九大地熱・火山研究報告
第 11 号 (2002) 44-55 頁

# GEOTHERMAL ENERGY IN THE PHILIPPINES: 2000 YEAR END REPORT AND UPDATE ON THE CURRENT DEVELOPMENT AND OPERATIONS

**Andresito F. Ulgado**

ABSTRACT

In the year 2000, geothermal energy continues to be the leading indigenous energy resource for electrical generation in the Philippines. It contributed 25 % to the country's power requirement in 2000. The country maintained its position as the second world`s largest producer of geothermal energy for electricity generation. A total of 1930.89 MWe installed capacity is contributed by six (6) geothermal fields with almost 37% (712.68 MWe) coming from Tongonan, Leyte. Two Geothermal Service Contractors, Philippine National Oil Company (PNOC-EDC) and Philippine Geothermal Inc., (PGI) a subsidiary of Union Oil of California (UNOCAL), are currently undertaking geothermal energy development in the Philippines. PNOC-EDC operates four (4) production fields (Leyte Geothermal Production Field, Southern Negros Geothermal Production Field, Bacman Geothermal Production Field and Mindanao Geothermal Production Field). PGI on the other hand operates two (2) geothermal fields namely Mak-Ban Geothermal Field and Tiwi Geothermal Field.

The most impressive increase in geothermal capacity came only in the last seven years. From 888 MWe in 1993, it increased to nearly 1931 MWe as even there were only two players involved in geothermal Field development in the country. This was mainly due to a major policy reform brought about by Executive Order No. 215 (EO 215), which allows the private sector to construct, operate and sell its power to the grid through the Build-Operate-Transfer scheme (BOT).

Geothermal resource potential of the country from 35 areas is estimated at 4,537 MW of which 1930.89 MWe is already being tapped. The development and exploitation of high-enthalpy energy prospects shall continue with the projected capacity addition of 730 MW as per medium-term energy plan. Maximizing and optimization of geothermal production technologies will also be continually tapped for exploitation of the country`s low enthalpy geothermal prospects and in projects involving direct use of geothermal systems.

Meanwhile, the recent passage and enactment of the reforms in the electric power industry also known as "Republic Act 9136" is expected to enhance private capital and broaden the ownership base of the power generation, transmission and distribution sectors. This means that inflow of capital investment in geothermal energy development is expected to increase with the passage of this law.

## 1. ACCOMPLISHMENT HIGHLIGHTS

The geothermal sector has continuously contributed in providing a reliable, efficient, safe, clean and environment-friendly energy for the country having produced a total gross generation of 11,317.18 gigawatt-hour (GWh) of electricity in year 2000. It has helped the economy by saving some US$MM533.86 in terms of foreign exchange through displacement of about 19.51 million barrels of fuel oil equivalent (MMBFOE) based on a yearly average price of US$27.36 per barrel of oil. Power production from geothermal also contributed nearly 25% of the country's total electricity requirement （Figure 1）.

Four (4) wells were drilled during the year, namely, KL4RD and KN5D in Mindanao Geothermal Production Field, BL3D in Southern Negros

Geothermal Division, Energy Resource Development Bureau
Department of Energy
Merritt Road, Fort Bonifacio, Makati City, Metro Manila
Philippines

Geothermal Production Field and TW1D in Bacman Geothermal Production Field, while drilling of three (3) production wells, namely, TW2D in Bacman Geothermal Production Field, PT-5D and PT-6D in Northern Negros Geothermal Field was ongoing as of yearend.

All wells drilled in Mt. Labo Geothermal Project were plugged and abandoned by PNOC-EDC in November. This is in preparation for the abandonment of the project area by PNOC-EDC.

For the realization of the Department's vision and mission the Geothermal Division (GD), Energy Resource Development Bureau (ERDB) continues to explore and develop the country's geothermal resources through continuous conduct of reconnaissance studies and the first-of-its-kind in the Philippines, the Controlled Source Magnetotelluric surveys.

The GD undertook reconnaissance studies namely, geological/geochemical investigations in Calayan Is., Cagayan and San Juan, Batangas, Controlled Source Magnetotelluric (CSMT) survey in Mabini, Batangas and Socio-economic profiling in Banton Is., Romblon.

In lieu of the GD's mandate of safeguarding the exploitation of the existing geothermal production fields to ensure proper management of the resources for a sustainable energy source, the Division successfully concluded the Japan International Cooperating Agency's (JICA) Expert Dispatch Program on Geothermal Reservoir and Resource Management in November. The highlight of the program was the donation by JICA to DOE of the geothermal wellbore simulator program, Wellsim. This is the very first geothermal reservoir program that the DOE has obtained.

