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UPDATE ON GEOTHERMAL DEVELOPMENT IN THE PHILIPPINES

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ABSTRACT

Amid the absence of new players in geothermal field development and the economic turmoil that has rocked the Asian Region, the Philippines' geothermal power plants have continuously increased during the last seven (7) years from 888 MWe in 1992 to about 1909 MWe in 1999. This has been realized through the deregulation of power generation thus allowing the entry of the private sectors through the Build-Operate-Transfer (BOT) scheme. A total of 695.25 MWe capacity addition was realized from Tongonan (595.25 MWe) and Mindanao (100 MWe) through BOT.

In 1998, the contribution of geothermal energy to the country's total energy requirements has increased from 18.7% in 1997 to 21.52%. To date, since production began in 1977, the Philippines has generated a cumulative total of 100,602.41 gigawatt-hour (GWh) of electricity. This is tantamount to some 173.45 million barrels of fuel oil equivalent (MMBFOE), which translates to about US$3.4 billion in terms of foreign exchange (forex) savings.

Due to the cost-cutting measures that the geothermal developers have been enforcing in response to the economic crisis in the Asian Region, there were no new nonexclusive geothermal exploration permit (NEGEP) applications received by the Philippine Department of Energy (DOE) since 1998. The NEGEPs that had expired were similarly not reapplied for extension. Nonetheless, exploration activities by the DOE's Geothermal Division were continuously undertaken until 1998 thru the implementation of its "National Inventory of Geothermal Resources" project. Reconnaisance geological and geochemical surveys were conducted in another three (3) provinces, namely, Bulacan, Palawan and Mt. Province.

Three (3) new geothermal areas, namely, Mt. Labo, Northern Negros and Cabalian, are presently in advanced exploration and development stage. An aggregate total of 340-MWe installed capacity is projected to be commissioned in these fields by PNOC-EDC.

1. INTRODUCTION

The Philippines remains the world's second largest producer of geothermal energy for power generation (Table 1). Currently, the Philippine Department of Energy (DOE) is supervising the operations of nine (9) geothermal service contract areas, of which, six (6) are producing fields (Figure 1) and three (3) are under advanced exploration stage. Two of the contracts are operated by the Philippine Geothermal, Incorporated (PGI), a subsidiary of the Union Oil of California (UNOCAL), while the rest are handled by the government-owned and controlled Philippine National Oil Company-Energy Development Corporation (PNOC-EDC). Total installed capacity now stands at about 1,909 megawatts (MWe) (Table 2). The largest installation is in Tongonan, Leyte with an aggregate capacity of 707.75 MWe or 38% of the total installed geothermal capacity.

The most impressive increase in this capacity came only during the last seven (7) years. From 888 MWe in 1993, this geothermal capacity increased to 1909 MWe even as there were only two players involved in geothermal field development (Figure 2). This was mainly due to a major policy reform brought about by Executive Order No. 215, which allows the private sector to construct, operate, and sell its power to the grid through the Build-Operate-Transfer (BOT) scheme. PNOC-EDC's capacity addition brought about by installation of Tongonan II and III power plants availed of the provisions of this Executive Order by entering into BOT contracts with California Energy. Mindanao geothermal project is, likewise, pursued through a BOT contract with OXBOW-Marubeni.

The BOT scheme is a contractual arrangement between the Government and a private contractor wherein the latter would be responsible in constructing and financing an infrastructure facility (power plants) for the Government. The Contractor operates and maintains the facility for an agreed period of time and in turn, be allowed to charge facility user fees, rents and other charges to recover both investment and operating expenses as well as to gain a reasonable rate of return. This has encouraged private sector participation in power generation, an industry once monopolized by the state-owned National Power Corporation (NPC), Balce, (1998).

In terms of actual production, the contribution of geothermal energy in 1998 to the country's total energy requirements has increased from 18.7% in 1997 to 21.52% (Figure 3). As of December 1998, the cumulative total electricity generation from geothermal energy totals 100,602.41 gigawatt-hour (GWH) (Table 3). This is tantamount to some 173.45 million barrels of fuel oil equivalent (MMBFOE), which translates to about US$3.4 billion in terms of foreign exchange (forex) savings, Year-End Report of the Geothermal Sector (1998).

