Geothermal Energy Development - A Boon to Philippine Energy Self-Reliance Efforts

by

A.P. Alcaraz[1] and M./s. Ogena[2]

ABSTRACT

The Philippine success story in geothermal energy development is the first of the nation's intensified search for locally available alternative energy sources to oil. Due to its favorable location in the Pacific belt of fire, teogether with the presence of the right geologic condition sfor the formaiton of geothermal (earth heat) reservoirs, the country has been able to develop commeercially six geothermal fields. These are the Makiling-Banahaw area, just south of Manila, Tiwi in Albay, Bacon-Manilto in Sorsogon, Tongonan in Leyte, Palinpinon in Southern Negros, and the Mt. Apo region of Mindanao.

Together these six geothermal fields have a combined installed generation capacity of 1,448 Mwe, which makes the Philippines second largest user of geothermal energy in the world today. Since 1977 to mid-1997, a total of 88,475 gigawatt-hours have been generated equivalent to 152.54 million barrels of oil. Based on the average yearly price of oil for the period, this translates into a savings of $3,122 billion for the country that otherwise would have gone for oil importations.

It is planned that by the year 2,000, geothermal shall be accounting for 28.4% of the 42,000 gigawatt-hours of the energy needed for that year, coal-based plants will contribute 24.6% and hydropower 18.6%. This will reduce oil-based contribution to just 28.4%.

Geothermal energy as an indigenous energy resource provides the country a sustainable option to other conventionla energy sources such as coal, oil and even hydro. Technologies have long been developed to maintain the environmental quality of the geothermal site. It serves to minimize changes in the support systems found on the land, water and air environments.

The country has hopped, skipped and jumped towards energy self-reliance anchored on development of its large geothermal resources. And as the Philippines pole-vaults into the 21st Century, the nation can look forward to geothermal energy to remain as one of the pillars of its energy self-reliance program.

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Geothermal Energy Development - a boon to Philippine energy self-reliance efforts.

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Key words: magma, geothermal, separator, effluent, turbogenerator.

Introduction

Important events in a nation's quest for self-existence and progress are often referred to as milestones. One such milestone occurred thirty years ago on April 12, 1967, when for the first time in the country, several light bulbs were lit by geothermal energy at Cale, a remote barrio in the town of Tiwi, Albay Province. This milestone marks the initial step toward Philippine energy self-reliance.

The occasion was the demonstration on the use of natural steam in generating electricity. The steam came from a 400-foot deep one-and-a-half inch diameter drillhole which the then Bureau of Mines helped drilled for the Commission on Volcanology's National Science Development Board - assisted project on geothermal studies. The Mapua Institute of Technology conveniently loaned its laboratory turbogenerator for the exercise.

From this insignificant start the Philippines through three decades of dedicated efforts of geoscientists, engineers and technicians, augmented by able assistance and training from foreign sources, has consistently maintained its enviable position as the second largest geothermal power producer in the world - a position the country had attained since 1979.

The Philippines success story in geothermal energy development is the fruit of the nation intensified search for locally available alternative energy sources to oil. It has helped the country the pursuance of its mandate to become increasingly self-reliant on its energy needs. And as nation pole-vaults into the 21st century, geothermal development and utilization is expected to be the forefront in meeting the challenges for a sustainable energy development required for undertaking.

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Geothermal energy as a power source

Geothermal energy, or energy from earth heat, is an indigenous resource that can be harnessed for the benefit of mankind. It's utilization requires three geologic conditions. First, there must be a source of abnormal underground heat. The magma that used to power the eruption of volcanoes, and which still have sufficient remanent heat, make good point-sources of heat for geothermal energy. The Philippines being mainly a volcanic archipelago in the Pacific belt of fire (Fig.1.), thus have a large geothermal power potential related to island arc volcanism (Fig. 2).

The second necessary condition is for the presence of adequate rock fractures or permeability to allow groundwater to percolate deep enough and circulate in the heated rocks above the heat source. This zone of hot fluids then becomes the geothermal reservoir. From it, thermal manifestations, (such as geysers, hot springs, mud pools, and others) may become evident on the surface (Fig. 3).

The third condition is that the geothermal reservoir must be within drillable depths so that the heated fluids could be brought up to the surface by drillholes and there utilized by man for his purposes. At present both vertical and directional drilling can be done to depths of three kilometers and a horizontal throw or reach of one and a half kilometers.

A fourth condition, though it is not an absolute necessity, is the presence of an impervious cap rock which hinders the mass escape of the hot fluids to the surface. Most often the overlying layers of sediments or volcanic debris deposited above the geothermal resource serve this purpose.

How the energy is converted to electric power

From boreholes, two types of heated fluids could be extracted. If pure steam comes out of the well, the geothermal resource is described as being vapor-dominated. Such are the steamfields of Lardarello in Italy, the Geysers of California in the United States and those of Matsukawa in Japan.

On the other hand, if a mixture of steam and hot water is discharged by the wells, the geothermal reservoir is said to be hotwater-dominated. This is the type of geothermal resource found in most countries utilizing the energy for power generation, such as New Zealand, Iceland, El Salvador and the Philippines.

In the case of vapor-dominated geothermal systems, the conversion of the energy into electricity, after some scrubbing, is a simple matter of conveying the clean dry steam to the turbogenerator to produce electricity.

The hotwater-dominated systems, however, require the mixed hot fluids from the wells to be first piped to a separator to separate the steam from the hot water or effluent. The steam, after scrubbing, goes to the turbogenerator, while the separated hotwater is reinjected back underground to help maintain reservoir pressure, supplement natural recharging of the reservoir, and as an environmentally acceptable method of disposing the geothermal effluent. Such is the method of geothermal energy power generation in the Philippines (Fig. 4).

The Philippines hops into geothermal development

In the seventies, there is no single event of international importance which could perhaps compare with the oil crisis of 1973. Its effects were dramatic both for developed and developing countries, but especially for those of the latter which got themselves trapped in an oil economy. The crisis exposed the risks of overdependence on oil for energy. For the Philippines, it provided one of the more severe tests in recent times of the nation's economic and political resiliency (G. Z. Velasco, 1981).

The aspiration to become self-reliant in energy emerged from the Philippine experience with the oil crises of the 1970s. Skyrocketing oil prices and supply instabilities forced the government to seek long-term solutions than just establishing government to government supply agreements and taking the helm of the oil industry. A new decisive move was the government's firm resolve to develope indigenous sources of energy, foremost of which is geothermal energy (W. O. Refuerzo, 1996).

With the help of the New Zealand government, the first semi-commercial geothermal power plant was put in operation on July 3, 1977 in Tongonan, Leyte. The field development was done by PNOC-Energy Development Corporation (EDC) while the pilot plant was put up by the National Power Corporation (NAPOCOR). The 3MW pilot power plant supplied power to the city of Ormoc.