The safety performance of the geothermal developers for the year generally deteriorated with overall Frequency Rate (FR) and Severity Rate (SR) of 2.5 and 54.4, respectively. The deterioration of the field developers' safety performance is largely attributed to PNOC-EDC's 22 Lost Time Accidents (LTA) with one (1) fatality resulting in 6,146 Days Lost. PNOC-EDC's LTA is predominantly due to a total of forty (40) vehicular accidents reported in its five (5) production fields (Leyte Geothermal Production Field, Southern Negros Geothermal Production Field, Bacman Geothermal Production Field, Mindanao Geothermal Production Field and Northern Negros Geothermal Project). There were no safety performance ratings for Mt. Labo (Camarines Norte/Sur and Quezon) and Mt. Cabalian (Southern Leyte) geothermal projects as operations in these areas were still suspended.

On the other hand, Philippine Geothermal Inc., has 3 LTA and 74 Days Lost for the year with sixteen (16) reported vehicular accidents in Tiwi and Makban Geothermal Fields.

## 2. STATUS OF GEOTHERMAL ENERGY DEVELOPMENT (Producing Fields)

2.1. Tiwi Geothermal Production Field (PGI)
The electricity generated by Tiwi plants in year 2000 increased by 28.48% with 1,233.52 gigawatt-hour and utilization factor of nearly 43% (Table 1) as compared to last year`s data. Forex savings contribution from Tiwi amounts to US$58.19MM.

2.2. Makban Geothermal Production Field (PGI)
Cumulative power generation from Makban plants with aggregate installed capacity of 425.73-MWe amounts to 2,588.52 GWh. While aggregate power production from Makban plants barely changed compared to last year's generation, it must be noted, nevertheless, that electricity delivered from Makban Modular Plants have increased by as much as 120% (Table 1).

2.3. Leyte Geothermal Production Field
(PNOC-EDC)
Tongonan plants delivered a cumulative total of 4,719 of electricity in year 2000. Among the power plants, only Tongonan I decreased its production by almost 15% compared to last year`s generation primarily due to load sharing.

Electricity generation from Tongonan plants displaced nearly 8 MMBFOE equivalent to an estimated forex savings of US$MM 222.44.

Three production (MG-25D, -17D and -2D) and three reinjection (5R1D, 1R8D and 2R4D) wells were worked over during the year. 1R8D and 2R4D were both acidized.

2.4. Southern Negros Geothermal Production Field
(PNOC-EDC)

Southern Negros Geothermal Production Field (Palinpinon I and II power plants) with total installed capacity of 192.5 MWe continue to increase their cumulative electricity production. In 2000, generation escalated by almost 26% as compared to last year having delivered a total of 1,371 GWh. This has displaced 2.36 MMBFOE tantamount roughly to US$MM2.36 of forex savings (Table 1).

Production well BL3D was completely drilled on 16 August 2000 to a total depth of 1,739 meters.

One production (LG3D) and one reinjection (NJ1RD) wells were acidized during the year.

2.5. Bacman Geothermal Production Field (PNOC-EDC)
Shutdown of Unit 2 of Bacman I power plant since May until year-end attributes to the decrease in aggregate power delivered by Bacman plants in year 2000. The Unit was shutdown because of excessive turbine vibration.

Cumulative power generation amounts to 621.19 GWh and accounts for 1 MMBFOE displacement translated to about US$MM 29.3 of forex savings (Table 1).

Two exploration wells, namely, TW-1D and TW-2D, were spudded in 2000. TW-1D was completed on 24 September 2000 to a total depth of 1,901 meters, while TW-2D was ongoing as of year-end.

Two (2) reinjection (CN2RD and PAL3RD) and two production (PAL6D and MO2) wells were worked over.

2.6. Mindanao Geothermal Production Field (PNOC-EDC)
With Mindanao II operating the whole year, aggregate electricity generation produced from Mindanao rose by as much as 89% with 784 GWh. Some 1.35 MMBFOE have been displaced equivalent to forex savings of US$37MM （Table １）.

One production, KN5D, and one reinjection, KL4RD, were completely drilled in 2000. KN5D was completed on 27 March to a total depth of 1,537 meters, while KL4RD was completed on 25 January to a total depth of 2,128 meters.

Two production wells, APO1D and SP4D, were worked over.

## 3. DOE ADMINISTRATION OF EXISTING GEOTHERMAL FIELDS

The Philipine Department of Energy is currently supervising the operations of nine (9) Geothermal Service Contracts (SC), of which, six (6) are producing fields and three (3) are under advanced exploration stage (Figure 2). Two of the contracts, Tiwi and Mak-Ban, are developed by Philippine Geothermal, Incorporated (PGI), a subsidiary of Union Oil of California (UNOCAL), while the remaining are handled by the government-owned and controlled corporation, the Philippine National Oil Company-Energy Development Corporation (PNOC-EDC).

Year 2000 has been a very significant year for the Geothermal Division-ERDB prevalently because during the second semester, the Geothermal Division's request for an Expert Dispatch on Geothermal Reservoir and Resource Management thru Japan International Cooperating Agency's (JICA) Expert Dispatch Program was realized. The dispatch program, which was participated in by four (4) staff of the Geothermal Division began in September and concluded on 29 November 2000.

