason (Geophysical Exploration), Dr. Benedikt Steingrímsson (Borehole Geophysics), Dr. Halldór Ármannsson (Environmental Studies) and Mr. Sverrir Thórhallsson (Drilling Technology) from Orkustofnun, Prof. Stefán Arnórsson (Chemistry of Thermal Fluids) and Prof. Valdimar K. Jónsson (Geothermal Utilization) from the University of Iceland, and Dr. Snorri Páll Kjaran (Reservoir Engineering) from the Vatnaskil Consulting Engineers Ltd.

Dr. Ingvar Birgir Fridleifsson has been the director from the beginning except for one training season in 1981 when Dr. Hjalti Franzson served as director, and three training seasons in 1986-1988 when Dr. Jón Steinar Gudmundsson served as director. Mr. Lúdvík S. Georgsson has been the deputy-director since 1990.

Table 1: Fellows of the UNU Geothermal Training Programme 1979-1998

Country	Geological exploration	Borehole geology	Geophysic. exploration	Borehole geophys.	Reservoir engineer.	Chemistry of therm. fluids	Environm. studies	Geotherm. utilization	Drilling technology	Total
Algeria	1					1		1		3
Bulgaria				1	2	2				5
Burundi	1									1
China		3	1	2	11	10		9	1	37
Costa Rica	1	1	2		1			1		6
Djibouti		1								1
Egypt		1			1	1				3
El Salvad.	1	1	1	2	4	1	1	1	3	15
Eritrea			1							1
Ethiopia		2	1	1	3	3		1	1	12
Greece			1					2		3
Guatemala		1				1				2
Honduras		1	1							2
Indonesia		3	3	2	3					11
Iran	1	1	1					1		4
Jordan				1	1					2
Kenya	1	4	7		3	4	3	1	2	25
Lithuania								1		1
Macedonia						1				1
Mexico	1		1		2					4
Nepal						1		1		2
Nicaragua					3	1				4
Pakistan	1	1			1	1				4
Philippines		3	4	4	7	5		3		26
Poland		1			3					4
Romania								5		5
Russia				1						1
Serbia				1	1	1				3
Slovakia				1	1					2
Tanzania	1									1
Thailand		1		2		1		1		5
Tunisia								3		3
Turkey		1			1	2		1		5
Uganda	2	1	1			1				5
Vietnam			1		1	1			1	4
Total	11	27	26	18	49	38	4	32	8	213

4. TRAINING SCHEDULE

The approximate time schedule of the Training Programme is shown in Table 2. The duration is 6 months. In general, all participants are expected to attend an introductory lecture course that lasts 4-5 weeks (three lectures and a practical each day). The aim of the lecture course is to provide a 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 practical training

in a specialized field and the execution of a research project that is concluded with an extensive research project report. Study tours are arranged to all the main geothermal fields under exploration and utilization in Iceland.

Table 2: The approximate time schedule for the UNU Geothermal Training Programme

UNU GEOTHERMAL TRAINING PROGRAMME IN ICELAND

Week	Geological Exploration	Borehole Geology	Geophysical Exploration	Borehole Geophysics	Reservoir Engineering	Environmental Studies	Chemistry of Thermal Fluids	Geothermal Utilization	Drilling Technology
1 2 3 4 5	Lecture course on all main aspects of geothermal energy exploration and utilization, practicals and short field excursions								
6	Field geology	Drilling	Resistivity methods	Course on well logging and reservoir		EIA Project planning	Sampling of fluids and gas		Drilling equipment
7	Maps and photos	Petrological logging	Thermal methods	engineering including:		Chemistry Physics	Scaling and corrosion		Drilling procedures
8	Structure analysis	Alteration	Magnetics	Logging and well testing practises		Biology Monitoring	Analytical methods	Heat transfer and	Well design Safety
9	Hydrogeology	Mineralogy	Gravity	Reservoir physics Reservoir simulation		Revegetation	Thermodynamics	fluid flow	Management
10				Tracer tests Computer programs		Health and safety	Geothermometers	Control systems	Rig operations
11 12	Excursion to the main geothermal fields of Iceland								
13	Field work in deeply	Aquifers	Data processing	Logging methods	Responses to	Gas dispersion	Water rock	Design of plants	Cementing
14	eroded strata	Modelling	techniques	Data evaluation	exploitation	and abatement	interaction	and systems	Completion
15 16 17 18 19 20 21 22 23 24 25 26	Project and report	Project and report	Project and report	Project and report	Project and report	Project and report	Project and report	Project and report	Project and report

