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The Current State of Geothermal Energy Development in the Philippines and Southeast Asia

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Abstract

The increasing demand for electricity, due to rapid economic growth and rising population, has been the main focus of energy policy in many Southeast Asian countries. With a projected power growth rate of 5-15 percent per annum, their target to attain energy security and to sustain economic growth compelled them to develop their renewable and indigenous sources of energy as alternate to their fossil-based fuel requirements. Two of these countries, the Philippines and Indonesia, are both ideally situated along the stretch of the Pacific Ring of Fire, and as such are largely endowed with geothermal resources. Geothermal development in the Philippines is now in its mature stage, where most of the geothermal fields have been operating for 10-30 years. On the other hand, Indonesia, with its 20,000 MW potential reserves, has been held back in its geothermal development. While the Philippines currently ranked second to the US with 1,931 MW installed geothermal capacity, Indonesia has installed only 807 MW, approximately 4 percent of its total potential. There are minor geothermal activities in Thailand, Vietnam and Malaysia; utilizing their low temperature resources mainly for direct heat application. This paper presents the current state, barriers and key components of the region's geothermal development. A brief discussion on possible candidate fields for Enhanced Geothermal Systems (EGS) in the Philippines is included.

Keywords: country status, geothermal development, Asia geothermal

1. Introduction

Southeast Asia is located in the southeastern part of the Eurasian plate, with the east-dipping subduction of Indo-Australian plate to the east and the south, and the west-dipping Philippine Sea plate and West Pacific plate to the west. It is currently accepted that the present-day tectonic activity of SE Asia has been governed by the interaction of Indo-Australian plate with Eurasian plate since the time that the India continent collided drastically with Asia during approximately 55 Ma (Charusiri et al., 2000, Packham, 1993). It is from this strategic location that the Philippines and Indonesia find their geothermal resources bountiful to be used for geothermal power generation. The Southeast Asian region is composed of ten countries located south of China and east of India, namely the Philippines, Indonesia, Malaysia, Singapore, Thailand, Vietnam, Borneo, Cambodia, Myanmar and Laos. This region is considered to be one of the most dynamic growth centers in the world, a center of increasing energy demands with power growth rate of 5-15 percent per annum. Hence, it is important that green energy sources are promoted in the region to protect the global environment. The unique historical, cultural and borderless relationship existing among the countries in the region compelled them to establish regional, sub-regional and bilateral collaboration in developing renewable energy to attain regional energy security and sustain their economic growth.

The Philippines and Indonesia contribute 71 % and 29 %, respectively, of total geothermal electricity production in the region. Only Thailand, among the other countries, has an installed 300 kW of geothermal binary plant. Many of other Asian countries also have geothermal potential that could be open for future development.

2. The Philippines

Electrical utilization of geothermal energy in the Philippines was first demonstrated in Tiwi, Albay in 1967 by tapping steam from a shallow gradient hole to turn a laboratory turbo-generator and lit up an electric bulb. Since then, geothermal development took a faster turn by installing the country's first commercial pilot plant in Tongonan, Leyte with a capacity of 3 MW. In 1980, a total of 446 MW was installed putting the Philippines second in rank to the United States in terms of installed geothermal plant capacity. The Philippines remains as the second largest producer of geothermal energy in the world with a total of 1,931 MW up to the present. This unparalleled growth of geothermal development in the Philippines has been attributed to many factors. First, to the impetus placed by the government in searching and developing indigenous sources of energy to reduce the country's dependence on imported oil. Second, was the strategic location of the Philippine archipelago, which finds its span along the 40,000 km stretch of the Pacific Ring of Fire; a zone of frequent earthquakes and volcanic eruptions along the basin of the Pacific Ocean (Figure 1). Third, but not the least, was the bold and aggressive strategies adopted by the government in putting more risk capital by fast-tracking the completion of geothermal projects. In this approach, development projects were committed after confirming the existence of a geothermal resource by drilling two or three successful wells without the long term testing and detailed resource evaluation (Alcaraz and Datuin (1981), Sarmiento and Bjornsson, (2007)).

