GEOTHERMAL ENERGY IN DEVELOPING COUNTRIES: ADVANTAGES AND CONSTRAINTS

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Abstract: This paper deals mainly with the advantages and how geothermal energy competes with other options for power generation based on Several case studies known to the author. The paper continues to discuss the factors that constrain a greater activity in geothermal energy projects in developing countries.

1. INTRODUCTION

Geothermal energy - the natural interior heat of the earth - is believed to originate from the slow decay of radioactive material in the earths crust. This energy is transmitted to the earth's surface everywhere. However, in most regions it is too diffuse to be noticed. In other regions of recent volcanism generally associated with the earths crustal plate boundaries there are large reservoirs **of** heat at shallow depths resulting from the intrusion of molten rock. In some areas, surface water comes into contact with the hot rock and the naturally heated water or steam forms convective flows, making it some of rise it toward the surface. The results may be such natural phenomena as geysers or hot springs.

The presence of water in a permeable bed **is** of great practical importance because it allows a much faster withdrawal of part of the sensible heat of the formations than heat conduction would. Yet, of the sensible heat of a formation saturated with water, only a small fraction is withdrawn with the fluids. Most current utilizations of geothermal energy rely on the presence of hot water or steam that can be tapped by drilling wells. The steam andlor hot water produced from a geothermal field can be used for space-heating and process heating and electric power production, the latter being the most practical and popular use of geothermal energy Since converting it to electric power facilitates its transmission and uses.

The basic geothermal technologies for the utilization of convective hydrothermal resources are mature, although there remain areas where improvements and newtechnologiescould lower the cost of geothermal generation, thus ensuring the stability and longevity of the industry. These technologies include geosciences technologies for exploration, field development, conversion technologies **for** drilling, and power plant equipment. Some twenty-four countries currently utilize their geothermal resources. In addition there are twenty-eight countries with untapped high-enthalpy resources, and dozens with significant low **or** medium enthalpy resources. The majority of the geothermal resources are located in developing countries

It has been recognized for some time that geothermal energy could make a significant contribution to the national energy supply of the developing countries where it **is** abundant.

The purpose of this paper is to present: (i) the comparative advantages of geothermal power development versus the other generating options, (ii) the constrains that impede an aggressive geothermal development; and (iii) the effect of the current institutional reforms on future geothermal developments.

2. POTENTIAL **OF** GEOTHERMAL ENERGY DEVELOPMENT IN DEVELOPING COUNTRIES.

The geodynamic situation of some developing countries, for example those located on the Pacific Coast or "Ring **of** Fire", characterized by active volcanism, is an ideal Setting for high-enthalpy geothermal fields. This exceptional environment led, in the past. a large number of developing countries to step up geothermal exploration programs.

Various attempts have been made to estimate the magnitude of the total energy that may be recovered from the geothermal energy resources of a country or a region, for example, the attempt made in Central America to estimate the geothermal potential in the six countries **of** the Central American Isthmus. for a planning study of the electrical interconnection of those countries. The estimate was based on the evaluation of two parameters: (i) the probable number of geothermal fields in the area, as inferred from available geologic and geochemical information. and the distribution patterns of the thermal waters; and (ii) the probable productivity of those potential fields as inferred from a statistical analysis of fields being developed in the region and elsewhere in the world. IDB/OLADE (1994), indicate that the "volume method in which calculations of the accumulated heat are performed, assuming "localized systems or sealed systems", is the most commonly used to estimate the resource base. However, geothermal experts have difficulty in stating with confidence how much of the geothermal energy resource base can ultimately be developed in a given country or region.

Much has been learned of actual thermal conditions and processes in the continental crust and upper mantle. but before the first exploratory deep wells are drilled, the industry has no credible data of the geothermal energy potential to convince national planners to include geothermal development in national energy plans. The inclusion of geothermal energy programs in energy national plans would be the appropriate incentive for the national authorities to propose laws and regulations for enhancing geothermal energy development.