The first PC-computer was bought to the Training Programme in 1982, and gradually computers have played an ever increasing part in the project work. All participants receive training in using PC-computers for word processing, interpretation of data as well as in using the Internet. Each of them is provided with a personal PC during their training in Iceland. Experience has shown that most trainees have access to PC-computers at home, and they can take their diskettes/CDs home and continue the work there. Thus there has been a considerable transfer of computer technology from Reykjavik to geothermal institutions in the developing countries. Participants having access to large computers at home are allowed to work on Unix computer system at Orkustofnun. All the participants are trained in using the Internet and encouraged to do so. In November 1998, some 70 former UNU Fellows are listed in the e-mail directory of the Geothermal Training Programme. An updated directory is sent out twice per year to all alumni of the Programme.

The main emphasis of the training is to provide the participants with sufficient understanding and practical experience to permit the independent execution of projects within a selected discipline in their home countries. Table 2 shows the time frame for the nine specialized lines of training which are offered. Each participant is meant to follow only one line of training, but within each line there is considerable flexibility. A significant part of the practical training is done in connection with the research projects of the Fellows. In many cases they bring with them data from geothermal projects in their home countries, but sometimes the research projects are integrated with geothermal exploration or utilization projects that are in progress in Iceland at the time of training. The project topic is always selected with respect to the conditions of the home country of the participant. Many of the project reports are written in such a way that they serve as manuals for performing certain measurements or interpretations dealt with in respective reports. All the project reports are published by the Training Programme. Since 1994, the reports have been published in the annual book "Geothermal Training in Iceland" which has an international publishing code (ISBN 9979). Copies can be obtained upon request. The reports are mailed regularly to former UNU Fellows and many of the leading geothermal institutions in the developing countries. The titles of all reports in 1979-1998 are listed on the home page of the UNU Geothermal Training Programme (www/os.is/unugtp/) and the abstracts of reports from 1988.

5. SPECIALIZED COURSES

The general structure of the specialized courses has remained the same during the twenty years, but the contents have of course progressively changed. The main contents of the specialized courses are as follows:

The **geological exploration** course offers practical training in basic geological mapping, which is commonly the first step in the geothermal exploration of an area. Participants analyze the geological structure of an area with regard to siting drill holes, both thermal gradient and production wells. Many of the participants have also been trained in mapping surface geothermal manifestations, including shallow temperature surveys and measurement of flow rates of springs. The field work is commonly conducted both in active geothermal and volcanic areas and in deeply eroded areas where the roots of extinct volcanoes and hydrothermal systems can be inspected. Participants should have a degree in geology. Eleven participants from ten countries have completed this course.

The **borehole geology** course gives training in making geological logs, analyses of drill cuttings and cores, and, in some cases, fluid inclusions. The identification of alteration minerals (microscope and x-ray diffraction) and the interpretation of the alteration mineralogy forms an integral part of the course. Many of the participants receive training in collecting and interpreting data on aquifers and in making geological models of geothermal reservoirs based on their own data and data from other disciplines. Participants should have a degree in geology. Twenty seven participants from ten countries have completed this course.

The **geophysical exploration** course is for practical training in conducting geophysical surveys of geothermal areas and/or interpretation of such data. The essentials of heat flow surveys, magnetic and gravity surveys, as well as resistivity depth soundings and profiling are covered. During the latter half of the training a selection can be made between further specialization in electrical surveys (Schlumberger, dipole, head-on profiling, TEM, MT, AMT, SP), magnetic surveys and gravity surveys. Emphasis is laid on the application of computers in the interpretation of geophysical data. Participants should have a degree in physics, geophysics or engineering. Twenty six participants from fourteen countries have completed this course.

The course in **borehole geophysics** covers the essentials of geophysical measurements in boreholes used for geothermal investigations, with the main emphasis on temperature and pressure measurements, but including lithology logs such as electrical resistivity, caliper, porosity and density logs, and well completion logs such as CCL, CBL, inclination and spinner logs. The participants undertake well measurements, but most of the time is devoted to the interpretation of logging data. Participants should have a degree in physics, geophysics or engineering. Eighteen participants from eleven countries have completed this course.