Meanwhile, the commercialization of geothermal power generation in the Philippines was made possible with the entry in 1971 of the Philippine Geothermal Incorporated (PGI), a subsidiary of Union Oil of California, developer of the Geysers geothermal field in the United States. PGI developed the Tiwi field in Albay for the steam requirements of power plants built by NAPOCOR. Later, the Makiling-Banahaw geothermal field south of Manila was added to the area of interest serviced by PGI.

Commercial geothermal power plants then came into stream one after another. The three Tiwi power plants with a combined 330 MWe installed capacity, complimented with a like 330 MWe capacity from the Makiling-Banahaw geothermal field, supplied much needed additional power to the Luzon electrical grid by 1984. Not to be outdone, PNOC-EDC developed the steam field with a power plant installed capacity of 112.5 MWe in Leyte and another 112.5 MWe in Southern Negros came into line in 1983 (Fig. 5). So by 1984, the Philippines with a total of 894 MWe (including 9 MWe of pilot plants) of installed capacity became well ensconed as the second largest user of geothermal energy for power generation in the world, next only to the United States (S. P. Javellana, 1991) (Table I).

Thus the energy self-reliance program of the government got off to a flying start. Dependence on imported fuel for her energy needs was cut down to about 65% from a high of 95%. The country was able to save millions of dollars that would have gone out to pay for oil importations. The crushing effects to the economy by the oil crises that came in 1973, and in later years, were somehow softened by this welcomed development. (Table II, Fig. 6).

Skips to a pause

Unfortunately, national events of a political nature brought to a halt these initial successes toward energy self-reliance. From 1984 to 1992, no additional geothermal capacity was installed. This fact reflects the varied fates of the energy plan brought by changing leadership. Thus the country experienced a crippling power shortage in 1988-1991.

Apart from the change in priorities of the national leadership, other factors have affected the energy program. The slowdown in geothermal development in the mid 80s resulted from the economic downturn, the softening of world oil prices and the high initial cost of transmitting power from proven geothermal resources to demand centers (F. M. Dolor, 1996).

Environmental prerequisites likewise accounted for delays in the implementation of geothermal activities. The private sector was also hesitant to get into geothermal exploration, development and utilization alleging that the economic and financial incentives are not adequate enough.

Thus, no other geothermal service contractor except the state-owned PNOC-EDC continued to engage in geothermal development. The corporation continued with its exploration activities of existing and new prospects. It also initiated short-term geoscientific contract services abroad in an effort to keep its trained personnel busy and intact.

Jumps to full steam ahead once more

However, things began to pick up once more after 1992. The formulation of the Energy Sector Action Plan (ESAP) liberalized the energy industry and encouraged private sector participation in energy generation. Construction of power plants by the private sector through schemes such as BOT (Built-Operate-Transfer); BOO (Built-Operate-Own); ROL (Rehabilitate-Operate-Lease); and ROM (Rehabilitate- Operate-Maintain) will go a long way to meet the demands for energy now that the country had acquired a tiger-cub economy.

The use of geothermal energy will again be one of the main pillars of this energy program. PNOC-EDC envisions an additional 800 MWe generation from the use of geothermal energy by the year 2000. These will be sourced from Mt. Labo, Camarines Norte (120MWe); Northern Negros, Bacolod (40MWe); Leyte to Cebu (200 MWe); and Leyte to Luzon (440 MWe). This does not include the Mt. Apo project which has earlier been confirmed for 104MWe (Fig. 5).

It is hoped that by the year 2000, geothermal shall be accounting for 28.4% of the 42,000 gigawatt-hours of energy planned for the year. Coal-based plants will contribute 24.6% and hydropower 18.6%. This will reduce oil-based contribution to just 28.4%.

Past and continuing challenges

In the early years of geothermal energy development in the Philippines, the main challenges to the endeavor were those concerning transfer of technology, man-power build up and sourcing of funds. These major problems have been properly addressed and given solution.

On technology transfer, the government engaged the services of foreign experts so that it could avoid much of the problems of adopting new technologies. It sought technical assistance from the four leading countries in geothermal energy utilization: New Zealand, Italy, Japan and the United States. From these countries (and Iceland later on) the Philippines availed much of its present capability and expertise on geothermal.

So that geothermal development efforts would later on be primarily Filipino, the PNOC-EDC embarked on a well- planned manpower development program. By working with foreign specialists in a scheme of on-the-job technology transfer, complemented with training abroad on specialized activities, a pool of young nationals ready to man energy development programs when foreign expertise would be phased out was built up in a short time (A. P. Alcaraz, 1981). Now this local expertise is being exported to other countries eager to also develop their own geothermal energy potential.

Because any centralized and decentralized energy installations are capital-intensive, one of the difficulties of the fledgeling geothermal development then was a scarcity of capital-resource. In terms of capital borrowings, the drying up of long maturity facilities and the rise of interest rates in all international capital markets certainly applied pressure to the pace with which a developing country had hoped to implement long-term energy plans (G. Z. Velasco, 1982).

Through the use of internally generated funds, foreign financial assistance, and later on loans from the Overseas Economic Development Fund (OECF) of Japan, the Asian Development Bank and the World Bank, the country was able to launch its bid for energy self-reliance with geothermal development as a main pillar. Now with a credible track record, coupled with a softening of attitude by foreign lending institutions toward energy development projects, the sourcing of funds to carry on the massive energy self-reliance program of the country is no longer so formidable.

However, there are two challenges that still face geothermal development today. The first is how to come to terms with environmentalism; and second, coming up with better incentives for geothermal developers.

Geothermal: the green option

When environmental activism in the eighties began to assert its demands on big development projects, geothermal became a favorite target for censureship, especially by the Non Governmental Organizations (NGO's). By way of countering their arguments, Agnes C. de Jesus, PNOC-EDC Manager for Environmental Management, discussed in her paper "***Geothermal: the green option***". (Energy Forum, Vol. II No. 2) about the advantages of geothermal as a sustainable option to other conventional energy sources such as coal, oil and even hydro (Table III).

The major advantages of geothermal over the fossil based options is its on site utilization which limits the impacts to just the area of production. Furthermore, technologies have long been developed to maintain the environmental quality of the geothermal site. It serves to minimize changes in the support systems found on the land, water and air environments (Ibid).

In recognition of the valuable environmental work it is doing in developing the country's geothermal resources, PNOC-EDC was the recipient of the first *Gawad Kalikasan* award from the Philippine Association of Environmental

Assessment Professionals (PAEAP) and the DENR. The award was for the company's exemplary performance in managing environment issues in its Mindanao I Geothermal Project which at the onset met strong opposition from Mt. Apo cultural minorities, the Church and NGO's.

For the third consecutive year, PNOC-EDC's BacMan Geothermal Production Field (BMGPF) was named the most outstanding firm for 1996 by the DENR-Region V. The project was cited for "its invaluable contribution to pollution control and management, environmental education campaign (EEC), community development, networking and its support and cooperation in the implementation of DENR programs."

