Philippine Country Update: 2005-2010 Geothermal Energy Development

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Keywords: Philippines, geothermal, renewable

ABSTRACT

Major developments and activities have taken place in the Philippine geothermal industry during the past five years, specifically in the corporate and policy fronts. These include the takeover by Chevron Geothermal Philippines Holdings, Inc. (CGPHI) of Unocal Philippines' geothermal steamfield operations in 2005, full privatization of PNOC-EDC (now know as Energy Development Corp. or EDC) in late 2007, and the sale of National Power Corporation's (NPC) geothermal power plants in Tiwi and Makiling-Banahaw to Aboitiz Power Renewables, Inc. (APRI) in 2008, and the Tongonan I and Palinpinon I/II power stations to EDC in September 2009. Furthermore, the Renewable Energy Bill was signed into law in late 2008, and went into effect in July 2009, providing legal definitions and financial and non-financial incentives to further develop all renewable sources of power, including geothermal.

Only EDC's Northern Negros Geothermal Power Plant (49 MWe) was commissioned in the last five years, although several small optimization schemes and plants in existing facilities were installed to raise the level of generation in these specific units. The installation of the Leyte optimization schemes and the rehabilitation of the NPC plants in Tiwi and Makiling-Banahaw prior to the sale, plus the commissioning of the Northern Negros plant should have significantly increased the country's installed capacity, however, these were offset by the decommissioning of 1 unit in Tiwi with an installed capacity of 110MWe. Presently, the country's total installed geothermal generation capacity stands at 1,902.32 MWe, accounting for 12% of the nation's total electric power supply. The relatively high availability of the geothermal plants resulted in the delivery of 10,311 GW-hrs of generation, or 17% of the nation's electricity production. The current global financial crisis has affected plans and programs on geothermal development. Expansion programs in most EDC-owned operating steamfields, scheduled even before full privatization, have been deferred until the full impact of the crisis is assessed.

These "setbacks" notwithstanding, the future for geothermal energy development looks promising. The NPC is set to privatize its remaining geothermal power plants in Bacon-Manito. The deferred expansion programs are expected to be back in the pipeline and go full-scale in the short-term. Moreover, new players have entered the geothermal development scene; the DoE awarded four service contracts (three via the Philippine Energy Contracting Round, PECR) in new areas. Detailed exploration activities are now being carried out in these prospects. With all these in the horizon, plus the incentives embedded in the RE Act, the Philippines is looking forward to an even more vibrant geothermal energy sector.

1. INTRODUCTION

The installed (operating) geothermal capacity of the Philippines stands at 1,902.32 MWe, from a total of seven operating geothermal concessions scattered throughout the country (Fig. 1). Although this figure is slightly lower than the capacity reported in the last country update (1,931 MWe; *Benito, et al., 2005*), the overall "geothermal landscape" has significantly changed especially in the area of steamfield operation and power plant ownership. These changes were driven by the Philippine government's thrust of maximum privatization of the energy sector.

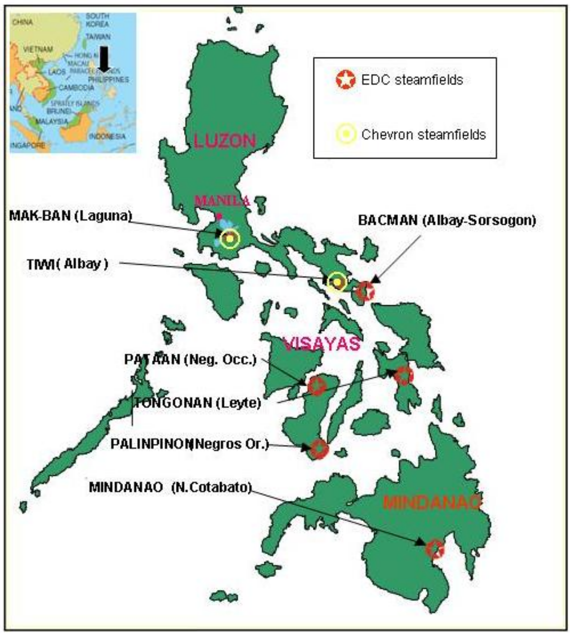

Figure 1. Location map of producing geothermal areas in the Philippines

The Philippine Department of Energy (DoE) remains as the main overseer of geothermal operations in the country. In 2005, Chevron Geothermal Philippines Holdings Inc. (CGPHI) took over the geothermal steamfield operations of Unocal Philippines in Makiling-Banahaw (Makban) and Tiwi.

