PRESENT AND FUTURE GEOTHERMAL PROGRESS IN DEVELOPING COUNTRIES AND MANPOWER TRAINING

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ABSTRACT

Present and future geothermal development and training demands for professionals in developing countries with significant geothermal resources have been assessed recently. An accelerated growth in the usage of geothermal energy for electricity generation is predicted from target figures for at least seven countries. During the next twenty years this growth might lead to a twenty fold increase of the total plant capacity presently installed. The accelerated development of geothermal energy will bring about a continuously increasing demand for trained professional manpower which has to be significantly increased to cope with future requirements. No information is available about the size of this increase but on the basis of foreseeable workloads it is estimated that an overall 3 fold increase of manpower might take place during the next ten years.

INTRODUCTION

An assessment of current and future usage of geothermal energy in developing countries, which sent fellows to the 1979 and 1980 Diploma Courses in Geothermal Technology at the University of Auckland, was recently undertaken by a UNDP Mission (Bolton et. al. 1980). In May 1980 the Mission visited twelve countries with on-going geothermal programmes and collected data about the status of geothermal work in fourteen other countries which are developing, or plan to develop, their geothermal resources. In addition, information was sought about the number of earthscientists and engineers required for on-going and future geothermal projects who would benefit from training in geothermal technology.

Although the information was collected to assess the future demand for the UNDP sponsored diploma course at Auckland, the Mission was able to obtain a good overview of actual and planned geothermal investigations in developing countries which is not well documented elsewhere. Since current and future development of geothermal energy together with related manpower requirements are of some interest to members of the New Zealand geothermal community, who have been involved in geothermal projects in some of these countries for almost twenty years, a summary of findings of the Mission is presented.

Status of current and future geothermal progress

The present status of geothermal development in the countries covered by the 1980 Mission report (Bolton et. al. 1980) varies from the stage of a reconnaissance survey to that of generation from large electrical power plants. In general, the current development appears to be related to the status of inventory work of geothermal prospects in each country. An assessment of this status is given in Table 1. In this table only geothermal fields which produce, or can produce, high enthalpy fluids ($> 8 \times 10^3$ J/g) are listed and classified as follows:

- developed (geothermal power plant has been installed or construction for such plant is in hand).
- proven (field has been proven by deep drilling),
- probable (field has been identified by scientific studies but no deep drilling has been attempted),
- possible (field has been identified by reconnaissance studies, more detailed scientific studies are required).

The majority of fields are in the category of possible and probable fields. In some countries the number of possible and probable fields may be greater than that listed; the figures cited, however, are based on inventory studies. It is likely that exploration of possible and probable fields will be dominant in near-future development programmes which explains why the demand for earth scientists at present exceeds that for engineers.

Present utilization of geothermal energy in countries which developed fields (Table 1) is restricted to electricity generation by using high enthalpy fluids. Only a few countries (China, India, and Turkey) are considering non-electrical usage of low enthalpy fluids on a pilot scheme basis; however, a few test plants for electrical usage of low enthalpy fluids have been built in China.

The installed capacity of geothermal power plants in developing countries, together with that planned for 1985 and for the year 2000, is listed in Table 2, this data upgrades similar infomation published recently (Di Pippo, 1980). An accelerated increase in use of geothermal power can clearly

Table 1. NUMBER OF GEOTHERMAL FIELDS IN DEVELOPING COUNTRIES AT VARIOUS STAGES OF EXPLORATION AND DEVELOPMENT

	Developed	Proven	Probable	Possible
* Argentina	-	-	-	10 a/
* Bolivia	-	-	1	- b/
Chile	-	1	1	3
* Colombia	-	-	2	- b/
Costa Rica	-	1	2	- b/
* Djibouti	-	1	-	- b/
* Ecuador	-	-	3	7
El Salvador	1	2	1	4
* Ethiopia	-	-	4	- b/
* Guatemala	-	1	2	- b/
* Haiti	-	-	-	1
Honduras	-	-	4	7
India	-	-	3	- b/
* Indonesia	1	2	5	10 a/
Jamaica	-	-	-	1
Kenya	1	-	2	- b/
* Mexico	1	2	5	10 a/
* Nicaragua	1	-	1	5
* Panama	-	-	1	5
People's Republic of China.	1	(?)	(?)	- b/
* Peru	-	-	-	4
* Philippines	3	2	1	7
* Republic of Dominica	-	-	1	3
* Republic of Tanzania	-	-	-	- b/
* Turkey	1	-	4	10 a/
Venezuela	-	-	-	1
Total	10	12	45	98(+)

* Countries not visited by the mission.

a/ The information available suggests that there may be a large number of potential fields, but no figures are available. An arbitrary upper limit of 10 has been placed on these in the table.

b/ The information available suggest that there are potential fields, but there is no indication of how many.

be predicted for developing countries from the figures listed in Table 2. Whereas it took at least ten years to establish the present generating capacity of about 430 MW in three countries (Mexico, Philippines, and El Salvador), it is likely that installation of plants for about an additional 680 MW may only take five years. The most rapid progress will take place in the Philippines but at least seven countries are planning to use geothermal energy by the year 2000 as a major energy source to satisfy their existing and predicted electricity demands. These countries have made tentativeplans allowing for a further increase to a total of about 7700 MW capacity between 1985 and 2000.