The Geothermal Resource Act of 1994

In order to provide for increased fiscal incentives to accelerate private sector participation, the Geothermal Resources Act of 1994 is currently before the House of Congress awaiting approval. The main features of the Act for a geothermal services contractor include:

- An 8 year holiday on production royalties;
- Tax incentives on customs duties for equipment, vehicles, supplies and materials;
- Filipino Participation Incentive Allowance (FPIA) equivalent to 5% of gross revenues;
- Development uplift allowance equivalent to 60% of development costs; and
- Exploration costs recovery in unsuccessful areas.

These incentives will significantly improve the cash flow and return on investment for the geothermal developer, and improve the IRR by about an additional 4.5%. The Act, therefore, should be approved and passed into law to stimulate private sector participation in the exploration and development of new geothermal fields.

Benefits to communities hosting geothermal development

Where before communities affected by energy projects were reluctant in accepting developers in their territory, they are now welcoming big business with open arms. Local-government units (LGUS) are now willing to stamp their seal of approval on new energy projects. Local officials are realizing that to play host to such projects not only means more jobs and business opportunities but now a steady source of income as well which can be used for their various projects (D. Q. Diokno, 1996).

As a financial benefit to communities hosting power plants, the Local Government Code (LGC) requires energy developers and power plant operators to pay directly 40% of royalties to the local government units, while 60% goes to the national government (Fig. 7). The local government share of the geothermal royalty is divided between the province (20%), the town (45%) and the barangay (35%).

Since the enactment of the LGC, PNOC for example has remitted royalty payments quarterly directly to the province of Negros Oriental, the town of Valencia and to barangay Puhagan amounting already to about P42 million.

With these financial windfalls and the clearing up of environmental concerns through consultation procedures, the company now finds it quite easy to get the necessary social acceptability for its energy projects.

Non-electrical use of the energy

Aside from the generation of electricity, geothermal energy can also be used for processes that require heat. There is a wide range of such direct or non-electrical usages which include residential, commercial, industrial and agricultural applications.

The first geothermal agro-industrial drying plant funded by the UN Development Program has recently been set up at the Southern Negros geothermal field. The facility was turned over to a consortium of farmers' associations and cooperatives in the area for technical evaluation and commercialization . It is foreseen that such uses of the energy will eventually be an important adjunct to the livelihood programs of host communities to geothermal development in the country.

Success story

Nowhere is the subject of energy self-reliance initiative best exemplified than in the governments phenomenal success in the exploration and exploitation of geothermal energy. The successful development of the geothermal resources at Laguna, Albay, Sorsogon, Leyte, Negros and Mindanao has made us the second largest producer of geothermal energy which enabled the Philippines to join the ranks of nations using geothermal steam to generate electric power.

In retrospect, P. V. Malixi, who was Senior Vice-President of PNOC from 1976-1986 and currently World Bank Project Director of the Leyte A Geothermal Project, said, "*I should say we fared exceptionally well. We have finally come to a point where we have internalized the technology and accumulated the experience to confidently pursue our undertakings. We have contributed immensely in the country's development efforts with the physical manifestation of our vision. And finally, our collaborative efforts have created an organization of men and women forging their talents, skills, expertise, and devotion that gave the Philippines the recognition so well deserved in the international geothermal community.*"

The country had hopped, skipped and jumped toward energy self-reliance anchored on development of its large geothermal resources. And as the Philippines pole-vaults into the 21st century, the nation can look forward to geothermal energy to remain as one of the pillars of its energy self-reliance program. Geothermal is a sustainable energy option and technical efforts are geared to maintaining the productive and renewable capacity of the resource to assure their continuous use.

Time was when volcanoes were feared for their eruptions. They still are, like the recent Mount Pinatubo catastrophic activity. However, such events are but only short transient episodes of unrest that pale against the long stretches of inactivity that eventually result in verdant fields for agricultural and economic pursuits.

The magma that used to power a volcano's eruption retains enough heat to provide the geothermal energy that we now use to generate electricity and other non-electrical usages in homes, agriculture and industry. Volcanoes truly are not just malefactors, but also benefactors of mankind (A. P. Alcaraz, 1965). The

Philippine surge in the successful development of its geothermal resources surely attests to this fact, besides being a boon to the country's energy self-reliance efforts (Fig. 8).

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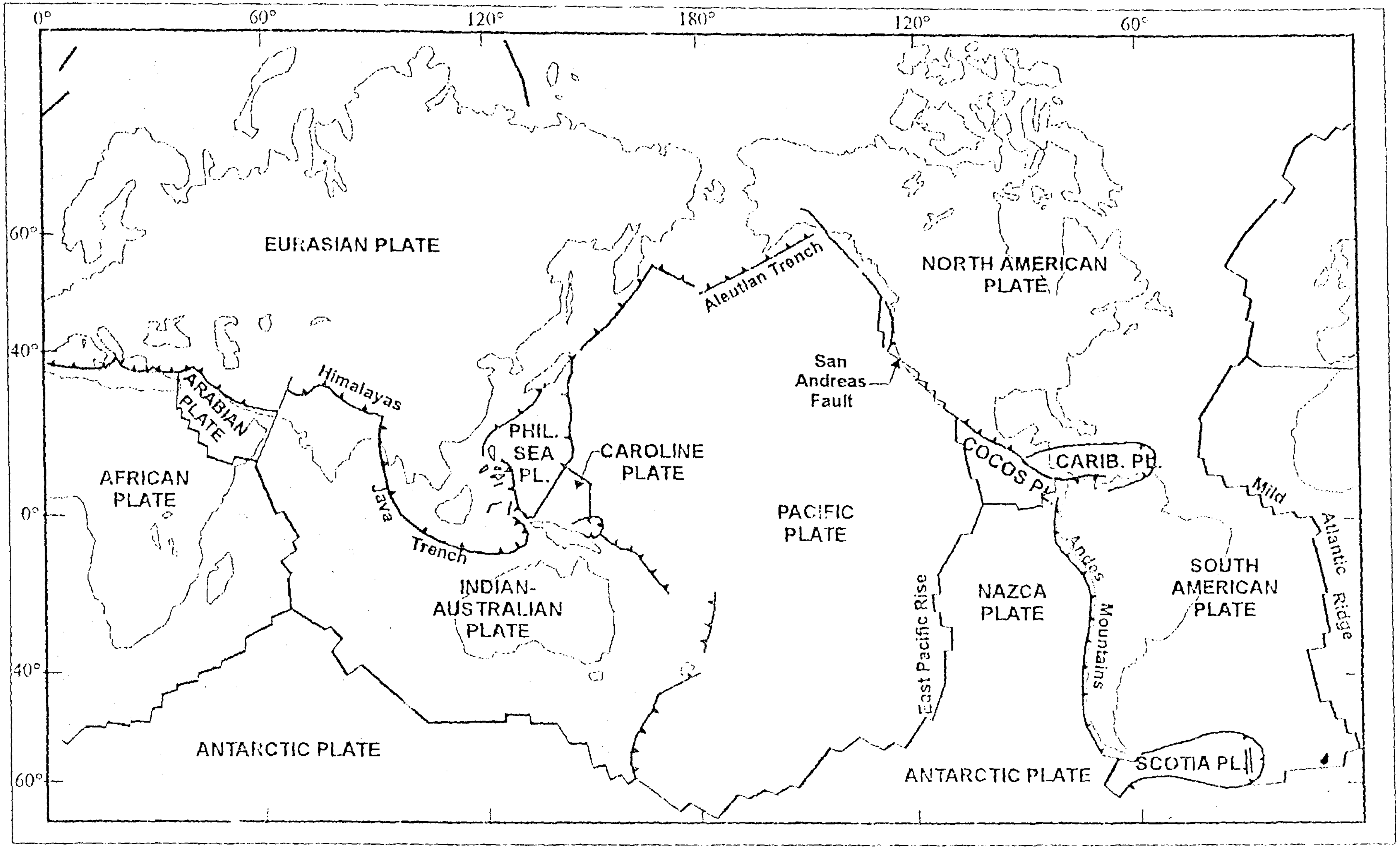