## 4. HIGHLIGHTS OF THE EXPERT DISPATCH ON GEOTHERMAL RESERVOIR AND RESOURCE MANAGEMENT

The transfer of expertise Mr. Ariki began his transfer of expertise by JICA expert is focus on the context that Geothermal Reservoir and Resource Management is principally the responsibility and concern of geothermal developers, such as PNOC-EDC and PGI, because it primarily involves taking decisions during the operation of the reservoir in order to change its operational conditions.

The Department of Energy (DOE) also recognizes this. This is why in conjunction with its mandate, the main role of the Geothermal Division in Geothermal Reservoir Management, is "*monitoring of the physical and chemical changes that occur in geothermal reservoirs in response to exploitation. This is done to ensure that the geothermal developers properly utilize and manage the country's geothermal resource.*"

Geothermal Reservoir Management as a whole is very complex. There are general notions on how this is done and dealt with, but rooms for deviations and changes are always reserved as geothermal reservoirs around the globe are individually unique and will therefore behave differently in response to exploitation.

One of the most difficult aspects of reservoir management is determining a time span for the management objectives. It must be noted that different objectives will entail different time span. There are cases for instance where depleting a given reservoir in 5 years instead of 30 years, is more viable from the pure financial point of view. Such cases are, however, usually unacceptable from the political or sociological point of view. For the DOE, of course, reliable availability of energy for a long time is considered more valuable.

The transfer of expertise under the Expert Dispatch Program has been focused substantially on Monitoring of Reservoir Performance under Exploitation. However, because of time constraint, tangible application, which is, dealing with actual field case was not done. Nonetheless, the transfer of expertise has been very effective in giving the Geothermal Division the overview of the subject. Moreover, the JICA expert has identified the important reservoir parameters that should be constantly monitored, the significance of monitoring these parameters, and lastly, the relationship of these parameters with each other that consequently bring about the changes in the reservoir.

With regard to Geothermal Resource Management, the JICA expert also gave the DOE staff the basic knowledge on the subject that there is no specific thumb rule on Geothermal Resource Management. It is also a broad and complex subject and differs depending on the objectives of the entity that will undertake the management strategy.

During the last part of the expert dispatch program, JICA donated to DOE thru GD the geothermal wellbore simulator program called Wellsim. This is a major breakthrough in GD as it is the very first reservoir program that the Division has obtained.

To set up the direction that the the DOE will follow in the future, the Geothermal Division has planned and programmed the following:

☞ Continue to review and study reservoir and resource management.

☞ Conduct detailed case studies using monitoring data measured at a specific geothermal field. Utilize Wellsim if necessary.

For a start, preliminary study on the reservoir performance of Makiling-Banahaw geothermal field for the last ten years will be continued.The study will investigate the Makban reservoir's pressure, temperature, massflow, enthalpy and chemistry histories.

☞ Reservoir activities of field developers will be continuously monitored through actual fieldwork applications.

☞ Set up simple wellbore simulation models to follow the service contractors' evaluations on the different production fields and make independent evaluations on how well the service contractors are predicting production.

☞ Follow the Decline Curves Analysis study done by the Geothermal Division. Geothermal Division will use Wellsim to find the relation between decline curves and the pressure drawdown observed/ measured in the different production fields. Other parameters such as temperature and chemistry of fluids will also be investigated.

## 5. ADVANCED EXPLORATION AND DEVELOPMENT

### 5.1. Mt. Labo Geothermal Project (PNOC-EDC)

All wells drilled in Mt. Labo Geothermal Project were plugged and abandoned by PNOC-EDC in November. This is in preparation for the abandonment of the project area by PNOC-EDC.

### 5.2. Northern Negros Geothermal Project (PNOC-EDC)

Two production wells, namely, PT5D and PT6D, were spudded in November 2000. Drilling of these wells was still ongoing as of year-end.

Production well PT-2D was worked over in November.

### 5.3. Mt. Cabalian Geothermal Project (PNOC-EDC)

PNOC-EDC did not have any activity in Mt. Cabalian

Geothermal Project.

## 6. PRELIMINARY EXPLORATION

### 6.1. DOE EXPLORATION

#### 6.1.1. Geological / Geochemical Survey

**Calayan Island, Cagayan**

A reconnaissance geological and geochemical surveys were conducted in Calayan Island, an island belonging to clusters of island-municipality collectively known as "Babuyanes Group" north of Aparri, from January 22 to February 07, 2000 to explore its geothermal potential. Babuyan Claro, another volcanic island reported to have thermal occurrences, was not reached because of bad weather and the danger of traveling high seas during the visit. As per communication with the local folks, thermal manifestations in Babuyan Claro occur as warm/hot springs and solfatara in the northern section of the island presumably related to Mt. Babuyan. However, this has to be confirmed.

Geological investigation and geochemical sampling of the different volcanic centers of Calayan Island were made to wit, Mts. Nangabaywanan, Macara, Calayan and Piddan, in order to categorize and classify their effusive equivalent.

Survey in Calayan revealed different volcanic rocks of Mio-Pleistocene age postulated to come from four volcanic centers dotting the island. A total of thirty-one (31) rocks and four (4) sets of water samples were collected. Aside from the geological and geochemical surveys, a rapid socio-economic profiling was also conducted during the visit. The conduct of the socio-economic profiling aims to determine the social and economic conditions of the island-municipality.

