CURRENT STATUS AND NEW GEOTHERMAL DEVELOPMENT AREAS IN INDONESIA

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ABSTRACT

Geothermal energy of Indonesia is mainly used to generate electricity. Their installed capacity until 1998 were 580 MWe. The intensive geothermal developments in Quaternary volcanics increase gradually since 2000, particularly in the existing contract areas. The new Law no. 27/2003 regulates the private sector may involve in developing geothermal energy by following a tender. The system of new Law uses a Joint Operation Contract or an Energy Sales Contract to accelerate its production. Currently, geothermal energy produced about 1206.5 MWe and contributes for approximately 4 % of the National electrical demand. There are seven new geothermal development areas are contracted and negotiated with Government and PLN. These will increase more than a thousand MWe of electric capacity in West and East of Indonesia in 2014 to 2016. Therefore, distributions of geothermal development areas will be spread out of all Indonesian Islands.

Keywords: Geothermal, Quaternary volcanic, the Law, energy capacity

1. INTRODUCTION

The intensive geothermal exploration and development in Indonesia have been begun from prior the oil crisis in 1970's. They were to solve a problem in increasing electrical demands and to substitute of energy resources from oil, coal and gas to renewable energy, such as geothermal power, which has an excessive amount of energy derive from the volcanic belt.

The geothermal prospects are most associated with high temperature surface discharged fluids, and with the Quaternary volcanism, which is located along magmatic arcs of Sumatra, Java, Nusa Tenggara, Moluccas to the north Sulawesi islands (Fig. 1). The heat sources are derived from shallow cooling magma and igneous intrusions.

The Geothermal Law No. 27/2003 regulates the upstream geothermal business, where private investors are encouraged to develop and to run geothermal business, which is an Independent Power Producers (IPP's). In accelerating geothermal exploration and production, Energy Sales Contracts (ESC) or Joint Operation Contract (JOC) and Power Purchase Agreement (PPA) are negotiated to PLN. This will accelerate and increase electricity production.

The objective of this paper is to inform a Geothermal Law, to identify the current geothermal resource and development. This will know the number of units and installed geothermal power generating capacity over the last 10 years.

2. TECTONIC SETTING AND GEOTHERMAL DISTRIBUTION

In general, all of the Indonesia geothermal areas are associated with volcanic arcs (Fig.1). The volcanic arcs are the result of the interaction of Indian – Australian, Eurasian, Pacific and Philippine Plates. Most of these arcs display micro continental arc volcanism associated with oceanic trench subduction zones (Cas and Wright, 1984). The Indonesian volcanic arcs can be divided into four arcs, the Sunda arc in the west and the Banda arc in the east, two small arcs situated to the north of the Banda arc, the Sangihe-north Sulawesi and Halmahera arcs (Fig. 1).

The Sunda arc represents part of the collision zone between the Indian-Australian plate to the south and the Eurasian plate to the north. The Banda arc is characterized by an anomalous tectonic setting compared to the Sunda arc. It represents part of the collision between the Pacific plate to the east and Eurasian plate to the north and Indian-Australian plate to the south. The north Sulawesi-Sangihe and Halmahera arcs are the complex junction between the Eurasian, Indian-Australian, Pacific and Philippine plates (Silver and Moore, 1981).

The geothermal areas which mostly located along these volcanic arcs (Fig. 1) are found out at about 276 locations (Geological Agency, 2011). Volcanic fractures or fault zones generally control geothermal surface manifestations, such as hot springs, fumaroles, mud pools and steaming grounds which have high temperature, flow rate and low to neutral pH (50 to 100oC, pH 2 to 7) and to provide an early sign for geothermal investigation and exploration in Indonesia.