3. PAST AND CURRENT ACTIVITIES IN GEOTHERMAL ENERGYDEVELOPMENT

Today there are more than 6000 MW of generating capacity on-line in seventeen countries. In the Latin American and Caribbean countries, which are of primary concern **of** the IDB, utilization **of** geothermal energy has been essentially in power generation, with four countries accounting for a total installed capacity of 920 MW . Another 110 MW are under construction or have been approved: Costa Rica (55 MW), Nicaragua (35 MW) and Guatemala (20 MW). A study carried out by GeothermEx (1985) for the World Bank, indicates that all the countries of the Americas, except Paraguay, have geothermal energy resources.

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Some of the countries were classified as having hundreds or perhaps thousands of megawatts (Mexico, Central American Countries, and Chile). Others were classified as having moderate but important potential for power generation (Argentina. Bolivia, Colombia, Peru and Venezuela). and the rest with low potential of the medium and low enthalpy type (Brazil and Uruguay)

Prime examples in the developing world of countries with outstanding geothermal resources are the Philippines and Indonesia, with estimated total potentia reserves of 8,000 MW and 16.000 MW, respectively.

It is clear, when one considers the geothermal energy potential of the developing countries, that the already installed capacity or under construction. had not been commensurate with this potential. Several known factors explain this predicament: (i) the lack of sufficient knowledgeable personnel with experience in geothermal exploration and development; (ii) hesitant attitude of the decision makers due to the risk and uncertainty associated with this resource. thus tending to favor more traditional power investments; (iii) the lack of laws related to development of geothermal resources; (iv) the lack of Sufficient external financing, and (v) the presumption of many governments that geothermal energy development is not justifiable in countries with abundant hydroelectric potential.

4. GEOTHERMAL ENERGY VERSUS OTHER OPTIONS

Geothermal energy has several advantages in electricity generation. The most prominent are: (i) proven viable technology: (ii) reasonable capital and operating costs; (iii) well defined lead times and cost for construction; (iv) flexibility to match expansion requirements, i.e additions can be made in modular increments; (v) utilizes an indigenous resource; [vi) controllable and predictable environmental effects: and (vii) diversification of supply in power generation conducive to an improved generation mix. These advantages, if properly taken into account will influence the decision of implementing the geothermal option.

In most developing countries the alternatives for baseload generation in addition to the geothermal option are: hydroelectric plants (with regulation), thermoelectric plants (oil or coal fired), and diesel-electric plants.

As a first indicator. in comparing the options listed above, the unit capacity cost (US$/KW) were calculated . The results are presented in Table 1

Table 1. Capacity **Costs of** Baseload Options

	range $/KW	average $/KW
- Hydro	1800 - 3600	2700
- Steam	1400 - 2300	1850
- Diesel	1260 - 1820	1540
Geothermal	2500 - 2800	2650

For Table 1 costs and other data, adopted by the Bank and planners in Central America and some Caribbean countries in establishing their expansion plans were utilized costs were updated to the January 1994 price level [It must be kept in mind that (i) the capacities of the options were between 30 and 125 MW for the thermoelectric and geothermal plants and between 70 and 450 MW for the hydroelectric plants that the costs were adjusted with the capitalization factor corresponding to the implementation period] From the results presented in Table 1, we note that the average unit cost for the different options have the following ranking (from the higher to the lower capital costs) hydroelectric plants $2700 KW geothermal plants $2650 KW Steam plants $1850 KW Diesel plants $1540 KW

The geothermal power plants capital costs come close to that of the hydroelectric plants However we must remember that the index was calculated with the annual average value of the installed capacity. If the capacity value for firm productton is employed then geothermal plants will have a iower unit capacity cost than the hydroelectric option. However, it is clear that the geothermal. as well as the hydroelectric are capital intensive options. constituting another barrier for their development.

A second indicator. the energy unit cost (US$/KWH), was estimated by dividing the total annual costs by the annual generation. The total annual costs consist of the annuity of the investment (discount rate: 12%). the yearly fuel costs, and the annual O&M . The results are presented in the Table 2.

