THE ROLE OF GEOTHERMAL ENERGY IN THE CONTEXT OF THE FUTURE ELECTRIC POWER SUPPLY IN INDONESIA

Vincent T. Radja

State Electricity Carporstion

JL. Trunojoyo Blok M I/135 Kebayoran Baru

Jakarta 12043 - Indonesia

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INTRODUCTION

The world geothermal electric power at the end of 1994, about 5000 MW, represents less than 1 % of the total electrical installed capacity, suggesting that geothermal energy plays a very minor role on the world energy scene. However, in developing countries, where electricity consumption is still limited but in which there is good geothermal potential, geothermal energy could, make a quite significant contribution to the total installed capacity.

At the moment there are at least 50 countries using or planning to use geothermal energy for electricity generation, 200 units have been in operation throughout the world since 1992, some with dry steam types of resources.

Predictions are that by 1995 the ASEAN geothermal electric power will reach 1500 MW, with Indonesia and Philippines playing important roles in terms of capacity, namely more than 1000 MW of this installed capacity.

At present the geothermal plant capacity in Indonesia is 144.75 MW Comprising one 30 MW,2 x *55* MW at Kamojang of conventional type, *two* non condensing monoblocks of 2 MW at Dieng and 250 kW at Kamojang and one binary cycle unit of 2.5 MW in Lahendong. By the end of 1994, 3 x 55 MW will be in operation, and based on the Sixth Five Year Development Plan (1994 - 1999) there will be added 740 MW in Java, 20 MW in Sulawesi and 10 MW as rural electrification at several locations for a total of more than 1000 MW.

This paper describeds geothermal energy resources in the context of the future electric power supply emphasizing Indonesia's case toward the year 2000.

1. OVERVIEW

The Indonesia archipelago has more than 13,000 islands, 6,000 of which are populated. Its five largest land masses, in descending order of size are Kalimantan, Sumatera, Irian Jaya, Sulawesi and Java, as shown in Figure 1. Population density varies from 4 persons per km^2 in lrian Jaya to 800 persons in Java.

The most populated area is lava, where more

than 60 percent of Indonesia's people live, although the island represents only 6.9 percent of Indonesia's total land area. In addition, Java is also the most industrialized island and consequently the electric power demand in lava is the highest among the islands of Indonesia. 70.12 percent the PLN'S (State Electricity Power Company) installed capacity is located in Java.

During the decade of eighties, the power sector in Indonesia grew rapidly. PLN, State Electricity Corporation, has quadrupled in size as its sales grew from 4.3 TWh in 1978/79 to 41.9 TWh in 1992/93, its installed capacity from 2,300 MW to 10,900 MW and the number of customers from 1.8 million to 13.8 million. Even so, Indonesia's current electrification ratio of 29.9 % is stili low. It implies that the demand for electricity is still high.

To meet the rapidly increasing demand of electricity in line with the National Energy Policy - to reduce strategically the oil consumption and to minimize the environmental impact-Indonesia is committed to develop alternative energy sources for electricity generation. One of the important and plentiful energy resources that has yet to be fully exploited is geothermal. This paper provides information on geothermal development in Indonesia, the past trends, current status and the future outlook. Based on the existing regulation PERTAMINA (State Oil and Gas Company) has the authority to undertake the exploration and development of geothermal energy in Indonesia. PERTAMINA and its private contractors may develop the resource for steam sales to PLN, or they may generates power for sale to PLN with or without including transmission of the electicity.

To accelerate development of geothermal energy in Indonesia, private investors have been invited as contractors to cooperate with PERTAMINA in exploration and production ventures. Taking into account the lack of capital and the fact that modern technology is not fully available in Indonesia, the government is considering several additional incentives to enhance geothermal development

An important question that must be addressed is whether it is more economical for government or private investors to develop geothermal resources. The government seemingly has a big advantage in that it can obtain funds through, grants and soft loans with low interest rates. The availability of low cost financing obscures the concept of risk. If the government secures financing for a project, the government is taking risk. Should the project fail *or* only be partially successful, government money must be used to pay back the loan, putting added burden to the national economy. Private investors, however, are willing to assume these risks for a

reasonable rate of return. Such willingness provides the government with the opportunity to divert its funds to low risk projects. Another advantage is that private investors develop these projects quickly in order to generate a return on their investment. This rapid development is a major consideration, given the soaring demand for electricity in Indonesia and the need to accelerate power projects is now prompting the government to expand the role that private investors play in geothermal development.