The Energy Development Corp. (EDC), which operates the Leyte, Bacon-Manito (Bacman), Palinpinon, Northern Negros and Mindanao steamfields and owns power plants in Leyte, Mindanao and Northern Negros, was fully privatized in 2007. EDC's evolution from a wholly government-owned corporation into a private entity began in 2006 with the public sale of 40% of its stocks; this was followed by the sale of the remaining 60% government interest, thru public bidding, to Red Vulcan Corp., a consortium controlled by the local company FirstGen Corp.

The most recent development in the privatization front is the sale of power plant assets of National Power Corp. (NPC) in Makban and Tiwi to Aboitiz Power Renewables, Inc. (APRI) which was culminated in the second quarter of 2009. In September 2009, the sale of the Tongonan I power station in Leyte and the Palinpinon I/II power plants in Southern Negros, was awarded to EDC.

The last phase of privatization of the geothermal energy sector is the scheduled sale of NPC's power plant assets in Bacman (150MWe). The Bacman power plant facility is scheduled for sale sometime in 2010. In a related front, the power transmission assets of NPC all across the country have likewise been privatized.

In late 2008, the Renewable Energy Act was signed into law. The law's implementing rules and regulations (IRR) draft, spearheaded by the DoE, were completed in June 2009, and the law duly went into effect in July 2009. It is widely anticipated that the law will have an overall positive impact on renewable energy development in the Philippines, which includes geothermal power development and generation. It is intended to spur development of geothermal and other renewables by defining their legal status, establishing a Renewable Portfolio Standard for utilities, promoting transmission access, and offering a range of tax and investment incentives. Apart from drafting the IRR, the DoE is now reshaping its organizational structure to accommodate the provisions of, and be more responsive to, the provisions of the Renewable Energy Act.

2. GEOLOGIC BACKGROUND

The Philippine Archipelago in the west Pacific Ocean can be classified into two general or major structural units – the mobile belt and a stable region (*Bureau of Mines and Geosciences, 1982*). The mobile belt is a broad zone of active deformation, characterized by pronounced seismicity and volcanism, running longitudinally through the whole archipelago. Rock sequences in the mobile belt are typically composed of Cretaceous-Paleogene metamorphics as basement units, overlain by Eocene to Miocene sedimentary rocks and topped by Tertiary to Quaternary volcanic units. Intrusive complexes cut through the sediments and young volcanics, and in areas through the basement complex as well. The southwestern part of the country, mainly Palawan and Sulu Sea, make up the stable region. Rocks here are typically Cretaceous to Mesozoic regionally metamorphosed sedimentary units, intruded by plutons and overlain by undeformed Eocene to Recent sediments.

Philippine tectonics is considered as one of the most active in the world (*Aurelio, 2000*). Tectonic activities are a result of interaction of three major plates – Eurasian, Indo-Australian and the Pacific (including the Philippine Sea Plate at its western margin; Fig. 2). Movement of the Eurasian Plate to the north is weak, estimated at 3mm/yr, while velocities of the Pacific (WNW direction) and Indo-Australian Plates (NE direction) are estimated at 80mm/yr and 107mm/yr, respectively (*Aurelio, 2000*). The Philippine mobile belt is bounded by subduction zones with opposing polarities (Fig. 3; *Aurelio, 2000*). In the east, the west-dipping East Luzon Trough and Philippine Trench are expressions of subduction of the Pacific Plate/Philippine Sea Plate. In the west, on the other hand, the east-dipping Manila, Negros and Cotabato Trenches are a result of subduction of the Indo-Australian Plate. Tectonic activities along both margins have given rise to the emergence of volcanic arcs parallel to the subduction zone traces which are also stretching longtitudinally across the islands. Some of these volcanic arcs host currently and/or recently active volcanoes, including those indirectly attributed to the development of hydrothermal convection cells and active geothermal systems. Moreover, eastward and westward subduction have resulted in the generation of the Philippine Fault, an active transcurrent fault running from the south in the island of Mindanao all the way north to the tip of Luzon. This fault is significant in terms of copper and gold mineralization, as all major copper and gold depositional areas in the Philippines are roughly aligned with, and controlled by, the trace of the Philippine Fault.

