UNITED NATIONS
DEVELOPMENT
PROGRAMME

UNDP

Distr.
GENERAL

DP/1982/41
5 April 1982

ORIGINAL: ENGLISH

GOVERNING COUNCIL
Twenty-ninth session
June 1982, Geneva
Agenda Item 6 (e)

POLICY

OTHER FUNDS AND PROGRAMMES

UNITED NATIONS REVOLVING FUND FOR NATURAL RESOURCES EXPLORATION

Geothermal Energy

Report of the Administrator

Summary

In accordance with Decision 81/24 of the twenty-eighth session of the Governing Council, the Administrator herewith reports on the nature and scope of requests for assistance in the field of geothermal energy and on the capacity of the Revolving Fund to respond thereto.

Virtually all developing countries having potential for geothermal energy exploitation in the near future have been surveyed. The immediate requirements for financial and technical assistance are considerable and will increase rapidly during the 1980s.

The Administrator herewith provides an analysis of the situation and in paragraphs 24 and 25 provides his conclusions concerning further action.

INTRODUCTION

1. In June 1981, at the twenty-eighth session of the Governing Council, the Administrator submitted the report and recommendations of the Working Group of Government Experts concerning the United Nations Revolving Fund for Natural Resources Exploration, amongst them specific recommendations concerning geothermal energy. The Governing Council decided to review at its twenty-ninth session the possible expansion, under its mandate, of the Fund's activities into geothermal energy exploration in the light of relevant decisions taken at the United Nations Conference on New and Renewable Sources of Energy in Nairobi in August 1981. The Administrator was further requested to report on the nature and scope of requests for assistance in the field of geothermal energy and the capacity of the Fund to respond thereto. The present report has been prepared in response to that request.

2. The Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy calls for "additional and adequate funds to meet the growing requirements for preliminary supporting actions and pre-investment activities related to the development of new and renewable sources of energy in developing countries"[1/] and reaffirms that "specific and additional resources should be directed through such channels as the United Nations Development Programme, the United Nations Revolving Fund for Natural Resources Exploration, the long-term financial arrangements for science and technology, the United Nations Development Programme Energy Account and others directly and indirectly involved, in accordance with national plans and priorities."[2/]

3. The present report is based on fact-finding missions by Fund staff and specialized staff from the United Nations to some 20 developing countries, co-ordinated by a joint task force. Information on other countries was sought by correspondence and, in the absence of a reply, by research.

4. The review was restricted to those countries with potential for HE (high enthalpy) geothermal systems suitable for power generation,[3/] since only a small minority of developing countries, principally China, the Democratic People's Republic of Korea, Hungary, and the Republic of Korea, use hot fluids for space heating in colder climates. In addition, only those areas favourably situated for exploitation of geothermal reserves before the year 2000 were considered.

1/ The Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy (United Nations publication, Sales No. 81. I. 24). p. 34.

2/ Ibid., p. 34.

3/ HE systems are generally regarded as those with fluids at temperatures greater than 180 degrees centigrade.

I. RESUME OF THE REVIEW OF GEOTHERMAL ENERGY DEVELOPMENT AND EXPLORATION IN THE DEVELOPING COUNTRIES

5. Some 50 developing countries have the potential for geothermal energy production. These countries are geographically distributed rather evenly between Africa, Asia and the Pacific, and Latin America. Only seven of the 50 are among the least developed countries (LDCs) and these seven are all in Africa. Only 13 developing countries have demonstrated geothermal potential, i.e. they have actual production plants under construction or fields proven by exploratory drilling.[4/] In one other country pre-feasibility work indicates a definite HE geothermal source, raising the number of countries with demonstrated geothermal potential to 14. Twenty-five additional countries have varying degrees of hope that reconnaissance and pre-feasibility studies[4/] will raise them into the above group; from the other countries insufficient data was available for the review .

6. In annex I, the current situation of HE geothermal energy development and exploration in the developing countries, as far as could reasonably be ascertained, is summarized by stage of development.