Table 2. **Energy** Unit Costs **of** the Baseload Options

	range $/KWH	avg $/KWH
- Hydro	0.050 - 0.100	0.0800
- Steam	0.060 - 0.090	0.0750
Diesel	0.070 - 0.090	0.0800
- Geothermal	0.040 - 0.050	0.0450

From the preceding Table, it can be seen that the geothermal generating option will generate electric energy from and average unit cost 50.035 to 50.045 per KWH, which is lower than the unit costs of the conventional plants which spans from 50.030 to 50.10 per KWH. This indicator - the generated energy unit cost - for baseload generating plants, is more indicative of the competitiveness of the different options than the unit cost of installed capacity previously presented.

From the foregoing presentation one couid conclude, that in general, the geothermal energy option is competitive, for baseload generation. However, these results are only a first indication of the relative competitiveness of the compared energy sources in generating electric energy. One must realize that the relative costs and advantages of the different options are, to a different degree, site-specific and dependent on i) the existing generating system, and ii) the real options available for expansion in a given country.

An option for a country's national economy and its power system, is a justifiable investment only if it is an integral part of the least-cost generation expansion plan for that panicular power system. In arriving at the optimal plan, the alternative options should have been included as expansion candidates in the optimization process. **All** options competing for a place in the expansion plan should have the same level of Studies (comparable risks).

To define the least-cost expansion generation plan, mathematical optimization models are used. The models, on the basis of the characteristics of the existing generating plants and those of the available expansion options, simulate all possibie configurations and sequences of plants to arrive at a planning horizon year, satisfying in every year, the reliability criteria adopted for the supply of electricity. To define which of the sequences is the optimal one, the models, through a Simulation of the economic operation of the power plants, calculate the value of the optimization objective function. The objective function generally is the present value of the operating costs, including unserved energy costs (unserved energy is the expected value of the curtailed energy for a given reliability criteria) and investment costs of the expansion sequence. The optimum or least-cost expansion plan is the one with the minimum present value.

It is impractical. tor the scope of this paper, to present in detail the optimal expansion plans for several countries; however, some light on the role that geothermal energy has piayed and can play in electricity production, can be derived from the overall results obtained in the most recent least-cost expansions plans utilized by the Bank in the economic justification for approval of loans for three development power programs. in which geothermal power projects. were an option.

The optimization process for the three indicated expansion programs considered three load growth scenarios (low, medium or most probable. and high). In the three demand scenarios all available geothermal projects were included in the least-cost expansion plan. The optimal timing for the commissioning of geothermal projects was affected only in the high demand scenario. mainly in last years of the planning period. The first available geothermal unit, in the three programs, consistently displaced all other available options. In the high scenario combustion turbines come first, but without affecting the date for commissioning of the first geothermal unit, defined in the most probable scenario. Finally, it was noted that the commissioning date of the geothermal units. available at later dates, was not greatly affected by the rate of load growth (the typical variation was of one year between the different scenarios).

In all three cases, under the low growth Scenario, all available geothermal units were included in the expansion plan for the scenarios under consideration. For the higher growth scenarios (medium and high) some of the peaking hydroelectric candidates and combustion turbines come in before the geothermal units, to fill the capacity (peaking) needs of the system, as was expected. Only when all available geothermal and hydro units were taken by the expansion plans, some fossil fuel steam plants were programmed. This meant that if more geothermal plants had been available, the fossil plants probably would have been further displaced.

The economic rate of return of the geothermal power plants object of the proposed Bank financing were found to be between 16.4% and 21.76% (minimum acceptable internal rate of return for an IDB financing is **12%).**

The above general findings reinforce the previous statement that the geothermal projects are very attractive for the economies of the developing countries endowed with the resource.

