Role of Geothermal in Indonesian Electricity Policy and Progress of Implementation

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ABSTRACT

Indonesia, the biggest archipelago country in the world spreads in equator and is endowed with numerous geothermal energy resources. This research is exerted to investigate Indonesian electricity policy in its connection with Indonesian energy mix policy. Some suggestion is derived as an input for smoothing the energy technology implementation policy. The comparative study of geothermal power plant to coal fired power plant is described in an effort to raise the electricity ratio. The geothermal energy potential and the current field works are described. Various geothermal energy technologies that have been applied in various areas of Indonesia, the price of steam, the electricity production and the community social responsibility are briefly described.

1. INTRODUCTION

The issue of using Renewable Energy (RE) and the global battle against climate change has become increasingly important for every nation on Earth to pay serious attention. Indonesia is exerting an effort to raise the RE implementation. Indonesia energy mix program has target to reduce the use of oil to be 20%, coal to be 33%, natural gas to be 30% and to raise the implementation of RE Technology to be 17% in the year 2025. The challenge is many sites are geographically difficult to be reach. Limited infrastructure, limited transport facilities, limited skilled human resources, weak local financial capability are the constraints. Natural disasters throughout the archipelago as Climate Change consequences raise the burden.

The projection of Indonesian population is shown in Table 1 (Runik Astuti and Suhartono, 2005).

Table 1: The projection of Population, in million.

Age	2000	2005	2010	2015	2020	2025
0-14	63.1948	62.2312	62.8762	62.045	62.5079	62.3925
15-64	132.9768	146.6722	160.6196	171.4924	180.7239	187.9985
65+	9.6747	11.2148	12.4094	14.6426	18.3078	23.2694
Total	205.8466	219.8983	234.1393	248.18	261.5396	273.6514

The growth of energy demand is driven by:

- Population growth that means increase demand for home lighting.

- Industrial growth to fulfill the growing need for food and good.

- Trading growth means increase transport operation.

The projection of energy demand by sector is given in Figure 1. Energy demand for transportation in 2020 increase 2.5 times than that need today, for industries increase 2.5 times and for electricity increase 5 times and than that in 2005.

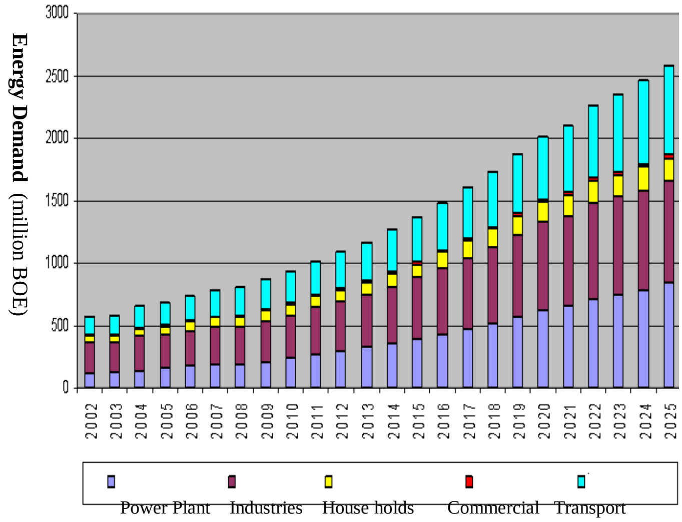

Figure 1: The Projection of energy demand by sector, published in 2005 (BPPT, 2003)

However, the fossil resources written in Blue Print PEN 2005-2025 (ESDM, 2005) indicates that:

- Good quality coal (sub-bituminous and bituminous) left for 50 years, counted since 2005 on production rate written in BP PEN and assumed that export is constant.

- Gas left for 47 years, counted since 2005, with exploration of 8.35 BSCF daily: 4.88 BSCF for export and 3.47 BSCF for domestic need.

- Oil production and import (efficiency scenario) have the same value in 2016, see Figure 2.

This means Indonesia will become a net imported oil country by 2016. However, Indonesia resigned from OPEC membership in Vienna OPEC Meeting in September 10, 2008, and declare that Indonesia is a net imported oil country now on. (AP/AFP/JOE, 2008). If Indonesian oil price lower than international price, the government should allocate a huge funding for domestic need.

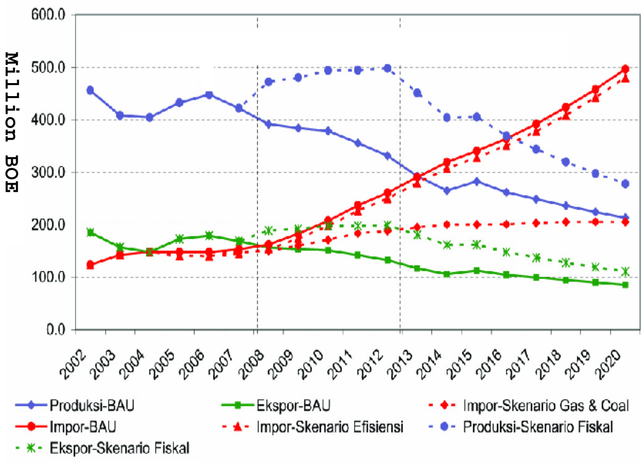

Figure 2: Limited Crude Oil of Indonesia, Blue Print PEN 2005-2025, Att L1 (ESDM, 2005) Note: BAU is business as usual, produksi is production, impor is import, expor is export, skenario is scenario.

Global Context. The world energy usage in 2010, 2020, 2030, 2040, 2050 is given as paralel grey lines in **Figure 3. It** gives a range of possibility to human to exerting an effort to overcome fossil fuel scarcity and to reduce CO_2 emission. The 2020 vertical grey line shows Nuclear and Renewable Energy (N&RE) is projected to contribute 25-57% of the world energy need. If the whole world omit coal usage, see the grey ball at the top of 2050 vertical grey line, N&RE will reach 60% and oil 40%. The other extreem possibility is at the brown ball that show coal usage 25%, oil 0% and N&RE 75%. This means many countries having technology capability use N&RE resources to fulfil their energy demand and to reduce CO2 emission.

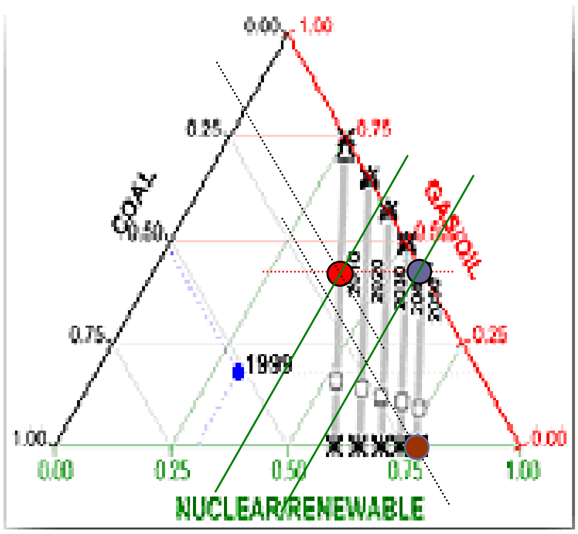

Figure 3: The projection of Coal, Gas/Oil and Renewable Energy/ Nuclear use world wide in the year 2010, 2020, 2030, 2040 and 2050 (Univ. of Wisconsin, Fusion Tech. Inst., 2008) .