In contracts written prior to 1990, private investor was solely a steam supplier to PLN. Private companies drilled wells and built the surface production facilities. PLN built the power plant and distributed the electricity. Private investors' earnings were based upon the amount of steam purchased by PLN. To accelerete development of geothermal in the near future, the government recognized that other opportunities had to be opened to the private sector. Consequently, the government elected to alter its geothermal energy regulations so that private industry can undertake the total project, including the building, operation and ownership of the power plant (without altering the respective responsibilities of the two state owned companies PLN and PERTAMINA)).

An adjustment in relation to regulatory aspects has been issued. Presidential Decree No. 45/1991 (PD 45) originally had been issued as the amendement to the Presidential Decree No. 22/1981 concerning the granting of mining rights for geothermal exploration and exploitation to PERTAMINA. Coincide- ntial with this new regulation, to revoke the Presidential Decree No. 23/1981, the Presidential Decree No. 49/1991 was also been issued. By Regulation PD 45/1991, allows PERTAMINA to sell electricity to PLN, other agencies, other state companies and national private companies including cooperative agencies. If necessary the Minister of Mines and Energy may grant licencies for exploration and exploitation of geothermal resource, on a small scale, (equal to or less than 10 MW) to other agencies as stated above for electric power generation and or for rural electrification.

Presidential Decree No. 49/1991, makes the contractor split 66% instead of 54% as provided for by the previous regulation.

These new policies provide incentives and advantages to private investors. Projects can be accelerated because there will be fewer delays related to securing financing for the power plant and benefit is increased because the projects generate revenue immediately. Also the cost of geothermal development should decrease because of the use of common facilities.

2. PAST TRENDS AND CURRENT STATUS

Indonesian Geological surveys have identified a total of 217 geothermal prospects. Based on the estimated reservoir temperatures, these prospects fall into two general catagories: low to moderate reservoir temperature ($< 150^0C$) and high reservoir temperature ($> 150^0C$). The low to moderate reservoir temperature prospects are usually suitable for use of binary cycles.

Recent investigation showed that among the 217 prospects mentioned above, 142 prospects do possess high temperature reservoirs, with an estimated resource potential of more than 16,000 MWe. These resources are spread throughout the country, from Sumatera which has a total potential of 4,900 MWe, to Java with potential of 7,800 MWe, Bali with 325 MWe, Nusa Tenggara of 350 MWe, North Sulawesi with potential of 1,500 MWe and Maluku and lrian Jaya joint with potentials of 1,200 MWe (Figure-2).

Various scientific exploration studies have been carried out at some of these prospects including: geological, geochemical and geophysical survey having different degrees of specificity that range from reconnaissance to detailed integrated surveys.

The first geothermal wells were drilled between 1926-1928 at Kamojang, West Java. The precise objective of the drilling is unknown, however, during that period the Dutch Government drilled 6 wells to depth of between 66 - 120 meters. Five wells were completely destroyed and only one well (well number 3) is still producing steam with temperature of 140^0C. As recorded in history, Kamojang, later, was chosen as the first geothermal field in Indonesia to be developed.

The success of exploration and development at Kamojang triggered development of other geothermal fields. and exploration was expanded to other fields in Java and Bali, Sumatera, Sulawesi and others islands in Easten Indonesia.

Participation of private companies in geothermal development was started in 1982, when the first Joint Operation Contract (JOC) was signed between PERTAMINA and Unocal Geothermal of Indonesia, Ltd. for development of the Salak field in West Java. This was followed by the second JOC, with Amoseas Indonesia, Inc. in 1984, for the Darajat fields also in West Java. Recently, another JOC was signed, on February, 28, 1993 with Unocal North Sumatera Geothermal, Ltd. for development of the Sarulla field in North Sumatera. The contract arrangement of this last JOC is a little bit different from those of the previous JOCs. Instead of developing the steam field only as at Salak and Darajat, the contractor in the Sarulla JOC will also build and construct the power

plant under a BOT scheme.

Based upon the results of exploration and exploitation activities to date, the current status of geothermal development in Indonesia is given in Figure-3.

To date of exploration andlor development wells has been carried out at 11 prospects; Kamojang (54 wells), Ciharus (1 well), Darajat (7 wells), Salak (17 wells), Wayang Windu (1 well), Cisolok (1 well), Banten (1 well), Dieng (26 wells), Lahendong (12 wells), Sibayak (3 wells) and Kerinci (2 wells), see Fioure 4.