5. THE PROCESS AND PHASES OF A GEOTHERMAL DEVELOPMENT EFFORT

We, at the Inter-American Development Bank. divide geothermal energy projects into two broad categories: Pre-investment Projects (reconnaissance and pre-feasibility level studies), and Capital Investment Projects (feasibility level studies, and field development/construction of power plants.). Since these classification have a bearing on the type of financing that it is possible to obtain, it is impollant at this point to define in more detail what it is meant by each project type.

5.1 Pre-investment Projects

5.1.1 Reconnaissance Studies

In order to develop geothermal energy projects in a given region or country it is desirable as a first step to undertake a field study of large areas covering between 10,000 and 50.000 km2, using fast, low-cost methods. The reconnaissance studies result in the selection of smaller areas of specific geothermal interest and in a very preliminary definition of the geothermal model of each area. It determines which areas should be given top priority and defines further exploration stages.

The geoscientific studies of a reconnaissance study involves Studies in volcanology in which petrologic analysis and radiometric age determination of sampled rocks are carried out, and geochemistry analysis of waters and gases. With the information obtained from the indicated studies. the basic characteristics of the geothermal fields are defined, i.e depth and age of the heat Source. temperature and ground circulation of the geothermal waters. including zones of recharge and discharge.

5.1.2 Pre-feasibility Studies

The aims of a pre-feasibiiity study are: i) to establish a quantitative model of a given geothermal field: limits of the reservoir, its depth. temperature, and zones of recharge; and. ii) the evaluation of the technical and economic consequences of the proposed geothermal model in order to facilitate the decision of going with the next phase of exploration.

In a typical pie-feasibility level study the following investigations are carried-out: i) geological prospections. ii) geochemical analysis of water and gases (major and trace elements), geothermometers. isotopic analysis and chemical alterations; iii) hydrogeological studies: iv) geophysical investigations. including gravimetry. magnetics, electric resistivity andlor magnetotellurics); iv) seismic activity andlor reflexion and refraction seismic surveys; and v) drilling of several small diameter wells (multipurpose and thermal gradient). and in some instances the drilling of few deep, commercial-diameter wells.

5.2 Capital Investment Projects

5.2.1. Feasibility Studies

The feasibility level studies are aimed at determining the electric power that it will be possible to produce from a given exploratory area of a geothermal field, identified and delineated during the pre-feasibility level studies. A study of this type should quantify the required investments needed to generate the above mentioned electric power, i.e number of wells to be drilled, the gathering system, the power plant equipment and the necessary electric transmission system to connect the power plant to the electric grid.
The major cost component of a feasibility level study are the cost of the drilling operations. The other costs are related to the geoscientific, reservoir engineering, power plant engineering and economic/financial studies

5.2.2 Field Development and Construction of the Power Plant

At this stage, development wells (production and reinjection) are drilled systematically to intercept the reservoir. and construction of the power plant and gathering system undertaken. For the case of flash (conventional) power plants. the time needed to implement a project of this type is **4** to **5** years. For the case of modular plants, this time period is reduced to **3** to **4** years.

5.3 The Normal Development Process

The above described stages constitute the "normal development process" that geothermal energy development has to follow. This process implies that the commissioning of the "first' geothermal unit in a given geothermal field would take several years in excess of the five years indicated above as required for field development and power plant construction. The current typical time span, within the public sector. is 12 years. This time span for additional units in the same field is reduced to 5 years

The indicated times presume no lost time for political or other external factors, but include the time required (between phases) by the public sector to decide in going ahead with the next phase and to finance it

The indicated length of time, inherent to what we have just called the current "normal process" to develop a geothermal resource, is definitely a barrier for the industry. This barrier is mainly characterized by the financial costs incurred during the long development period, and also by the increasw of other related risks. On the other hand, the "normal process" diminishes the "geothermal risk to acceptable levels. In a number of instances, in which a geothermal development efforts were taken through "accelerated paths". bypassing some of the phases of the "normal process"-ended in failures with serious detrimental effects on subsequent geothermal energy developments in the affected country.

The shortening of the process should come through simplification of the bureaucratic processes. from advances in the exploratory technologies able to produce the same amount of geoscientific information and from improvements in the design and the technologies for the manufacturing of power plant equipment but not by diminishing the exploratory efforts.