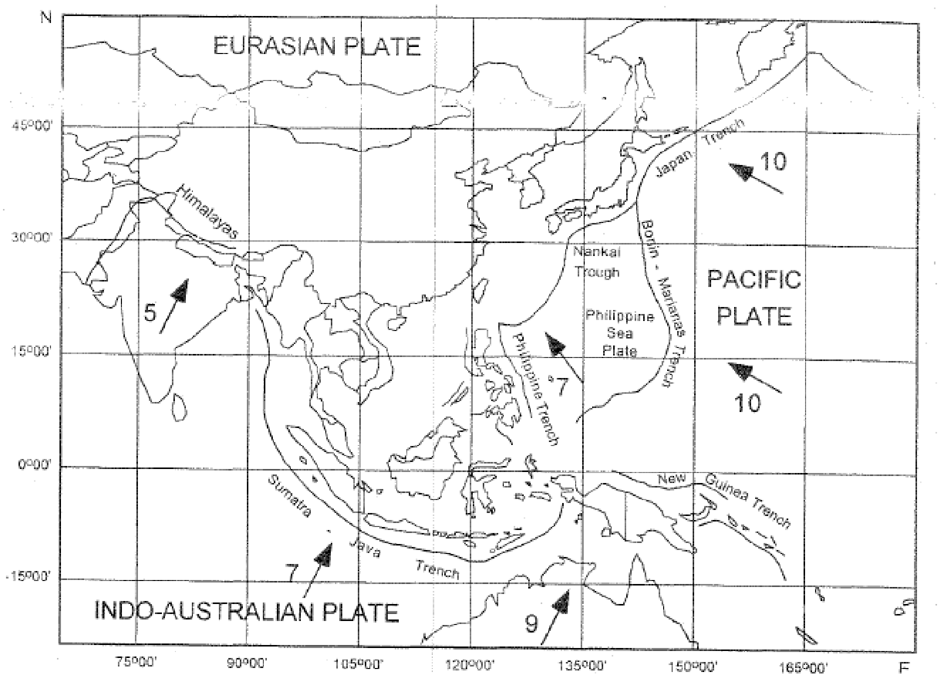

Figure 2. The Philippine in relation to major tectonic plates

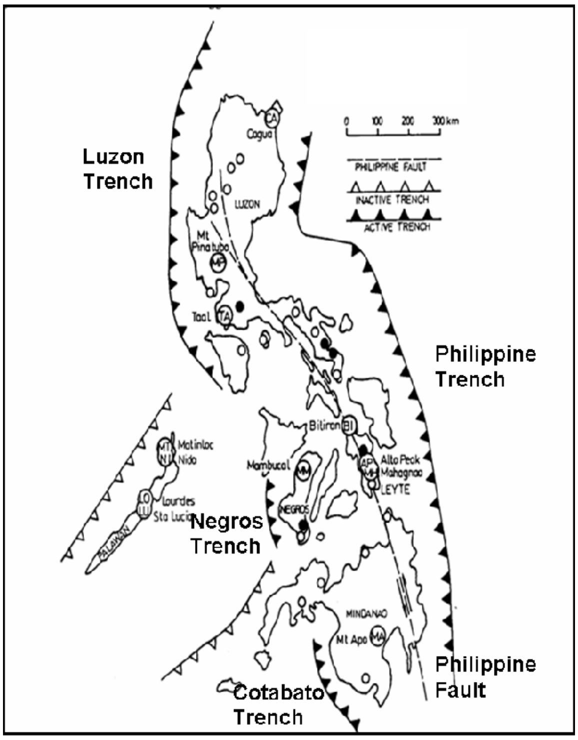

Figure 3:Philippine subduction zones and the Philippine Fault

3. GEOTHERMAL RESOURCES AND POTENTIAL

The occurrence of high enthalpy hydrothermal systems in the Philippines is closely related to, and appears to be controlled by, subduction and subsequent volcanic arc formation. The seven (7) operating fields in the country reflect the abundance of these high temperature systems, all directly or indirectly correlatable with inactive volcanism. In addition to these producing areas, other prospect areas that have been previously identified and initially explored (Fig. 4) are likewise volcano-related (spatially and most probably hydrothermally).