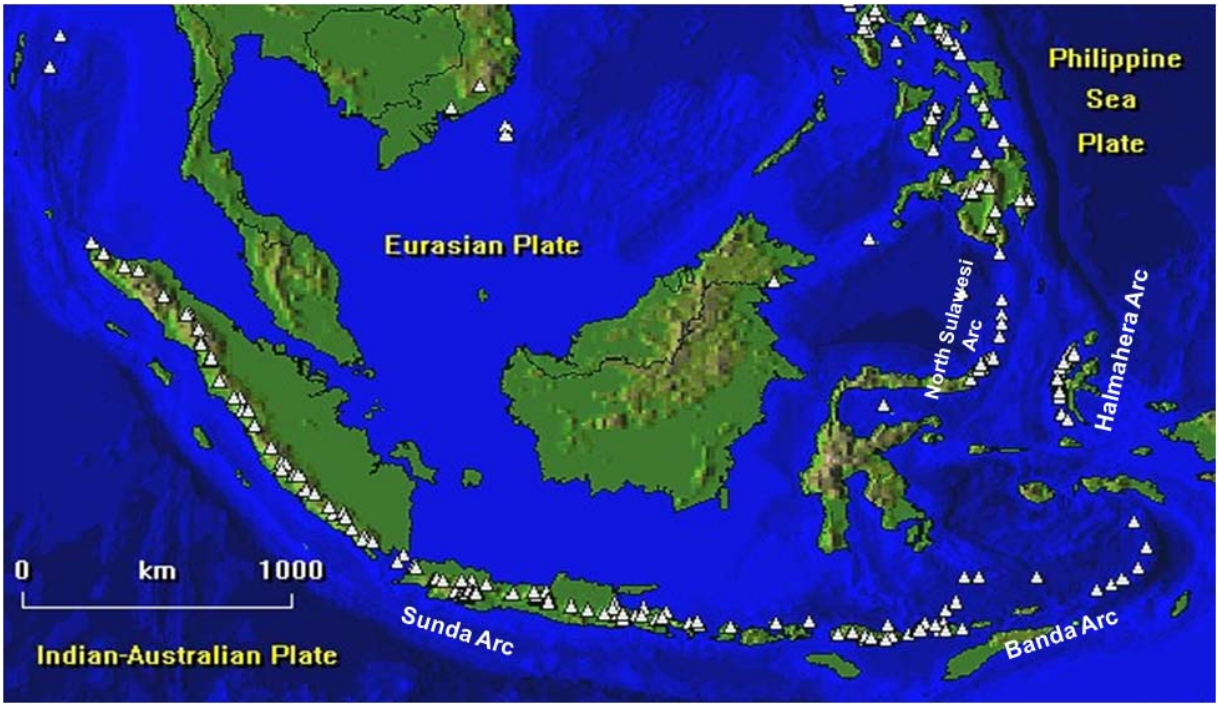

Fig.1 Distribution of Quaternary volcanics of Indonesia and Philippine, which are related to geothermal areas (from Smitshonian, 1990's)

3. GEOTHERMAL REGULATION

A number of the Indonesian laws and regulations apply to energy development activities. They are a regulation on Oil and Gas, A law on mining development and other laws. A geothermal industry needs a legal basis, which is then declared in 1980's. The Presidential decrees (PD) No. 22/1981 instructed the state-owned oil and gas company (PT. Pertamina) to explore Indonesia's geothermal potential, and ordered the National electricity state company (PT PLN) to buy its electricity production.

The amended President decree no. 22/1981 was renewed by a new regulation. It was the Presidential Decree (PD) No 45 Year 1991, and declare developing geothermal industry. This PD outlines two alternatives: Firstly, Pertamina (The Indonesian Oil State Company) or its contractors can develop and operate the steam field, then selling the steam of electric generation to the National Electric State Company (PLN) or other parties, called as a JOC (Joint Operation Contract). Secondly, The Pertamina and its contractors are allowed to develop, to operate the steam field and to generate the electricity, then continued to sell the electricity to PLN or other consumers, called as a ESC (Energy Sales Contract) or a total project.

The New Geothermal Guidelines were declared by the Presidential Decree No. 76/2000 which replaced the previous Decree. Under this PD 76/2000, the Government of Indonesia will take all or part of the exploration. It means taking a risk of exploration drillings.