Furthermore, the private sector due to its inherent flexibility, can reduce substantially the amount of time it takes the public sector to develop a geothermal resource. The reduction can easily be of the order of 35%. In the private sector it is possible to reduce the phases to just two, instead of the four previously described for the public sector.

6. THE FINANCING USED **BY** DEVELOPING COUNTRIES

With exception of Philippines and Indonesia. the developing countries currently show a predominant sectoral institutional arrangement whereby the public or Government owned power utility has monopoly to develop geothermal resources. With this institutional sening for geothermal development, the financing sources utilized by these countries can be summarized as follows: (i) <u>for the Pre-investment Phases</u> (reconnaissance and pre-feasibility level studies), a prominence bilateral financing is noted - mainly Italy through the United Nations Department of Technical Co-operation for Development UN/DTCD - approved as grants and to a lesser extend multilateral financing (IDB, World Bank, ADB. EEC, OPEC Fund) as grants, contingent recovery technical cooperations, and soft loans; (ii) <u>for the capital investment phases</u> (geothermal exploration. field development and plant construction), the countries have used to a greater extend the financing available in multilateral agencies (Inter-American Development Bank, Asian Development Bank, the World Bank. the African Development Bank. the Caribbean Development Bank, the European Economic Community, United Nations Revolving Fund), and to a lesser extend bilateral financing (USA, Japan, Italy. France, UK). The financial conditions of the loans approved for investment projects have been typical ordinary capital loans, namely loans whose financial conditions are not different from loans approved to other development projects in the same sector and country.

Besides the above indicated financial sources, there has been some financing from suppliers credits. These loans usually have covered the external component of purchases of equipment for the power plant, field gathering system, and electric transmission system. Also the export credit agencies of industrialized countries have provided attractive credits (Eximbank of US and Japan) for the purchases of equipment manufactured in their respective countries. Development finance institutions of the industrialized countries have approved some concessional tied financing, for example, the financing provided by the Overseas Economic Development Fund -OECF to Costa Rica for the package related to the field gathering system, power house and transmission system of the Miravalles I geothermal project

While the lenders mentioned above have different lending criteria, the "general bankability criteria" requires the demonstration of the technical and economic viability of the project and the financialiinstitutional soundness of the executing agency.

The IDB in support of geothermal energy development in the Central American countries have approved the operations listed in Table 3. Table 3 serves to illustrate the types of financing mechanisms available and the typical amount required for each type of project or activity.

7. NEW TRENDS AND GEOTHERMAL DEVELOPMENT

7.1 **Power Sector Reforms**

It is now quite evident that power sector reforms and privatization are taking place in most developing countries. The demand for infra-structure and public services is imposing high financial burdens to most developing countries. The electric power sector, in general, accounts for a significant portion of public investment and debt. This has been the major motivating force for the international financial organizations to support reforms of the energy sectors of developing countries.

Several developing countries already are supporting private sector activities in an attempt to reduce pressure on their national budgets. The most prominent are: Argentina. Philippines, Indonesia, Colombia. Chile, China, Jamaica, Peru, Thailand and Pakistan. In these countries private companies, in partnership with foreign corporations, are offered contracts to build and operate power plants and sell the steam andlor electricity to the national utility under a firm agreement on pricing arrangements and repatriation of profits between the public and private sector parties involved.

It must be emphasized that the privatization stage now begun presents new challenges. The first. **as** mentioned before, is the participation of the private sector in activities in the infrastructure and oil and gas sectors that in recent decades were traditionally reserved, in the great majority of the countries, to the public sector. Secondly, the need for even greater emphasis on environmental problems and renewable energy, as emphasized during the most recent Bank replenishment of capital, to assist borrowing member countries in adopting energy development strategies which are environmentally sustainable. Thirdly, in face of the financial and environmental constraints, the attention must be paid to energy conservation. with more weight being given to policies for the management of demand and enhancing the efficiency of the enterprises in the sector. Lastly. the need to support the strengthening of the regulatory role of government in a sening of increasing decentralization and participation by the private sector in a key sector of very special economic characteristics.