The production fields' operations highlights are discussed below.

3.1 Tiwi, Albay and Makiling-Banahaw (Mak-Ban), Laguna

The most significant change in the Tiwi and Mak-Ban operations is the improvement of power plant individual unit performance, made possible through major rehabilitation works done by NPC on both plants prior to the sale of these assets to APRI. The rehabilitation works enabled the units to generate electricity at or very close to installed capacities (Table 2). Mak-Ban Plant D is contractually considered a standby plant. Mak-Ban Plant C is currently not capable of generating at its full capacity, but this is considered a temporary condition and is therefore still counted as running capacity. Tiwi Plant B (previously 110 MWe installed capacity) has recently been decommissioned. All these considered, the installed capacities of Tiwi and Makban currently stand at 234 MWe and 457.7 MWe, respectively. The running capacities, as defined in Table 2, are 234 MWe and 402 MWe respectively. Given steam supply and plant conditions as of October 2009, fieldwide generation could reach about 165 MWe at Tiwi and 305 MWe at Mak-Ban.

3.2 Tongonan, Leyte

Optimization plants were installed in most of the existing power plant facilities in Leyte to improve generation. The optimization plants consist of either topping plants where separation pressures are raised to 1.2MPaa and steam is diverted to a high pressure turbine while the residual liquid is flashed at normal separation pressure of 0.7MPaa, or bottoming plants where residual brine from the conventional 0.7MPaa separator is flashed anew at slightly lower pressure to recover more steam that is then channeled to a low pressure generating unit. The latter plants were installed in sectors where silica saturation and scaling potentials were not anticipated to cause problems. The total additional generation output of the optimization plants is 50 MWe.

3.3 Palinpinon, Negros Oriental

Except for scheduled minor plant and steamfield preventive maintenance works, all plants in Palinpinon have been operating at near running capacity since the late-1990's.

3.4 Bacon-Manito (BacMan), Albay/Sorsogon

The Bacman-II Cawayan unit has not been operating since 2006 due to a major turbine breakdown, which has unfortunately remained non-operational to date. Moreover, the Bacman-I generating units have persistently encountered rotor vibration problems, hence have not produced at even close to full capacity. The average load for Bacman-I has been about 55 MWe for the 2 turbine generators combined. Only Bacman-II Botong has been producing at close to rated capacity until recently, when a major fire accident destroyed the cooling tower. As of this writing, this problem has not been remedied and is expected to persist even until the sale of the plant in 2010.

3.5 Mindanao, North Cotabato/Davao

All units have been on normal and full load operation in Mindanao; this remains the most reliable and efficient power plant asset in the EDC portfolio.

3.6 Northern Negros, Negros Occidental

The field/plant was operated for about a year and a half after commissioning in February 2007, after which the plant had to be shut down due to massive scaling problems encountered in the wells. Reservoir "rehabilitation" works were implemented for a full 10 months before the plant was re-commissioned. Currently, drilling in the M&R sector is on-going to augment steam supply to the plant.

Apart from the 1902.32 MWe installed (operating) capacity from the 7 producing steamfields, the estimated total untapped geothermal potential of the country is about 2,600 MWe. Included in this estimate are identified expansion areas within existing geothermal concessions, particularly those awarded to EDC. These planned expansion projects which are likely to be developed into production steamfields and power plants in the next five years, are the following:

Figure 4. Identified geothermal prospects for advance exploration and/or field development

3.7 Nasulo, Palinpinon II Optimization

Estimated to add 20MWe to the Palinpinon operations, this expansion project calls for the tapping of excess steam in Nasuji and Sogongon sectors of the field, currently available at the wellhead of producers either throttled at the wellhead or not hooked up to the Nasuji and Sogongon modular plants. Additional production well drilling is therefore not required, although an additional injection well may need to be drilled at the start of operations. The expansion project is envisioned to be online by 2012.