Figure 1 **LITHOSPHERE PLATES OF THE WORLD**

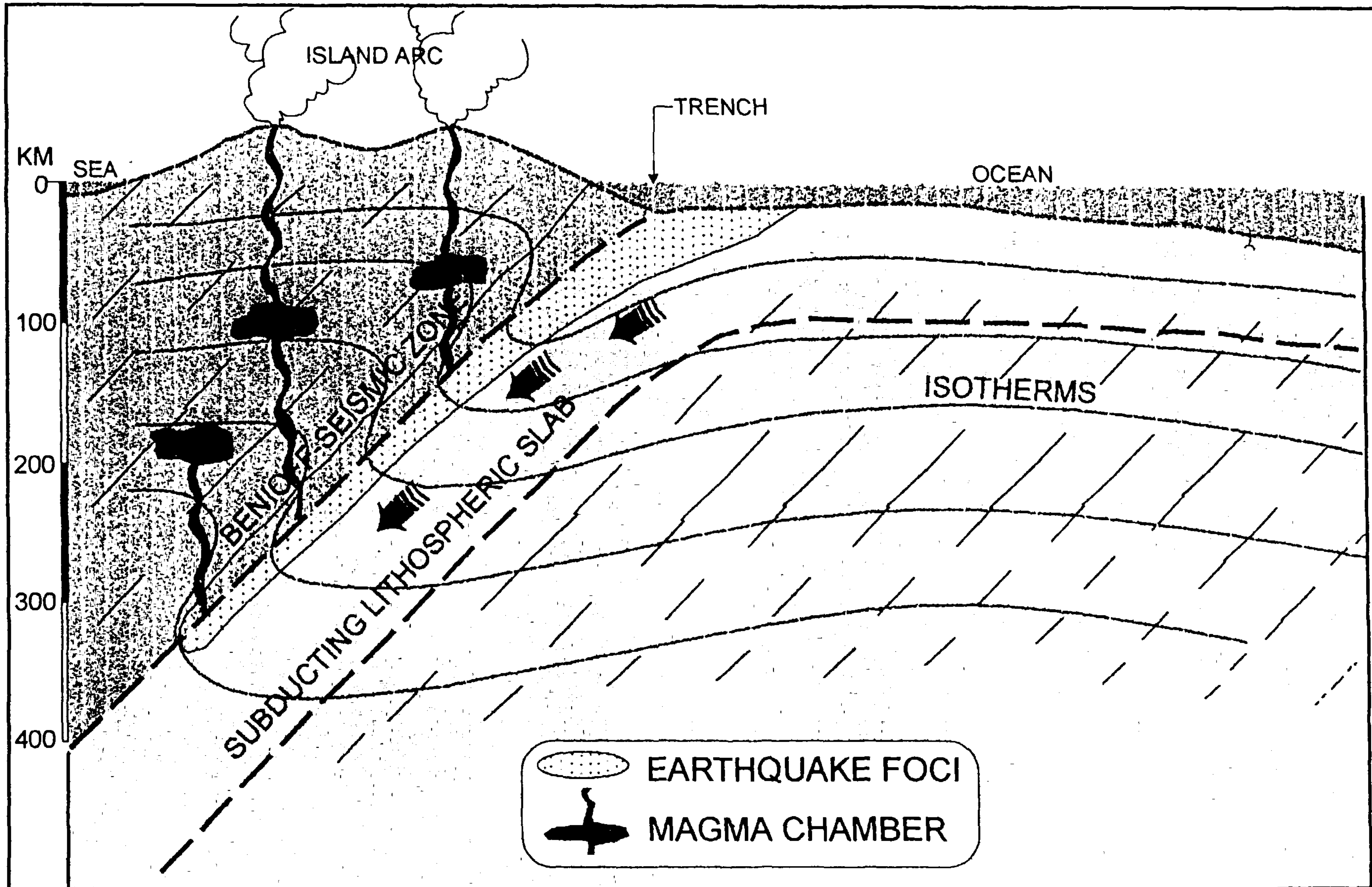


Figure 2

SCHEMATIC DIAGRAM OF SUBDUCTION PROCESS UNDER ACTIVE ISLAND ARCS,LIKE THE PHILIPPINES, THAT GIVES RISE TO EARTHQUAKES AND VOLCANIC ACTIVITY IN SUCH GEOLOGIC ENVIRONMENTS. (Adopted after Sugimura / Uyeda: "Island Arcs", 1973)