Category A, installed geothermal production capacity:

7. At present seven developing countries are producing electricity from geothermal energy and only four of these to any significant extent. At the end of 1981 the total geothermally generated installed capacity of the developing countries was approximately 740 mega watts (MW).

Category B, geothermal fields being prepared for production, with assured financing:

8. Generating capacity is currently being installed in another three countries and significantly increased in some of the others. In addition, production capacity is being expanded in currently exploited fields in Indonesia, Kenya, Mexico and Turkey.

Category C, proven geothermal fields, not financed for production:

9. Three additional countries (Chile, Costa Rica and Djibouti) are known to have a proven, hitherto unfinanced geothermal resource, and at least four countries from Categories A and B are seeking finance needed to bring new fields into production.

10. The activities in categories A-C are all beyond the proposed terms of reference for the Fund's involvement in geothermal exploration.[5/]

[4/] See annex II for definitions of these terms as used in this report.
[5/] See the Report of the Working Group of Government Experts on the United Nations Revolving Fund for Natural Resources Exploration (E/1981/23).

Category D, geothermal prospects defined by pre-feasibility studies for an exploration drilling programme:

11. At least 14 countries currently require an exploration drilling programme on one or more prospects. In addition to the seven countries listed in paragraphs 8 and 9 above, there are Argentina, Bolivia, Colombia, Ethiopia, Guatemala, Uganda and Yemen. Assuming a suitable drilling rig is available, the average cost of a successful project involving 3 deep wells is estimated at US$ 8.5 million (in the range US$ 7-12 million depending on local conditions). Exploration drilling in Ethiopia and India is currently being undertaken and being charged to the Indicative Planning Figure (IPF); both of these countries are considered to have other areas ready for exploration drilling.

Category E, geothermal reconnaissance studies indicating areas for pre-feasibility studies:

12. At least 23 countries require pre-feasibility studies prior to exploration drilling, including 12 additional countries: the Dominican Republic, Ecuador, Fiji, Grenada, Honduras, Madagascar, Panama, Papua New Guinea, Peru, Thailand, Vanuatu and Venezuela. The average cost of such studies is in the order of US$ 1 million but it may range from US$ 0.5 million in relatively straightforward cases to US$ 3.5 million in cases where small-diameter, shallow, multipurpose bore-holes are required. Such projects normally continue the verification of any indicated resource by exploration drilling. The estimated total average cost per successful project is US$ 9.5 million.

Category F, geothermal reconnaissance studies still having to be carried out:

13. In a large number of countries reconnaissance studies still have to be carried out. Such work normally costs in the order of US$ 0.25 million for each area or small country; and may be charged to the national IPF and handled by organizations such as the Latin American Energy Organization (OLADE) or by bilateral aid programmes such as those offered by France, Italy, New Zealand, the United Kingdom of Great Britain and Northern Ireland and other countries. A continuous stream of projects will be graduating from this category to Category E, and will require additional financing in the future.

14. For purposes of financial projections the proposed activities of the Fund are restricted in this report to countries in Categories D and E, i.e. to pre-feasibility and exploration drilling projects. Only under exceptional circumstances would the Fund be involved in reconnaissance studies.

15. To date 15 projects in the field of HE geothermal energy in 13 countries have been financed under the UNDP IPF.

(a) In four countries (Chile, El Salvador, Kenya and Turkey) the projects have involved exploration through to the proving of an exploitable resource. Exploration drilling projects are currently underway in Ethiopia and India.

Such activities are similar to those proposed for the Fund, except that in these IPF-funded projects the work normally began with reconnaissance studies;

(b) In Nicaragua another project went as far as a successful pre-feasibility study, with a field subsequently proven by drilling financed from other sources;

(c) Four of the projects have been essentially reconnaissance (Honduras, Kenya, Madagascar and Panama) and have developed prospects for further work which has been followed up only in Kenya to date; and

(d) Another four projects dealt with training and specialized technology (Djibouti, Mexico and Philippines (2)).