3.8 Mindanao 3, Mindanao

An estimated 50 MWe of additional resource is available from Tabaco sector of the Mindanao geothermal system, due largely to the expansion of the two-phase zone on top of the liquid reservoir in the system. Two production wells are currently available from this sector, and about 3 or 4 more production wells and 2 injectors are necessary for the commissioning of the Mindanao-3 expansion project. Commissioning date is eyed in 2014.

3.9 Tanawon-Rangas

In Bacman, the Tanawon and Rangas sectors have also been identified as expansion areas. Two wells have been drilled in Tanawon, and the estimated resource potential here is 50 MWe. Although no step-out well has yet been drilled in Rangas, it is expected that this sector will be good for another 40 MWe considering its proximity to the postulated upflow zone of the Bacman geothermal system. Target commissioning date is late 2016.

4. FUTURE DEVELOPMENTS

Of these identified geothermal prospects, a few are in the advanced exploration stage – where exploration wells have been drilled and tested, and post-drilling evaluation have been conducted. In these advance exploration areas, given the presence of subsurface as well as more detailed surface data, potential power estimates are taken to be more realistic compared to those prospects where only initial exploration surveys have been done (Fig. 4). In the future, more exploration activities in the "greenfield" prospects, and new technologies such as Enhanced Geothermal Systems, could increase the estimated untapped geothermal potential of the Philippines.

The target of 650 MWe additional geothermal capacity is anchored on 1) EDC's expansion program within its current service contract areas, and 2) development from current exploration programs by new industry players. Although already targeted for development prior to 2005, the global financial crisis has forced the postponement of these development activities. Nevertheless, expansion programs are still in the medium term horizon of EDC. These expansion areas include: Kayabon (estimated at 40MWe) within the Bacman service contract area, Dauin (40MWe) in Southern Negros, and Cabalian in Southern Leyte (50-80MW). If all projections come to bear, EDC's production fields' expansion and greeenfields' development projects will add 290-320 MWe to the country's geothermal power capacity.

Three of the advance exploration areas offered by the DoE in the 2008 edition of the annual Energy Contracting Round - Biliran Island, Amacan (Compostela Valley Province) and Mabini (Batangas Province) – have been awarded to three separate consortiums. Advanced exploration activities are now on-going in these sites; these exploration surveys are expected to lead to exploration drilling in the near future, and hopefully field development and production. The 2009 contracting round is scheduled in October 2009, and those areas previously offered that did not receive bids will again be on the table, together with new areas for private investment offer. It is hoped that this coming contracting round will attract even more investors than the previous editions, especially with the passage of the Renewable Energy Law and its Implementing Rules and Regulations which effectively improves and makes more attractive geothermal development investment opportunities in the Philippines.

5. GEOTHERMAL UTILIZATION

Geothermal utilization in the Philippines is largely confined to power generation. As of end 2009, the total installed geothermal operating capacity in the country is 1,902.32 MWe (12% of the nation's total installed capacity) from the seven (7) producing geothermal service contract areas, producing about 10,311 GWh/yr (Table 1). Geothermal plants generally perform at relatively high capacity factor and availability, so geothermal energy accounts for about 17% of the country's total electrical generation, which is still dominated by fossil fuel contributions at 66%. In terms of the renewable energy mix, geothermal is the second largest renewable source contributor to the country's electricity requirements, supplying 36% of the existing total renewable generation. Hydropower is top renewable source at 63%, with all other renewables combined amounting to less than 1% of the nation's renewable generation.

Projects totaling 650 MWe capacity are anticipated to come onstream by early-2015. These projects should bring the Philippines' geothermal capacity to about 2,552.32 MWe, and generation to about 15,758 GWh/yr, in five (5) years time. In terms of percentages of renewable and total generation capacity, however, geothermal is projected to remain near its current levels of 36% and 12%, respectively, in 2015. This is due to other sources of power, both renewable and fossil, growing at roughly the same rate as geothermal.