2. PRODUCING FIELDS

2.1 Tiwi, Albay

For quite sometime, PGI had been combating the negative effects of the cold water influx on the reservoir of the Tiwi geothermal field in Bicol, Southern Luzon. PGI had made several studies including grout injection and dewatering of the cold water intrusion, but all to no avail. However, during the last three (3) years the cold water influx has been serving as a

recharge to the Tiwi reservoir. PGI has reported that the output of Tiwi has improved since.

Electricity generation in 1998 by the field's 330-MWe geothermal power plant declined by as much as 20% because in the last quarter of the year only one unit (Unit 5) of the power plant was operational. The other five (5) had been severely damaged by typhoon "Loleng" that hit the country in October.

As of July 1999, PGI is negotiating with the state-owned National Power Corporation (NPC) on the Tiwi Rehabilitation Project aimed at optimizing the field's existing power plants to improve generation efficiency.

To date, a cumulative total of 35,531.38 GWh of power have been generated by Tiwi since production began in 1979.

2.2 Makban, Laguna

The Makiling-Banahaw (Makban) geothermal field is located 70 km. south of Manila on the southeast flank of Mt. Makiling, a dormant composite volcano. An aggregate geothermal capacity of 425.73 MWe is currently installed in the field comprising of 330-MWe Makban, 80-MWe Makban Modular and 15.73-MWe Makban Binary power plants.

Since production began in 1979, the field has delivered a cumulative total of 38,711.40 GWh of electricity as of December 1998. This is equivalent to a displacement of approximately 66.74 MMBFOE and tantamount to some US$MM 816.89 of forex savings. A total of 73 production and 14 reinjection wells have been drilled in Makban.

2.3 Tongonan, Leyte (PNOC-EDC)

Recent geothermal development activities in the Philippines have been focused largely on the Greater Tongonan geothermal field in Leyte, Eastern Visayas that hosts the known largest geothermal resource in the country. The implementation of the BOT legislation has been responsible in realizing the expansion program in Tongonan field which includes optimization studies to thermodynamically and economically match steam field to power plant.

Currently, a total of 707.75 MWe of geothermal generating capacity are installed in Tongonan field broken down as follows: 112.5 MWe Tongonan I operated by NPC; Tongonan II BOT plants (209.36-MWe) composed of 131.86-MWe Upper Mahiao Binary and 1 x 77.5-MWe Malitbog; and Tongonan III BOT plants (385.89-MWe) comprised of 3 x 5.75-MWe Tongonan I Topping cycle, 2 x 6.35-MWe Mahanagdong A Topping, 1 x 6.38-MWe Mahanagdong B Topping, 1 x 14.56-MWe Bottoming cycle, 2 x 60-MWe Mahanagdong A, and 2 x 77.5-MWe Malitbog.

Topping cycle plants are installed in Tongonan I, Mahanagdong A and Mahanagdong B Sectors, while bottoming cycle in the Malitbog Sector. Tongonan II power plants commissioned in 1996 export electricity from Leyte to Cebu via an AC submarine cable, while Tongonan III commissioned in 1997 transports power from Leyte to Luzon via a DC submarine cable.

The usual load-sharing scheme implemented in the field in 1997 ended in May 1998. In the same month, the remaining 50.89-MWe Optimization Project dedicated for Leyte-Luzon grid (Tongonan III) was also completed. With these, the power plants in Leyte have been in full operation since May 1998. Consequently, Tongonan's electricity gross generation of 3,111.98 GWh in 1998 escalated by as much as 200% as against last year's 998.38 GWh.

To date, Tongonan power plants have generated a cumulative total of 10,802.13 GWh of electricity.

In anticipation of increased fluid extraction and reinjection once the entire power plants in the Greater Tongonan field become fully operational, PNOC-EDC has continued conducting precise leveling and microgravity surveys since 1997 to obtain new baseline values against which past and future reservoir changes can be evaluated.