The resources potential can be divided into four categories:

- Potential Resource is the broadest measure of the potential for a prospect, and is normally based solely on regional exploration, with the potential calculated only from the size of the prospective area.

- The Possible reserve is a refinement of the resource potential of a prospect and draws upon the results of geological, geochemical and geophysical surveys.

- The Prohahle reserve notential represent further refinement of the resources potential of a prospect and requires at least one deep exploration well in addition to the geoscientific surveys.

- The Proven reserve potential has highest degree of confidence and requires data from at least three exploration wells.

As shown in figure-3, about 1057 MW or 7% of the total estimated resource potential of lndonesia has been proven by drilling.

Presently, Kamojang is the only field which is operated commercially. The first 30 MW power plant came on line in 1983, followed by the second and third units, of 55 MW each in 1988, giving a total capacity of 140 MW. Developments of the next units is planned. The proven reserves of the Kamojang field, as indicated by drilling results to date, is about 250 MWe. The performance of the Kamojang Power Plants is very satisfactory.

At Dieng, in Central Java, a 2 MW geothermal power plant has been operated since 1981. This was originally a pilot plant, installed with the objective of studying the utilization of Dieng steam which is quite different in quality from that of Kamojang steam. To date the electricity produced at Dieng is utilised to by PERTAMINA solely for it'sfield operations.

Recently, a 2.5 MW binary-cycle plant was installed at Lahendong, North Sulawesi. So that by the end of 1994 the total installed capacity

will be 309.5 MW including 2 new units of 55 MW at Salak and 1 new unit of 55 MW at Darajat. This total is still less than 1 % of the total national resource potential.

Drilling and power plant construction is currently being carried out at the Salak and Darajat fields, the two fields under JOC operation scheme. Exploration drilling started in late 1994 in Sarulla North Sumatera, Wilis in East Java and Ulumbu on Flores island.

3. FUTURE OUTLOOK

In the future, the electricity demand in Indonesia, as mentioned earlier, is projected to grow in high rate. A base scenario over the next 10 years is expected to be as follows :

Within the sixth Five Year Development Plan or REPELITA VI (1994/95 -1998/99) growth is projected to be about 16 %, decrease to 9% within the next five year period or REPELITA VII (1999/00 - 2003/04) and to about 8% within the succeeding period or REPELITA VIII (2004/05 - 2008/09) (Finre-5).

It is interesting to note that the growth rate in areas outside of lava, within REPELITA VII and REPELITA VIII, are expected to be greater than those in Java. This seems to be in line with the growth trends of the industrial centres. From the supply side, it is estimated that the energy that will be needed to meet these growing demands will be about 1.1 billion BOE per year over the next *20* years. In light of the existing oil reserves it seems likely that most of the oil consummed will have to be suplied from imported sources.

The most important primary energy needed for domestic development during the next 20 years is electricity. An estimate shows that installed estimate capacity of power plants could reach **45** - 50 GW. In this case, utilization of alternative energies in the future will have to play an important role. PLN generation plans to the year 2008 are as shown in Figure 6.

Alternatife energy resources such as hydro, gas, coal are abundant in Indonesia. However, the utilisation of these energies in the future will not only be based on the availability of these resources, but on their environmentally acceptability. Application of new technologies during the development of all resources, so as to meet environmental requirements, will be a key factor.

Another factor that should be considered in the future is the possible change from reducing oil dependency only to reducing dependency on coal and gas. This step would be taken due to the increasing demand for fossil fuels as raw materials for industries.

The role of private sector in the energy development will be another key factor in the ficture. More opportunities will be given to the private sector to participate in energy development and operation so as to reach balance between energy supply and demand in the next 20 years.

As far as geothermal energy development is concerned, it has been proven in many parts of the world that geothermal energy is relatively clean therefore, it is a favourable energy for future development. However, considering the prospect distribution and the geography of Indonesia, a strategic plan should be developed to optimize the utilization of this energy and there are several points that must be taken into account:

a. Geothermal energy can not be stored and transported. It has to be locally utilised and commercial utilisation at this time is still limited to generation of electricity.

b. Drilling **a** depths of 1000-2000 meters is required; and incurrs high costs and risks. Economic evaluation for projects is important especially if private investment is involved. From this paint of view, geothermal energy has to be utilised soon after it is developed.

c. Private industries could be potential buyers for geothermal power in the future, although PLN is currently the main user (or buyer) of this energy.

d. Depending upon size, the initial units (s) of any development may take 6-7 year to build after contract signing. The nature of contract arrangements, meaning energy sale or electricity sale, would significantly impact the development time-frame.

e. Technological advanceds applied to energy development and operation will create competition between geothermal and other alternative energies.