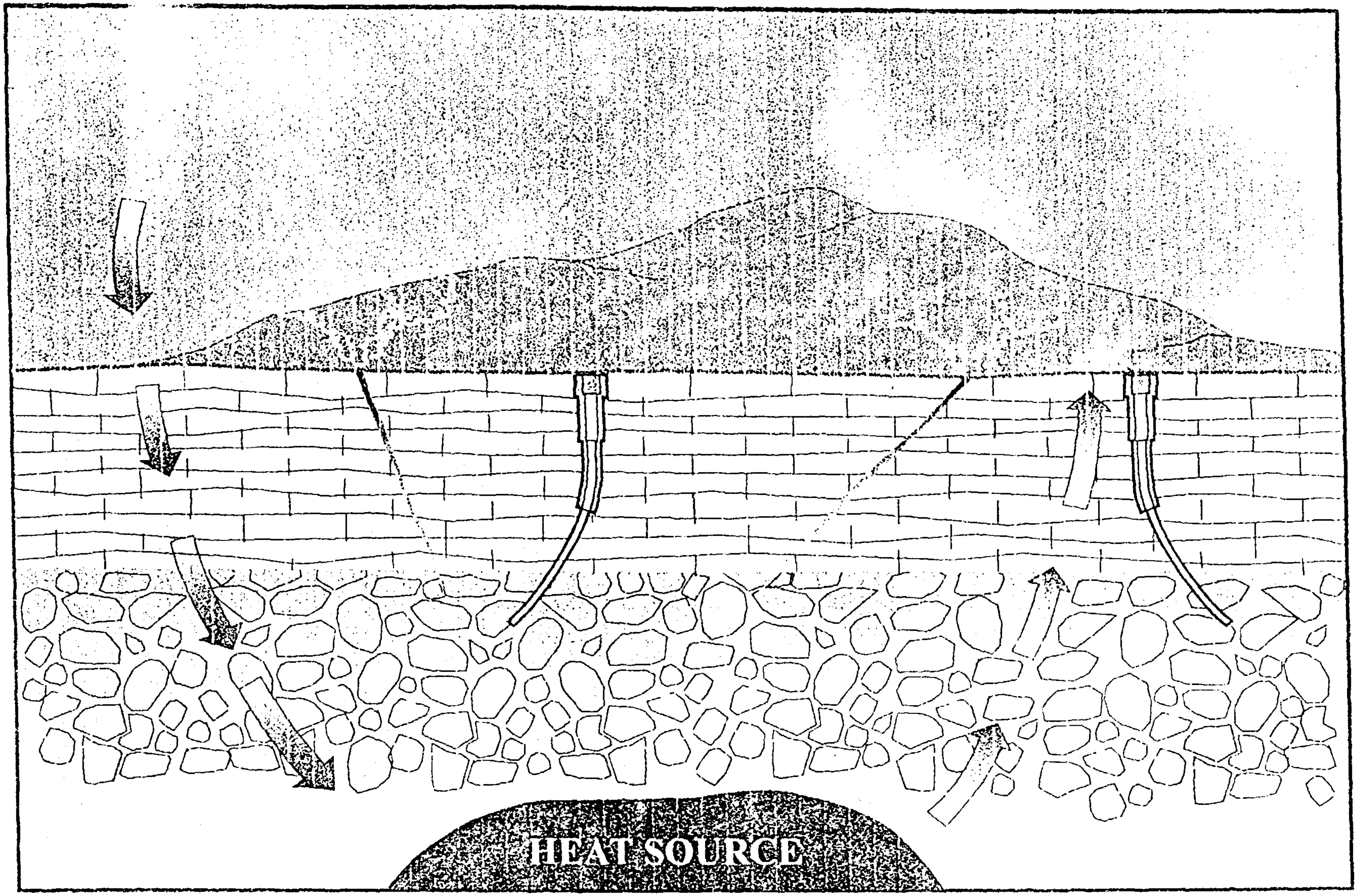


Figure 3

Rainfall seeps into the earth where it will be warmed the earth's heat. In a few places, magma occurs close enough to the earth's surface to heat the water that can be reached by drilling wells. The hot warter is brought to the surface, flashed to steam, and delivered by pipeline to electrical generating plants.