The **reservoir engineering** course 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. Both surface and downhole measurements are considered and the interpretation of flow tests of wells, injection tests and interference tests. It is also possible to specialize in production engineering of geothermal fields. The course requires a sound background in mathematics. Participants should have a degree in engineering, physics, geophysics, mathematics or hydrogeology. Fourty nine participants from eighteen countries have completed this course.

The **environmental studies** course covers environmental impact assessments (EIA), laws and policies, the planning and execution of EIA projects and environmental auditing. Aspects of reservoir engineering and geothermal chemistry are treated, including sampling and analytical methods, injection and tracer studies, scaling and corrosion along with methods of interpretation. Physical methods of monitoring geothermal areas such as aerial thermography, refraction measurements, seismic monitoring and gravity and levelling methods for subsidence are studied. Biological impact is considered in some detail as well

as the management of wastes, toxic chemicals, air pollution and noise. Occupational health and safety are introduced and abatement methods such as H_2S abatement and ground re-vegetation feature too. As a bacground, energy statistics and forecasts are considered and case histories of exploration and environmental impact studies introduced. The projects are from wide-ranging disciplines as are the Fellows themselves who are required to have a degree in science or engineering. This course was started in 1997. Four participants from two countries have completed this course.

The course on **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. Much emphasis is placed on the application of chemical thermometers and the calculation of mixing models. Environmental aspects of the thermal fluids are also considered. The participants need a solid background in chemistry. They should have a degree in chemistry, geochemistry or chemical engineering. Thirty eight participants from eighteen countries have completed this course.

The course in **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. Due to the wide spectrum covered by geothermal engineering, the participants have to be very selective in their specialization. Most of the participants specialize in the design and/or feasibility studies of district heating systems and/or in the application of geothermal steam and water in industry. One specialization is the selection, installment and operation of downhole pumps in geothermal wells. Participants should have a degree in engineering. Thirty two participants from fifteen countries have completed this course.

The course in **drilling technology** provides engineers with the information and on-site training necessary to prepare them for the work as drilling engineers or supervisors. The course is thus training in the planning and supervision of drilling and not in the task of drilling itself. The course deals with the selection of drilling equipment, the design of wells and casing programs, as well as cementing techniques. The cleaning and repairs of production wells is also covered. Participants should have a degree in engineering. Eight participants from five countries have completed this course.

6. TEACHING MATERIAL

Most of the teaching is done by tutorials and practical work where the teacher works with two or three trainees and use is made of available textbooks and articles in journals as appropriate. In some instances, however, a special effort has been required to compile text material and manuals as teaching material for the training. Most of this work has been done by the regular teachers of the Training Programme, who are mostly staff members of Orkustofnun and the University of Iceland. Some texts have also been written by visiting scholars from other countries. Some of the teaching material has been published in reports, and is available from the Training Programme. Examples include the texts on hydrogeology (Sigurdsson, 1987), geophysical exploration (Hersir and Björnsson, 1991), geothermal logging (Stefánsson and Steingrímsson, 1981), reservoir engineering (Kjaran and Elíasson, 1983), geothermal reservoir physics (Bödvarsson, 1987), geothermal district heating (Karlsson, 1982), direct use of geothermal energy (Lund, 1987; Lund, 1996), and one dimensional inversion of Schlumberger resistivity soundings (Árnason and Hersir, 1988). This last report contains the description of a computer program, user's guide and a diskette for a PC-computer. A few of the teaching texts are already into their second and third editions.