The Geothermal Law No. 27/2003, Development geothermal areas regulates the upstream business of geothermal and private investors were encouraged by the Indonesian Government to develop and to run geothermal business, so-called Independent Power Producers (IPP's), which had to sell geothermal power under Energy Sales Contracts to PLN. This resulted in accelerated exploration and production drilling, which came to increase electricity production.

4. GEOTHERMAL POTENTIAL RESOURCES

The country of Indonesia has abundant geothermal resources, which are located along volcanic belts. There are about 276 manifestation identified, with total potential capacity estimated approximately 29,000 MW (Geological Agency, 2011). The potential geothermal resources are mostly explored and developed for electricity by PT. Pertamina, Private Investors and PT.PLN. They may have high temperature or high enthalpy geothermal resources (>220^{o}C) in 21 areas, for generating electricity (Fig.2). The areas are mostly belong to the Pertamina concession, such as: Sibayak, Salak, Wayang Windu, Kamojang, Darajat, Lahendong, and Dieng (existing geothermal power plants). The other Pertamina Concession areas are: Sallura, Sungai Penuh, Hulu Lais, Lumut Balai, Ulubelu, Kawah Cibuni, Patuha, Karaha, Iyang Argopuro, Bedugul and Kotamobagu. These potential resources have not been developed yet for electricity generation. However, in the near future, several geothermal fields will support electrical capacity of Indonesia.

The other geothermal potential resources are also located in remote areas and small islands, which are located on the eastern part of Indonesia, such as Flores, Lomblen, Ambon, Halmahera and other islands (Fig.2). Few areas have been developed by PT. PLN such as Ulumbu, Mataloko, and Tulehu. PT. Bakri Power develops Sokoria, and Halmahera (PT. Star Energy). They are located outside of Pertamina's concession. Therefore, in a near future, small scale geothermal power plants will support additional geothermal electric capacity and will reduce government subsidy in electrical prices.

In the western part (Sumatra and Java islands) and eastern part of Indonesia (Nusa Tenggara and Maluku islands), the geothermal fields are still many (Fig.2). They are outside of the Pertamina's concession areas. The Geological Agency (2011) identified a speculative resource of western Indonesia geothermal area more than 7000 MW, and to the east it identify of approximately 2000 MW (Fig.2).