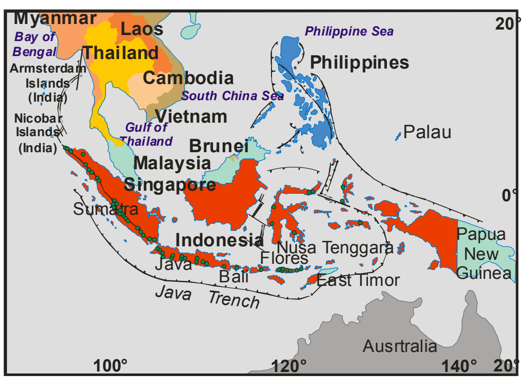

Figure 1: *Map of the countries comprising the Association of South East Asian Nations*

Figure 2 shows that, for the last thirty years, historical development of geothermal resources in the country followed a staircase structural pattern where step increases in installed capacities preceded a 10 year lull from the two major periods of development: from 1979-1984 and 1993-1997. No geothermal plants were installed from 1984-1992 because of funding problems and weaker demand for electricity. It was during this period that the country was besieged with political instabilities causing the slow down of the economy.

The subsequent years after 1999 was another setback for the industry as there had been no geothermal plants added to the national grid. An oversupply of electricity, caused by the entry of many IPPs and BOT contractors into power generation, and again the slow-down of the Philippine economy, due to the effects of

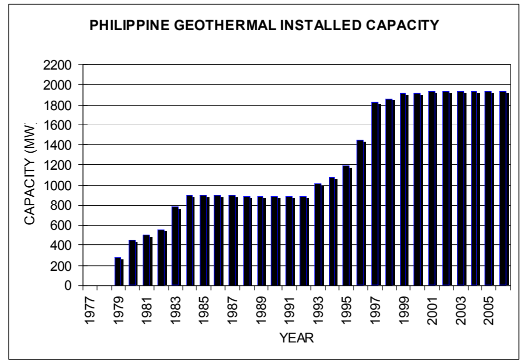

Figure 2: *A graph of the installed geothermal capacity in the Philippines*

the Asian financial crisis, created a standstill in the geothermal expansion programme of the government. In fact, this power surplus led to the spiralling price of electricity because all IPP and BOT contractors/operators are guaranteed a minimum off-take of their plant capacities. Consumers pay for the cost of energy, whether they are lifted or not from these plants.

Figure 3 illustrates the percentage share of geothermal energy in the country's total installed capacity and generation mix. The maximum percentage share attained based on the total capacity was 17.21% in 1984 but its total share in terms of the actual generation mix had reached 19% in 2003.

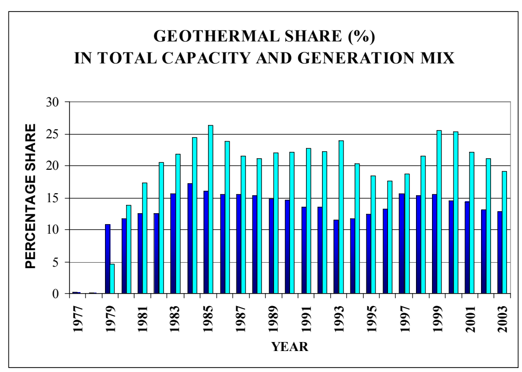

Figure 3: *Annual share of geothermal contribution to the total capacity and generation mix of the country.*

2.1 *Greenfield Areas/Contracting Round*

The Department of Energy (DOE) estimated the total geothermal potential of the Philippines to be up to 4,790 MW. To confirm these reserves and achieve the government's goal of (i) increasing the installed capacity to 1,200 MW in the next decade (Benito et al., 2005), and (ii) surpassing the USA as number one producer of geothermal energy in the world, the Department of Energy kicked-off the