Most of the installed geothermal plants, especially the large capacity ones, are single-flash types; double flash and binary types make up the rest of the power plant types (Table 2). There are a total of 53 units installed/running in the different geothermal power plant sites. Of the 1,902.32 MWe total installed (original installed capacity plus optimization schemes and plants, which contribute intermittently to the total power generation), the overall running capacity is 1,773.62 MWe. The corresponding load factor (except NPC plants-in-EDC fields) amounts to about 75%.

Direct use of geothermal energy in the Philippines is very limited (Table 3). Only 3.3 MWt has so far been tapped, split between bathing and crop drying, yielding 39.58 TJ/yr of heat flow.

Since 2005, a total of twenty five (25) deep wells have been drilled (Table 4), of which only one (1) was for exploration while the rest were make-up and replacement wells in existing operating fields. Twenty two (22) of the M&R wells drilled were for production purposes and two (2) for brine injection.

Technical manpower directly involved in geothermal operations in the Philippines currently stands at 1547 (excluding NPC power plants' manpower count), only slightly higher than several years ago (Table 5). There is, however, a trend of slightly increasing technical manpower through the years. With expected renewed interest in geothermal energy development in the short term, this trend is expected to be carried over in the next few years. With its principal role as monitoring agency, the Philippine DoE is understandably a minority in the industry, numbering only 26. This translates to about 1.7% of the country's total geothermal technical workforce. The bulk of the technical manpower count comes from the private sector, with majority coming from EDC (1207, 78%) and CGPHI contributing 301 (19.4%) technical personnel. The number of consultants brought into geothermal operations in the Philippines is insignificant at 0.9% (13 personnel total), reflecting the capability of home-grown personnel to handle most of the technical aspects of geothermal operations.

Total investment in geothermal energy development and utilization between 2005 and 2009 reached US$521M (Table 6). Majority of the expenditures was on surface exploration surveys and exploration drilling activities, as well as research and development studies (US$359M). A total of US$161.92M was allocated for field development and production costs. These figures are slightly up from those during the period 2000-2004. Exploration and R&D costs increased by 2.7%, while field development costs were raised by about 32%.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the management of the Philippine Department of Energy, Energy Development Corp., and Chevron Geothermal Philippines Holdings, Inc. for the support and for providing the data used in this update.

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Table 1. Present and Planned Production of Electricity (based on installed capacity)

	Geothermal		Oil Based		Coal		Natural Gas		**TOTAL FOSSIL FUEL**		Hydro		wind		Biomass		**TOTAL OTHER RENEWABLES**		***Total***	
	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	**Capac-ity MWe**	**Gross Prod. GWh/yr**	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	**Capac-ity MWe**	**Gross Prod. GWh/yr**	***Capac-ity MWe***	***Gross Prod. GWh/yr***
In operation in December 2009	1,902.32	10,311.00	3,619.20	4,687.46	4,377.10	16,027.54	2,763.00	19,484.12	**10,759.30**	**40,199.12**	3,291.00	10,042.93	33.00	57.84	5.48	28.78	**38.48**	**86.62**	***15,991.10***	***60,639.67***
Under construction in December 2009	none	none	none	none	206.00	754.31	none	none	**206.00**	**754.31**	50.50	154.11	none	none	none	none	none	none	***256.50***	***908.42***
Funds committed, but not yet under construction in December 2009	70.00	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none	***70.00***	
Total projected use by 2015	2,552.32	15,758.00	3,373.00	4,368.49	6,979.00	25,677.14	3,681.00	25,957.68	**14,033.00**	**56,003.31**	4,180.00	12,755.83	244.00	427.49	92.95	48.87	**336.95**	**476.36**	***21,102.27***	***84,993.50***

Table 2. Utilization of Geothermal Energy for Electric Power Generation as of 31 December 2009

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash
2F = Double Flash
3F = Triple Flash
D = Dry Steam

B = Binary (Rankine Cycle)
H = Hybrid (explain)
O = Other (please specify)