With the limitation, constraints and effects of the factors listed above, development of geothermal energy in Indonesia in the future will have to compete with that of other energy sources.

The government's role is important and still needed. Tax reductions recently given through Presidential Decree No. 49/1991 resulted in reduction of the energy (steam) prices of up to 8 %, causeing geothermal energy to become more competitive with that of other sources of energy.

Since private industries wil create a potential market in the future it is hoped that during the development of industrial estates there will be consider ation of the use of energy available near these centers especially of those energies which can only he utilized locally.

4. FUTURE **DEVELOPMENT** SCENARIO

A scenario for future development can be envisioned based on the following approach steps :

Potential markets for large scale geothermal energy purchases seems to be on the big islands such as Sumatera, Sulawesi and Java-Bali where various industrial estate are located or planned. This is the reason that geothermal activities have been concentrated on these three islands for the last ten years. Markets will also be available on other islands in East Indonesia, however, it is likely that these will be more favourable for smaller scale and rural power developments.

Commitments have been made between PERTAMINA and its JOC partners (as producers of the energy) and PLN (as *the* user or buyer of the energy) for initial developments in several new fields; Salak (220 MW), Darajat (55 MW) and Dieng (95 MW) in Java, Ulubelu (40 MW) Lumut Balai (40 MW) Sibayak (22 MW) in Sumatera and Lahendong (20 MW) in Sulawesi. Except for Lahendong which is operated by PERTAMINA, the other fields will be operated by JOC partners. Commitments have also been made for the next incremental units of 80 MW at Kamojang, for Patuha at 40 MW. Karaha at 55 MW, Wayang Windu at 40 MW in Java and for Candi Kuning on Bali at 60 MW. These commitments will give a total 1998 capacity of 767 MW in addition to the existing capacity of 144.5 MW (see Fioure 7).

Potential prospects meaning prospects being exploratorily drilled or promising prospects that may be developed on the basis of detailed scientific survey results are considered in *the* development plans 10-25 years. Hence in Java-Bali there are 6 prospects falling in this category, in Sumatera there are 8 prospects and in Sulawesi there are *2* prospects. Their potential is in the order of magnitude, of more than 1400 MW.

It is important to note that the invesment climate in *the* geothermal industry is getting better as indicated by the increasing numbers of interested private companies as listed in figure-8, some of wich have submitted development proposals for fields in which they are interested. All of these proposals are for electricity sales (BOO). In the future development scenario, it is being assumed that most fields will be operated by the private sector under JOCs with PERTAMINA.

These approach steps describe the development scenario until the year 2020. Smaller scale developemnts are not however included in the figures. This category is estimated to comprise 74 MW, mostly in East Indonesia. (Flores, Lombok. Ambon, Sumbawa, together with micro geo binary cycle of 100 kW - 1000 kW in more than 15 locations through out the country.

5. CONCLUSION

Geothermal energy is one of the important and plentiful alternative energies that will be developed. As a relatively clean energy source it's utilization will minimize negative impacts to the environment thus ensuring that it will meet one of the national criteria for energy development in the future. The current installed capacity is 309,5 MW which is less than 1 % of the total estimated resource potential.

To accelerate geothermal development new regulations have been issued. Of importance is the reduction of the corporate tax from 46% to 34%. This has caused geothermal to become more competitive in price with those of other sources of energy.

An Increasing number of private companies showing interest in Indonesian geothermal development indicate an improving investment climate in this industry. Presently, three private companies are operating under JOCs with PERTAMINA, and more investors are expected in the near future.

To meet the great demand for electricity over within the next 25 years, increased geothermal development is planned. Large scale developements are projected on the three big islands Sumatera, lava-Bali and Sulawesi, while smaller scale capacities could be developed in East Indonesia. Capacity total of about 2500 MW is estimated for the year 2000. The figure does not include the smaller scale developements which are estimated about 74 MW.