First Philippine Energy Geothermal Contracting Round (Geothermal I) in March 2004 followed by Geothermal II in August 2005. These contracting rounds were launched to encourage the involvement of private and foreign investors and hasten the development of greenfield areas. It was evident that the two current steamfield operators (PNOC Energy Development Corp. and Chevron Geothermal Holdings Inc, formerly UNOCAL of USA) would not take more risks in developing other areas, when the National Power Corporation (NPC) lost its mandate to build additional power plants, and to sign Power Purchase Agreements (PPAs) that guarantee sale of energy production. Table 2 shows the various greenfield and expansion areas included in Geothermal I and II contracting rounds. In Geothermal I, no bid was submitted for greenfield areas. Private investors preferred to negotiate on existing production fields through expansion and optimization projects where the risks are minimal. Unfortunately, obstacles were encountered due to disagreements on steam price and the demand for availability of a signed PPA. The Geothermal II contracting round did not attract private and foreign investors, and disagreements on the financial provisions and terms of the service contract between PNOC-EDC and the DOE led to another failure in the bidding. However, it is likely that these greenfield areas would be developed in the future, now that there is growing impetus and ardent global interest for renewable energy sources, and in view of the Kyoto Protocol, which provides for incentives on projects with carbon gas emission reduction.

Table 1: *List of geothermal areas offered for the Philippine Energy Contracting Round in 2004 and 2005.*

AREA	ESTIMATED CAPACITY
	(MW)
Daklan, **Northern Luzon**	20
Cabalian, Southern Leyte	60-110
Biliran.Leyte	20-40
Amacan, Compostela Valley	20-40
Dauin, Negros Oriental	40-80
Natib, Bataan	40
Mabini, Batangas	20
Montelago, Mindoro Oriental	20-40

2.2 Legal framework

In 1978, Presidential Decree (P.D.) 1442 or the Geothermal Service Contract Law was promulgated governing exploration, development and utilization of geothermal resources in the Philippines. To achieve self-reliance in the country's energy requirements and address various obstacles in geothermal development, Congress continues to enact enabling laws.

A Contractor engaged in the development and exploitation of geothermal resources must have prior government's approval by entering into a Geothermal Service Contract with the Department of Energy. PD 1442 provides that the contractor supply the expertise, technology and funding requirements for resource exploration and development. A service contractor has the sole right and exclusivity to develop the area concomitant with a work program and commitment. It also provides that the contractor receives various incentives in the form of operating cost recovery: exemption from payment of customs and import duties for materials; machinery and equipment needed in geothermal operations; 40% of the net proceeds, after deducting all necessary expenses incurred from the gross revenues; and repatriation of capital investment and remittance of earnings derived from its service contract operations.

The issuance of Executive Order 215 (E.O. 215) in 1990 was in response to a power shortage crisis in the late '80s and the deteriorating NPC's financial condition. This E.O. was issued, effectively removing NPC's monopoly in power generation, and allowed the private sector in the construction, ownership and operation of power plants. EO 215 facilitated the entry of independent power producers (IPPs) into geothermal power generation through Build-Operate-Transfer (BOT) contracts. The BOT arrangement allowed PNOC EDC to accelerate the expansion of its installed geothermal capacities by 708 MW, through ten year contracts with Ormat, Magma, CalEnergy and Oxbow/Marubeni for Leyte and Mindanao. In 2007 and 2009, all the Leyte and Mindanao BOT power plants will be totally transferred to PNOC-EDC respectively.

While this E.O. had attracted private and foreign companies to invest into BOT power plants, no private or foreign companies have so far ventured into greenfield areas. It is apparent that the Foreign Investment Act of 1991, stipulating a maximum of 40% equity for foreigners in exploration, development and utilization of natural resources, hindered the entry of foreign capital in greenfield development. It is also likely that the ratio on the government and contractor's share at 60:40 on the net proceeds from geothermal operations serves as a disincentive to private developers. Therefore, PNOC-EDC remains the only geothermal service contractor under PD 1442. The service contract of Chevron (CGHI) preceded PD 1442 and is not covered by the terms of this decree. As a government corporation, the viability of PNOC EDC is enhanced by loans from Japan's Official Development Assistance (ODA), World Bank (WB) and Japan Bank for International Co-operation (JBIC) with government guarantee (Dolor, 2005). It is imminent that Congress has to pass a more private investor-oriented geothermal law to attract private sector participation into greenfield development.