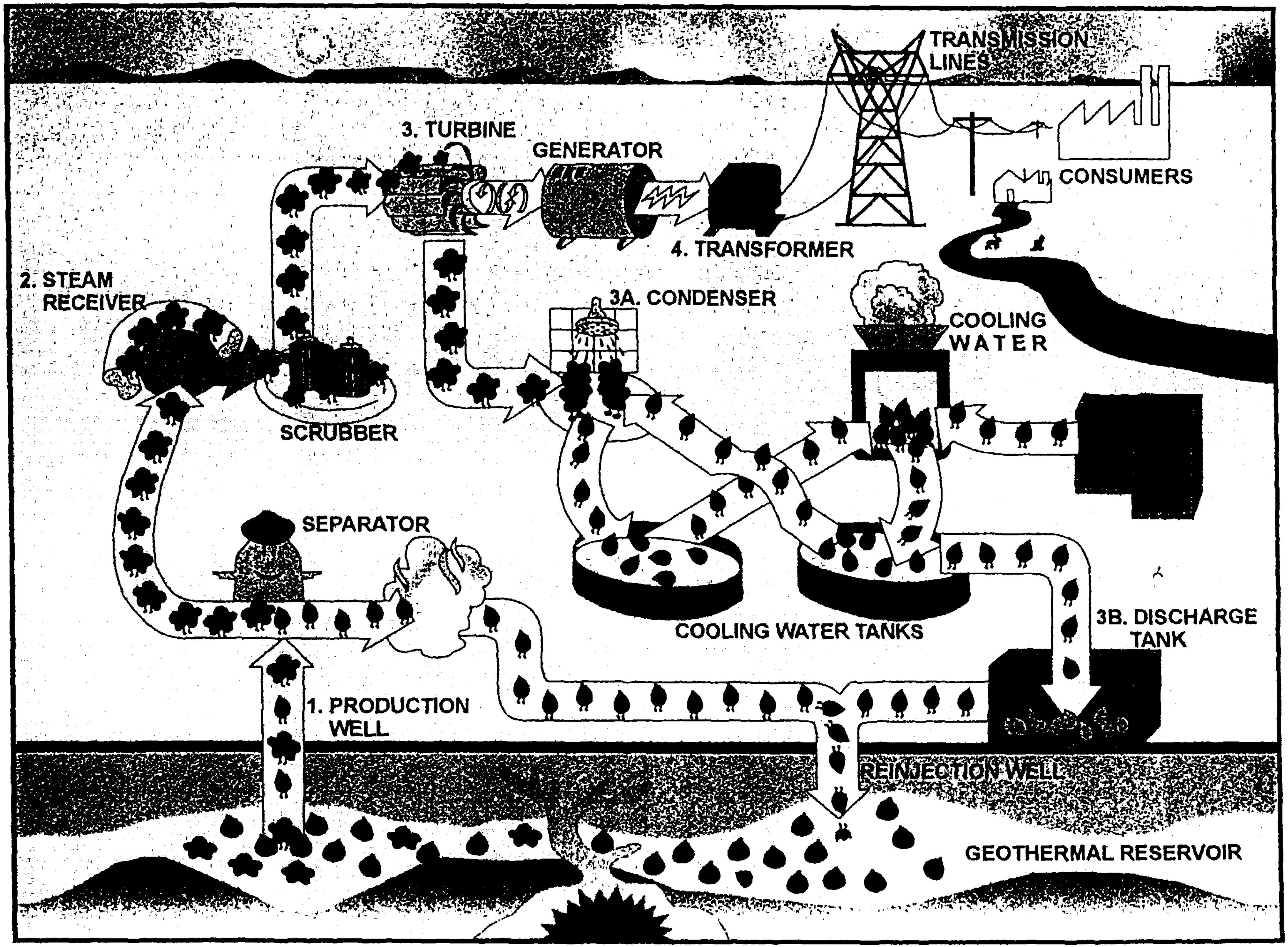


Figure 4 **GEOTHERMAL ENERGY IS CONVERTED INTO ELECTRIC POWER**

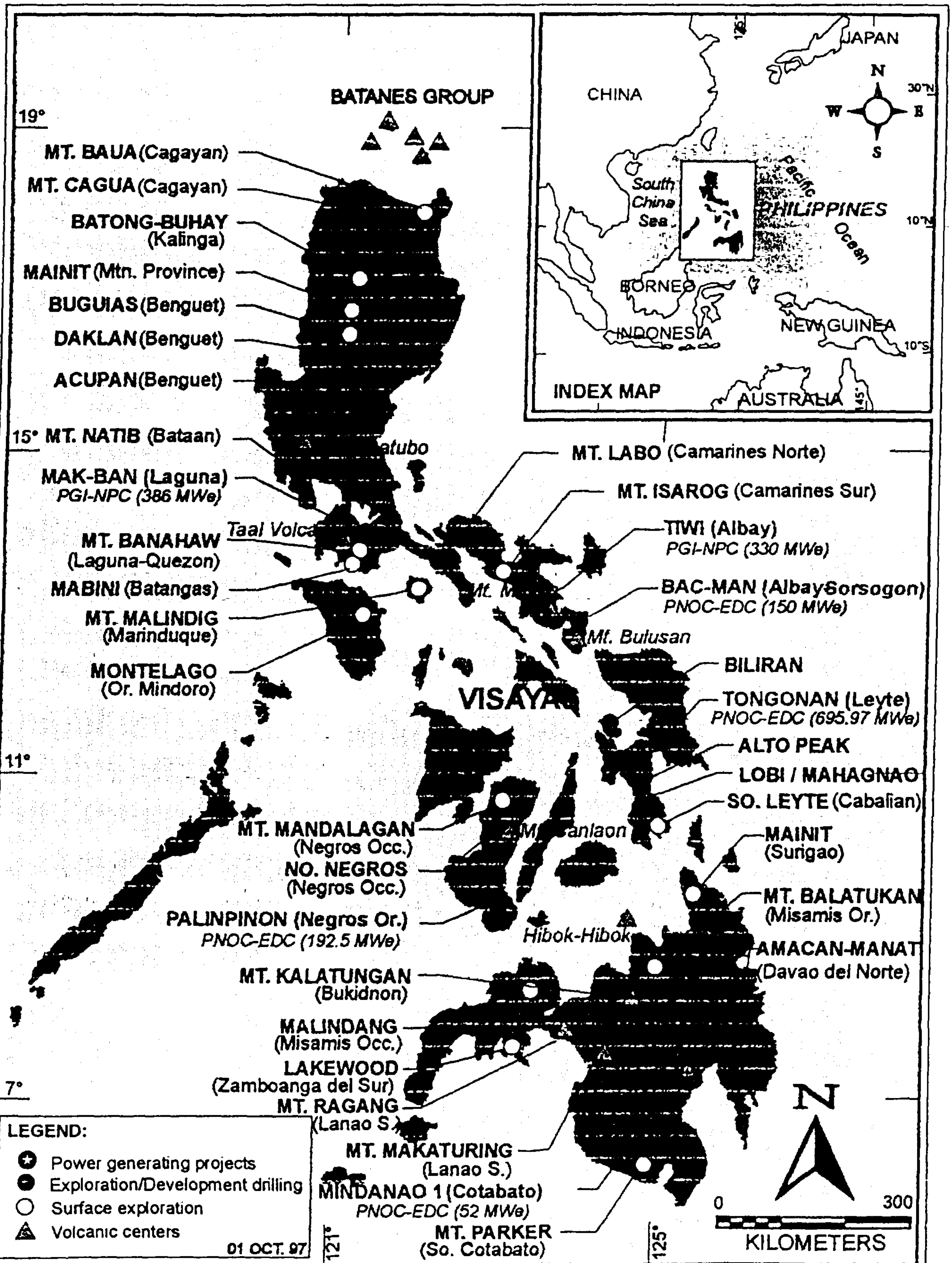
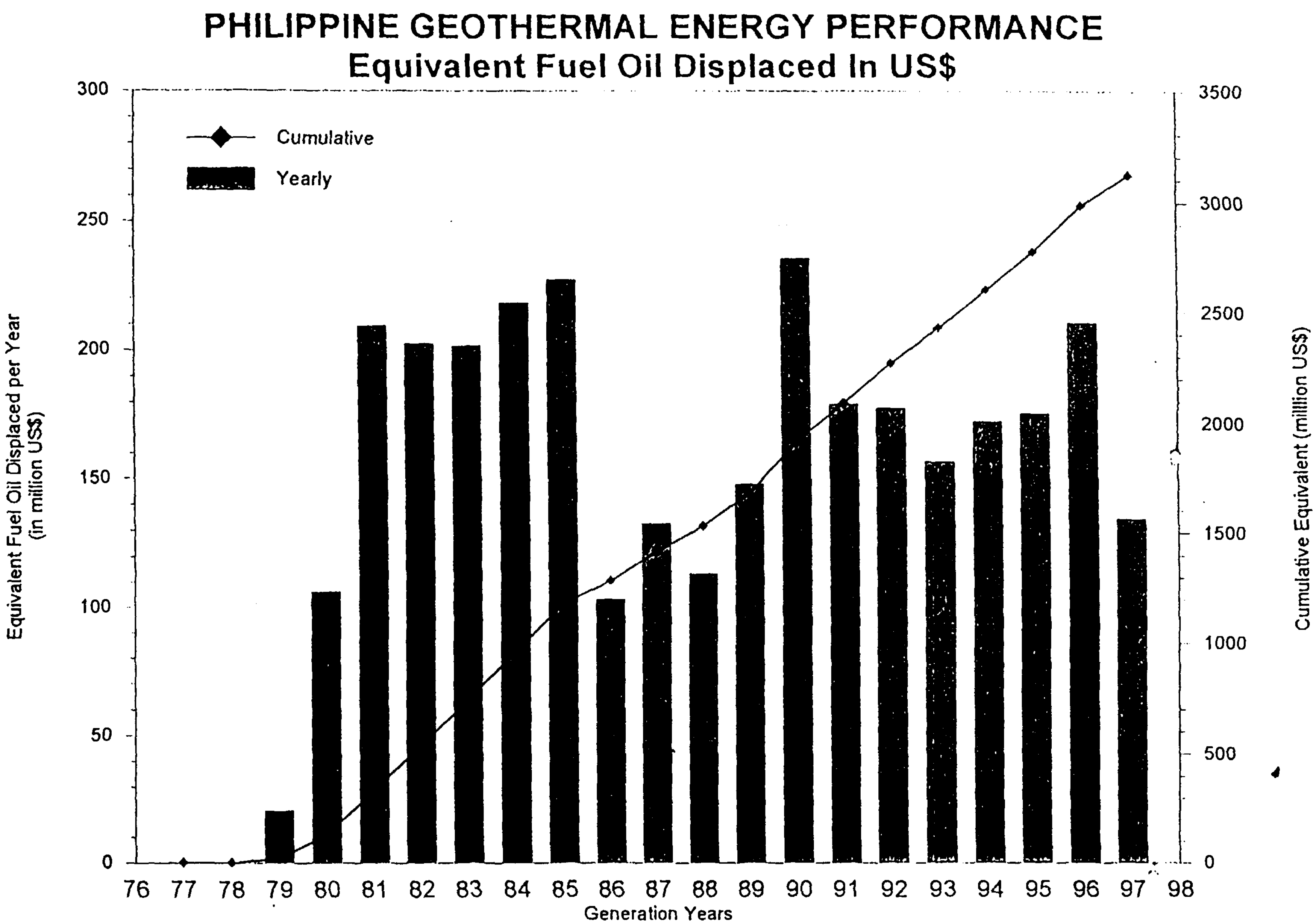