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Figure 1

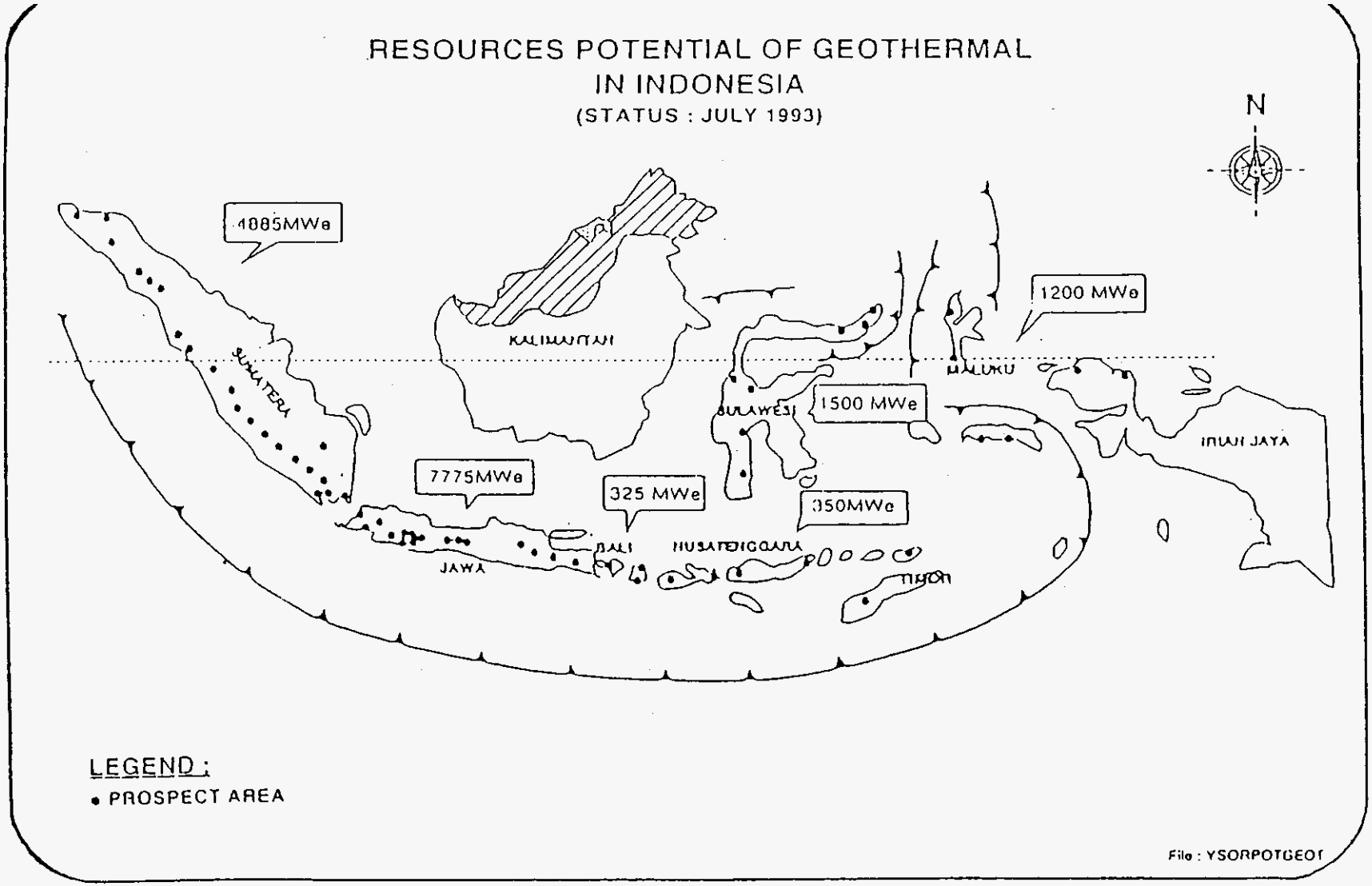
RESOURCES POTENTIAL OF GEOTHERMAL
IN INDONESIA
(STATUS : JULY 1993)
N
4885MWe
1200 MWe
1500 MWe
7775MWe
325 MWe
350MWe
SUMATERA
JAWA
BALI
LEGEND :
• PROSPECT AREA
File : YSORPOTGEOT

Figure 2

INDONESIA'S GEOTHERMAL ENERGY POTENTIAL AND CURRENT INSTALLED CAPACITY AS OF JUNE 1993

AREA	POTENTIAL MWe					INSTALLED CAPACITY (MW)
	TOTAL	PROVEN RESERVE	PROBABLE RESERVE	POSSIBLE RESERVE	RESOURCE	
SUMATERA	4885	65	340	2430	2050	–
JAWA–BALI	8100	927	445	1828	4900	142.00 2.50
SULAWESI	1500	65	110	430	895	–
OTHER ISLANDS	1550	–	–	200	1350	
TOTAL	16035	1057	895	4888	9195	144.50 144.50