2.3 Privatization and Power Structure

The long history of power monopoly, inefficiency and the burgeoning debt of the NPC, which significantly contributed to the Philippine fiscal deficit, constrained the government to introduce further drastic reforms in the country's power industry. In 2001, the Electric Power Industry Reform Act of 2001 (EPIRA LAW) was enacted to provide a framework for the restructuring of the electric power industry, including the privatization of the assets of NPC, creation of a competitive power market structure, and the definition of responsibilities of the various government agencies and private entities. Similarly, the Law was passed to ensure the quality, reliability, security and affordability of the supply of electric power; to ensure transparent and reasonable prices of electricity in a regime of free and fair competition and to enhance the inflow of private capital and broaden the ownership base of the power generation, transmission and distribution sectors. Impetus on the development of renewable energy was also included, among others, in the provisions of the law.

To restructure the power industry, the EPIRA Law created the Power Sector Assets and Liabilities Management Corp. (PSALM) to dispose the assets and assume all the liabilities of NPC.

Table 2 shows the various geothermal power plants scheduled in the ongoing privatization.

In parallel, PNOC EDC undertook its own privatization program by offering its 40% equity to the public by enlisting the company at the Philippine Stock Exchange. It is one of the biggest and most successful Initial Public Offering (IPO) ever listed in the Philippine Stock market with 80-90% of the total shares sold to foreign investors.

Table 2: *List of NPC geothermal power assets for privatization.*

Power Plant	Capacity (MW)	Owner	Schedule
Tiwi	330	NPC	Under Bidding
MakBan	402	NPC	Under Bidding
Tongonan I	112.5	NPC	First Half 2007*
Palinpinon I and II	192.5	NPC	2nd Half 2007*
Bacman I and II	150	NPC	2008*

**Indicative Dates*

This Act also created the National Transmission Corporation (TransCo), Energy Regulatory Commission (ERC) and the Wholesale Electricity Spot Market (WESM). Under the law, TransCo will open up the transmission line access to big and industrial users and power generators. The true cost of electricity that will be determined by ERC will be unbundled to show transparency. A competitive spot market which was also created is currently operating where electricity output are pooled for direct sale to the end-users in real time. It is here that geothermal power would be able to promote its competitive advantage given the continuing increase in the price of oil. With the privatization of geothermal power plants, it is expected that the share in total generation mix from geothermal sources would jump significantly because of improved efficiencies and projected increase in the market share.

2.4 Benefits to Host Communities

Realizing the critical role of the host communities, Rule 29 Part A of the Implementing Rules of the EPIRA provides that host local government units or region will be recognized and compensated at P0.01/kWh of electricity sales which shall apply to generation facilities and/or energy resource development projects located in all barangays, municipalities or cities, provinces or regions. With assurance to the local government units on their share of the benefits from the resource or generation facilities, the expected opposition to the projects could be lessened, and harmony and cooperation of the host government and local people could be obtained for the project.

2.5 Power Demand and Programs

For the planning period 2006-2014, an average annual power demand growth of 4.8% was used. Based on this figure, the projected additional capacities required during the period may be from 4,000-4,350 MW, distributed as follows: with half required in Luzon and equal split for Mindanao and Visayas (DOE, 2004). The geothermal component of this forecast shows that an additional capacity to be supplied from geothermal sources could be a minimum of 529 MW as shown in Table 3.

Table 3: *List of geothermal prospects programmed for development to meet future power demands.*

AREA	CAPACITY (MW)	AVAILABILITY
Northern Negros	49	2007
Tanawon	40	2009 (indicative)
Manito-Kayabong	40	2011 (indicative)
Nasulo	20	2008
Cabalian I	50	2010 (indicative)
Cabalian II	40	2011 (indicative)
Dauin	40	2012 (indicative)
Mindanao III	50	2008
Batong Buhay	120	Indicative
Biliran	40	Indicative
Amacan	40	Indicative
TOTAL	**529**	

2.6 Resource Technology and Management

The management of maturing geothermal fields, which have been operating in the last 10-30 years in the country, paves the way to advancement of resource technologies originally applied in the oil and gas industry. Stimulation techniques, which are conducted to improve reservoir permeability and well output, have been very successful in minimizing drilling of maintenance and replacement (M&R) wells and, consequently, in sustaining production. Acidizing, which consists of injecting HCL and HF mixtures, is conducted for wells suffering from mud damage, either newly drilled or existing production wells, and for reinjection wells which have shown declining injection capacities. Buning, et. al., (1995) reported very significant improvement in capacities of 9 out of 10 wells initially acidized by PNOC-EDC. Other stimulation techniques like hydro-fracturing, with and without proppants, had been tried in geothermal wells in the Philippines with mixed results.