One guest lecturer with an international reputation is invited every year as a UNU Visiting Lecturer to give a lecture series and to lead discussions with the trainees. The UNU Visiting Lecturers have stayed from about two weeks to two months in Reykjavik. The following have been UNU Visiting Lecturers:

1979	Donald E. White	USA	1980	Christopher Armstead	UK
1981	Derek H. Freeston	New Zealand	1982	Stanley H. Ward	USA
1983	Patrick Browne	New Zealand	1984	Enrico Barbier	Italy
1985	Bernardo Tolentino	Philippines	1986	Russel James	New Zeal.
1987	Robert HarrisonUK	1988	Robert O. Fournier	USA	
1989	Peter Ottlik	Hungary	1990	Andre Menjoz	France
1991	Wang Ji-yang	P.R. China	1992	Patrick Muffler	USA
1993	Zosimo F. Sarmiento (UNU Fellow 1980)	Philippines	1994	Ladislaus Rybach	Switzerland
			1995	Gudmundur Bodvarsson	USA
1996	John Lund	USA	1997	Toshihiro Uchida	Japan
1998	Agnes Reyes (UNU Fellow 1979)	Philippines/New Zealand			

Many of the lectures of the UNU Visiting Lecturers have been published by the Training Programme and are listed by author in the reference list. Some of these have served as important teaching material. Copies of the publications are available on request. A separate list is available on all reports published by the UNU Geothermal Training Programme.

7. BUILDING OF SPECIALIST GROUPS AND EVALUATION

Table 1 lists the countries of origin of the participants during 1979-1998 and their specialized courses. The largest groups have come from China (37), Kenya (25), and the Philippines (26). Eight other countries have sent 5-15 participants. The aim of the UNU Geothermal Training Programme is to concentrate its training efforts so as to assist in building up groups of specialists in the geothermal departments of selected countries with significant geothermal potential. Priority for training is given to candidates from carefully selected institutions from developing countries where geothermal exploration and development is already under way. The limiting factor is in some cases the availability of sufficiently qualified staff in the recipient institutions. The fact that participants must speak English fluently has, for example, hampered participation from certain parts of the world such as Latin America. Table 3 shows how the leading recipient countries have sent professionals for specialized training in most of the courses offered. Relatively few experts have been trained in geological exploration and drilling technology, as these subjects are generally mastered in the home countries. The environmental studies course has only been run experimentally for two years, but there is a large demand for training in this course.

Table 3: Number of trainees from four countries

Number of trainees from four countries in specialized courses 1979-1998

	China	Philippines	Kenya	El Salvador
Geological Exploration			1	1
Borehole Geology	3	3	4	1
Geophysical Exploration	1	4	7	1
Borehole Geophysics	2	4		2
Reservoir Engineering	11	7	3	4
Chemistry of Fluids	10	5	4	1
Environmental Studies			3	1
Geothermal Utilization	9	3	1	1
Drilling Technology	1		2	3
Total	37	26	25	15

Assessment of the training has mainly taken the form of interviews with former trainees and their directors. A representative of the Training Programme visits the main recipient countries every few years, and meetings are also arranged in connection with international geothermal conferences. Some

changes have been made in the detailed contents of some of the specialized courses based on the feedback from the trainees and their institutions. But generally speaking, the effort to have the training tailor-made to the abilities of the individual and the needs of the recipient country/institution, seems to have been very successful. The number of fully qualified applicants each year is normally much greater than the number of scholarships available. All the participants are selected after private interviews with staff members of the Training Programme and on the recommendation of the recipient institutions. It is therefore not surprising that many of the former trainees have become the leading specialists in their countries in their given fields. Our records indicate that about 80% of all our trainees are still working in the geothermal sector. A few of the Fellows from the first years of training have gone into retirement.

8. SELECTION OF PARTICIPANTS

Specialized practical training is considerably more expensive than group training because of the high teacher-to-student ratio. On average, a full time teacher takes care of three students during the intensive training. The total cost of training per student in Reykjavik (including international travel and per diem) is over USD 30,000. Much care is therefore taken in selecting the participants. The selection procedures of the UNU are adhered to, which involve site visits by representatives of the Training Programme to the countries of potential candidates and personal interviews with all candidates. The potential role of geothermal energy within the energy plans of the respective country is assessed, and an evaluation made of the institutional capacities in the field of geothermal research and utilization. Based on this, the training needs of the country are assessed and recipient institutions selected.

