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GEOTHERMAL DEVELOPMENTS IN DEVELOPING COUNTRIES AND IMPACT OF GEOTHERMAL TRAINING AT AUCKLAND

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ABSTRACT

The impact of training offered by the Geothermal Institute (University of Auckland), future training demands, and present and future geothermal developments in developing countries were assessed by the 1983 UNDP-MFA Geothermal Training Mission. Comparing the results of the 1983 Mission with those of a similar Mission undertaken in 1980 showed that:

The capacity of installed geothermal power plants in eight developing countries has increased from 475 MW in 1980 to 1210 MW in 1983; an additional capacity of 565 MW was under construction.

The documented total number of geothermal professionals has increased from about 400 in 1980 (12 countries) to about 1400 in 1983 (16 countries).

About 300 of the 1400 professionals had received training overseas; 103 of the 300 professionals were trained in Auckland between 1979 and 1983.

Demand for geothermal training in 1983 was higher (about 65%) than that in 1980.

About 70% of all ex-students trained in Auckland were working full time in geothermal projects in 1983; 90% of all employers stated that the aim of the Auckland Course was adequate and 70% said that the performance of the fellows had significantly increased.

INTRODUCTION

An assessment of present and future geothermal developments of developing countries and their likely training demands was undertaken in 1983 by a Joint UNDP-NZMFA Geothermal Training Mission. In addition, the impact of training given by the Geothermal Institute, University of Auckland, was assessed to obtain the necessary information upon which future funding and estimates of future intakes for the Geothermal Diploma Course at Xuckland can be based.

The survey included the analysis of questionnaires which were sent to a sample group of 84 fellows Erom 14 developing countries and to 17 New Zealand fellows who had attended the annual Diploma Courses at Auckland between 1979 and 1982 (i.e. 4 years intake). Separate questionnaires were also sent to the supervisors of this group of 101 ex-students. Information about present and future geothermal developments, problems affecting present developments, present staf Eing, and training requirements was obtained from a third questionnaire which was mailed to a total of 30 organisations which had sent students to the Auckland Course between 1979 and 1982.

The Mission checked most of the information of these questionnaires and visited between October and December 1983 a fotal of 11 developing countries (China P R, Costa Bica, Ecuador, Ethiopia, India, Indonesia, Kehya, Mexico, Philippines, Tanzania, Thailand). The findings of the 1983 Training Mission have been compiled (Hochstein et al., 1984; Hochstein, 1984) and can be compared with the results of an earlier Training Mission conducted by UNDP in 1980 (Bolton and Hochstein, 1980; Fridleifsson, 1983). Since findings of both missions are based on material supplied by organisations in developing countries and also on information collected independently by each mission, a representative picture of geothermal developments, present manpower and training demands was obtained. Comparisons of the two surveys can be made which can be used to predict future trends in geothermal developments and manpower in Third World countries.

Assessment of the impact of the 1979-1982 Geothermal Diploma Courses (University of Auckland):

The assessment was based on the return of 83% of questionnaires sent to 101 ex-students and of 72% of separate questionnaires sent to their supervisors. Many questions were similar and the returns allow an independent assessment of the training as seen by the employers and the ex-students.

Composition of the group: The group of 101 was made up of 59% earth scientists and 41% engineers, the fellows belonged to the following disciplines: 30% geologists, 19% geophysicists, 10% geochemists, 18X drilling and production engineers, 14% general geothermal engineers, 9% utilisation and plant engineers. At the end of 1983, 68% of the group were working full-time in geothermal projects, 10% had worked part-time and 13% had had no opportunity to take up geothermal work. About 10% of the fellows, mainly with part-time involvement, had left their employers(i.e. attrition rate of 10%). Allowing for the fact that about half of all foreign students are bonded for up to 3 years and that 13% of the sample group had no opportunity of working in geothermal projects, the proportion of retention is very satisfactory. The proportion of retention of trainees from developing countries attending other international training courses is usually lower (between 30 to 45% according to LLO-Sangkok experience).

The 101 fellows of the group were selected out of 186 applicants; ranking by the employers showed that about 60% of the group come from the upper 30% of their professional group.