**Banton Island, Romblon**

The favorable results of geological and geochemical surveys in 1996 resulted to a follow-up detailed geological mapping from February 27 - March 8, 2000 in order to establish the local stratigraphy and identify structural features of the island.

Results of the study showed Banton Island to be underlained by banded andesite porphyry with variable amounts of volcanic fragments collectively known as the Banton Volcanics. Pyroclastics, another major rock type, was found generally occupying the valley.

There was no significant alteration within the vicinity of the hot/warm springs except for a wide area of fossil hydrothermal alteration at higher elevations atop the location of the hot springs at Tongonan. The locals termed this as "white clay" and was quarried in the past for pottery.

Faults are generally trending northeast to north-south dipping 45° to almost vertical either to the west or to the south. Joints trend northwest and north-south dipping almost vertically. Deformations of the bands were noted along Points Putbanwa near Mainit area and Matagar near Poblacion. In almost all of the outcrops, the rocks appear highly fractured.

Based on topography and degree of alteration, the south side of the island seems older. Andesites in the area are highly fractured. Peaks are eroded and alteration is more advanced, outcrops are brownish even at high elevation. Mt. Amponggo probably constitutes the youngest deposit as inferred from its still well formed peaks.

Geophysical exploration is recommended in the area to characterize and define the nature of subsurface geothermal system.

**San Juan, Batangas**

In line with the Geothermal Division's thrust of further assessing candidate areas for small-scale geothermal development, a follow-up geological and geochemical surveys were conducted on August 17-22 and August 28-September 10, 2000. Areas surveyed were the interior barangays of the municipality and the immediate vicinities of the thermal spring. The primary objective of the survey is to map various lithologies and structures to correlate existence of the hotspring area. A total of 63 square kilometers was covered yielding sixty (60) rocks and six (6) sets of water samples. Aside from the survey, public information campaign was also conducted with both the municipal and barangay leaders of the municipality.

Results of the study show that the area is underlain mainly by NW-SE trending low grade undifferentiated metamorphosed rocks intercalated with hornfels(?), shale and marbles. This rock is disposed in the northern portion of the surveyed area. The rock is intruded by hornblende quartz diorite belonging to the group of intrusive mass popularly known as San Juan Diorite. This diorite is believed to have triggered porphyry copper mineralization in the Lobo and Taysan areas. The diorite is overlained in the south and southeast margin of the surveyed area by bedded to boulder tuffaceous sandstone. Bedded tuff and reefal limestone, the most widespread in the area occurs as the youngest lithological unit in the area. The area has not undergone intense tectonic disturbances as shown by the relatively few mapped faults generally trending NW-SE.

The prospect area represents a blind geothermal resource that need to be subjected to geophysical exploration to locate concealed geologic structures and determine heat source.

6.1.2. Controlled Source Magnetotelluric Surveys (CSMT)

CSMT Equipment Retest

Retest of newly repaired equipment was done on March 16, 2000. Result of testing showed failure of the receiver to register readings at Frequenzy 0.625 Hz, 1.25 Hz, and 2.5 Hz. Memory error also occurred and collected data were missing. This prompted the Geothermal Division to send the receiver back to Japan for further checking. The equipment was returned by the manufacturers on April 13, 2000 for further retest. This time the equipment performed well.

**CSMT Survey at Mabini, Batangas**

A Controlled Source Magnetotellurics (CSMT) survey was conducted at Mabini Geothermal Prospect (MBGP) Mabini, Batangas from April 10 - May 12, 2000. The purpose of the survey is to characterize the resistivity signature of the prospect and to test the reliability of the newly repaired CSMT equipment.

A total area of 18 $km^2$ was covered by the survey wherein fifty-seven (57) stations were occupied utilizing two-transmitter dipole locations at Brgys. Pulong Anahaw and Orense-Anilao East, respectively.

MBGP encompasses the entire Calumpan Peninsula, a NE-SW trending Quaternary volcanic chain about 15 kilometers SW of Batangas City. It forms part of the southwestern volcanic belt traceable from Bataan Peninsula, Laguna - Batangas provinces and down to Mindoro Island. Compared with other geothermal prospects in the country, MBGP is a potentially important one not only because of its geothermal signatures (such as impressive surface thermal manifestation, occurrence of young volcanic activity, relatively high subsurface temperature, etc.) but also due to its proximity to the port of Batangas, a potential user of geothermal power.

The readings were made in Brgys. Nag-Iba, Pulong Anahaw, San Teodoro, Estrella, Mainit, Ligaya, Solo, Malimatoc I and II, Sto. Tomas, Pilahan, Laurel and Bagalangit. The total number of readings actually is 57, 5 of which are re-tests. Re-test was made due to noisy to extremely noisy data or inconsistent readings. Twenty-seven (27) stations were measured in the southern sector using the transmitter dipole in Pulong Anahaw while 30 stations were occupied in the northern sector using the second dipole site in Orense-Anilao East.