The use of chemical inhibitors also reduces the frequency of work-over of wells affected by calcite and silica deposition. With a Calcite Inhibition System (CIS), the output decline rate has been significantly reduced (Siega et al., 2005). The successful trial of using silica inhibitors in controlling silica deposition inside the wellbores had significantly delayed the acidizing and workover of OP-2RD in Botong sector of the Bacman II geothermal field (See at al., 2005).

Other typical wellbore and reservoir challenges which have been encountered included collapsed casings, damaged liners, cooling due to incursion of cold fluids and reinjection returns, output decline in the wells due to normal run-down, well collapse and, lately, presence of high total discharge solids in steam. These challenges have been mitigated by adopting suitable techniques that slow down output decline and access permeable zones previously untapped for production and injection. These techniques include re-lining, zone isolation, casing perforation, re-drilling, well deepening and steam-washing.

To optimize the resource, high pressure Inlet and topping/bottoming plants, and combined cycle units are adopted representing the new generation of efficient power plants. Wells with large diameter casings are also drilled to reduce the number of wells in a given production field

2.7 Potential for Enhanced Geothermal Systems

Advanced exploratory works had been conducted in about 22 geothermal sites in the Philippines where at least two deep wells were drilled in each area. Since only 8 areas have been developed for commercial operation, there remains a big potential for other sites to be considered for Enhanced Geothermal Systems (EGS) application. In this case, the EGS application refers to those typical hydrothermal systems discussed by (i) Capetti (2006) where he reported the success of stimulation jobs on tight and low productivity wells in Larderello, and (ii) Robertson-Tait and Johnson (2006) in Desert Peak Nevada where they proposed hydraulic stimulation jobs in well DP23-1. Table 4 highlights the areas that could be suitable for preliminary evaluation for EGS application in the Philippines. Due to lack of permeability at depths, development programs in these areas were deferred and/or cancelled even though high temperatures close to 300°C were encountered. Other areas bearing acid fluids in their discharge composition are not included in the list.

Table 4: Candidate areas for possible application of EGS in the Philippines

Area	Wells Drilled /Depth (meters)	Temperature (°C)	Remarks
Daklan, Northern Luzon	5/2400	200-293	Low permeability volcanics and sedimentary complex
Natib, Bataan	2/2751-2915	265-280	Low permeability pyroclastics and caldera materials
Amacan, Davao	1/2700	265	Diorite of low permeability

3. Indonesia

Indonesia is similarly situated in the so called Pacific Ring of Fire. Its geothermal potential is estimated to be between 20,000 for the high temperature resources and 27,000 MW if the potential for low temperature resources are included (Ibrahim et al., 2005a). It is considered to be the largest geothermal reserves in the world (Fauzi et al., 2005, Suryantoro et al., 2005, Ibrahim et al., 2005). The first test holes in Indonesia were drilled by the Dutch in Kamojang in the 1920s, and followed by a countrywide inventory of the thermal features (Fauzi et al., 2005). In 1972, the government conducted a more complete inventory with technical assistance from Italy, Japan, New Zealand and the USA. The results of these studies became the basis for issuing new policies that would accelerate geothermal development in the country. Pertamina was then mandated in 1974 to spearhead the development of this indigenous resource. Despite the country's huge geothermal potential, there has been relatively little development during the last 20 years particularly in the 2000-2005 period, mainly because of a severe economic crisis that had adversely affected power demand and growth (Ibrahim et al., 2005). To date, a total of 807 MW, representing 3-4% of the estimated reserves, have been installed in 7 geothermal areas. In comparison, power generation from oil based plants contributes 45.5%, coal at 21%, natural gas at 17.9% and hydro at 11 % from a total of 35,572 MW (Atmojo, 2006).