II. REACTION OF GOVERNMENTS TO REVOLVING FUND'S ENTRY INTO GEOTHERMAL ENERGY EXPLORATION

11. The reaction of the Governments to the proposed entry of the Revolving Fund into geothermal exploration may be summarized as follows:

(a) Five Governments have expressed interest in seeing the Fund embark on exploration drilling programmes immediately. These were Costa Rica, Guatemala, Mexico, Turkey, and Yemen. Three others - Nicaragua, Thailand and Vanuatu - were interested in the Fund carrying out exploration drilling if the results of pre-feasibility studies currently underway were positive.

(b) Four additional Governments - Honduras, Indonesia, Papua New Guinea and the Philippines - were interested in the Fund embarking on pre-feasibility studies followed by exploration drilling; and

(c) Numerically, the largest class of requests was for reconnaissance programmes; however, such studies do not fall within the Fund's anticipated sphere of activities (See paragraphs 14 and 24).

17. Of the 20 or so countries surveyed directly, only one was not interested: Madagascar, which has never accepted the modalities of the Fund. Chile, which is in the process of defining its national policies; Kenya, which currently has assistance in geothermal exploration under a second IPF-funded project; and Djibouti, which already has access to sufficient funds, were not interested at the present time.

18. The proposed replenishment formula, namely 5 per cent of the fair market value of the energy produced, payable for a period of 15 years or until a ceiling of three times the Fund's costs in constant prices is reached, formed an integral part of discussions with would-be recipient countries. This formula was generally considered to be equitable. Obviously, more detailed discussions and comments would ensue during project development negotiations.

III. FINANCIAL CONSIDERATIONS

19. Based on the investigations referred to above, and neglecting other factors such as the essential and all-important economic feasibility studies, present identified global financial requirements for geothermal exploration projects in the developing countries over the next few years may be indicatively estimated as follows:

	US$
10 exploration drilling programmes	85 000 000
24 pre-feasibility studies, 12 of which would probably continue to the exploration drilling stage	126 000 000
TOTAL	211 000 000

It is further considered that there are at least 12 countries requiring reconnaissance studies which would cost an additional US$ 3-4 million.

20. On the basis of the above estimates, countries showing interest in using the Fund have proposed projects with financial requirements in the order of US$ 40 million based on a phased approach to project development.

21. The Fund considers it reasonable to begin one project in each of the years 1983, 1984 and 1985, provided that sufficient financial support is forthcoming. The average cost of a successfully completed, large (50-200 MW) project, consisting of both pre-feasibility studies and exploration drilling, is expected to be in the order of US$ 7-12 million over a 2-3 year period. Such funding would provide only some 10 per cent of the interested countries' present financial requirements, which are expected to escalate in the next few years as the developing countries begin to realize their geothermal potential.

22. The Fund's approach to geothermal projects would be essentially the same as in its other mineral exploration projects, i.e. a phased approach involving a Minimum Work Programme of expenditure, followed by a phased second stage if warranted. As the success rate of geothermal projects at the exploration drilling phase is higher than in mineral projects, a lower replenishment ceiling with an operating period of 15 years has been proposed for projects ending in production (i.e. three times the Fund's project expenditure in constant prices as opposed to ten times project expenditures for solid minerals).

IV. PROJECT SELECTION

23. In selecting geothermal projects for execution, the Fund would take the following special factors into account:

(a) The priorities, over-all requirements and possibilities for the development of all sources of energy, including new and renewable resources, within the country concerned;

(b) Confirmation during the initial stages of project development of third party interest (e.g. World Bank or regional development banks) for potential investment follow-up if the exploration is successful;

(c) The possibility of co-financing with specific donor countries or international organizations at the exploration stage.

V. CONCLUSIONS

24. There is an obvious immediate demand by a number of developing countries for additional financing and technical assistance for the various stages of geothermal development. The Fund is particularly well adapted for prefeasibility and exploration drilling programmes and would provide an additional source of funding to that available from the IPF and the UNDP Energy Account, which will continue to be used for all categories of geothermal activities. As the Fund is not specifically involved in general reconnaissance work or training and research activities, ways and means of combining Fund and IPF inputs on particular projects should be an important consideration in project design.