Initially processed data shows several stations exhibiting low resistivity values which might either be due to thermal manifestation, presence of structures such as a fault, altered ground and sea water. Based on the initial results, it seems that a geothermal system is indeed present beneath the prospect. If the data gathered are good and indeed indicate such system, follow-up and detailed fill-in CSMT survey should be conducted in the area.

## 7. HIGHLIGHTS OF SAFETY ASPECT OF GEOTHERMAL OPERATIONS

The year 2000 is a milestone period on the safety aspect of the Geothermal Industry. The Geothemal Division was able to integrate the overseeing and monitoring of the safety and health aspect of both the geothermal field developers and the power plant operators with the approval of the revised Geothermal Safety and Health Rules and Regulations (GSHRR) and the Medical Surveillance Guidelines on February 11 and March 3, 2000, respectively.

On the 2$^{nd}$ Quarter the Independent Power Producers (IPP) under the Built-Operate-Transfer (BOT) scheme under contract with PNOC-EDC have already coordinated with the Geothermal Division for their compliance to the requirements of revised GSHRR, and hopefully the power plant under the National Power Corporation (NPC) will start their compliance by the year 2001. NPC's delayed compliance to the revised GSHRR is due to their current manpower restructuring caused by the pending Energy Industry Reform Bill.

7.1. Inspection and Monitoring
In line with the mandate of utilizing indigenous, environment friendly and safe source of energy the Geothermal Division conducted occupational safety and health monitoring, workplace monitoring, physical inspection of facilities and equipment, inspection of explosive magazine and assessment of substandard acts and conditions of various geothermal production fields, projects and power plants.

For the year 2000 the Geothermal Division conducted field inspection on the following geothermal fields and projects and geothermal power plants operated by PNOC-EDC, PGI, Ormat, California Energy, and Mindanao Geothermal Partnership:

a. Southern Negros Geothermal Production Field (SNGPF)
b. Mindanao Geothermal Production Field (MGPF)
c. Leyte Geothermal Production Field (LGPF)
d. Bacman Geothermal Production Field (BGPF)
e. Northern Negros Geothermal Project (NNGP)
f. Tiwi Geothermal Production Field (TGPF)
g. Mak-Ban Geothermal Production Field (MGPF)
h. Ormat Phils. (Ormat)
i. California Energy (CalEn)
j. Mindanao Geothermal Partnership (MIGP)

For the same period, the Division also conducted inspection of four (4) PNOC-EDC explosive magazines at BGPF, LGPF, M1GPF, and SNGPF.

7.2. Issuance of Permits
With the inclusion in the monitoring and overseeing of the geothermal power plant operators the Safety Unit prepared and issued a total of forty (40) Safety Officers Accreditation permits;twenty two (22) for PNOC-EDC, nine (9) for NPC, six (6) for PGI, one (1) for CalEn, one (1) for MIGP and one (1) for Ormat.

7.3. Safety and Health Statistics
For the year 2000 the Safety Unit were able to consolidate, evaluate and analyze the safety statistics submitted by geothermal field developers (PNOC-EDC, PNOC-EDD and PGI) and BOT power plant operators (Ormat, CalEn and MIGP).

7.4. Others
The Geothermal Division in coordination with the geothermal industry players was able to consolidate the different safety practices of the geothermal industry and come up with a draft of Geothermal Industry Safety Code.

7.5. Safety Performance of Geothermal Field Developers
The safety performance of the geothermal developers for the year generally deteriorated with overall Frequency Rate (FR) and Severity Rate (SR) of 2.5 and 54.4, respectively. These have increased from last year's figures by about 35% in FR and 94.1% in SR.

The deterioration of the field developers' safety performance is largely attributed to PNOC-EDC's 22 Lost Time Accidents (LTA) with 1 fatality resulting in 6,146 Days Lost. PNOC-EDC's LTA is mainly due to a total of forty (40) vehicular accidents reported in its five (5) production fields (LGPF, SNGPF, BGPF, MGPF and NNGP). There were no safety performance ratings for Mt. Labo (Camarines Norte/Sur and Quezon) and Mt. Cabalian (Southern Leyte) geothermal projects as operations in these areas were still suspended.

On the other hand, PGI has 3 LTA and 74 Days Lost for the year with reported sixteen (16) vehicular accidents in Tiwi and Makban.
Among the four (5) production fields that PNOC-EDC operates, the safety performance in Mindanao Geothermal Production Field (MGPF) and Northern Negros Geothermal Project (NNGP) are the most commendable having maintained the highest safety performance rating without LTA resulting in zero (0) Frequency Rate (FR) and Severity Rate (SR). Likewise, Bacman Geothermal Production Field (BGPF) has remarkably improved its safety performance rating as evidenced by 85.7% and 98% decreases in LTA and Days Lost, respectively. This is translated to 1.2 FR and 4.9 SR, a far great improvement from last year's FR of 8.6 and SR of 250.1.