Renewable Electricity Development (RED) could facilitate a Long Term Electricity Supply that quarante Environment Protections, but often some components are foreign dependency. The global mind set on the selection of energy resource considers:

- Energy Economy (Capital cost, Operation & Maintenance Cost, Refurbishment).

- Social Economy (Industrialization, Employment Creation, Local Participation, Multiplier Effect)

- Reliable / Proven Technology.

For the countries having limited technology and financial capability, this mind set become a barrier to apply RE conversion. The limited international cooperation related to RE Technology Transfer and Implementation becomes the most difficult problem to be solved. Need to rise the worldwide willing to bridging the technology gap in an appropriate cost.

2. INDONESIA ELECTRICITY AND FOSSIL FUEL RESOURCE CONDITION

There is a contrary situation world wide. The willing to use RE resources is limitted by the RE technology and funding capability. On the other hand, the fossil fuel resources available locally while people also need electricity desperately. Electrification ratio throughout Indonesia in 2003, 2008 and 2013 is shown in **Table 2.** The electrification ratio is planned to increase from 50% in 2003 to be 90% in 2020.

Table 2. Electrification ratio evolution by province, in the year 2003, 2008 and 2013.
(ESDM, 2004)

	%	%	%
Province / Wilayah	**2003**	**2008**	**2013**
Jawa-Bali-Madura	59.5	67.3	77.3
NAD	56.2	69.8	86.5
Sumut	67.1	78.2	93.2
Sumbar	60.5	72.9	94.3
Riau	38.5	47.1	56.9
Sumsel, Jambi dan Bengkulu	38.6	49.9	65.8
Lampung	34.0	50.7	78.7
Bangka Belitung	57.8	71.7	87.1
Kalbar	43.3	57.3	78.9
Kaselteng	51.1	61.2	73.6
Kaltim	49.8	65.4	91.1
Sulutengo	46.2	53.5	63.0
Sulseltra	53.7	55.7	58.1
Maluku dan Maluku Utara	48.3	64.3	89.7
Papua	27.4	34.0	42.6
NTB	28.4	33.1	40.7
NTT	22.4	28.7	37.2
Tarakan	66.0	87.9	100.0
Batam	68.7	96.0	100.0
Total Indonesia	54.8	63.5	75.2

The electricity development is given in **Table 3.** The total electricity need in 2020 is 73.56 GW. The Coal Fired Power Plant (CFPP) will increase 9.11 Giga Watt in the period 2005-2017. The Steam power plant will increase 9.97 Giga Watt. So, 19.08 GW of 25.44 GW primary energy need in 2015 (or 78%) are fossil fuel.

2.1 Electricity Development Challenge for Java-Bali

Electricity demand in Java-Bali is 80% of the total electricity in Indonesia, see **Table 4.** The population in Java-Bali is 60% of the total. Industries in Java contribute income therefore need to maintain their existence. In the fossil fuel scarcity, the huge electricity need in Java-Bali can be supplied by geothermal power plant or nuclear power plant. But people afraid with nuclear power plant make the only alternative is geothermal power plant. Oppose the implementation of energy solution is wasting time, as racing with those who digging and lifting the fossil fuel resources continues for various reasons and interests.

Table 3: The projection of Power Plant Development until the year 2020, in Giga Watt.
(Sukma Saleh Hasibuan, 2004)

	2000	2005	2010	2015	2020
Hydro PP	3,02	3,54	5,92	7,45	8,1
Diesel PP	2,55	2,59	2,59	2,59	2,59
Gas PP	1,2	1,45	3,18	4,38	5,82
Coal fired PP	5,93	8,81	12,52	17,92	25,72
Geothermal PP	0,79	1,51	1,99	3,97	8,83
Steam & Gas PP	6,86	8,31	10,6	15,1	21,6
Steam PP - Gas	0,86	0,86	0,86	0,86	0,86
Nuclear PP	0	0	0	0	0,6
Steam PP - MFO	1,13	1,15	1,4	1,4	1,4
TOTAL	22,33	28,21	39,04	53,65	73,5

Table 4: The electricity production, selling, peak load and the electricity subscribers in Indonesia
(DOT, 2008a)

	2007	2008	2009	2010
	Production (GWh)			
Jawa - Bali	106817	114294	122295	130855
Other Islands	28049	31051	34654	38716
	Selling (GWh)			
Jawa - Bali	93144	99665	106641	141106
Other Islands	25120	27917	31254	34996
Growth (%)		7.9	8.1	8.1
	Peak Load (GWh)			
Jawa - Bali	16478	17631	18866	20186
Other Islands	5346	5873	6921	7221
	Subscribers			
Jawa - Bali	25491000	26760000	28182000	29691000
Other Islands	12189000	12906000	13727000	14599000

2.2 Coal Resources Limitation.

Coal deposit was projected as big as 38.9 billion tones (58.6 % lignite, 26.6 % sub-bituminous, 14.4 % bituminous and 0.4% anthracite), of these deposits: 67.15% in Sumatera, 32.45% in Kalimantan and the rest spread in other sites (Adiarso and Esti, 2004). Leonard (1979) gave classification based on coal's calorie content. Lignite or brown coal or low rank coal has calorie of 6300 - 8300 btu/lb or 3500 - 4611 Kcal/kg. Sub-bituminous has calorie of 8300 - 11500 btu/lb or 4611 - 6389 Kcal/kg. Bituminous has calorie of 11500 - 14000 btu/lb or 6389 - 7778 Kcal/kg. Deposit of low rank coal is 2.8 billion tones and it is not economic for export. This deposit might produce 3000 MW electricity for the next 50 years (ESDM, 2003 p.8).

Coal production increased very fast from 600000 tones in 1984 to 35 million tones in 1995. Coal export in 1996 was 26 million tones (Djiteng Marsudi, 1996). In 2003, coal export was 75% of its production (ESDM, 2003 p7).

Most of the power plants in Java that were constructed in eighties are Coal Fired Power Plant (CFPP) that need sub-bituminous coal intake, those are: Suralaya (3400 MW); Paiton - PLN (4*400 MW); Paiton - Private (4*600 MW); Tanjung Jati A (2*600 MW); Tanjung Jati B (2*600 MW); Cilegon (400 MW); Jawa Barat (2*600 MW). The prize of electricity generated by CFPP is 6 cents US$ per kWh.