25. Although the Fund presently does not have an adequate financial reserve to undertake large-scale geothermal projects in the order of US$ 10 million each, by authorizing the Fund to extend its activities into this field it is hoped that impetus will be given for additional contributions to the Fund for this purpose. The approval of one project per year over the next few years appears to be a reasonable target.

- - - - -

Annex I

CURRENT GEOTHERMAL DEVELOPMENT AND EXPLORATION ACTIVITY IN THE DEVELOPING COUNTRIES

A. Countries with Actual Installed Geothermal Production Capacity at the End of 1981:

	Megawatt(MW) Capacity	Number and name of fields
Philippines*	446	4 Mak-Ban, Tiwi, Tongonan, Palimpinon
Mexico*	180	1 Cerro Prieto
El Salvador	95	1 Ahuachapan
Kenya*	15	1 Olkaria
Indonesia	2.25	2 Kamajang, Dieng
China	2.0	6 Yang-pa-ching
Turkey*	0.5	1 Kizildere
TOTAL	740.75	

B. Countries with new Geothermal Fields Currently Being Prepared for Production with Assured Financing

India (1 MW), Mexico, Nicaragua* (35 MW), Philippines (220 MW), Portugal

C. Countries with Proven Geothermal Fields not Financed as yet for Production

(i)**	Chile	(ii) El Salvador
	Costa Rica*	Indonesia
	Djibouti*	Philippines

D. Countries with Geothermal Prospects Defined by Pre-Feasibility Studies for an Exploration Drilling Programme

(i)	Argentina	Guatemala*	(ii) Costa Rica	Mexico
	Bolivia	Uganda	Djibouti	Nicaragua
	Colombia*	Yemen*	El Salvador	Turkey
	Ethiopia*		India	

---

* Indicates country visited for review.
** In categories C-F, (i) lists new countries and (ii) lists countries already listed in a higher category.

E. Countries where Geothermal Reconnaissance Studies have Indicated Areas for Pre-Feasibility Studies

(i)	Dominican Republic	Panama*	(ii)	Bolivia	Indonesia
	Ecuador*	Papua New Guinea		China	Kenya
	Fiji	Peru*		Djibouti	Mexico
	Grenada	Thailand*		El Salvador	Nicaragua
	Honduras*	Vanuatu		Ethiopia	Philippines
	Madagascar	Venezuela		India	Turkey

F. Countries where Geothermal Reconnaissance Studies Still Have to be Carried out

(i)	Algeria	St. Lucia	(ii)	Costa Rica	Papua New Guinea
	Burma	St. Vincent and the Grenadines		Honduras	Philippines
	Democratic Yemen	Sudan*		Kenya	Yemen
	Dominica	United Republic of Tanzania*		Panama	
	Mozambique	Viet Nam			
	Rwanda				

- - - - -

Annex II

I. TERMS USED IN THIS REPORT TO DEFINE VARIOUS STAGES OF GEOTHERMAL EXPLORATION PROJECTS

(A) Reconnaissance Study, comprising regional and/or semi-detailed investigations of a mainly geological and geochemical type.

(B) Pre-feasibility Study, including investigation of the prospect area(s) by detailed geology and geochemistry and by specific geophysical prospecting. In special circumstances, the pre-feasibility study may include the execution of some small-diameter drilling (slim holes); and

(C) Feasibility Study, having two main stages:

(a) exploration drilling, including a limited number (2-4) of wells and (b) production drilling and engineering, including the drilling of a number of wells sufficient to demonstrate the availability of the fluid required to supply the first permanent power unit (or of the thermal plant in case of direct use).

II. ADDITIONAL TECHNICAL INFORMATION

Additional technical information may be found in the Report of the Technical Panel on Geothermal Energy for the second session of the Preparatory Committee for the United Nations Conference on New and Renewable Sources of Energy, December 1980 (A/CONF.100/PC/23).

- - - - -