2.4 Palinpinon, Southern Negros (PNOC-EDC)

The Palinpinon geothermal field is located in southern Negros on the southeastern flanks of a young volcanic complex. Power plants with a combined capacity of 195.5 MWe are installed in Palinpinon. These plants have generated as of December 1998 a cumulative total of 9,840 GWh of electricity. This production corresponds to a displacement of about 17 MMBFOE which contributed some US$MM 208 of forex savings. A total of 43 production and 26 reinjection wells have been drilled in the field.

As a result of PNOC-EDC's cost-cutting measures recent activities by PNOC-EDC in Palinpinon include workover of some problematic wells and conduct of precise leveling, microgravity and regional gravity surveys. Precise leveling and microgravity surveys are done to monitor mass changes in the reservoir due to fluid withdrawal. On the other hand, regional survey was conducted to identify the subsurface geologic structures in the field.

2.5 Bacon-Manito (Bacman), Albay/Sorsogon (PNOC-EDC)

The Bacon-Manito Geothermal field is located in the provinces of Sorsogon and Albay in the Bicol Peninsula. A first stage geothermal power plant development of 110-MWe in the Palayangbayan sector (Bacman I) was commissioned in 1993. In 1994, a 20-MWe extension in the Cawayan sector (Bacman II) was commissioned followed by the additional 20-MWe in the Botong sector, which was commissioned in May 1998.

As of December 1998, the power plants have delivered a cumulative total of 3,386.38 GWh of electricity displacing around 5.84 MMBFOE. One (1) production well, MO4, was completely drilled in 1998. To date a total of 24 production and 12 reinjection wells have been drilled in Bacman.

Meanwhile, on 06 October 1998, President Joseph Ejercito Estrada inaugurated the Manito Livelihood Geothermal

Project. The project is the energy sector's response to President Estrada's call to implement pro-poor programs. It is a joint undertaking by the DOE, National Power Corporation (NPC), National Electrification Administration (NEA), PNOC-EDC and the Local Government of Manito, and located at Pawa, Manito, Albay within the Bacon-Manito Geothermal Power Project. It is a showcase of the electrical and nonelectrical uses of geothermal energy.

A low-enthalpy well (MO2) was utilized for the 1.5 MWe geothermal plant to generate power, while the exhaust from the power plant is used to operate a multi-crop drying plant, which is capable of drying 3 tons of copra per day and various agricultural and marine products like cassava, fruits, fish and squid (DOE-Philippines, Manito Geothermal Livelihood Project Proposal).

The main objective of the project is to develop an integrated support facility to the Comprehensive Agrarian Reform Program (CARP) in Manito that will promote agricultural intensification, environmental enhancement, and economic development in the project area.

The project would contribute to greenhouse gases mitigation specifically carbon dioxide (CO_2) thru increase vegetation in the area and displacement of fuels emitting greenhouse gases, e.g., coal, diesel and others.

Since 06 October 1998 until 25 January 1999, the power plant has generated a cumulative total of 0.18 GWh of electricity supplying the power requirement of Manito town in Albay. For the drying plant, a cumulative total of about 5 tons of cassava and copra have been processed. As of July 1999, the plant is still on shutdown due to well and turbine maintenance and repair.

2.6 Mindanao, North Cotabato/Davao (PNOC-EDC)

The Mindanao field that is located on the northwest slopes of Mt. Apo in the northern part of Cotabato and Davao province is the country's sixth geothermal production field. During its first phase of development, a power plant (Mindanao I) with installed capacity of 52-MWe was commissioned in 1996. On 17 June 1999, the additional 48-MWe Mindanao II became operational.

With a total of 365.02 GWh of electricity generation in 1998, Mindanao I has increased its power production by 29.42%. It has contributed an estimated foreign exchange savings of US$MM11.50 from a displacement of about 0.50 MMBFOE.

Two (2) production wells, namely, SP-4D and APO-1D, and one (1) reinjection well, KN-1RD, were worked over for clearing of blockages, while production wells, TM-1D, APO-2D and MD-1D were acidized.