Performance of the group: An assessment of the overall academic performance based on the assessment of the fellows (first figure) and that of the supervisors (second ffgure in brackets) showed that:

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TABLE 1: Installed Capacities of Geothermal Plants, Actual Staffing Strengths and Training Requirement of Developing Countries (Country Estimates, 1983)

Country	Installed capacity and capacity (b) under construction (MW)	Estimated present staffing strengths (professionals)	No of staff with overseas training	Likely No of applicants for 1984 and 1985 (Auckland Course)	Likely No of candidates Lor 1985-89 (Auckland Course)	No of trainees on 1979-1983 courses
A. Countries with installed and producing geothermal plants						
China P.R.	8.7, (500$_{th}$)[c]	450/9[d]	30	14	80	11
Indonesia	32.5, 110[b]	~110/4	-50	14	45	25
Kenya	31.5, 15[b]	20/2	11	6	15	7
Mexico	205 +, 440[b]	~150?/2	20+	0	2 (85+)[e]	4
Nicaragua[a]	35	- 35/1	~15	?	?	1
Philippines	781	400/5	52	10	36+	20
El Salvador[a]	95	~ 50/1	~15	2	5+	3
Turkey[a]	20 , (30$_{th}$)?[c]	- 45/2	-20	2(?)	4(?)	4
Sub totals	1209+ 565[b]	-1260	~215	48	187+	75
B. Countries with plants (or pilot plants) prepared or committed for construction						
Costa Rica	55	6/1	-5	1	10	0
Guatemala[a]	15	15/1	- 7	?	?	0
India	1+, (10$_{th}$)[c]	50/4	~ 30	4	25	7
Portugal[a] (Azores)	3	?	?	?	?	0
Sub totals	74	71+	42	5	35	7

Country	Discovery	Est.present staffing strengths (professionals)	No of staff with overseas training	Likely No of applicants for 1984-85	Likely No of candidates for 1984-89	No of trainees for 1979-83 courses
C. Countries with proven geothermal fields (not financed yet for preparation)						
Chile[a]	(El Tatio)	?	?	0	?	2
Djibouti[a]	(Coubet-Lake Asal)	7/1	?	?	?	0
Ethiopia	(Aluto)	35/2	~15	6	20	11
Sub totals	-	42+	15+	6	20	13
D. Countries with geothermal prospects defined by pre-feasibility studies or with ongoing drilling programmes or with pre-feasibility studies in progress						
Colombia[a]	-	~15/2	~8	2	3	4
Ecuador		5/1	-4	1	3	1
Thailand	-	20/3	-12	4	11	3
(other countries in group D are: Argentina, Bolivia, St Lucia, Yemen A.R., Dominican Rep., Panama, Peru, Rumania, Vanuatu)						
Sub totals	-	~40	-24	7	17	8
Totals		~1413+	296+	66	259+	103

a) Country not visited by 1983 Geothermal Training Mission.
b) Second figure in this column lists plant capacity under construction or not fully commissioned at the end of 1983.
c) Production of low temperature geothermal fluids (non-electric usage).
d) Number of organisations per country involved in geothermal development or research.
e) Training estimate in parentheses for Mexico relates to local training.

21%[23%] performed better than expected, 54%[70%] as expected, and 25%[7%] performed below expectation.

In terms of average grades achieved in their Diploma examinations, 31% of the group attained above average grades, 51% average, and 18% below average grades; 8% failed the Diploma Course. The group performed significantly better in their projects where practical work was involved and which took 2 months of their study time to complete. Here the performance was 46% above average, 41% average, and 13% below average.

Assessment of the Course by the group: Various aspects of the course were independently assessed by the ex-students (first figure) and by their supervisors (second figure in brackets). The returns showed the following:

89%[92%] found that the aim of the Auckland course was adequate, 7%[6%] thought it was too high, 4% [2%] found that the aims were too low-

Performance of professional routine work after completion of the course was also assessed; 60% (72%] of the group showed significant improvement, 32%[24%] some improvement, and 8%[3%] found there was no improvement. With respect to performance of professional non-routine work, the results were: 78%[59%] significant improvement, 22%[29%] some improvement, 0%[12%] no improvement.

In terms of interaction between fellows and other staff, 88% of all fellows believed that they could present their point of view (related to their own work) more clearly as a result of the course, 64% [40%] thought that they can also assess problems of other disciplines.