3.1 Operating Areas

The first geothermal production in Indonesia commenced in Kamojang in 1978 using 250 kW geothermal turbine. Capitalizing on this success, PLN installed a 30 MW power plant in 1978 and 2x55 MW units in 1987. Subsequent development involved the participation of foreign companies in Gunung Salak and Darajat through joint venture partnership by means of the Joint Operations Contract (JOC) and Energy Sales Contract (ESC). The JOC serves as the contract between Pertamina, who represents the government and acting as the owner of the service contract; and the private or foreign contractor, who is responsible for development of the steamfield and conversion of energy to electricity and its delivery to the buyer. The ESC serves as the contract for sale of electricity to PLN either by Pertamina and/or the contractor. Here, either PLN or the Contractor has the option to build the power plants. These joint operating partnerships led to a significant contribution of 585 MW to the overall geothermal installation in the country as shown in Table 5.

Table 5: Installed geothermal capacities in Indonesia in 2004

Geothermal Field	**Installed Capacity (MW)**	**Developer**
Sibayak	2	Pertamina
Gunung Salak	330	Chevron
Wayang Windu	110	AsiaPower/MNL
Kamojang	140	Pertamina
Darajat	145	Amoseas/Chevron
Dieng	60	Geodipa
Lahendong	20	Pertamina
Total	**807**	

3.2 Legal Framework/Geothermal Law

At the height of geothermal development in Indonesia in the mid '90s, PLN signed 11 contracts with a capacity of 3,417 MW but only three had moved forward (Energy News, 2002). These planned projects should have been on stream between 1998 and 2002 but were suspended in the wake of the 1997 financial crisis. These contracts are now being restructured and negotiated in accordance with PD 133/2000. It should have catapulted Indonesia as the number one geothermal producer in the world. The suspension of the various projects with signed contracts, in the aftermath of the Asian crisis, caused a chilling effect on the entry of foreign investors and developers in geothermal energy. Now, Indonesia needs greater economic stability and confidence for investors' interest to revive these projects. The government is now taking the opportunity with the crisis gradually easing out and economic recovery taking off to restructure the energy sector particularly those involving the development of geothermal resources by introducing appropriate legislations.

Realizing the limited oil reserves and the abundance of renewable sources in Indonesia, the government launched in 2002, the National Energy Policy to enable coordination on the synergy of all stakeholders in the energy sector. Its missions are summarized as follows:

- To guarantee a domestic energy supply
- To increase the added values of energy sources
- To manage energy sources in an ethical and sustainable manner
- To provide an affordable energy for low income people and develop domestic capacities in the field of energy management

Prior to this issuance of the NEP, the government started to issue Presidential Decrees governing the conduct of geothermal exploration and development in the country vis-à-vis: PD 16/1974, PD 22/1981, PD 23/1981, PD 45/1991 and PD 49/1991. These decrees mandated Pertamina to be the lead company in conducting exploration, exploitation and utilization of steam into energy. It was under these decrees that large scale development contracts were signed to install 3,400 MW of power plants in 2002.

Within the mandate of Pertamina and under Article Six of PD No. 45/1991, the Directorate General of Oil and Gas and the Directorate General of Electricity and New Energy control and provide technical guidance for the implementation of geothermal exploitation, according to their respective duties and field of authority. Thereafter, the Ministry of Energy and Mineral Resources (MEMR), through the Directorate General of Oil and Gas, would be responsible for issuing a principal permit and for setting up Joint Operation Contracts among investors, Pertamina, and PLN. The Directorate General of Electricity and Energy Development is responsible for downstream certification. The Government further supports the development of geothermal resources by lessening the risk through the issuance of PD 76/2000, where Government bears the capital risk when an exploration program fails to find a well with sufficient potential for production.

The Geothermal Law of 2003 was passed to remove any obstruction in geothermal development and make competition more challenging and rewarding. It strengthens the legal basis for the development of geothermal resources. It also supports the opening of investment opportunities on the upstream activities and the release of downstream activities to foreign or private companies. This Law operates consistently with the Electricity Law 20/2002 which covers the downstream business activities of the power generation. The Implementing Rules and Regulations are yet to be prepared and approved as of June 2006 (Atmojo, 2006). Some of the most significant provisions under the law specify the following:

- All cooperation contracts that were already in existence before the law became effective would remain in effect until the end of the terms of the contracts.
- Government assumes the exploration risks by drilling 2-3 wells to confirm the commercial existence of a resource, the awarding of the service contract to be determined through a public bidding
- Geothermal Business Permit to be granted by the Government or the Regional Government depending on the location of the resource
- Total tax upstream is 34%

3.3 *Geothermal Road-map and Development Challenges*

As part of the NEP of Indonesia, future geothermal development has been planned in accordance with a Geothermal Road-map that covers the time frame for the country's 20,000-27,000 MW potential shown in Figure 4.