As of December 1998, Mindanao I has contributed a cumulative total of 647.05 GWh of electricity. A total of thirty two (32) wells have been drilled in Mindanao 1, 27 of which are production and 5 are reinjection.

3. ADVANCED EXPLORATION AND DEVELOPMENT

3.1 Mt. Labo, Camarines Norte/Sur and Quezon

The Mt. Labo Geothermal Project with area coverage of 93.34 km^2 is the only geothermal prospect in the Philippines that is situated in the boundaries of three provinces, namely, Quezon, Camarines Norte and Camarines Sur found in the Bicol Peninsula. At present, activities in the project are still concentrated on exploratory drilling. A total of eight (8) exploratory wells have been drilled so far.

PNOC-EDC undertook other activities such as geologic and structural mapping at Kilbay-Alawihaw geothermal prospect, located south of Mt. Labo.

3.2 Northern Negros, Negros Occidental

The Northern Negros Geothermal Project covers an area of 4,310.84 hectares situated in Mambucal, Negros Occidental in Visayas Island. A projected 40 MWe of geothermal capacity is expected to be commissioned in this project.

To date, a total of eight exploratory wells have been drilled in Northern Negros by PNOC-EDC. Two of these wells (PT-2D and PT-4D) have successfully discharged with total estimated potential of 8 MWe.

3.3 Mt. Cabalian, Southern Leyte

The Mt. Cabalian Geothermal Project of PNOC-EDC is situated in Mt. Cabalian, Anahawan, Southern Leyte in Visayas. A power plant with 100 MWe installed capacity is projected to be commissioned in Cabalian by year 2006. So far, only one exploratory well (SL1D) has been drilled in the project. A bottomhole temperature of about 230^0C was measured in the well.

Other activities in Cabalian by PNOC-EDC include a one and one-half month magnetotelluric (MT) survey in Cabalian in 1997 utilizing Phoenix V-5 MT system. The MT survey was conducted to further characterize the subsurface geometry of Mt. Cabalian and further define the nature of the hydrothermal resource in Southern Leyte. The MT data interpretations reveal the presence of a prominent high-resistivity feature beneath the main body of Mt. Cabalian. This finding supports the PNOC-EDC geophysical model that defines the existence of a high-density intrusive body that probably feeds the geothermal resource in Southern Leyte.

4. PRELIMINARY EXPLORATION

For the period 1995-1998, the DOE spanned the whole country conducting preliminary exploration surveys in areas where the thermal manifestations were reported or are likely to occur. This national inventory of geothermal resources has identified prospect areas with encouraging geothermal characteristics, to wit: Salvador, Lanao del Norte; Camiguin de Babuyanes, Cagayan; Balut Island, Davao del Sur; Colombio, Sultan Kudarat; Banton Island, Romblon; Tinoc, Ifugao; and Bontoc, Mountain Province. Initial characterization based on preliminary geological and geochemical evaluations classified the prospects as low- to high-temperature geothermal systems.

So far, the Tinoc Geothermal Prospect was able to get the attention of PGI. The latter conducted exploration studies over the area under three (3) Nonexclusive Geothermal Exploration Permits (NGEPs) in 1996. Unfortunately, however, PGI found the resource too small for their purpose.

Further, most of the remaining above-enumerated geothermal areas occur in small islands and are, therefore, appropriate for off-grid development.

During the same period, the two (2) Philippine geothermal developers, PGI and PNOC-EDC, also undertook exploration activities over Kalinga, Buguias-Tinoc and North Davao geothermal prospects. PNOC-EDC is yet to submit the results of their study over North Davao. PGI, on the other hand, concluded that Batong-Buhay side of the Kalinga prospect is not attractive, as its heat source is more of a young volcanic system rather than a geothermal system. But PGI is willing to extend their exploration permit to probe the Tinglayan side, which they hope to be hosting a separate system. As aforementioned, PGI found the thermal manifestations of Buguias-Tinoc prospect as expressions of an aging volcanic system and do not indicate presence of an economically viable geothermal system.