On the whole, there is good agreement between the assessment of the course made by the fellows, their supervisors and by the University (academic performance only). The 1983 Training Mission concluded therefore that the Auckland Geothermal Diploma Course meets the training requirements of Third World countries and that transfer of modern technology can be achieved by a one-year University course at the graduate level. Furthermore, such training can be given at a level which is examinable and which adheres to standards which are compatible with those of 4th year graduate courses at the University of Auckland. The academic performance of the group has shown that with appropriate tuition and motivation, students from developing countries can perform as well as New Zealand students.

Assessment of problems experienced by organisations involved in geothermal developments

The 1983 Training Mission also collected information about the status of geothermal projects in developing countries, future development plans, present and future manpower, and training demands which all are interrelated. To assess whether the syllabus of the Auckland Course is realistic and covers adequately problems as faced by the organisations in their present work, information was also collected which defines these problems. The information collected might not be representative since only 60% of all 30 organisations returned the questionnaire. Since the returns, however, cover organisations from 9 countries with a combined working force of about 900 professionals, the replies nevertheless are indicative of problems which might affect other organisations as well.

With respect to staffing, 67X of all organisations agreed that the lack of adequately trained professional staff appears to be the most important factor which impedes geothermal development, whereas the lack of adequately trained technicians and labour was only cited by 33% of the organisation as an impeding factor. The prospect of obtaining suitable staff from universities and technical institutions posed no major problems. The returns quantify, therefore, the relation in demand for trained professional and technicians.

Stages of geothermal development, in which considerable difficulties have been encountered were ranked as follows:

Reservoir engineering (understanding of the reservoir) was cited in 67% of all returns,
reinjection and coping with environmental problems (53%),
the pre-feasibility phase, i.e. problems in selecting one or more prospects for deep exploration drilling (47%).

The least problems were encountered in:

Reconnaissance exploration phase,
plant construction,
production drilling,
fluid transmission,
corrosion and materials,
plant and field maintenance;

which were cited only in 1 or 2 questionnaires.

The problems experienced by 18 organisations appear to be related to topics which supervisors listed when asked to make suggestions as to which topics be covered in more detail in future courses. The topics listed by supervisors were: reservoir assessment (pre-feasibility stage), reservoir engineering, and well measurement; all three topics were cited in about 30% of all their returns.

Status of present and future geothermal developments

As a result of various fact-finding missions and the on-going UNDP/World Bank Energy Sector assessment program, the classification of developing countries with geothermal prospects has been changed from that used in 1980 (Bolton and Hochstein, 1980). The 1983 Mission used the following grouping:

A: Countries with installed and producing geothermal fields.
B: Countries with geothermal plants (or pflot plants) prepared or codtted for construction.
C: Countries with proven geothermal fields (not financed yet for preparation).
D: Countries with geothermal prospects defined by pre-feasibility studies or with on-going exploratory drilling.
E: Countries with significant or suspected significant geothermal prospects where reconnaissance is planned.

This classification has been used in Table 1 which summarises installed capacity of geothermal plants, manpower, and future training demands of all countries in Group A, and for some countries in Group B, C, and D. Table 1 is incomplete and covers mainly countries which have sent students to the Auckland Course between 1979 and 1984.

The 1983 Mission visited countries from each group and found that training demands are highest in group A and B countries.

If one compares the data in Table 1 with similar data in Tables 2, 3a, 3b of Bolton and Hochstein (1980) which summarise the status of geothermal developments in 1980, the following changes and trends are indicated:

The capactty of geothermal plants installed in developing countries (group A) has increased from about 475 MW in 1980 to about 1210 MW at the end of 1983; i.e. an increase by a factor of 2.5. An additional total capacity of 565 MW is under construction or near completton. The direct use of low temperature geothermal energy still is limited and

is documented for only 3 countries in group A which use about 540 MW thermal energy. Future developments related to low temperature usage are not indicated in the survey; developments in all other countries are related to production of electricity.

The total number of countries involved in geothermal developments has slightly increased from 25 countries in 1980 to 28 in 1983. The number of countries in which economic production of high temperature geothermal fluids has been established by deep discovery wells has increased from 11 in 1980 to 14 in 1983. Discoveries can be predicted for most countries in group D.