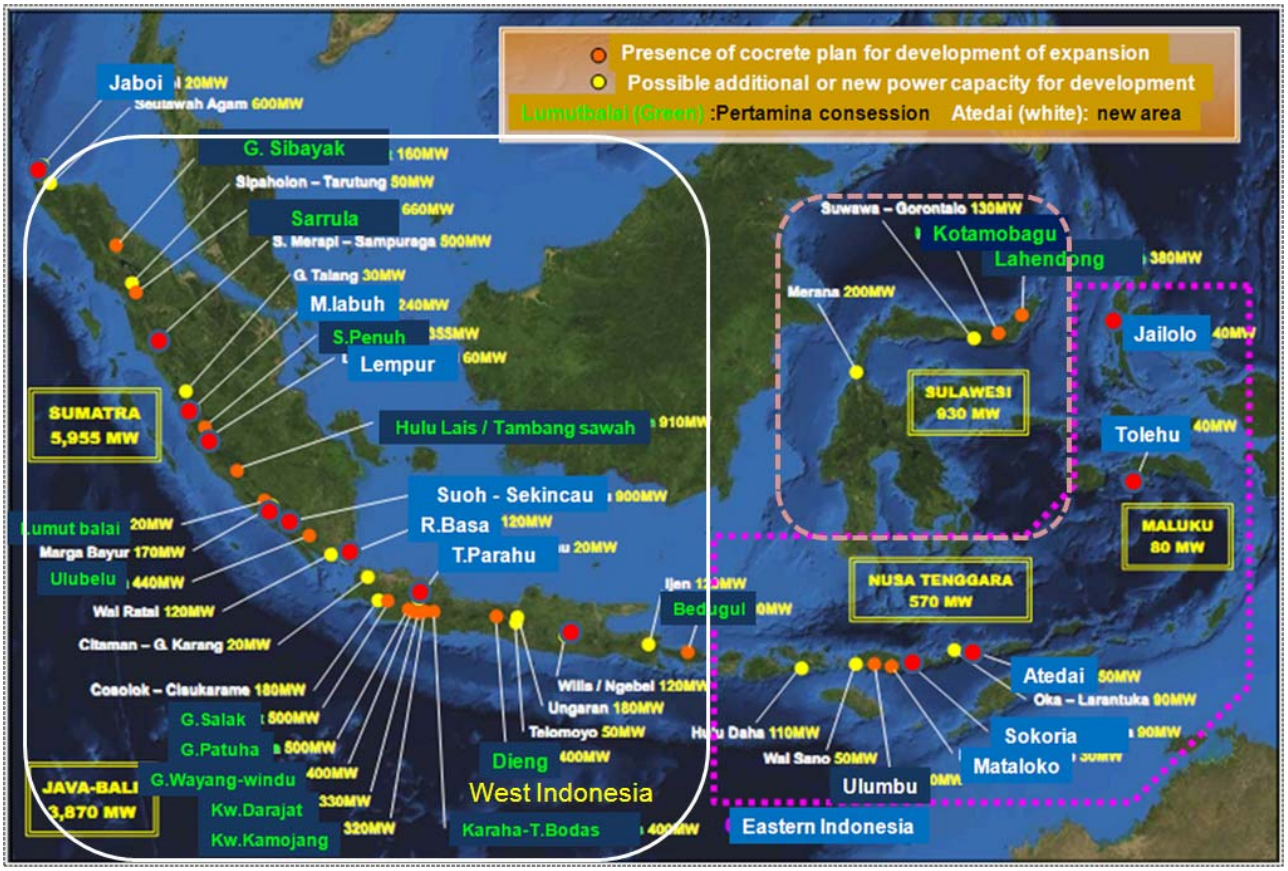

Fig. 2 Map Showing the Resource Potential in Promising Geothermal Fields, modified from JICA (2007)

5. GEOTHERMAL EXPLORATION AREAS

As known, geothermal exploration and development contracts increased in the early of the year 1990, by involving private and foreign investors. However, they decreased at the end of 1998's, because the Indonesian's financial crisis (Nasution and Sukhyar, 1998). Few contracts were suspended and re-scheduled. However, by a new regulation (Law no. 27/2003), new developers or Private companies may involve in developing new geothermal concession areas. Therefore, increasing electrical capacities from geothermal energy will increase faster.

The present geothermal exploration areas are located in the western and eastern part of Indonesia (Fig. 2 and 3). The exploration has been carried out by doing intensive geological, geochemical and geophysical studies, which are followed by drillings. The intensive resource studies, particularly geosciences and drillings will improve the proven reserve of geothermal capacity (Table 1). Factors influencing the number of good wells to drill are Rock permeability, resource temperature (>220^{o}C) and pressure (> 9 ton/hr), which are the major parameters influencing the well flow rate. These factors will also determine the well productivity and thus the number of wells needed to supply the power plant's energy requirements.

For the last ten years in the western part, the drilling exploration has been carried out in Sarulla, North Sumatra Province; Hulu Lais, Bengkulu Province; Lumut Balai, South Sumatra Province; and Ulubelu, Lampung Province (Fig. 2). in the eastern provinces, The drilling explorations have been carried out in Ulumbu and Mataloko, East Nusa Tenggara Province; Tolehu, Maluku province; Tompaso and Kotamobagu, North Sulawesi Province. These well-drillings are to confirm reservoir conditions. Therefore, promising geothermal resources are confirmed by well discharges of high temperature reservoir.