Moreover, it must be recognized that because of its characteristics and the magnitude of the investments required by the electric power sector, it is unrealistic to expect that <u>full</u> responsibility for expansion of public electric power service, in the near and medium term, be shifted to the private sector, Instead it will be only partial and gradual, because in the power sector the privatization process is more complex than in other production sectors. It necessarily requires. as a first step, reinforcement of the regulatory role of government which must come accompanied by regulatory and control agencies with appropriate technical and financial capacity

Considering the case of geothermal energy development within the context of the on-going reforms. it is clear that before geothermal energy development becomes an attractive proposition for the private sector, government policies have to be in place, providing both access to the geothermal resources and appropriate incentives. Except for Philippines and Indonesia. that already have very favorable government policies toward the development of geothermal energy, the private sector mainly had subscribed power contracts for thermoelectric generation - the preferred form of the private sector, due to its low capital requirements and short implementation time. The few incursions of the private sector in geothermal energy had been for power plant construction and some field development on an already proven resource. It will take several years, if not decades, before the above indicated conditions, for geothermal development are established by governments.

Table 3 List of Geothermal Projects Financed by the IDB

No.	Country/Geothermal Field	Date	Type of Operation Loan or TC	Amount ($x10[3])	Status
1	Costa Rica: Prefeasibility Study Miravalles Geothermal Field.	1975	Contingent Recovery TC	500	Completed
2	Costa Rica: Phase II. Feasibility of Miravalles I.	1979	Loan	4.100	Completed
3	Costa Rica: Phase III. Upgrading feasibility of Unit I plus feasibility Unit II.	1980	Loan	8,800	Completed
4	Panama: National Reconnaissance geothermal study	1982	Non-reimbursable TC	570	Completed
5	Panama: Advanced of prefeasibility study geothermal fields Chitre-Calobre and Valle de Anton.	1982	Contingent recovery TC	1,200	75% completed
6	Regional: Training Courses (5) and Seminars (3) in several geothermal disciplines: geochemistry; geophysics; vulcanology; drilling; reservoir engineering: and exploitation. Program Administrator: OLADE.	1982	Non-reimbursable TC	1,100	Completed
7	Guatemala: Field development and power plant construction. Zunil I (15 MW)	1983	Loan	25.600	Fld Dev comp. Pwr plnat canc.
8	Guatemala: Prefeasibility studies in Zunil II and Amatitlan.	1983	Soft Loan	2,000	Completed
9	Guatemala: Feasibility Study second geothermal plant in priority field (Zunil II or Amatitlan).	1983	Loan	8.500	Completed
10	Costa RIca: Field development and power plant construction. Miravalles I (55 MW)	1985	Loan with Japonese cofinancing	60,000	Power plant in operation
11	Costa Rica: Feasibility study Miravalles 3 and 4 Units	1985	Loan	14,000	Under execution
12	Dominican Republic: Evaluation of previous studies. Yayas-Constanza geothermal field.	1986	Non-reimbursable Short-Term TC	25	Completed
13	Dominican Republic/Costa Rica: Assistance by Costa Rica to the Dominican Republic. Logging and evaluation of geothermal well.	1986	Non-Reimbursable TC/INTRA	25	Cancelled
14	Costa Rica: Field development and power plant construction for Miravalles II	1989	Loan	72.400	Under execution
15	Costa Rica: Feasibility study Rincon de ia Vieja or Tenorio geothermal fields (includes drilling rig)	1989	Loan	9,500	Under execution
18	Regional: Preparation of guidelines for all phases of a geothermal project. Program Administrator: OLADE.	1989	Non-reimbursable TC	280	Completed
19	El Salvador: Feasibility Studies for the Ahuachapan Estabilization/Rehabilitation and the feasibility of Berlin I condensing plant	1990	Preinveslment loan	2,000	Completed
20	El Salvador: Feasibility study in San Vicente geothermal field plus installation of well head unit of 5 MW in Berlin	1992	Loan	14,600	Under execution
21	Colombia: Advisory panel (first meeting) for Nevado del Ruiz geothermal field	1994	Non-reimbursable TC	30	To be held in 1995
22	Nicaragua: Revaluation of energy potential and feasibility of stabilization of field production and equipment rehabilitation (units 1 and 2) and feasibility of Unit 3.	1994	Non-reimbursable TC with Italian funds	676	Execution will start early 1995
23	El Salvador: Field development and power plant construction 2x25 MW modular units in Berlin geothermal field.	1994	Loan	124,000	Execution lo start in 1995
24	El Salvador: Stabilization of production of the Ahuachapan geothermal project and rehabilitation of power plant equipment	1994	Loan	53.000	Execution to start in 1995