In 1996, PT.PLN (the national electricity provider) needed 7 millions tones of coal for all CFPPs they managed. This need increased to be 36 millions tones by the end of 2003 for generating 11000 MW electricity. This electricity production increased to be 17000 MW by the end of 2005. If these CFPPs (or PLTU in Indonesian language) increase by three in the year 2020 (ESDM, 2003 p.11) and they need good quality coal, the domestic coal demand will increase to be 98.73 million tones in 2020. Adding with an export at "constant" amount as in 2005 makes the total annual demand in 2020 becomes 191.5 million tones.

Herman D. Ibrahim (2008) gave information on a severe depleting of Indonesian coal, see Table 5. It shows that coal production in 2008 has reach 170 million tons annually. This means the ratio reserve to production become shorter or to become 29 years. Comparing the data in Table 5 and those written in Blue Print PEN (ESDM, 2005), it is found that within three years (2005-2008), coal is depleting severely.

- Depleting acceleration of Coal {(50 -29)/3} is 7 times

- Depleting acceleration of Gas {(47-32)/3} is 5.6 times

- Depleting acceleration of Oil {(16-10)/3} is 2 times

Table 5: Annual coal production in 2008
(Herman D. Ibrahim, 2008)

Energy Resources	Proven Reserve	World Percentage	Annual Production	Ratio Reserve To Production [Year]
Coal	5000 mTons	0,55%	170 mTons	29
Natural Gas	2300 mTOE	1,39%	72 mTOE	32
Oil	700 mTons	0,43%	68 mTons	10

DOT (2008b) gave a bigger data of coal production based on coal selling income received by Financial Department.

- income from coal selling in 2007 was 5.19 *1012 IDR, the coal production was 217 million tons;

- income from coal selling in 2008 was 6.84 *1012 IDR, the coal production was 232 million tons.

- in 2009, the income was projected to be 10.20 *1012 IDR, the coal production was projected to be 261 million tons. (Doty Damayanti, 2009). However, only 30 million tons has been realized until the end of April 2009

The use of low rank coal in the CFPP (or PLTU in Indonesian language) that designed for sub-bituminous coal causes many problems. This case happened in PLTU Suralaya that was designed for 5500 kcal/kg coal but then the intake is changed to a lower rank coal of 5100 kcal/kg. Further change was to use coal of 4700 kcal/kg (70%) that mixed with a lower rank coal 30%.

The owners of coal mining are private companies and they prefer to export. This cause PT.PLN has difficulties as their buying ability lower than the international buyers.

In the case of PLTU Tanjung Jati B at Cilacap that run out of fuel intake (sub-bituminous coal of 5900 kcal/kg), PT.PLN stop its operation and use diesel power plant as back up (Doty Damayanti, 2008).

In 2025, the use of coal is projected to be 405 million tons annually, but these depleting acceleration facts put the energy security in Indonesia in a risk.

Therefore clearing alarm should be ring loudly and repeat.

Need to stop coal export especially sub-bituminous and bituminous coal that is needed to run the existing CFPPs and the emerging CFPPs that has been planned and constructed. Coal inside the earth is limited. When the greedy attitudes win over the willing to support the nation then the ability to fulfill the domestic need becomes weak.

1st Stage Accelerated Electricity Development

Knowing this coal resources limitation and had experiences on the risks of using low rank coal as intake for PLTU that designed for sub-bituminous coal, the 1st stage accelerated electricity development (AED) program of 10.000 MW was derived. Several PLTUs that use low rank coal of 4200 cal/kg will be constructed (DOT, 2006). Funding need for the 1st AED program is about 5.8 $*10^9$ US$ and 32.3 $*10^{12}$ IDR (OIN and DOT, 2009a). Currency exchange on April 24, 2009 was 11,542 IDR per USD.

2.3.1 Java island

Day and DOT, 2009; OIN and DOT, 2009a; 2009b; 2009c quoted PT PLN data about the construction planning of several PLTU's in Java island, those are:

1. PLTU Labuhan (2x300 MW) is planned to finish by June 2009, but it is delayed until September 2009

2. PLTU Indramayu (3x330 MW), to finish by September 2009, but it is delayed until January 2010.

3. PLTU Rembang (2x315 MW) by September 2009, but it is delayed until January 2010.

4. PLTU Teluk Naga (3x315 MW) by February 2010, but it is delayed until April 2010.

5. PLTU New Pelabuhan Ratu (3x350 MW) that need 481 *106 US$ is planned to finish by February 2010. the construction was started in September2007.

6. PLTU Pacitan (2x315 MW), to finish by February 2010,

7. PLTU New Suralaya (1x 625 MW) by March 2010, will be exerted to finished earlier, in December 2009

8. PLTU New Paiton (1x 660 MW) by March 2010. It is exerted to finish earlier, in December 2009

9. PLTU Tanjung Awar Awar (2x350 MW), it is planned to finish by October 2010,

10. PLTU Adipala (1x 660 MW) by 2012.

In this development, Indonesia cooperates with People Republic of China through Bank of China and China EXIM Bank to solve the funding limitation that causes delay.

The production cost of PLTU by the end of 2008 is 1317 IDR/kW. This is more expensive than the selling price that is only 630 IDR/kW (OIN and DOT, 2009b). This means the electricity development will need subsidy continuously. The projected subsidy for electricity in the year 2009 was 42.5 1012 IDR, but the real subsidy need in the two semester of 2009 has raised to be 48.2 1012 IDR (OIN / MAS, 2009)

2.3.2 Out side Java

Nurseffi (2009) wrote a brief report on PLTU development outside Java and the cost needed, as a part of the 1st stage AED program, those are:

11. PLTU Meulaboh, Nangro Aceh Darusalam,

- package 1: 614.33 *109 IDR

12. PLTU (4 units) Bangka Belitung:

- package 1: 142.188 *109 IDR
- package 2: 286.84 *109 IDR

13. PLTU Kalteng (Central Kalimantan): 744.68*109 IDR

14. PLTU (2 units) Kalbar (West Kalimantan):

- package 1: 172.03 *109 IDR
- package 2: 369.28 *109 IDR

15. PLTU (2 units) Lombok, NTB (West Nusa Tenggara),

- package 2: 285.49 *109 IDR

16. PLTU Bima, NTB:

- package 1: 120.49 *109 IDR
- package 2: 101.17 *109 IDR

17. PLTU (2 units) Amurang, Sulut (North Sulawesi)

- package 2: 324.7 *109 IDR

18. PLTU Gorontalo: package 2: 310.128 *109 IDR

19. PLTU Kendari, Sulteng (South East Sulawesi),

- package 2: 123.3 *109 IDR

20. PLTU (2 units) Kupang, NTT (East Nusa Tenggara):

- package 1: 134.53 *109 IDR
- package 2: 280.98 *109 IDR

21. PLTU Ende, NTT, package 2: 94.7 *109 IDR

22. PLTU Tidore, Malut (North Maluku):

- package 1: 100.35 *109 IDR
- package 2: 118.4 *109 IDR

The Director of PT.PLN has signed a 10-years credit agreement with 23 Regional Development Banks (BPD) of the regions where the PLTU will be installed. Government gives a guarantee for this financial agreement. Total allocated funding is 4.732 *1012 IDR This approach is exerted by PT PLN in order to reduce the dependency of oil and to reduce oil subsidy. This is a new investment alternative to support the local development that can give many advantages to the society directly.