3) As of end 2008

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1]	Type of Unit[2]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2009[3] GWh/yr	Total under Constr. or Planned MWe
Mak-Ban	A	1979	2		1F	126.4	126.4	794	0
	B	1980	2		1F	126.4	126.4	805	0
	C	1984	2		1F	109.2	109.2	97	0
	D (backup plant)	1995	2		1F	40	0	237	0
	E	1996	2		1F	40	40	211	0
	Binary	1994	3	N	B	15.7	0	0	0
Tiwi	A	1979	2		1F	120	120	501	0
	B	1980	2	R	1F	0	0	0	0
	C	1982	2		1F	114	114	506	0
Leyte	Tongonan-1**	June, 1983	3		1F	112.5	94	763.076	
	Upper Mahiao	June, 1996	4		B	141.89	141.89	764.816	
	Malitbog	July, 1997	3		1F	233.7	233.7	1742.09	
	Mahanagdong	July, 1997	3		1F	176.91	176.91	1241.05	
	Opti Plants					50.89	60.89	234.639	
	Malitbog Bottoming	Sept. 1997	1		2F				
	Tongonan Topping	May, 1997	3		O- Back Pressure Turbine				
	Mah A Topping	May, 1997	2		O- Back Pressure Turbine				
	Mah B Topping	May, 1997	1		O- Back Pressure Turbine				
Negros Is.	NNGP		1		2F	49	49	16.089	
Southern Negros	Pal I**		3		1F	112.5	103	1257.12	
	Pal II**								
	Okoy 5	Dec. 1994	1		1F	20	20		
	Nasuji	Feb., 1994	1		1F	20	20		
	Sogongon	May, 1995	2		1F	40	40		
Mindanao	Mindanao I	March, 1996	1		1F	52.3	52.3	330.58	
	Mindanao II	June, 1999	1		2F	50.93	50.93	420.487	
Albay-Sorsogon	BacMan I**	Dec., 1993	2	N	1F	110	55		
	BacMan II**								
	Botong	April, 1998	1	N	1F	20	20		
	Cawayan	March, 1994	1	N	1F	20	20		
S Negros	Nasulo								20
Albay-Sorsogon	Rangas-Tanawon								90
Mindanao	Mindanao 3								50
Total			53			1902.32	1773.62	9920.95	160

* Installed capacity is maximum gross output of the plant; running capacity is the actual plant generation assuming full steam supply
** NPC-owned power plants

Table 3. Summary Table of Geothermal Direct Heat Uses as of 31 December 2009

[1] Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

[2] Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°((TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

[3] Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10^6 W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less,
since projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]			
District Heating [4]			
Air Conditioning (Cooling)			
Greenhouse Heating			
Fish Farming			
Animal Farming			
Agricultural Drying[5]			
Palinpinon Drying Plant (Year? t	1	17.34	0.55
Manito Drying Plant (Year? To Year	0.63	9.59	0.48
Industrial Process Heat[6]			
Snow Melting			
Bathing and Swimming[7]			
Laguna Hot Springs	1.67	12.65	0.24
Agco Hot Springs+Other resorts			
Other Uses (specify)			
Subtotal	3.3	39.58	
Geothermal Heat Pumps			
TOTAL	3.3	39.58	

[4] Other than heat pumps
[5] Includes drying or dehydration of grains, fruits and vegetables
[6] Excludes agricultural drying and dehydration
[7] Includes balneology

Table 4. Wells Drilled for Electrical, Direct and Combined Use of Geothermal Resources from January 1, 2005 to December 31, 2009 (excluding heat pump wells)

[1] Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1]		1	x	x	x	3.01
Production	>150° C	22	x	x	x	51.18
	150-100° C					
	<100° C					
Injection	(all)	2	x	x	x	4.27
Total		25				58.47

Table 5. Allocation of Professional Personnel to Geothermal Activities (Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Year	Professional Person-Years of Effort						TOTAL
	(1)	(2)	(3)	(4)	(5)	(6)	
2005	1186			12		272	1470
2006	1186			8		292	1486
2007	23			8		1435	1466
2008	23			10		1484	1517
2009	26			13		1508	1547

Table 6. Total Investments in Geothermal in (2009) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999			x	x		
2000-2004	350	122.58	x	x	74	26
2005-2009	359.33	161.92	x	x	44.59	55.41

Source:Philippine Energy Plan