In as much as studies have revealed that the remaining geothermal prospects are low-temperature, small or off-grid, the DOE is now focusing on technologies and projects giving possibility of direct/indirect utilization of this type of geothermal resources.

5. FUTURE STRATEGIES

The development and exploitation of high-enthalpy geothermal prospects shall continue with the projected capacity addition of 574 MW as per the medium-term Philippine Energy Plan for the period 2002-2008 (Table 4). Four (4) of the prospects are under a Geothermal Service Contract with PNOC-EDC.

Improvements in geothermal production technology, such as the binary, topping and bottoming plants, made possible the exploitation of low enthalpy geothermal resources and spent brine for power generation contributing significantly to increasing geothermal energy production. The technologies would continually be tapped for exploitation of the country's low enthalpy geothermal prospects and in projects involving self-sustaining, direct use of geothermal systems. The Department conducted an inventory and it identified 32 provinces with thermal manifestations nationwide. These prospects are on top of those studied by PNOC-EDC.

More projects like the Manito Livelihood Geothermal Project will be pursued during the present administration in response to the President's call for socially responsive programs, which will provide direct impact to the people. On the downstream side, interconnection projects will be pursued by NPC to make power from geothermal energy accessible to the different areas of the country.

Meanwhile, the DOE will continue to conduct exploration activities to assess identified geothermal areas to effectively reduce the risk of prospective geothermal service contractors. To encourage private sector investment, the DOE is drafting a bill, which will provide more attractive incentives for geothermal development such as the Filipino Participation Incentive Allowance (FPIA), development uplift allowance, cross cost recovery, and income tax and royalty holidays. With the passage of this legislation, the DOE hopes new players will participate in geothermal energy development.

6. FUTURE TARGETS

In order to meet the country's targeted energy self-sufficiency of 47% by year 2008 as per the Philippine Energy Plan (PEP 1999-2008), the geothermal sector sets its targets for the period. Projected geothermal power generation shall increase from 9,900 GWh by the end of the year to 13,865 GWh by 2008 which shall translate to a fuel oil displacement of 178 MMBFOE equivalent or US$3.6 to US$4.6 billion in foreign exchange savings. The capacity additions are expected to entail drilling of about 328 geothermal wells. In terms of percentage contribution to the power generation mix, geothermal contribution shall decrease from about 23.10% to 18.47% even if there is increased generation. This is due to the onset of natural gas utilization mainly by the year 2002.

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Table 1. World Installed Geothermal Plant Capacities