PT. PLN needs 31.9 106 tons coal per years for the 35 PLTU's constructed in the 1st stage AED program. In order to secure operation of these PLTUs, PT. PLN arranged the 1st and the 2nd auctions for coal provisions, 48% of the coal needed have been contracted and 48% will be contracted consecutively. Meanwhile, PT PLN has only 15% coal stock to back up the CFPP's operation.

The 3rd auctions is directed to provide 3.6 106 tons coal per year for PLTUs that are scheduled to operate by 2010, those are: PLTU Teluk Naga, PLTU Pelabuhan Ratu, PLTU Nagan Raya, PLTU Bangka, PLTU Belitung, PLTU Bengkalis, PLTU Tarahan Baru, PLTU Asam-asam, PLTU

Pangkalan Susu, PLTU Selat Panjang and PLTU Tanjung Balai Karimun. A new criterium is derived for the 3rd auctions: the coal provider should had experiences to transport 200,000 tons coal per year within Indonesia archipelago and have proven coal mining reserve as big as 20 106 tons (DOT, 2009d).

It is likely that this criterium seems difficult to be achieved if the description in section 2.2 is considered.

Climate Change has raised the natural disasters that danger the distribution operation throughout Indonesia archipelago. Increase the risk of the ships that brought fossil fuel to sink.

The number of ships to keep continuous coal supply for the whole archipelago is limited. When these facts are considered then PLTUs for West Nusa Tenggara, East Nusa Tenggara, North Sulawesi, South East Sulawesi, North Maluku seem not appropriate. Need to derive a strategy based on the past experience, current situation and outlining the path forward for sustainable energy development. Electricity development should be derived based on the existing local resources to make the electricity development cost effective in the long run.

When it is not late to change, it is suggested to reconsider the policy on electricity development, replace inappropriate technology implementation with renewable energy (RE) resources that available locally, such as geothermal, wind, hydro, solar and biofuel.

Simultaneously reconsider the electricity pricing versus geographical condition and the limited transport.

3. GEOTHERMAL POWER PLANT (GPP) FOR ELECTRICITY GENERATION

The clearing alarm for coal depleting and the fact that Indonesia endowed with abundant geothermal energy drive the government to derive the 2nd stage accelerated electricity development (AED) program of 10.000 MW. Give a priority for geothermal, hydro and other RE resources until 70% of the total capacity (Antara, 2008).

In 2003, the total RE contribution until 2020 was projected as big as (6.736/73.56=) 9.17%. That consist of geothermal power plant of 4915 MW or (4915/6737=) 70% of the total RE implementation plan, see **Table 6**. If Indonesian Government will install 2 unit of nuclear power plant (PLTN) of 2 GW by the year 2016-17 and another 2 GW by 2023-24, the target of new and renewable energy implementation by 2025 will be (10.746/73.56=) 14.7%. The clean coal technology is expected to contribute another 2%. However, the local financial and technology capability in the country might shrink this development target.

Table 6: The Projection of Installed Electricity Power Plant in the year 2020 that applying Renewable Energy Resources. (BPPT, 2003).

Resources	Potential		Installed Capacity per 1996	Installed Capacity per 2003	Installed Capacity projected for 2020
	thousand BOE	MW	MW	MW	MW
Geothermal	105610,68	19658	309,5	1654,19	4915
Microhydro	2464,59	458,75	20,85	59,5	153,38
Solar	2155.6 10^9	1203 10^5	0,88 (3,09)	118,95	405,68
Wind	16630.5 10^3	9286.61	0,38	1,55	4,38
Biomass	267585,54	49807,43	177,85	259,51	457,85
Biogas	127,47	684,83	0,06		
Gambut	16,88 10^5			233,33	800
Ocean thermal	1289376,49	240000			
Total	**2155.64 10^9**	**1 204 10^5**	**509.52 (511.73)**	**2327,03**	**6736,29**
National Energy Need			**99745,81**	**163079,67**	**585535,8**
Sharing of RE (%)			0,51	1,43	1,15

Note: In Indonesian language BOE is SBM that stand for Setara Barel Minyak.

3.1 Geothermal Resources

Among the renewable resources, geothermal is a rational choice for a large-scale electricity generation. No fuel is burned to heat water into steam. Geothermal is a local resource that is not depending on the climate and can not be exported makes it as local energy that good for local development. However, until 2004, Pertamina had installed 827 MW GPP only, see Table 7.

The old projection in 2003 as shown in Table 6 could not be reach. By that time the willing to apply RE technology competed with the easier fossil fuel power plant technology. The other constraints for GPP development are: a high investment capital, non-total project system that raises tax, floating aspect that raise the risk for investor. The existing mind set: "the electricity price of GPP is less competitive compare to those of fossil fuel power plant that receive subsidy". These are the challenges that should be faced.

As the time running and the field data give a possibility to do an evaluation. That mind set shifted. The electricity price of GPP based on the field data is further described in section 3.5.

Some regulations related to geothermal development were Keppres RI No.22 /1981; Keppres RI No.45/ 1991; Keppres RI No.49 /1991 and Keppres RI No.76 /2000. The latest regulations to accelerate geothermal implementation is UU Panasbumi No 27/2003. The installed capacity is progressing to be 1052 MW in 2008 and increase further to be 1169 MW in 2009.

Table 7: Technology used for Geothermal Power Plant in Indonesia (Operasi PT PGE, 2009)

Location	2004	Technology used
	MW	Dry steam plant / Flash plant / Binary plant
Sibayak	2	Back Pressure
SRL		-
Lumubalai		-
Ulubelu		-
Salak	345	Flash plant
Darajat	150	Dry steam
Wayang Windu	110	Dry steam
Patuha		-
Kamojang	140	Dry steam
Karaha		-
Dieng	60	Flash plant
Bedugul		-
Lahendong	20	Separate Steam Cycle
TOTAL	827	

API (2004) give data on geothermal resources by islands.

- Sumatera: resources 13.820 MWe, used 2 MWe

- Sulawesi: resources 1.946 MWe, used 20 MWe

- Jawa – Bali: resources 9.706 MWe, used 785 MWe

- Other islands: resources 3.766 MWe, used 20 Mwe

Bambang Setiawan (2009) renewed the data. The geothermal potential is estimated as 27,510 MWe: reserve 14,172 MWe; proven 2,287 MWe; probable 1,050 MWe; and possible 10,835 MWe , see Figure 4.