On the other hand, the safety performance rating of Southern Negros Geothermal Production Field (SNGPF) has drastically deteriorated with 2.4 FR and 6426.8 SR. The poor performance is mainly ascribed to the one fatality that resulted in 6,146 Days Lost.

Accidents for the year were commonly caused by Struck By/Against (35.4%) and Caught In/Between (27.7%). Usually affected parts of the body were Hands and Fingers (35.4%) and Eyes (15.38%). Personnel frequently involved were Drilling Group Personnel (44.67%) and Mechanics/Machinist (29.23%). Most of these accidents occurred at Drill Sites (43%) and Maintenance (35.38%).

## 8. PLANS AND PROGRAMS

The development and exploitation of high-enthalpy geothermal prospects shall continue with the projected capacity addition of 730 MW as per medium-term Philippine Energy Plan for the period 2002-2010 (Table 3 ).

The Binary, topping and bottoming plants geothermal production technologies will also be continually tapped for exploitation of the country`s low enthalpy geothermal prospects and in projects involving self-sustaining, direct use of geothermal systems.

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 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 to prospective geothermal service contractors.

Meanwhile, the recent passage and enactment of the reforms in the electric power industry also known as "Republic Act 9136" is expected to enhance private capital and broaden the ownership base of the power generation, transmission and distribution sectors. This means that inflow of capital investment in geothermal energy development is expected to increase with the passage of this law. This will also ensure the quality, reliability, security and affordability of the supply of electric power.

Relative to this, the DOE will develop a policy direction towards the privatization of government agencies related to energy, deregulation of the power and energy industry, and reduction of dependency on oil-fired plants. These shall encourage more private sector investments and participation of new players in geothermal energy development.

## REFERENCES

Geothermal Sector Monthly Highlights (2000). Geothermal Division, Energy Resource Develoment Bureau, Department of Energy, internal report.

Geothermal Sector Accomplishment Report (2000). Geothermal Division, Energy Resource Development Bureau, Department of Energy, internal report.

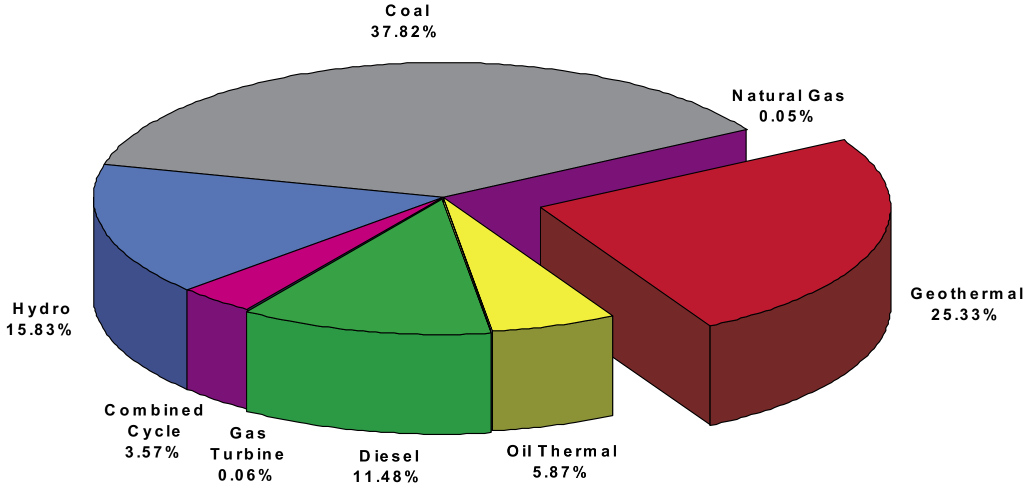


Fig.1 Energy Mix 2000

Table. 1 Geothermal Performance

| POWER PLANT | Installed Capacity (MWe) | Electricity Generation (GWh) | Capacity Utilization Factor (%) | Fuel Oil Displacement (MMBFOE) | Forex Savings (US$ MM) |
|---|---|---|---|---|---|
| **Tiwi** | **330.00** | **1233.52** | **42.67** | **2.13** | **58.19** |
| **Makban** | **330.00** | **1952.91** | **67.56** | **3.37** | **92.12** |
| **Makban Binary** | **15.73** | **48.23** | **35.00** | **0.08** | **2.28** |
| **Makban Modular** | **80.00** | **587.38** | **83.82** | **1.01** | **27.71** |
| **Tongonan I** | **112.50** | **628.10** | **63.73** | **1.08** | **29.63** |
| **Tongonan II** | **219.48** | **1515.72** | **82.65** | **2.61** | **71.50** |
| **Tongonan III** | **390.70** | **2575.07** | **76.18** | **4.44** | **121.47** |
| **Palinpinon I** | **112.50** | **762.08** | **76.31** | **1.31** | **35.95** |
| **Palinpinon II** | **80.00** | **608.90** | **86.89** | **1.05** | **28.72** |
| **Bacman I** | **110.00** | **313.60** | **32.55** | **0.54** | **14.79** |
| **Bacman II** | **40.00** | **307.59** | **87.78** | **0.53** | **14.51** |
| **Manito Lowland** | **1.50** | **0.06** | **0.46** | **0.00** | **14.51** |
| **Mindanao I** | **54.24** | **390.09** | **85.64** | **0.67** | **0.00** |
| **Mindanao II** | **54.24** | **393.94** | **93.20** | **0.68** | **18.40** |
| **Total** | **1930.89** | **11,317.19** | **67.67** | **19.51** | **18.58** |