Table 1. Geothermal resource and exploration areas

Location & Island	Number of Fields	Exploration areas	Geothermal associated control
Sumatra	72	* 5, **8, $^{+}$ 8	Great Sumatra fault zones and the Quaternary volcanic
Java and Bali	66	*6, **5, $^{+}$9	In the Quaternary volcanic lineaments
West Nusa Tenggara	7	**1, $^{+}$1	In the Quaternary volcanic
East Nusa Tenggara	26	*2, **5, $^{+}$4	In the Quaternary volcanic lineaments
Sulawesi	32	*3, **5	The Tertiary & Quaternary volcanic
Moluccas & Halmahera	14	*1, **1	The Tertiary & Quaternary volcanic

Note: Intensive exploration : *Dd : Deep drilling (>1000 m); **Gt : Geosciences & gradient thermal
$^{+}$G : Geosciences (geology, geochemistry & geophysics)

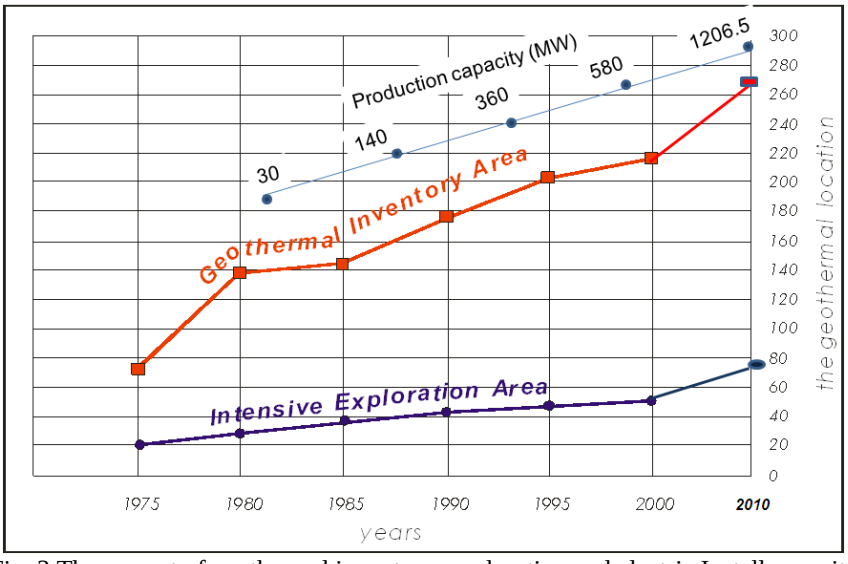

Fig. 3 The current of geothermal inventory, exploration and electric Install capacity

6. GEOTHERMAL DEVELOPMENT AREAS

Most of new geothermal development areas are concentrated in the western part of Indonesia (Sumatra, Java and Bali islands) compared to the eastern part (Nusa Tenggara, Sulawesi and Moluccas islands). This may be caused by several factors; big capacity geothermal potential areas, the new industrial developments, the population growth and density, and also the national electrical demands (> 10%). All remarkably increase in the western part, particularly in Java Island. One of the major factors to support a power sector development program is the "Independent Power Producer (IPP) model" that offers a relatively high electric price, giving the private sector faster returns in investment. Therefore, to the early of 2001, an investment in power sectors starts to increase and attracts the private companies to involve in geothermal industrial developments.

The growth rate of geothermal development for electricity in Indonesia is relatively slow. It is significantly affected by price of competing hydrocarbon power and hydro power. In 1980's, the installed capacity of geothermal electricity has been 140 MWe. The additional capacity over 400 MWe in 1990's has shown that geothermal power reaches 580 MW (Table 2). Recently, it increases to about 1206.5 MW (2011), supporting approximately 4 % of the total national electricity consumption (Fig. 3). The national installed generation capacity of all energy has been approximately 29,000 MWe in 2010 (Fig.3), excluding the captive power (private own generator). Accordingly, geothermal power as a clean energy is attractive to industry for the future development instead of oil fueled and gas fueled power plants.

Table 2. Development areas and plan commissioning of geothermal energy in Indonesia 2011-2014