Preliminary survey found that Sumatera has 84 points of geothermal resources, Java 76 points, Sulawesi 51 points, Nusa Tenggara 21 points, Papua 3 points, Maluku 15 points and Kalimantan 6 points. Only 78 points of these 256 points of geothermal resources have been explored. Only 7 points has been used for electricity generation. Most of geothermal sources in Indonesia have temperature higher than 225 C and suitable for electricity generation.

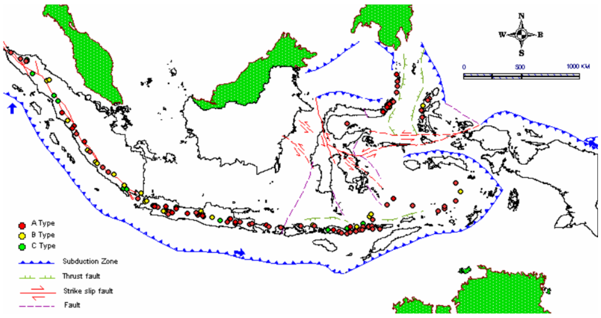

Figure 4: Distribution of active volcanoes (red) and tectonic in Indonesia archipelago.
Blue line is a cross section of Indian Plate, Australian Plate, Philipine Plate and Pacific Plate

Proven geothermal resources in 13 locations are given in Table 8. The feasibility studies of 8 points have been accomplished for further development.

Table 8: Status geothermal resources at 13 locations (Dirut PGE, 2009)

PT PERTAMINA GEOTHERMAL ENERGY - OWN OPERATION						
NO.	AREA	POTENSI CADANGAN (MW)				
		PROVEN				
		2004	2005	2006	2007	2008
1	KAMOJANG	200	200	230	300	300
2	LAHENDONG	80	80	80	80	80
3	SIBAYAK	40	40	40	40	40
4	ULUBELU	-	-	-	140	200
5	LUMUT BALAI	-	-	-	-	200
6	TOMPASO	-	-	-	-	-
7	KARAHA BODAS	30	30	30	30	30
8	HULULAIS	-	-	-	-	-
9	SUNGAI PENUH	-	-	-	-	-
10	KOTAMOBAGO	-	-	-	-	-
	TOTAL	350	350	380	590	850
PT PERTAMINA GEOTHERMAL ENERGY - KOB						
1	GUNUNG SALAK	380	380	380	380	380
2	DARAJAT	260	260	260	260	260
3	WAYANG WINDU	220	220	220	236	231
	GRAND TOTAL	**1210**	**1210**	**1240**	**1466**	**1721**

Blue Print PEN 2005-2025 (ESDM, 2005) shows the road map of geothermal development until 2025 that reach 9500 MW. This is equal to the saving of 167.5 million barrel of oil per year. To achieved this target, more geothermal power plants will be installed with yearly planning:

- 70 MW in 2010 (Java 5, NTB 5 and Sumatera 60 MW;

- 158 MW in 2011 (NTT 8, Sulawesi 45, Sumatera 105 MW);

- 1028 MW in 2012 (Bali 10, Java 340, Maluku 20, NTT 3, Sulawesi 70 and Sumatera 585 MW);

- 740 MW in 2013 (Jawa 555, NTB 20, Sumatera 165 MW);

- 2620 MW in 2014 (Jawa 1185, Maluku 20, NTB 10, NTT 30, Sulawesi 80 and Sumatera 1295 MW).

Of these planning, Pertamina will contribute to install about 1342 MW GPP by 2014 (GRE, 2009).

3.2 Geothermal Technology

Based on the resources condition, there are 3 types of GPP.

- Dry steam plant take a good quality steam out (> 200C) of fractures in the ground & use it directly to drive a turbin. The GPP in Darajat, Wajang Windu and Kamojang uses this principle, see Table 7.

- Flash plant take hot water over 200°C out of the ground, water boils as it rises to the earth surface then separates the steam phase in the steam/water separator. The steam is then flowed through a turbine, see Figure 5. GPP in Salak and GPP in Dieng use this principle.

- The binary system can operate with geothermal fluid having temperature between 107°C - 182°C. It requires the use of a closed circuit heat exchanger to heat an organic fluid such as iso-butane that vaporizes at much lower temperature. The vapor is then used to turn the turbine to spin a generator to produce electricity. The condensed steam and remaining geothermal fluid from this plant are injected back into the earth. GPP in Lahendong uses this principle. Another name of Binary cycle is Separate Steam Cycle.

3.3 Geothermal Power Plant (GPP) Progress

3.3.1 Lahendong in North Sulawesi; Ulubelu in Lampung and Lumut Balai in South Sumatera province

There are 3 GPP in Lahendong mountainous area. The first having capacity 20MW was start operating in August 2001. The second having capacity 20MW was start operating in June 2007 and the third is under test since April 2009. The fourth is expected to operate by 2011. The cost for the third Lahendong GPP is 36 million US$ from the loan of JBIC (Japan Bank for International Cooperation). PT. Pertamina earns 173 IDR per kWh.

Eight well will be drilled to support the third Lahendong GPP (DOT, 2009a).

The discussed loan of 500 *1016 US$ from the World Bank is expected can be used by January 2010. This funding will be used to install Lahendong unit V in Tomohon and Lahendong unit VI in Tompasa. Geothermal sources in Tomohon and Tompasa have a potential to generate electricity of 120 MW (GRE, 2009)

This loan will also be used to explore geothermal resources at Ulubelu unit III and unit IV in Lampung province and also, Lumut Balai unit I, II, III and IV in South Sumatera province, each having capacity of 10 MW

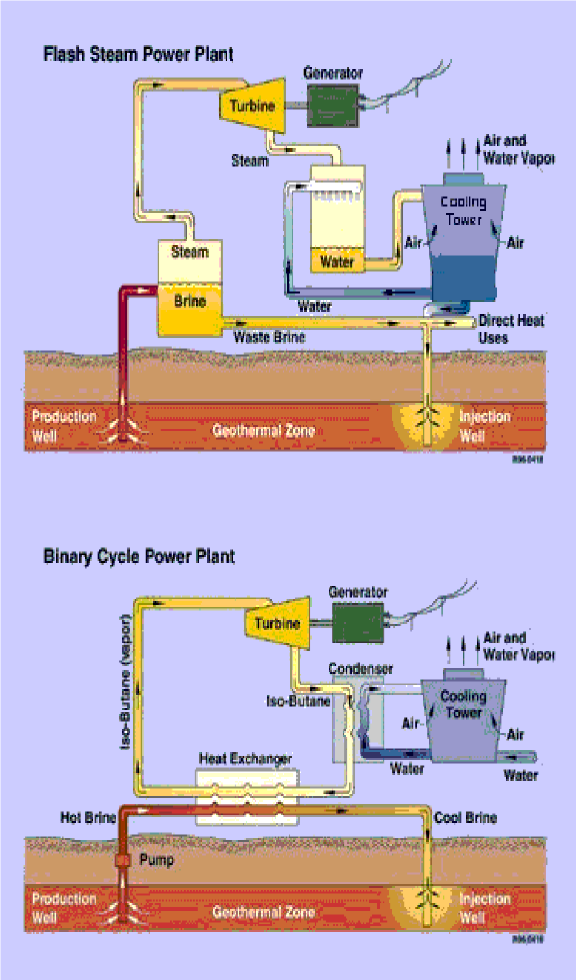

Figure 5: Flash Steam GPP and Binary Cycle GPP (INNEL, 2003)

3.3.2 Salak Mountain in West Java Province

In Salak Mountain, Chevron Geothermal Salak (CGS) has 92 wells that have been exploited: 61 production, 19 re-injection, 7 monitoring, 5 Plug &Abandon, see Figure 6.