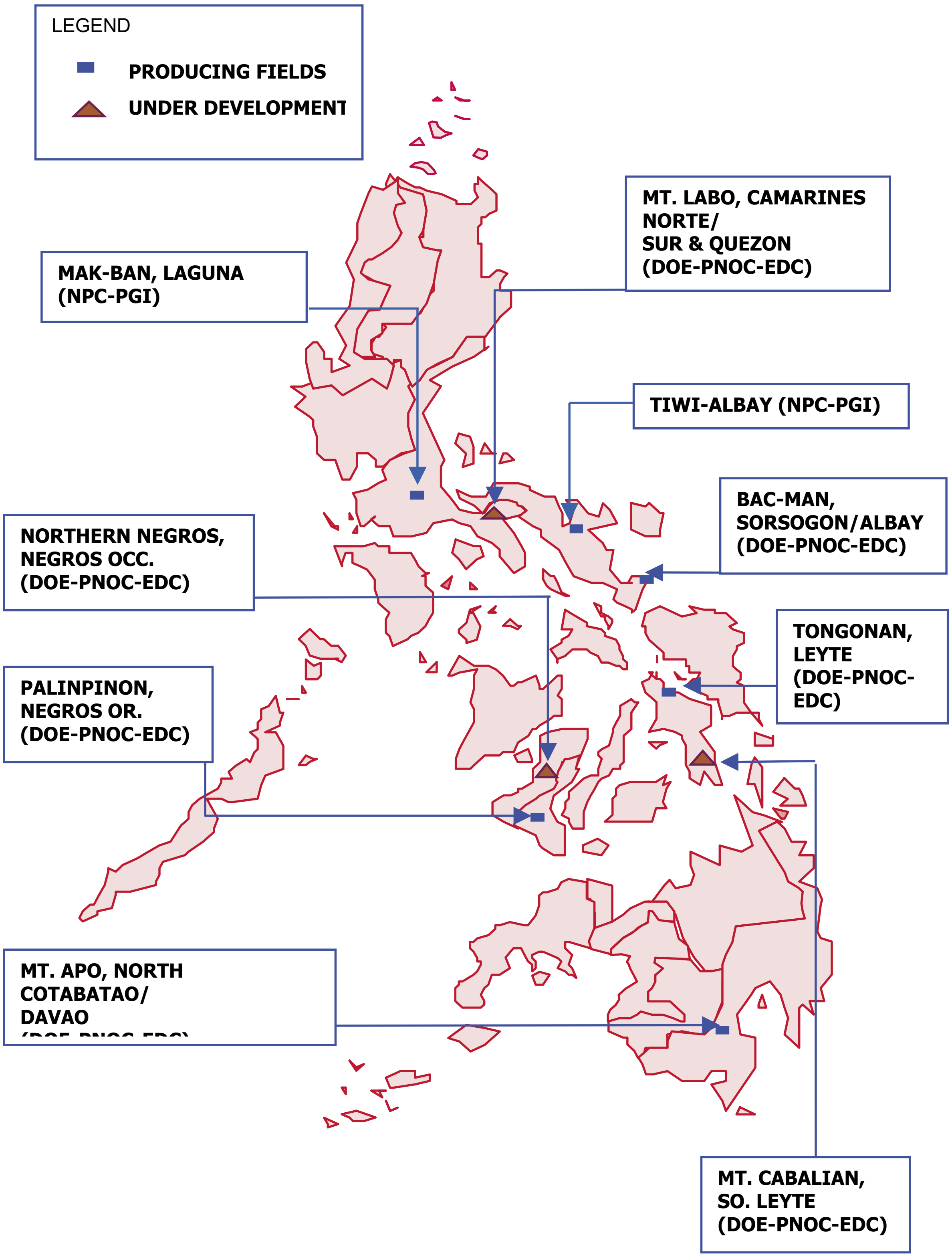


Fig. 2 Geothermal Service Contract Areas

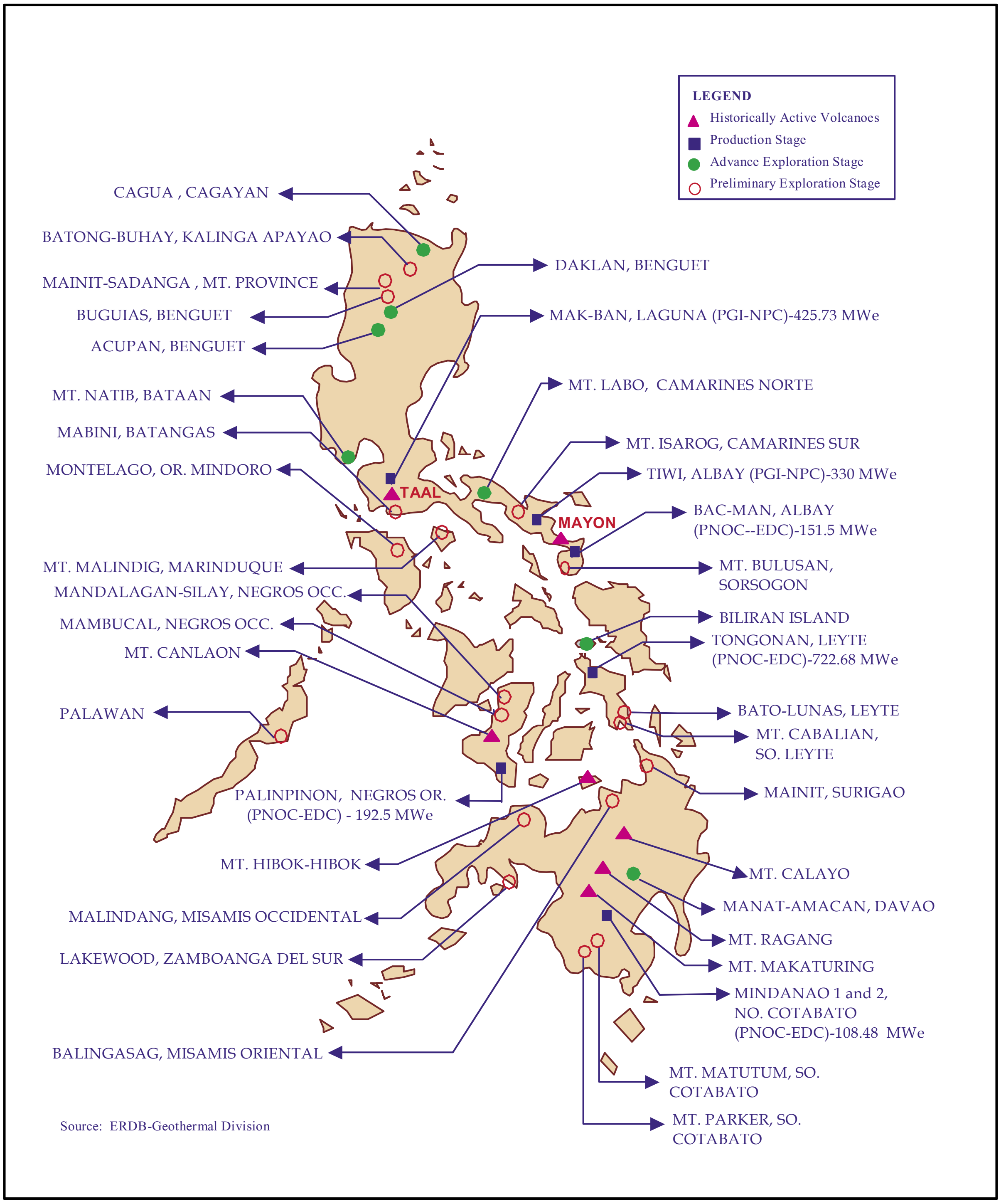


Fig. 3 Philippine Geothermal Energy Resources

Table. 2 Producing Geothermal Fields in the Philippines

| FIELD | INSTALLED CAPACITY (MWe) | OPERATOR STEAMFIELD/POWER PLANT |
|---|---|---|
| TIWI | 330.00 | PGI/NPC |
| MAK-BAN | 425.73 | PGI/NPC-ORMAT |
| TONGONAN I | 112.50 | PNOC-EDC/NPC |
| II | 219.48 | PNOC-EDC/CALEN |
| III | 390.70 | PNOC-EDC/CALEN |
| SOUTHERN NEGROS | | |
| Palinpinon I | 112.50 | PNOC-EDC/NPC |
| Palinpinon II | 80.00 | PNOC-EDC/NPC |
| BACMAN I | 110.00 | PNOC-EDC/NPC |
| BACMAN II | 40.00 | PNOC-EDC/NPC |
| MANITO | 1.50 | PNOC-EDC |
| MINDANAO I | 54.24 | PNOC-EDC/OXBOW |
| MINDANAO II | 54.24 | PNOC-EDC/OXBOW |
| | | |
| Total | 1930.89 | |

Table. 3 Geothermal Capacity Addition (2002-2011)

| PROJECT | CAPACITY ADDITION (MW) | Commissioning Year |
|---|---|---|
| Northern Negros | 40 | 2004 |
| Montelago | 20 | 2005 |
| Rangas Tanawon | 40 | 2005 |
| Mt. Cabalian | 110 | 2005 |
| Mahagnao | 80 | 2006 |
| Natib | 40 | 2007 |
| Batong-Buhay | 120 | 2009 |
| Buguias-Tinoc | 120 | 2009 |
| Lakewood | 80 | 2010 |
| Mabini | 40 | 2011 |
| Leyte (PNOC-EDC) | 40 | 2011 |
| | | |
| TOTAL | 730 | |