No	area	Drilling depth (m)	Capacity (MW) 2011	PPA (Cent US)	Plan & capacity (MW) 2014-2016	Developer
1	Kw.Kamojang,West Java	1200 to 1600	200	7.03	Add. capacity 60	PT. PGE, JOC, ESC
2	Kw.Darajat, West Java	1300 to 2500	260	6.95	Add. capacity 60	PT.Chevron,JOC, Esc
3	G.Wayang Windu, West Java	1300 to 2400	220	8.39	Add. capacity 220	PT. Star Energy,Esc
4	G. Salak, West Java	1300 to 3000	375	8.46	Add. capacity 110	PT. Chevron, JOC, Esc
5	Kw.Patuha, West Java	700 to 1800	-	8.10	110	PT. Geodipa, JOC
6	Kw.Krahabodas, West Java	1000 to 2000	-	8.46	55 ?	PT.PGE, JOC,
7	Kw.Cibuni, West Java	800 to 1400	-	6.90	10	PT. Yala Teknosa,Esc
8	G.Dieng, Central Java	1200 - 2100	60	9.81	?	PT. Geodipa, JOC
9	Kw.Bedugul, Bali	1200 -2100	-	7.15	10	PT. Bali Energy,JOC
10	G.Sibayak, North Sumatra	1400 to 2200	10	7.10	Add. capacity 30	PT.PGE, Esc
11	Sarulla, North Sumatra	1300 to 2100	-	6.79	110	PLN&Consortium,Esc
12	Kw.Hulu Lais, Bengkulu	1000 to 1800	-	?	55	PT.PGE, Esc
13	Lumut Balai, South Sumatra	1200 to 2000	-	?	110	PT. PGE, Esc
14	Kw.Ulubelu, Lampung	1100 to 2000	-	7.00?	110	PT. PGE, Esc
15	Kw.Lahendong, North Sulawesi	1100 to 2200	80	4-4.7	Add. capacity 60	PT. PGE, JOC
16	Volc.Tompaso, North Sulawesi	1200 to 2100	-	6.00?	60	PT. PGE,Esc
17	Kotamobagu, North Sulawesi	1500 to 1900	-	6.00?	55	PT.PGE, Esc
18	Kw.Ulumbu, West Flores	700 to 1800	5	7.00	Add. 5 (2012)	PT. PLN
19	Kw.Mataloko, Central Flores	250 to 750	1.5	7.30?	4 x 2.5	PT. PLN,
20	Volc.Tolehu, Ambon	900 to 930	-	9.60	2 x 10	PT. PLN
	Total Capacity		1206.5		2315	

(from PLN, 2001, API, 1998)

PPA: Power Purchase Agreement JOC: Joint Operation Contract, ESC: Energy Sales Contract. Expl:Exploration

The early geothermal development, several deep production wells will be drilled, continued by steam piping to power plant constructions, which are taken within 2-3 years. The new geothermal fields will be developed in several prospect areas, and will be commissioned between years 2014 - 2016. In western part of Indonesia, the new geothermal fields are Jaboi, Sarulla, Lumut Balai, Ulubelu and Patuha prospects (Fig.2 and Table 2). To the eastern part of Indonesia, new development areas of geothermal fields are located in Ulumbu, Mataloko, Tolehu, Tompaso, Kotamobagu and Jailolo geothermal prospects (Fig.2).

Based on the PLN data, the cost of electricity produced by geothermal power plants, is agreed under Power Purchase Agreements (PPAs) varies between US $0.042/KWh to 0.084/KWh for negotiated Energy Sales Contracts (ESCs). The highest selling price declared by the government as high as US $0.097/KWh for ESC.

7. CONCLUSION

The Indonesia geothermal areas are associated with volcanic arcs and tectonics. They distribute along Sumatra, Java, Nusa Tenggara, Moluccas and north Sulawesi Islands. The geothermal Speculative Resources are located in 276 areas with capacity ± 29,000 MW. The new Geothermal Law No. 27/2003 regulates the upstream business of geothermal and private investors to develop geothermal business by involve in the Government Geothermal tender. The Independent Power Producers (IPP's) may sell geothermal power under Energy Sales Contracts and Joint Operation Contract to PLN. The geosciences study and drilling explorations improve the proven reserve geothermal capacity. Factors influencing the number of good wells to drill are rock permeability, resource temperature (>220^{o}C) and pressure (> 9 ton/hr). The geothermal development areas are increase to more 100% to the new future, from 1200 MWe in 2011 to 2200 MWe in 2014 to 2016. Therefore, significant increase geothermal development areas and their install capacity.

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