Salak Geothermal Power Plant is the biggest in Indonesia, the capacity is 3,000 GWh/year. Total electric generation per Desember 2008 was 32,730 GWh that equivalent to 60.7 MMBOE (PMK-PGE, 2009a). Figure 7 show the actual and the planned production of Salak GPP in 2008. The differences of actual and planning are caused by shutdown and overhaul for turbine inspection, changing gas SF-6 at 150 kV substation, turbine vibrations and problem in the relay transformer protection.

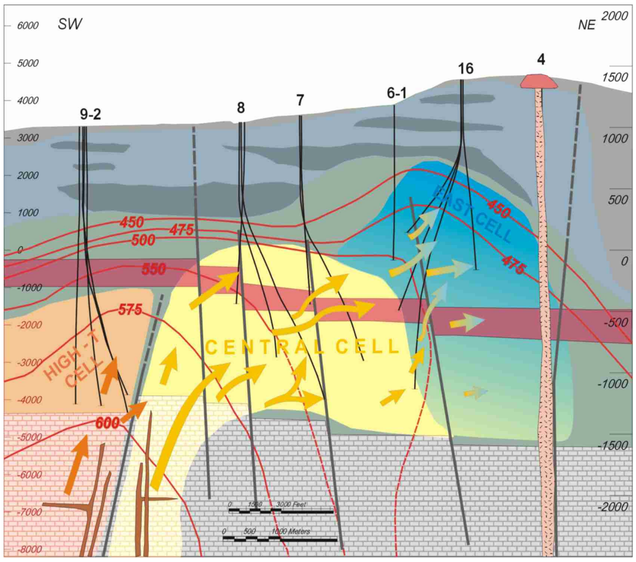

Figure 6: Geothermal sources in Salak mountain.

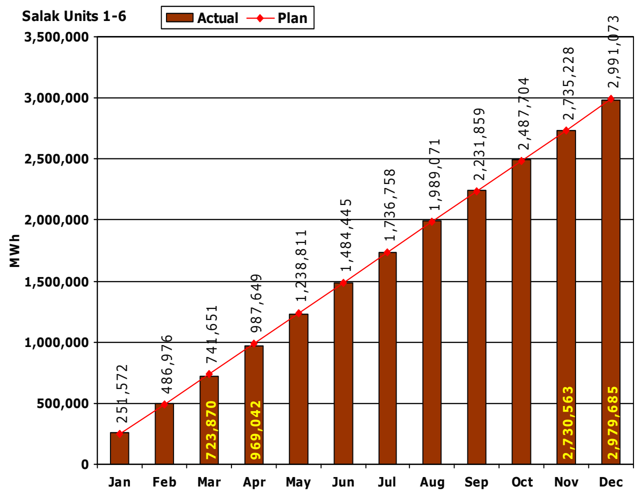

Figure 7: CGS (Chevron Geothermal Salak) electricity net production (MWh) in 2008 (PMK-PGE, 2009a).

The actual and planning differences are caused by shutdown and overhaul for turbine inspection, changing gas SF-6 at 150 kV substation, turbine vibrations and problem in the relay transformer protection.

CGS considers some steps to optimize resources and funding, such as:

- Manage the steam supply field section including the infill wells, upgrade and install new facilities.

- Manage the project implementation in the highest value to fulfill the production target

- Derive an efficient of injection program to avoid production loss related to thermal breakthrough or limited injection capacity.

- Evaluate the exploitation strategy to raise the energy recovery efficiency.

- Evaluate the possibility to expand the production capacity

For example, to manage the steam supply field section can be seen from the exerted effort to upgrade the well AWI 3-5. It was spud-in on May 7, 2007 and release on May 22, 2007. Its measurement depth (MD) is 5060 meters. The true vertical depth (TVD) is 4415 meters. Its reservoir is 3493

MD shows temperature of 249 C. This well is active to support the electricity production of CGS Unit 4, 5, 6 that is projected will give annual electricity of 10.23 MWe.

3.3.3 Darajat Mountain in West Java Province

In Darajat mountain, Chevron Geothermal Indonesia (CGI) has 37 wells that have been exploited: 23 production, 4 re-injection, 5 monitoring, 5 Plug & Abandon.

Darajat GPP Unit I having capacity of 55 MW that was operated since 1994. Unit II: 94 MW that was operated since 2000, Unit III: 110MW that was operated since 2007. Joint operation contract was signed in 1984, time of contract 30 years with additional elongation for 10 years. Total electric generation per December 2008 was 14,111 GWh that equivalent to 26.2 MMBOE (PMK-PGE, 2009b). Figure 8 shows the actual and the planned production of Darajat GPP in 2008. The development plant for Darajat GPP until 2013 is shown in Table 9.

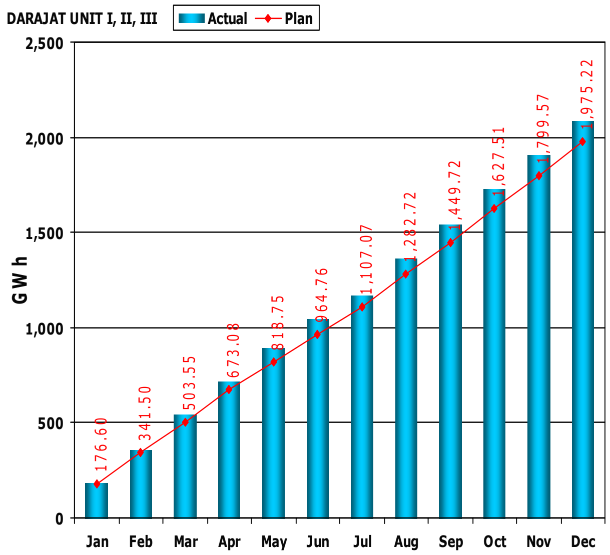

Figure 8: CGI electricity net production (MWh) of Darajat GPP in 2008 (PMK-PGE, 2009b).