Many developing countries covered by the survey have experienced difficulties in raising loans for future developments or serving existing debts which will restrict future geothermal developments, although geothermal energy schemes might be less effected than other power schemes. It is therefore possible that the target capacity of geothermal plants by the year 2000 will be lower than that of about 8800 MW estimated in 1980 (Bolton and Hochstein,, 1980). Future discoveries in group D countries, however, might change this.

More than 1400 professionals are presently involved in geothermal work and research in 16 countries (see Table 1). It has been estimated that in 1983 a total of about 2100 f300 professionals were involved, either part-time or full time, in geothermal developments of the 28 countries in groups A, B, C and D. In the documented groups of professional staff (i.e. about 1400) at least 296 have received some overseas training (i.e. about 21%). Of the 296, a total of 103 have been trained at Auckland during 1979 and 1983 (i.e. over a 5 year period).

The number of professionals in group A and group B countries has increased from at least 400 in 12 countries in 1980 to about 1400 in 16 countries in 1983. Even if one allows for the large number of Chinese professionals (see Table 1), who were not covered by the 1980 survey, it appears that the number of professionals involved in geothermal work has almost doubled between 1980 and 1983 and thus has overtaken the increase as predicted in 1980. Allowing for this development, the 1983 Training Mission predicted that for the 'period betwen 1984 to 1989 global training of at least 500 geothermal specialists from all countries in group A to E will be required. The demand for training at Auckland has increased; in 1980 a total of 154 potential candidates from 12 countries were indicated for a 5 year period whereas in 1983 this number has increased to 260 candidates from 13 countries for the same period.

Possible trends in future training

If one considers the developments in geothermal training whfch have taken place between 1980 and 1984, the following trends are indicated:

1. Some training will be taken over by national courses which will be established by 1990 in countries with high training demands. A national training course was established in 1983 in Mexico (University of Mexicali) vith a first intake of 12 students. Other national training courses will probably be established during the next 5 years in China P R, Indonesia, and the Philippines. Development of specialised training will depend on the establishment of research (graduate) schools.

2. Demand by developing countries for graduate study training (i.e. study for ME, MSc, PhD) involving highly qualified professionals will increase significantly in the near future. The demand for graduate study training of ex-Diploma students has increased rapidly at Auckland between 1981 and 1983. Restricted entry to the graduate school attached to the Geothermal Institute had to be introduced in 1983. At present, the annual intake at Auckland balances the output '(about 4 candidates per year). Over 25 professionals from developing countries are presently undertaking geothermal research studies at the graduate level in the US. Any significant development of national geothermal training courses and establishment of research schools in developing countries, however, will depend upon training of suitable candidates who have to run these courses.

3. Demand for short-term specialised national and inter-regional courses will increase. At present such short-term courses are given on an irregular basis in Indonesia, The Philippines, and at the OLADE Headquarters in Quito (Ecuador) for all Latin American countries.

4. The output of the four established international training courses at Auckland (New Zealand) and Reykjavik (Iceland) which cover overview and special training, and at Pisa (Italy) and Kyushu (Japan) with less emphasis on special training, will not increase significantly in the future; the present output is about 35 fellows per year for the first two centres and about 25 to 30 fellows per year for the last two courses (Pridleifsson, 1983).

If one assumes that the demand for training will continue to increase, it appears that the development of national geothermal training courses is highly desirable and that sponsorship of the curriculum development of such courses should be favourably considered already at this stage by international and bi-lateral aid agencies.

CONCLUSIONS

Twenty eight developing countries are presently involved in the development of their geothermal resources; this work is carried presently by a manpower of about 2100 professionals of which about 20% have received some training in developed countries. Demand for future training is high (about 500 professionals between 1984 and 1989). The rate of development of geothermal power in 11 countries which lead to an increase of installed plant capacity by a factor of about 2.5 between 1980 and 1983, will probably decrease slightly in the future but the predicted training demand appears to be unaffected by possible retrenchments.

The impact of the Auckland course is significant since about 35% of all professionals from 16 countries covered by ,this survey, and who had been trained overseas, received their training at Auckland between 1979 and 1983. Both employers and ex-students rate the 1979-1982 Geothermal Diploma Courses as satisfactory and most employers stated that the performance of the fellows had significantly increased after attending the course. This achievement was made possible by the Division of Global and Inter-regional Projects UNDP and the Aid Division of the NZ Ministry of Foreign Affairs, who have sponsored the Auckland Courses since 1979.

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