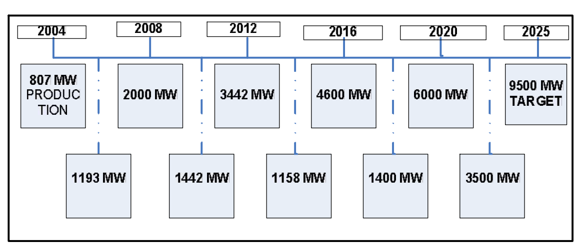

Figure 4: Geothermal road-map for Indonesia. (After Atmojo, 2006)

The areas where future geothermal development will take place are shown in Table 6.

Table 6: *Areas for the geothermal road-map*

Field	Developer	Prod-uction 2004	Dev't. Planning 2008	Dev't. Planning 2012
Sibayak	Pertamina	2	10	40
Sibual-Bualu				
(Sarula)	PLN		220	220
Sungaipenu	Pertamina			55
Hululais-Tambang Sawah	Pertamina			55
Lumut Balai	Pertamina		110	110
Waypanas (Ulu Belu)	Pertamina		110	110
Cibeureum-Parabakti (Salak)	Chevron	330	0	110
Panga-lengan				
Kawah Cibuni	Yala Teknosa		10	0
Gunung Patuha	Geodipa		120	60
Wayang Windu	MNL	110	110	110
Kamojang-Darajat				
Kamojang	Pertamina	140	60	60
Darajat	Amoseas	145	190	110
Karaha, Cakrabuana	KBC		55	55
Dieng	Geodipa	60	120	60
Iyang, Argopuro	Pertamina			55
Tabanan, Bali (Bedugul)	Bali Energy		10	110
Lahendong	Pertamina	20	60	40
Kotamobagu	Pertamina			60
Tulehu	PLN			16
Mataloko	PLN		2	6
Ulumbu	PLN		6	0
Total		**807**	**1193**	**1442**

The geothermal Road-map specifies a 6,000 MW installed capacity in 2020, a significant target considering the achievements even in the Philippines and the USA. To attain this objective, Ibrahim et al, (2005) and Atmojo (2006) identified some of the challenges and concerns that need to be addressed by the government and all the stakeholders in the Indonesian geothermal industry:

- subsidies on fossil oil, geothermal energy price not competitive
- prohibitive investment requirement
- growing concern by investors on possible changing of contract terms, sanctity of signed contracts
- conflict on Geothermal Law of 2003 and Regional Autonomy Law of 1999 on tax imposition
- steam/electricity price determination and long delayed price negotiation
- difficulty in determining and acquiring land for expansion and development
- unavailability of the IRR on Geothermal Law which could cause a conflict with the provisions of Electricity Law 20/2002 specifically for direct award of projects on renewable sources of energy and Geothermal Law 27/2003 which provides for requiring qualified operator or developer to manage a geothermal field.
- certainty on the buyer of steam and electricity
- synchronization of other regulations such as protected zone, environment, and regional regulation (Perda)

The government of Indonesia should therefore finalize the IRR covering both the Geothermal and Electricity Laws to enhance the legal framework for the country's geothermal roadmap.

4. Other Southeast Asian Countries

Geothermal development in other Southeast Asian countries has not really taken-off in view of the very limited power potential associated with their low enthalpy resources. The prevailing year round tropical climate in the region restricts the utilization of these resources for space heating, a major application of geothermal energy in Europe.

Table 7 shows a summary of the development status and the description of the thermal features of known geothermal areas in other countries of Southeast Asia.

Subtavewung (2005) reported that the first geothermal exploration study in 1981 in Thailand was concentrated in northern part of the country, through the cooperation between Electricity Generating Authority of Thailand (EGAT) and French Agency for Energy Management (FAEM) at the Fang hot spring, resulting in the installation of the geothermal binary cycle power plant with a capacity of 300 kW in 1989. Rakasaskulwong (2004) estimated that Thailand could save 10.12 MWt with an annual thermal utilization of 173.05 TJ corresponding to savings of 4,152 tons of fuel oil per year.