If these developments are normalized for five-year periods, the figures cited point to an overall 3 fold increase in developnent rates in post 1985 five-year periods. Implications of such high development rates in relation to manpower requirements are:

a) some realistic, forward planning of manpower requirements in relation to future targets has to be started at this stage, in all countries with major development plans,

b) there will be an accelerated demand for trained staff by developing countries with major targets.

Table 2. INSTALLED AND PLANNED GENERATING CAPACITY OF GEOTHERMAL PLANTS IN DEVELOPING COUNTRIES AS AT MAY 1980.

country	Installed capacity (MW)	Under construction (MW)	Planned capacit (total) by 1985 (MW)	Target capacity by year 2000 (MW)
Costa Rica	-	-	40	up to 380
El Salvador e/	60	35	150	up to 500
Ethiopia	-	-	15	a/
India	-	1 b/	a/	a/
Indonesia	0.25 c/	30	150	up to 2,000
Kenya	-	15	30	a/
Mexico	150	30	180 d/	up to 4,000
Nicaragua e/	-	35	70	up to 720
		6	a/	a/
		202	425 d/	up to 1,250 f/
		20	20	a/
Total	436	374	about 1,100	up to 8,850

Notes:

a/ No forecasts have been made.
b/ Non-electrical use (refrigeration plant).
c/ Experimental units.
d/ Further expansion planned by 1985 (but details not immediately available).
e/ Not visited during mission
f/ By 1990 (deadline might be shortened).

Manpower requirements and training needs

The term "manpower requirements" is used here in a narrow sense and relates only to a group of professionals (i.e. excluding technicians) required to carry out a given geothermal programme within the time limit set by the country's development targets. It is assumed that most of these professionals would benefit from training in developed countries to achieve these targets. The Mission also estimated the numbers of professionals presently engaged in geothermal programmes, excluding the contributions made by aid agencies and contractors. The figures for present manpower, Tables 3a and 3b, are only rough estimates, especially for countries where more than one agency is involved.

Two different approaches were used to assess manpower requirements:

1) collection of country estimates through an exchange of views between the national authorities and members of the Mission.
2) Estimates by the Mission on the basis of forseeable workload.

In collecting this information, the Mission found that there is a lack of manpower planning even for close targets, with the exception of two countries with an established record of geothermal development (Mexico and the Philippines). It was also found that little was planned because of a lack of expertise in this field, as well as the uncertainty which prevails at some critical stages of geothermal development (especially at the prefeasibility stage).

The country estimates for training were primarily collected to obtain an idea about the likely future demand for the UNDP sponsored Diploma Course at the University of Auckland. Training requirements for the periods of 1981-1982 and 1981-1985 are listed in Table 3a for countries visited. A minimum of 82 candidates for the next *two* years and of 154 candidates (five countries only) for the next five year periods is indicated.

These are quite large figures considering that the total "geothermal manpower" of these countries is only about 400 of which about 10% (total of 38 fellows) have already obtained some specialised training at the University of Auckland during 1979 and 1980. It is possible that the figures for manpower training listed in Table 3a might have been overestimated for a few countries and underestimated for most others. For 1981-1982 the training estimates, however, are based on more certain grounds and reflect realistic needs.

Information about professional manpower requirements for geothermal developments, and hence an estimate of manpower training, is not well documented. UN agencies have already noted this problem (United Nations University, 1979). Any short term demand for such manpower can usually be

Table 3a: ACTUAL MANPOWER AND MANPOWER REQUIREMENTS OF MISSION COUNTRIES (COUNTRY ESTIMATES)

country	Installed capacity and capacity under construction (MW)	Estimated present manpower (professionals)	Indicated number of applicants for 1981 and 1982 courses	Number of candidates interviewed	Likely maximum of candidates for 1981 to 1985 courses	Number of trainees of 1979-1980 courses
(a) Countries with installed plants or plants under construction						
People's Republic of China	ab. 8(?)	large a/	up to 12	-	up to 25 c/	6
Indonesia	30	ab. 50	15	9	up to 25 c/	8
Kenya e/	15	ab. 15	8	2	up to 15	3
Mexico	180	ab. 100	up to 8	3 b/	up to 20	2
Philippines	223	ab. 80(+)	up to 12	9 b/	up to 25 c/	7
Turkey e/	20	ab. 35	5	1	up to 12	1
(b) Countries with proven fields or prospects under exploration						
Chile e/	-	ab. 10	1	1 b/	- a/	2
Costa Rica	-	4	1	1 b/	- b/	-
Ecuador	-	ab. 5	3	3 b/	- a/	-
Ethiopia d/	-	ab. 10	6	6	up to 12	2
Honduras d/	-	- a/	1 or 2	1 b/	- a/	-
India d/	-	ab. 30(+)	10	3	up to 20	3
Totals	476	ab. 340(+)	up to 82	39	up to 154	34