COUNTRY	1990	1995	1998
USA	2774.60	2816.70	2850.00

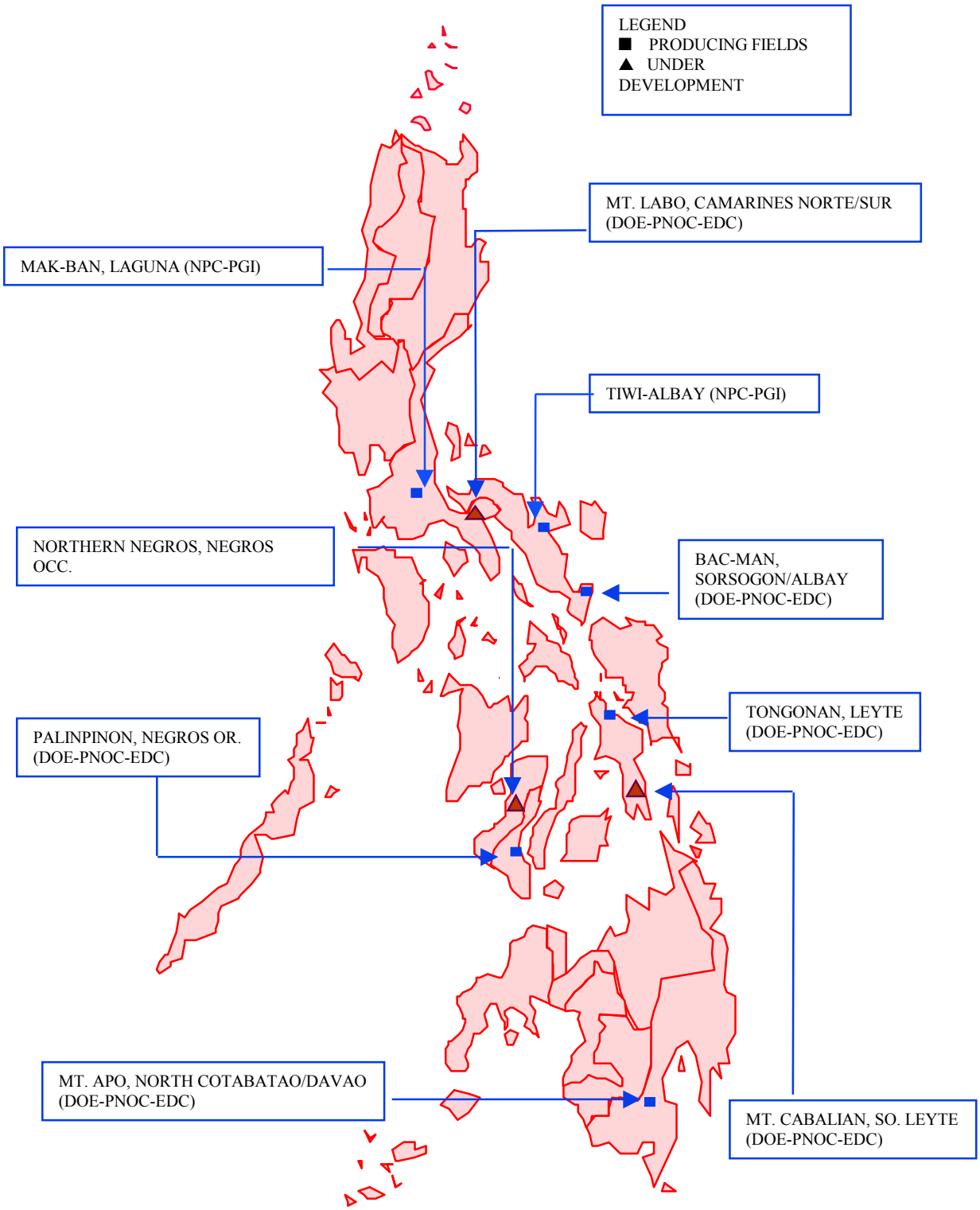

Figure 1. Geothermal Service Contract Areas

Philippines	**891.00**	**1191.00**	**1861.00**
Mexico	700.00	753.00	743.00
Italy	545.00	631.70	742.00
Indonesia	144.75	309.75	589.00
Japan	214.60	413.70	530.00
New Zealand	283.20	286.00	364.00
El Salvador	95.00	105.00	105.00
Iceland	44.60	49.40	80.00
Nicaragua	35.00	35.00	70.00
Costa Rica	0.00	55.00	65.00
Kenya	45.00	45.00	45.00
China	19.20	28.78	32.00
Turkey	20.60	20.60	21.00
Russia	11.00	11.00	11.00
Portugal	3.00	5.00	8.00
France	4.20	4.20	4.20
Greece	2.00	2.00	2.00
Argentina	0.67	0.67	0.70
Australia	0.00	0.17	0.40
Thailand	0.30	0.30	0.30

Table 2. Producing Geothermal Fields of the Philippines

Field	Installed Capacity (MWe)	Operator Steamfield/ Power plant
1. Tiwi	330.00	PGI / NPC
2. Makban	425.73	PGI / NPC-ORMAT
3. Tongonan I	112.50	PNOC-EDC / NPC
II	209.36	PNOC-EDC/Cal. Energy
III	385.89	PNOC-EDC/Cal. Energy
4. So. Negros		
Palinpinon I	115.50	PNOC-EDC / NPC
Palinpinon II	80.00	PNOC-EDC / NPC
5. Bacman I	110.00	PNOC-EDC / NPC
Bacman II	40.00	PNOC-EDC / NPC
6. Mindanao I	52.00	PNOC-EDC/Oxbow
Mindanao II	48.00	Marubeni
	1,908.98	