Table 7: *Status and thermal features in other Southeast Asian countries (See text for references)*

Country	Installed /Planned Capacity	Hot Springs	Measured Tempe-rature (°C)	Estimated Capacity
Thailand	300 kWe	114	32-99	10-12 MWt
Vietnam	0/120 MW	269	>30	649 MWt
Myanmar	-	43	32-51	No country estimate
Malaysia	-		43-78	Possible binary power gene-ration
Singapore, Brunei, Laos and Cambodia	No reports of geothermal activities seen in published articles and literatures			

There has been no additional geothermal installation in the country since then.

In Vietnam, Cuong et al (2005) reported that geothermal utilization is mainly found in spa, treatment, bottling and tourism. It was started in 1997 by Pharmacy Company of Binh Dinh province in producing 700 tons/year of mixed crystal salts and iodine by evaporating the iodine-salt solution using the heat from geothermal fluids. Geothermal exploitation for electric power generation was initiated in cooperation with ORMAT Company and Electric Investigation and Design Company No. 1. A pre-feasibility report aimed at constructing 6 electric geothermal plants in central Vietnam, with the total capacity up to 112.7 MW, was already completed and awaiting implementation.

In Malaysia, geothermal resources are identified in the state of Sabah in the island of Borneo. Sabah is geologically complex and located at the fringe of a volcanic belt and, hence, is not surprising to find geothermal manifestations such as fumaroles, seepages, mudpools and hotsprings (Chong et al., 2000) as observed in Tawau Hills Park. The geothermal systems are however classified as low enthalpy systems and favor application dealing with hot bath and recreational spot and medical applications. In the Andrassy Prospect area in Tawau, fifteen active manifestations were documented in 2001 which gave geothermometry results in the range where power generation via binary cycle is possible (Chong and Noh, 2001).

Based on the Ministry of Energy of Myanmar (MOE, 2007), the country is one with great numerous geothermal potential that could be tapped to fulfil its future energy requirement. However, no significant stride has occurred in the country since 1995, when geologists from Ministry of Oil and Gas Enterprise (MOGE) and Caithness Resources Inc. from United States performed reconnaissance surveys by collecting water samples from 10 hot springs out of 43 previously studied hot springs in the country. Other foreign companies and institutions collaborated with the state MOGE were UNOCAL, Geothermal Energy New Zealand Ltd. (GENZL) both in 1990 and the Electric Power Development Co. Ltd. (EPDC) of Japan in 1987. Spring surface temperatures in the range of 65°C and maximum projected subsurface temperatures of up to 300°C were reported by the Ministry of Energy (MOE, 2007). There has been very limited information from these studies except those obtained above and therefore verification on these data could not be made.

Singapore, Brunei, Cambodia and Laos currently have not documented their potential and programs for geothermal development. Brunei is an exporter of oil and therefore sees very small contribution from geothermal energy for its fuel requirement. Cambodia and Laos rely mainly on their hydropower resources and currently do not have any published report on their geothermal energy potential.

5. Conclusions

Geothermal development in Southeast Asia has been delayed significantly in the last ten years. These delays were caused by various factors associated with political instabilities, economic crisis and investment or funding difficulties.

Future geothermal activities in the Philippines will be relatively on a smaller scale relative to previous developments, with a possible addition of 529 MW in the next 5 years. There appears to be a big potential as well on the extension and application of EGS in the Philippines for existing fields, and those which were not developed because of lack of reservoir permeability.

Future geothermal power development in Asia will take place mostly in Indonesia with a target installed capacity of 3,442 MW in 2012 and total capacity of 9,500 MW in the year 2025. However, more supporting measures would be required to improve the country's investment climate and make geothermal power competitive with those from oil based power plants. A strong political will should be exercised by the government to develop this indigenous resource, backed up by a well established and rigid legal framework that would support entry of foreign capital to ensure needed funding in the development.

Supporting measures or incentives are also required to develop low enthalpy resources and EGS throughout the region, especially in finding applications not only for power generation and space heating but also for other industrial applications.

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