COMMITED PROJECTS FOR GEOTHERMAL DEVELOPMENT UNTIL THE YEAR 1998 *) AS OF AUGUST 1994

Fiqure :

	LOCATION	CAPACITY (MW)
1.	SUMATERA	40
	– ULUBELU #1,2	40
	– LUMUT BALAI #1,2	22
	– SIBAYAK PILOT #1	
2.	JAVA – BALI	
	– SALAK #3,4,5,6	220
	– DARAJAT #2	55
	– DIENG #1,2,3	95
	– PATUHA	40
	– KARAHA	55
	– WAYANG WINDU	40
	– CANDI KUNING	60
	– KAMOJANG #4,5,6	80
3.	SULAWESI	
	– LAHENDONG #2	*20*
	TOTAL	767

*) EXCLUDING SMALLER SCALE UNITS (TOTAL 25,9 MW)

Figure 4

NUMBER OF GEOTHERMAL WELLS IN INDONESIA

AREA	EXPL. WELL	DEVELOP. WELL	TOTAL
KAMOJANG	16 *)	38	54
CIHARUS	1	–	1
DIENG	10	16	26
LAHENDONG	10 *+)	2	12
BANTEN	1	–	1
CISOLOK	1	–	1
WAYANG WINDU	1	–	1
SIBAYAK	3	–	3
KERINCI	2 ***)	–	2
DARAJAT (JOC, AMOSEAS)	7	–	7
SALAK (JOC. UNOCAL)	13	4	17
TOTAL	65	60	125

NOTE :
*) Include 5 expl. wells drilled by DUTCH
**) Include 3 expl. wells drilled by VSI
***) Drilled by VSI

Figure 5

ELECTRIC POWER DEMAND FORECAST
BASE SCENARIO

LOCATION	PE		ODE	
	1993/94	1998/99	2003/04	2008/09
JAVA				
CONSUMPTION (TWh)	38.6	79.9	120.5	170.9
PEAKLOAD (MW)	6,512.0	13,372.0	20,536.0	28,959.0
GROWTH (%)	–	15.2	8.8	7.0
OUTSIDE JAVA				
CONSUMPTION (TWh)	10.2	23.0	40.0	65.7
PEAKLOAD (MW)	2,069.0	4,399.0	7,479.0	12,170.0
GROWTH (%)	–	16.8	11.1	10.1
INDONESIA				
CONSUMPTION (TWh)	48.9	102.9	160.5	236.0
PEAKLOAD (MW)	8,581.0	17,771.0	27,835.0	41,129.0
GROWTH (%)		15.8	9.3	8.0

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Figure *6*

PLN GENERATION EXPANSION PLAN

TYPE **OF** GEN	1993	1998	2003	2008
HYDRO	2134	3196	6803	8640
DIESEL	1936	1994	1662	1632
GEOTHERMAL	142.5	742.9	1255	1255
OIL	2210	1985	1860	607
COAL	2130	6990	12850	24570
GAS TURBINE	939.4	2106	3483	6100
COMB. CYCLE	3220	6964	7030	7368
NUCLEAR	–	–	–	–
TOTAL	12892	23978	34943	50772

Figure 7

GEOTHERMAL DEVELOPMENT SCENARIO TO THE **YEAR** 2020

AREA	EXISTING	COMMITTED INCREMENTAL DEV. WITHIN NEXT 5 YEARS	POSSIBLE OTHER INCREMENTAL DEV. WITHIN 10 YEARS	**POTENTIAL** ADDITIONAL DEVELOPMENT **TO THE YEAR** *2020*	**TOTAL**
SUMATERA	–	110.0	*220.0*	670.0	1,000.0
JAVA–BALI	142.0	240.0	*330.0*	588.0	1,300.0
SULAWESI	2.5	20.0	*20.0*	157.5	200.0
TOTAL	144.5	370.0	570.0	1,415.5	2.500.0

NOTE : SMALLER SCALE DEVELOPMENTS (ABOUT74 MW) ARE NOT INCLUDED

Figure 8

LIST OF INTERESTED PRIVATE COMPANIES IN GEOTHERMAL DEVELOPMENT .AS OF JUNE 1993

	TOTAL NUMBER		PROPOSAL EVALUATION	UNDER NEGOTIATION	CONTRACT SIGNED
	1984	1993			
FOREIGN	2	3	–	–	3
DOMESTIC *	–	13	3	1	–
TOTAL	2	16	3	1	3

NOTE : *) IN COOPERATIONWITH FOREIGN COMPANIES