Table 9: The development plant Darajat GPP

CGI DEVELOPMENT PLAN - 2009 UP TO 2013	2009	2010	2011	2012	2013
NET PRODUCTION: MWh					
- Unit I	423,989	421,601	390,548	422,472	421,3
- Unit II	710,370	768,845	764,513	708,920	777,0
- Unit III	894,643	828,749	907,891	899,813	816,2
TOTAL	2,029,002	2,019,194	2,062,952	2,031,205	2,014,7
REVENUE: $000					
- Unit I	17,247	17,934	18,170	19,076	19,6
- Unit II	42,879	48,455	50,110	47,490	53,6
- Unit III	57,394	55,439	63,245	64,093	59,8
TOTAL	117,521	121,828	131,526	130,660	133,1
EXPENSE	75,486	118,771	80,838	67,129	150,5
CAPITAL	13,449	8,380	5,254	10,578	6,5

3.4. Steam and Electricity Production

Before GPP produces electricity, need to explore and to predict the prospect, then to drill the well until the subsurface reservoir to get the geothermal fluids ("gas") and to convert it into electricity. Then, sell it in a competitive price. PMK-PGE (2009c) gives information on the steam and electricity productions of four GPPs until January 2, 2009, see **Table 10** and **Figure 9.**

The realization of steam and electricity productions of three geothermal resources is higher than that of the planned production.

Table 10: The percentage of the steam and electricity production of four geothermal power plants until January 2, 2009.

Sites	Steam production (SP) planning	S P Realization until Jan.2, 2009	%	Electricity production (EP) planning	EP Realization until Jan.2, 2009	%
Wayang Windu (MNL)	6,826.0	7,241.6	106.1	941.6	1,029.9	109.4
Salak (CGS)	23,352.2	26,413.5	113.1	2,893.9	3,229.9	111.6
Darajat (CGI)	12,385.2	14,658.2	118.4	1,971.3	2,277.9	115.6
Dieng (GDE)	2,034.6	1,644.2	80.8	257.0	235.2	91.5

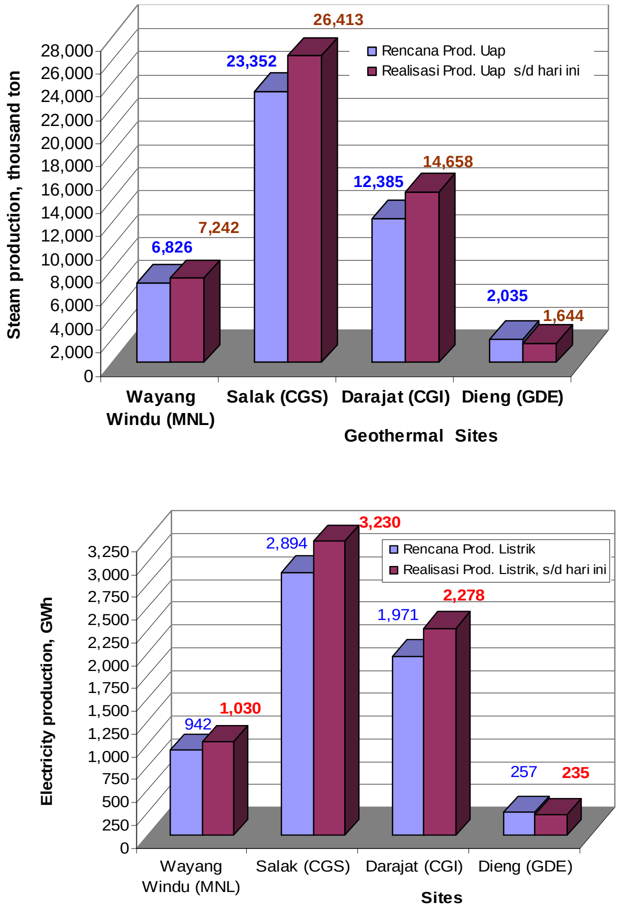

Figure 9: Steam and electricity production of four geothermal power plant (GPP) in Java island until January 2, 2009 (PMK-PGE, 2009c)**.** The planned production: blue, the realization: purple.

3.5 Electricity Price from GPP.

The price of electricity from Dieng GPP and from MNL Wayang windhu GPP in the year 2008 is given in Figure 10. The price of steam from CGS 1,2,3 of Salak GPP, the price of electricity from CGS 4,5,6 of Salak GPP, the price of steam from CGI 1, the price of electricity from CGI 2 and CGI 3 Darajat GPP are also shown.

The real price of electricity from Dieng GPP is flate at about 5 cents/kWh. The price of electricity from Wayang Windhu GPP reaches 6 cents/kWh and then decline to 5.55 cents/kWh. The real price of electricity from Darajat GPP reaches 6 – 6.4 cents/kWh by the end of 2008. The price of electricity from Salak GPP reaches 7 cents /kWh.

The variation in cost is depending on the infrastructure conditions, the resource conditions, the technology selection to match the resource, the existing infrastructure, the distance to the settlements that derive the grid connection and the government regulation.

Agusman Effendi (2004) gives information that the economical electricity price is 7 cents US$ / kWh.

The electricity price from Wayang windhu GPP is cheaper than the electricity price from coal fired power plant described in section 2.2, that is 6 cents US$ per kWh.

This shows that the electricity from GPP is able to compete with that from coal fired power plant.

GRE (2009) quotes Abadi Purnomo statement: ”The ideal electricity price of GPP is 11 cents US$ per kWh. Meanwhile, PGE sell the electricity to PT PLN at 4.45 cents US$ per kWh. PGE is expecting PT.PLN to buy their electricity at 8 cents US$ per kWh”.

In order to give a rough picture about the cost to construct GPP, the Darajat GPP is evaluated for this purpose. The overall cost in 2007 was 81,353,000 US$ that consist of:

- steam field facilities tooks 17% and infrastructure 1%

- direct operation cost 51% and field office cost 6%

- administration (office, C&S Fees and others) 25%

Revenue from the steam and electricity generation was 81,350,000 US$ (PMK-PGE, 2009b). This budget covers Actual Operational Excellence Cost, those are:

- Safety Expenses US$ 233,986 of the planned budget US$ 341,834

- Environmental Expenses US$ 48,830 of the planned budget US$ 162,321

- Industrial Hygiene Expenses US$ 10,381 of the planned budget US$ 146,222

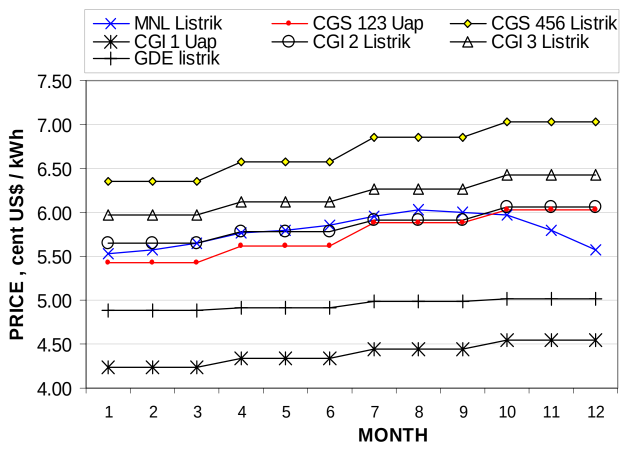

Figure 10: The electricity price of four GPP in Java island (PMK-PGE, 2009c).