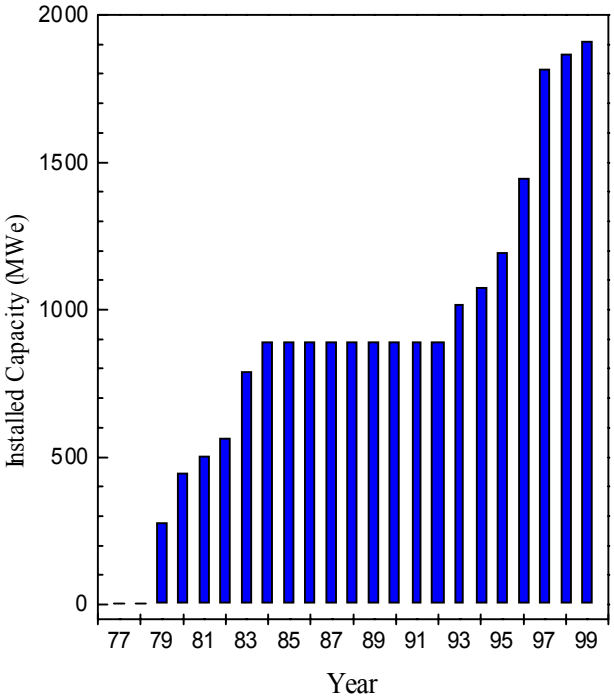

Figure 2. Yearly Installed Geothermal Capacity (MWe)

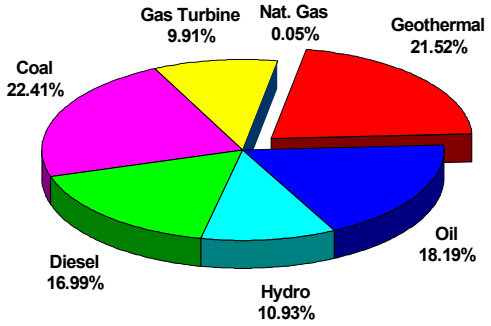

Figure 3. 1998 Generation Mix

Table 3. Philippine Geothermal Energy Performance

Year	Installed Capacity (MWe)	Gross Genration (GWh)	Fuel Oil Displaced (MMBFOE)	Foreign Savings (MMUS$)
1977	3	1.00	0.00	0.02
1978	3	3.00	0.01	0.06
1979	278	636.94	1.10	19.98
1980	446	2,044.85	3.53	105.03
1981	501	3,569.19	6.15	208.37
1982	559	3,563.86	6.14	201.54
1983	784	4,081.98	7.04	201.49
1984	894	4,531.46	7.81	217.90
1985	894	4,952.18	8.54	227.20
1986	894	4,577.30	7.89	103.07
1987	894	4,521.97	7.80	132.31
1988	888	4,845.91	8.36	113.04
1989	888	5,308.66	9.15	147.82
1990	888	5,464.76	9.42	235.55
1991	888	5,759.98	9.93	179.16
1992	888	5,696.80	9.82	177.58
1993	1018	5,667.25	9.77	156.34
1994	1074	6,319.69	10.90	172.37
1995	1194	6,134.52	10.58	175.57
1996	1448	6,538.73	11.27	210.25
1997	1819	7,430.88	12.81	234.07
1998	1861	8,951.50	15.43	188.91
TOTAL		100,602.41	173.45	3,407.64

Table 4. Geothermal Capacity Addition (2002-2008)

Project	Capacity Addition (MW)	Commissioning Year
Northern Negros	40	2002
Montelago	16	2002
Mt. Cabalian	110	2006
Amacan	40	2007
Mt. Labo	20	2007
Batong-Buhay	120	2007
Buguias-Tinoc	120	2007
Bato Lunas	60	2008
TOTAL	**526**	