This means that the presence of private Sector in the exploratory phases of geothermal energy development will be scarce, to say the least. Therefore. if the public enterprises. with the help of the international financial institutions. do not continue with the exploratory efforts, then once the already discovered resources are utilized. very few geothermal fields will be incorporated in the inventory of geothermal fields with proven resources.

7.2 Advances of Renewable Energy

At the UN Earth Summit in Rio de Janeiro (June, 1993) the world leaders signed Agenda 21, which provides a framework for sustainable development into the 21st Century. The basic tenets of Agenda 21 are that economic development and environmental sustainability are inseparably linked. From this Agenda 21 and the Action Plans of other Summits, governments and multilateral donors have agreed that numerous renewable technologies and energy conservation measures are feasible and desirable for developing countries. There is definitely a transition underway to a world in which renewable energy systems and energy conservation will be commonplace. The transition involves important reforms of the energy sectors of the developing countries. The important question is not whether this transition will take place, but rather how long will this transition take and whether geothermai energy will keep its relative advantage. Taking into account mat the on-going emphasis on renewables is for decentralized applications and small energy users, geothermal energy due to its inherent characteristics would not be able to take advantage of the opportunities offered by the indicated transition.

7.3 Environmental Considerations

The geothermal industry has taken for granted that geothermal energy development is classified as a renewable energy resource automatically making it an ideal example of sustainable energy development. Geothermal energy has also been recognized to be environmentally superior to fossil fuel generation because it produces much lower emissions of contaminants, particularly CO_2. Based on these considerations the Global Environmental Facility approved a recent grant operation for a geothermal project in the Philippines. The industry expects to benefit from the environmental and social considerations that are driving renewables into the market place, but it (the industry) should be aware that unfortunately there are still instances in which geothermal energy has been classified (Goodland, 1993) as non-renewable and unsustainable. These type of statements if left unattended might create additional constraints to already existing ones.

8. CONCLUSIONS

1. Geothermal energy projects are a very attractive proposition for the economies of the developing countries endowed with the resource. Efforts should continue in the identification and project preparation of additional geothermal projects to increase the number of candidate geothermal projects for expansion of the developing countries' power systems.

2. Under the influence of softening oil prices and new constraints the trend for expanding geothermal energy utilization has decreased. This Situation reflects the changes occurring in the energy sector of the developing countries. However. due the many favorable factors inherent to geothermal energy development the industry% recuperation is viable, but dependent on a coordinated effort of all of us. involved. in some manner or another, in the utilization of this important energy resource.

3. The possibility exits in developing countries to attract private investment in geothermal projects. but before this happens, government policies have to be in place, providing access to the geothermal resources as well as appropriate incentives.

4. The presence of private sector in the exploratory phases of geothermal energy development will be scarce. Therefore. if the public enterprises do not continue with the exploratory efforts. no new geothermal fields will be incorporated in the inventory of geothermal fields with proven resources.

5. For the indicated purpose, the agencies in charge of geothermal energy development should convince government decision - makers of the need to assign priority to continue exploring and developing geothermal energy in their countries, with the help of the international financial institutions.

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