Figure 5 **PHILIPPINE GEOTHERMAL AREAS**



PHILIPPINE GEOTHERMAL ENERGY PERFORMANCE
Equivalent Fuel Oil Displaced In US$
Cumulative
Yearly
Equivalent Fuel Oil Displaced per Year (in million US$)
Cumulative Equivalent (million US$)
Generation Years
0
50
100
150
200
250
300
0
500
1000
1500
2000
2500
3000
3500
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98

Fig. 6

DISTRIBUTION OF ROYALTIES FROM ENERGY DEVELOPERS AND POWER PLANT OPERATORS

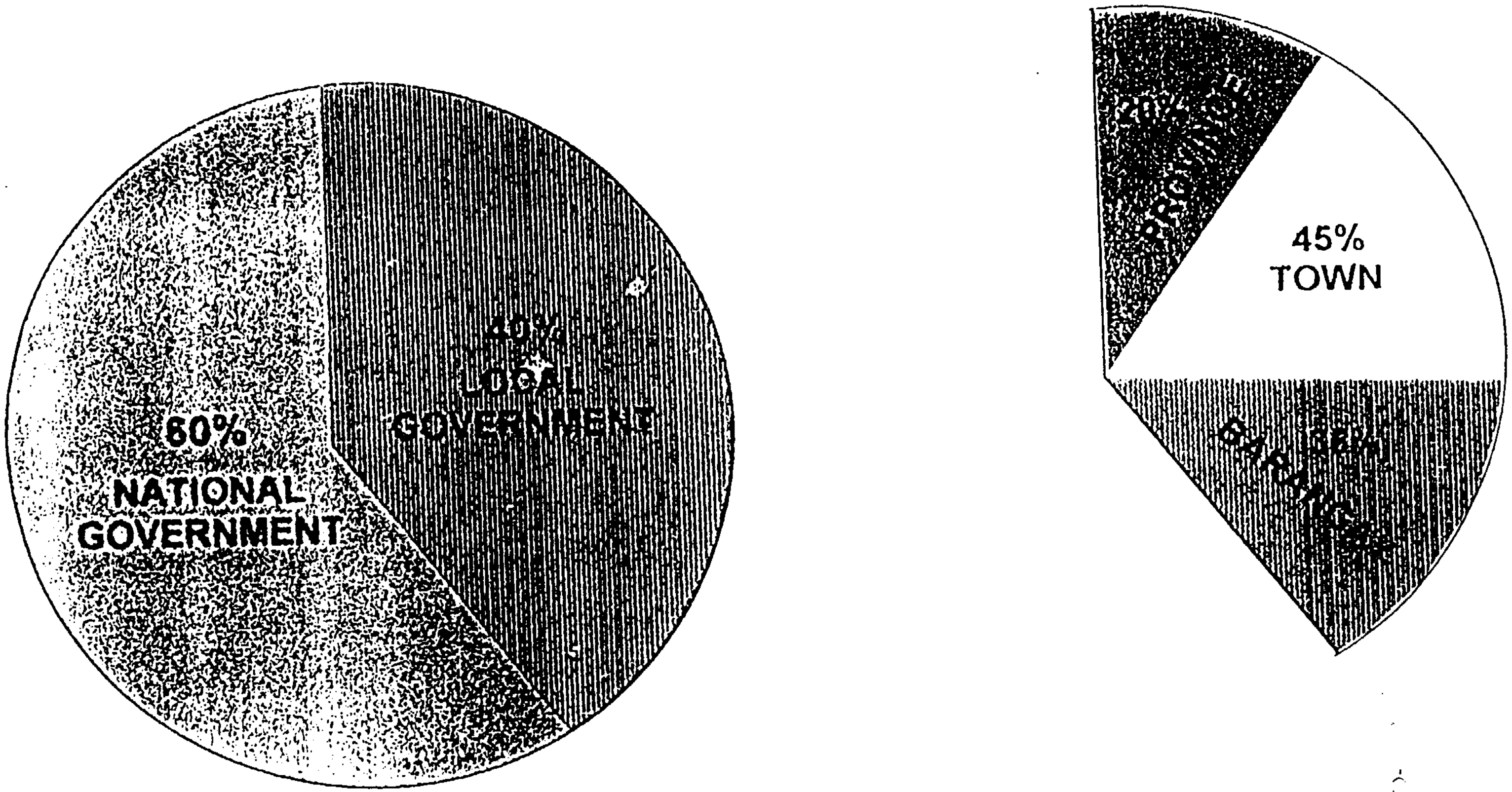


Fig. 7

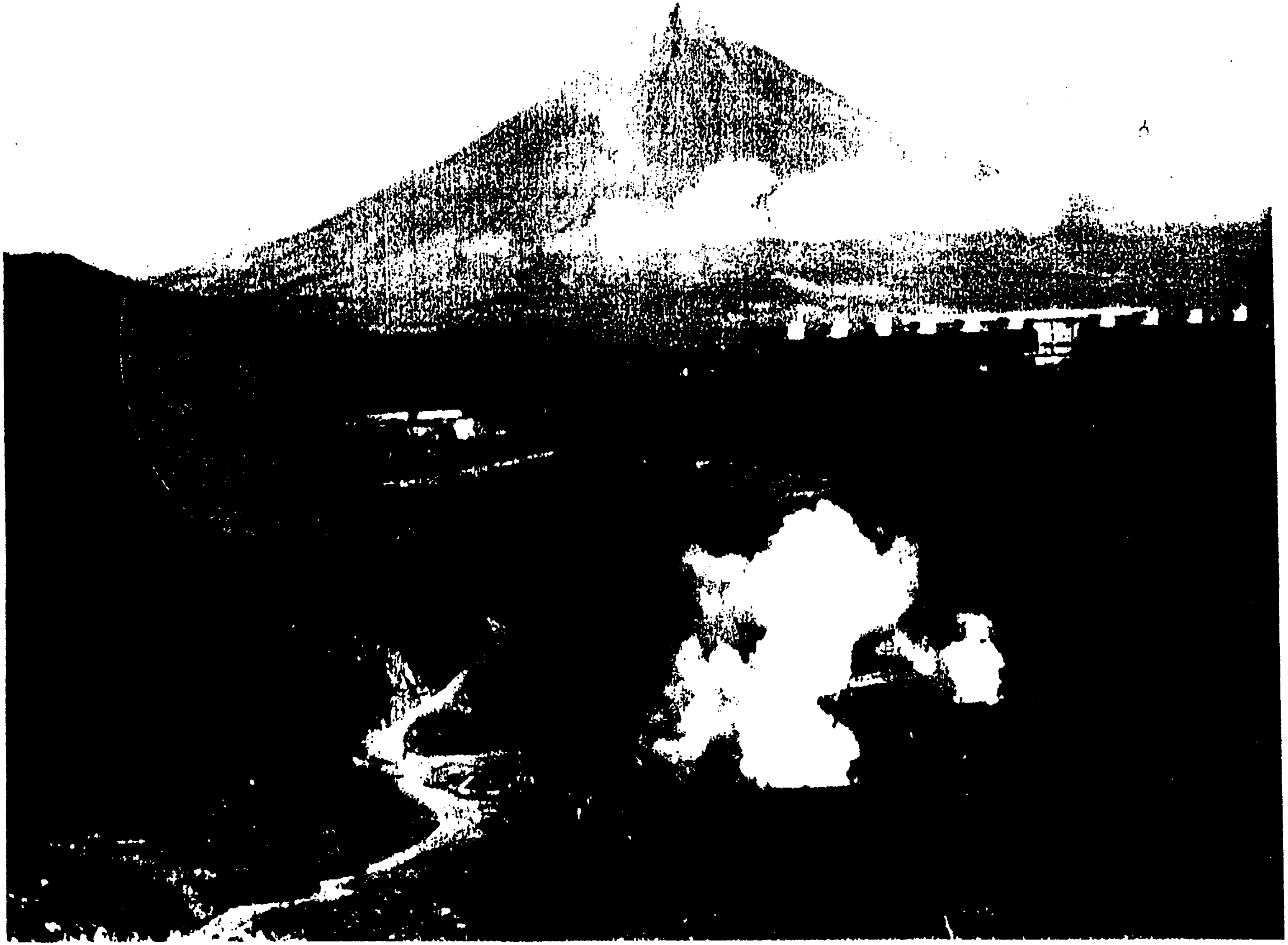


Figure 8 **BAC-MAN I POWER PLANT WITH MAYON VOLCANO IN THE BACKGROUND**

GROSS GENERATION OF PGI AND PNOC FIELDS (GWH)

YEAR	MAKBAN	TIWI	PGI	TONGONAN	PALINPINON	BACMAN	M1GPF	PNOC	TOTAL
1977				1.00				1.00	1.00
1978			.	3.00				3.00	3.00
1979	191.74	441.20	632.94	23.65				23.65	656.59
1980	1080.31	957.62	2037.93	23.65	1.92			25.57	2063.50
1981	1645.71	1892.89	3538.60	23.65	19.59			43.24	3581.84
1982	1533.80	1999.98	3533.78	23.65	21.08			44.73	3578.51
1983	1547.60	2318.10	3865.70	161.78	52.28			214.06	4079.76
1984	1774.60	2343.00	4117.60	257.27	156.59			413.86	4531.46
1985	2247.67	2045.00	4292.67	419.53	239.98			659.51	4952.18
1986	2018.18	1873.41	3891.59	430.99	254.72			685.71	4577.30
1987	2247.10	1470.72	3717.82	485.09	319.06			804.15	4521.97
1988	2199.70	1828.54	4028.24	439.46	378.21			817.67	4845.91
1989	2431.17	2006.35	4437.52	449.03	418.14			867.17	5304.69
1990	2538.24	1956.76	4495.00	513.24	455.76			969.00	5464.00
1991	2451.83	2039.11	4490.94	512.07	756.97			1269.04	5759.98
1992	2437.54	1997.45	4434.99	522.79	739.02			1261.81	5696.80
1993	2143.89	2116.89	4260.78	562.65	790.64	53.18		1406.47	5667.25
1994	2294.29	2013.60	4307.89	587.73	869.97	554.10		2011.80	6319.69
1995	1927.62	1722.83	3650.45	637.13	1131.10	715.17		2483.40	6133.85
1996	2520.15	1524.82	4044.97	673.06	1177.19	643.51		2493.76	6538.73