The candidates must have a university degree in science or engineering, a minimum of one year practical experience in geothermal work, speak English fluently, and have a permanent position at a government energy company, research institution, or university. The directors of such institutions are invited to nominate candidates for training in the specialized fields that are considered most relevant to promote geothermal development in the respective country. Nominations, including the curriculum vitae of the candidates, should be sent to the Training Programme in Iceland. The candidates should normally be under 40 years in age. Training starts in late April and ends in late October each year. Nominations must be received in Reykjavik before 1st August each year for participation in the training starting the following year. Due to the high cost of international travel, site visits for interviewing candidates cannot be held in all requesting countries every year. Therefore, interviews are held in a given country for candidates for two or three years at a time. Participants from developing countries and some Central and Eastern European countries normally receive scholarships financed by the Government of Iceland and the UNU that cover international travel, tuition fees and per diem in Iceland. The participants therefore do not need other funds for their training. The UNDP and the International Atomic Energy Agency (IAEA) as well as the European Union have also financed fellowships for several trainees through the years. Qualified participants from industrialized countries can also be accepted on condition that they obtain similar scholarships from their own institutions/countries.

9. FINANCES AND THE FUTURE

Figure 1 shows the number of Fellows completing the six months specialized training per year during 1979-1998. In the last five years there have been 15-18 Fellows per year. There is a steady flow of requests from all over the world for training at the UNU Programme, and only a portion of the requests can be met. In view of this, it is planned to continue with the six months specialized research and training as the main activity of the Programme. We intend, however, to start shortly enrolling a few outstanding former UNU Fellows for a M.Sc. Programme in geothermal science and engineering in cooperation with the University of Iceland. Many of our trainees have already completed their M.Sc. or Ph.D. degrees when they come to Iceland, but several excellent students who have only B.Sc. degrees have made

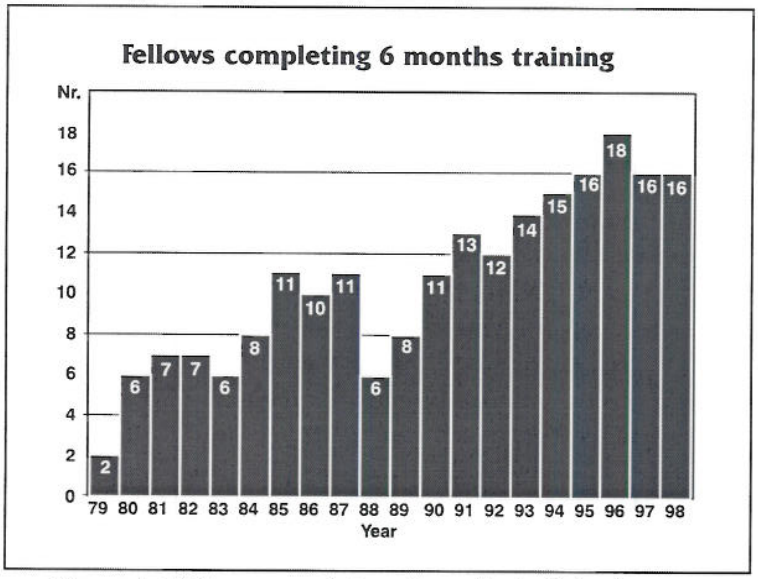

Figure 1: Fellows completing 6 months training by year

requests to come again to Iceland for a higher academic degree. Their six months studies in Iceland would form a part of their graduate programme.

During 1979-1982, the financing of the UNU Geothermal Programme was shared equally by the UNU and the Government of Iceland. Since then, the Government of Iceland has carried the lions share (approximately 80%) of the annual financing. Through the years, international agencies such as UNDP, the IAEA, and EFTA/EU (Brussels) have financed one to three Fellowships per year. These have both been for six months and shorter periods of time. Fellowships awarded by UNU/Iceland have only been for six months training, apart from a few UNU Special Fellowships for senior scientists for short visits in the early years of the Geothermal Programme. Over seventy people have come for short training and study visits (2 weeks to 4 months) during 1979-1998 in addition to the 213 who have completed the six months training.