Note:

a/ No reliable information available
b/ No proper interview was made except noting the interest of these candidates
c/ Maximum number estimated by Mission on the assumption that only a few candidates might be submitted by countries with smaller development (i.e. figure gives maximum number of candidates who could be accommodated at Auckland).
d/ Countries with on-going geothermal projects assisted by UNDP
e/ Countries with previously sponsored geothermal projects by UNDP

satisfied in developed countries by a pool of contractingcompanies and sometimes by pooling of manpower between government and government controlled institutions. In developing countries these manpower resources usually do not exist.

Since training needs of countries not visited by the Mission are rather incomplete (see, for example, Table 3b), some independent estimateswere made by the Mission.

The first estimate was obtained by using the predicted accelerated rate of development of geothermal power (see Table 2) as a starting point. Although the impact of various factors, which will affect the predicted growth in geothermal manpower, could not be fully assessed (for example, contribution by contractors and aid programmes, repeated employment of staff in more than one geothermal project, staff losses due to normal attrition etc), the Mission predicted an average staff (professional) growth rate of at least 1.5 for subsequent five-year periods for countries with major geothermal development targets. Using the figures for presently employed manpower as listed in Table 3a, this implies a total increase of more than 400 professionals for the twelve countries by the end of this decade. The growth rate is similar to that cited for Central American countries for 1980 to 1985 in the UNU report (United Nations University, 1979).

A second estimate was made considering the case of thirteen Latin American counfries which at present have no geothermal plants under construction but which already are involved in geothermal programmes. Assuming that all of these countries would try to establish viable self-contained institutions leading to the development of one pilotpowerplant per country within the next ten years, and allowing for present staff, the Mission estimated that a total of about 300 professionals could be required over the next ten years; these numbers are not included in Tables 3a or 3b.

Taking all estimates into consideration, the Mission predicted an almost exponential growth in demand for geothermal training (and geothermal expertise) for this decade and this will probably continue to the end of the century.

CONCLUSIONS

About twenty-five developing countries are presently pursuing or considering, using geothermal energy; twelve of these countries were visfted this year by a UNDP Mission to assess theirtraining requirements. The technological "break-through point" has been reached in three of these countries (Mexico, Philippines, and El Salvador) with a total installed capacity of geothermal power plants of about 430MW (i.e. about 25% of the total worldwide capacity of geothermal plants in 1980).

The total capacity of plants under construction in six countries (Indonesia, Kenya, Mexico, Nicaragua, El Salvador, and Turkey) is about 370MW. An accelerated development of geothermal power is indicated for seven countries by target figures of about 1100 MW of total capacity by 1985 and of about 9000 MW by the year 2000.

An accelerated demand for training of professionals can be predicted for this decade from these targets. About 400 earth scientists and engineers are involved in the present geothermal programmes, supported by professionals from private industry and aid agencies. It is estimated that the present geothermal manpower of developing countries has to be increased by about 50 to 100% for subsequent 5 year periods (i.e. by about 500 to 1200 between 1980 and 1990) to achieve the targets.)

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Table 3b: INFERRED MANPOWER *AND* MANPOWER OF COUNTRIES NOT VISITED BY MISSION (BUT WITH ESTABLISHED INTEREST IN THE AUCKLAND COURSE)

Country	Installed capacity and capacity under construction (MW)	Estimated present manpower (professionals)	Indicated number of applicants for 1981 and 1982 courses	Number of candidates interviewed	Likely maximum of candidates for 1981 to 1985 courses	Number of, trainees of 1979-1980 courses
Guatemala	-	ab. 8	1	-	- a/	-
Nicaragua e/	35	- a/	- a/	-	- a/	1
Panama	-	ab. 7	1	1 b/	- a/	-
El Salvador e/	95	ab. 25	- a/	-	- a/	1
Tanzania	-	- a/	- a/	-	- a/	2
Total	130	ab. 40(+)	2	1	-	4

Note:

a/ For meaning of notes a/, b/, e/ see footnotes in Table 3a.

b/ Other developing countries (adjacent to Mission countries) which are involved with some geothermal reconnaissance studies are: Argentina, Bolivia, Caribbean, Djibouti, Peru; it is possible that some of these countries might send a few candidates to the Auckland course from 1982 onward if they were invited to do so.