1997*	1474.51	980.45	2454.96	413.81	756.61	426.16	145.11	1741.69	4196.65
TOTAL	36705.65	33528.72	70234.37	7160.24	8538.83	2392.12	145.11	18236.30	88470.67

Note: * as of June 1997

RRMD/RRM6/TRANSFER/FOREXSAV.XLS/POM/9-18-97

Table 1

PHILIPPINE GEOTHERMAL ENERGY PERFORMANCE

YEAR	Geothermal Energy Generation (GWH)			Fuel Oil Displaced (MMB)	Average Oil Price (US$/bbl)	Savings (MM US$)
	PGI	PNOC	TOTAL			
1977		1.00	1.00	0.00	11.33	0.020
1978		3.00	3.00	0.01	12.32	0.064
1979	632.94	23.65	656.59	1.13	18.19	20.59
1980	2037.93	25.57	2063.50	3.56	29.79	105.99
1981	3538.60	43.24	3581.84	6.18	33.86	209.11
1982	3533.78	44.73	3578.51	6.17	32.80	202.37
1983	3865.70	214.06	4079.76	7.03	28.63	201.39
1984	4117.60	413.86	4531.46	7.81	27.89	217.90
1985	4292.67	659.51	4952.18	8.54	26.61	227.20
1986	3891.59	685.71	4577.30	7.89	13.06	103.07
1987	3717.82	804.15	4521.97	7.80	16.97	132.31
1988	4028.24	817.67	4845.91	8.36	13.53	113.04
1989	4437.52	867.17	5304.69	9.15	16.15	147.71
1990	4495.00	969.00	5464.00	9.42	25.00	235.52
1991	4490.94	1269.04	5759.98	9.93	18.04	179.16
1992	4434.99	1261.81	5696.80	9.82	18.08	177.58
1993	4260.78	1406.47	5667.25	9.77	16.00	156.34
1994	4307.89	2011.80	6319.69	10.90	15.82	172.37
1995	3650.45	2483.40	6133.85	10.58	16.60	175.56
1996	4044.97	2493.76	6538.73	11.27	18.65	210.25
1997*	2454.96	1741.69	4196.65	7.24	18.53	134.09
TOTAL	70234.37	18240.30	88474.67	152.54		**3121.62**

Note: * as of June 1997

RRMD/RRM6/TRANSFER/FOREXSAV.XLS/POM/9-16-97

Table II

Table III Estimated Capacity Cost of Conventional and New and Renewable Power Projects
(After G. R. Balce-1997)

RESOURCE	UNIT COST (US $/kW)
OIL	900
GAS	750
COAL	1,150
HYDRO	2,000
GEOTHERMAL	2,000
BIOMASS	
RICEHULL	1,400
BAGASSE	1,335
MUNICIPAL SOLID WASTE	2,500
OCEAN	
OTEC(FLOATING-MOORED)	11,000
(LAND-BASED)	4,800
TIDAL	1,600
SOLAR	7,000
WIND	1,000