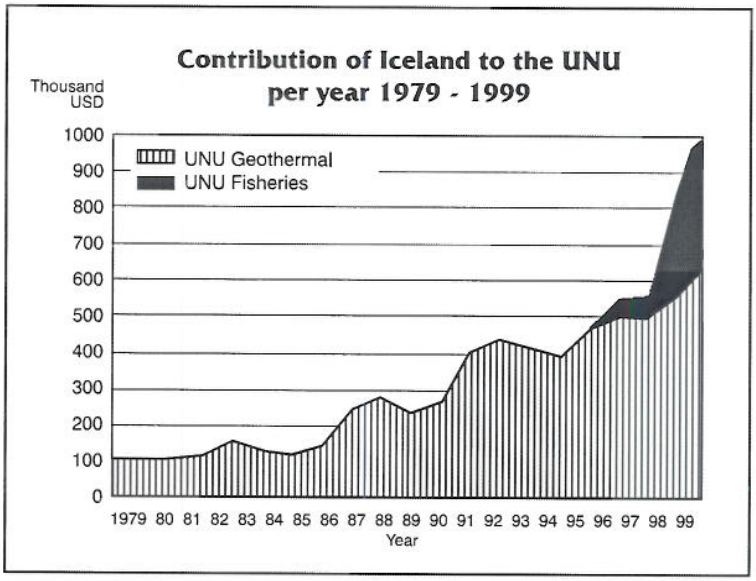

Figure 2: Iceland's contribution to the UNU

Figure 2 shows the annual contribution of the Government of Iceland to the United Nations University for specialized training in Iceland 1979-1999. The contribution is decided in the annual State Budget. The payments for the UNU Geothermal Training Programme go directly to Orkustofnun. All accounting is kept separate for the UNU Geothermal Programme at Orkustofnun. The accounts are audited annually by the National Audit Office of Iceland. The Government has been very supportive and public opinion polls have shown the UNU Geothermal Training Programme being regarded the most successful method of development aid supported by the Government of Iceland.

The UNU Fisheries Training Programme started operating in Iceland in 1998 on the basis of an Agreement on Cooperation betweeen the UNU, the Government of Iceland, and the Marine Research Institute. The training methods and mode of selection of participants are based on the experience of the UNU Geothermal Training Programme. The annual contributions from the Government to the UNU Fisheries Training Programme are paid to the Marine Research Institute. The separate accounts for the UNU Fisheries Programme are audited annually by the National Audit Office of Iceland.

The UNU Fisheries Training Programme is expected to grow in size similar to the Geothermal Programme. The demand for training in fisheries studies is expected to be much larger than in geothermal energy since so many more countries are highly dependent on fisheries than geothermal energy. Five specialized courses are offered: Fisheries Policy and Planning; Marine Resources, Assessment and Monitoring; Fishing Technology and Fleet Operations; Fish Handling, Processing and Quality Management; and Management of Fisheries Companies and Marketing.

The total contribution of the Icelandic Government for the UNU Geothermal Programme during 1979-1999 amounts to 6.3 million USD, and that for the UNU Fisheries Programme (during 1996-1990) about 0.9 million USD. The total contribution to the UNU activities in Iceland will thus amount to 7.2 million USD. As can be seen from Figure 2, the Icelandic State Budget for 1999 is expected to include a contribution of almost 1 million USD to the training activities of the UNU in Iceland in these two subjects where Iceland is amongst world leaders in expertice. Both of these specialities are of national importance in Iceland, since approximately 70% of the export earnings of Iceland come from fish products, and about 48% of the total primary energy of Iceland is provided by geothermal energy. With a total population of 274.000, Iceland is contributing about USD 3.60 per capita to the training and research activities under the name of the United Nations University. The Government of Iceland considers the UNU a most suitable venue for channelling a part of its multilateral development aid. The feedback from the recipient countries has been very favourable with regard to the geothermal energy training. It is commonly stated in public debate in Iceland that the research and training activities in cooperation with the UNU are the most effective development aid undertaken by Iceland. Similarly, the programme has been held in high regard by the UN system (Figure 3).

Figure 3: The Secretary General of the United Nations, Mr. Peres de Cuellar, visited the UNU Geothermal Training Programme in 1983. Seen from right are: Ingvar Birgir Fridleifsson, director of the UNU Geothermal Training Programme, Perez de Cuellar, Lu Run, UNU Fellow from P.R. of China, and Jakob Björnsson Director General of Orkustofnun

The Foreign Minister of Iceland, Mr. Halldór Ásgrímsson, said in his opening speech at the 20th Anniversary Workshop of the UNU Geothermal Training Programme in October 1998, that a significant portion of Iceland's aid for international development will continue to be channelled for supporting the development of high-level manpower in the fields of geothermal energy and fisheries, as well as in other areas for which Iceland has comparative advantage to make significant contribution to international development.

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