Note: MNL is stand for Magna Nusantara Limited, CGS is Chevron Geothermal Salak, CGI is Chevron Geothermal Indonesia. GDE is Geothermal Dieng. Uap is steam, Listrik is electricity

3.6. Environmental Advantage of GPP

A GPP of 1000 MWe having life time of 30 years will save 465 million barrel oil. This equivalent has counted the degradation of the plant (API, 2004). CO_2 emission per kWh of various power plants is given in **Figure 11.** The newest generation GPP emits only 0.3 lb of CO_2 per MWh of electricity generated. This is 1000 times lower than that release from a plant using natural gas (methane), or more lower than that released from a coal fired power plant. INNEL (2007) state that the average sulfur-emissions rates from GPP’s is only a few percent of those from fossil fuel power plant. Its nitrogen oxide emissions are much lower than that from fossil fuel power plants. Nitrogen oxide combine with hydrocarbon vapor in the atmosphere will produce a gas that causes adverse health effects and crop losses as well as smog.

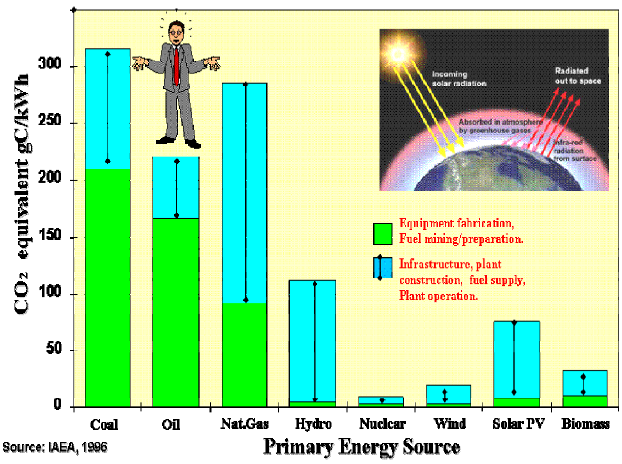

Figure 11: CO_2 emission/kWh of various power plants

4. COMMUNITY SOCIAL RESPONSIBILITY (CSR) PROGRAM

4.1. Bedugul, Bali

n 2005, Java-Bali electricity network provided 535.12 MW for Bali island. The electricity demand in Bali island was projected would increase to be 700 MW in 2007 and for security, the electricity development planning suggested expansion of 60 MW annually. There is a geothermal resource at Bedugul mountain that lie in the border between Buleleng regency and Tabanan regency. Bedugul is one of the famous tourist objects. Three wells had been explored in 1998 (Ayu Sulistyowati, 2005). However the local do not want GPP. The locals live surround Bedugul geothermal resources believe that mountain is a holy area and therefore they reject the proposal of GPP implementation. Also, the disaster of mud explosion in Porong, East Java frightens the Baliness.

Previously, it was thought Bali island need to own GPP and the electricity development planning is:

- Bedugul GPP stage 1 (10 MW) would finish in 2007

- Bedugul GPP stage 2 (55 MW) would finish in 2008

But these GPP constructions are delayed and the next stage becomes uncertain.

- Bedugul GPP stage 3 (55 MW) in 2009

- Bedugul GPP stage 4 (200 MW) in 2010

In 2005, PLTG Pemaron (2x40MW) construction in the famous Lovina beach in the north was opposed by the locals.

These cases indicate the only possibility of electricity development for Bali island is a diesel power plant.

4.2 A sample of CSR from Darajat GPP, West Java

CGI, the management of GPP in Darajat mountainous area, has CSR program below.

- Education and training 20,126 US$ (only 25% was used)

- Health and service 74,772 US$ (all allocated budget was used)

- Business development (coffee plantation, cattle, picohydro and automotive) 98,556 US$ (110%)

- Environment and cultural activities (tree planting and sport competition) 5,697 US$ (only 35% was used)

- Infrastructure development (school facility and street lighting) 169,809 US$ (185%)

- Donation 21,739 US$ (all allocated budget was used)

- Crash program 47,002 US$, all allocated budget was used

Some of these CSR program have been executed with budget exceeding the allocated budget..

The allocated budget for education and culture is small but only 25% was used. The education activities do not deal with geothermal.

Stakeholders involve in Darajat GPP are:

- PT. PERTAMINA

- PT. PLN (Central Office in Jakarta, PTIP & P3B)

- Ditjen Minerba Pabum in Department of Energy and Mineral Resources (or ESDM).

- Garut and Bandung Regencies

- Three Sub-Regencies or District

- Twenty Kampongs

- Papandayan Nature Reserve

- State Owned Forest Company

4.3 Institutes to be Contacted Related to GPP Implementation Project

Geothermal developer should interact with:

- Geological Agency for Preliminary Survey& Exploration

- PEMDA (Local Government) for Permission and to check the Local Development Plan and Monitoring

- DEPNAKER for Permission of Foreign Experts and workers

- Ditjen Minerba Pabum for Permission of GPP Project Development Plan and Monitoring

- DJLPE (Directorate General for Electricity and Energy Development) for advice related to the national electricity planning. Note: - DJLPE is under Department of Energy and Mineral Resources.

- DEPKEU (Financial Department)

- Ditjen Bea Cukai for taxes

5. CONCLUDING REMARKS

Energy can contribute to three pillars of sustainable development: economic, social and environment. But the local and national context (political, social, economic and culture) should be taken into account for all energy interventions since one solution does not fit all.

- More attention needs to be paid to “social issues related to energy use” than in the past to get a better understanding and motivation necessary for sustainable conservation of natural resources.

- Need to identify an effective approach for capacity building, to arrange a practical training to exchange valuable field experiences and share recent development and results, to arrange community educations to the people lives around geothermal resources since the beginning to avoid friction that might rise later and to work and cooperate with informal leaders in the region.

- Providing a questionnaire that makes a wider public can express their opinions, their expectations and checking point of problems and suggestions to make the situation easier to draw a solution while collecting data based.

The geothermal program /research should covers activities:

- to focus on characterization and management of geothermal reservoirs and exploration programs,

- to manage and to perform research and development activities in the heat cycle of geothermal systems

- to run activities that targeting to reduce cost and to increasing deployment of geothermal resources

- to ensure the availability of successful geothermal technologies implementation for electricity generation for national use,

RE proponents in various institutes could help to reach the national target of implementation, to improve the existing regulation and to initiate the international cooperation, while those in many industries could help to produce the components and to improve the quality. On the way forward facing 2050, all developed countries should arrange the technology transfer program in an appropriate cost.. For this to happen, need to develop a new mental model, needs to influence vision, influence measure, influence deed to shape a positive thought to challenge the energy problems across the globe to aim global survival.

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