GEOTHERMAL RESOURCES DEVELOPMENT IN INDONESIA

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ABSTRACT

Indonesia is a country that has a lot of geothermal resources. They are mainly distributed along the Indonesia Volcanic Belt, while others are also associated with non-volcanic environment (sedimentary or tectonic). As of December 2012, has been identified 299 geothermal locations with geothermal energy potential total of about 28,635 MWe consisting of 7,247 MWe Speculative Resources, 4,886 MWe Hypothetical Resources, 13,391 MWe Possible Reserves, 823 MWe Probable Reserves and 2,288 MWe of Proven Reserve.

Currently, the total of issued geothermal working areas (WKP) are 58 WKP consisting of 19 existing WKP (pre-the Law No. 27/2003) with its total geothermal energy potential about 10,869 MWe and 39 new WKP (based on the law No. 27/2003) with total geothermal energy potential about 4,758 MWe.

Indonesia has set a long-term policy for the development of geothermal energy, as embodied in the Geothermal Development Road Map 2004-2025. Indonesia has a target to develop geothermal energy around five percent of our national energy needs, or about 9,500 MWe generated by geothermal energy in 2025. Currently, Indonesia's geothermal energy produces only about 1,341 MWe, or less than 5% of the total resource potential of geothermal energy in Indonesia. Now, there are nine power plants in Indonesia that produce electricity from geothermal energy consists of 377 MWe in G. Salak, 200 MWe in Kamojang, 270 MWe in Darajat, 227 MWe in Wayang Windu, 60 MWe in Dieng, 80 in Lahendong, 12 MWe in Sibayak, 110 MWe in Ulubelu and 5 MWe in Ulumbu.

I. INTRODUCTION

Indonesia has abundant geothermal resources that identified until December 2012 are distributed on 299 locations with the total energy potential about 28,635 MWe. Geothermal locations in Indonesia mainly distributed along the Indonesian volcanic belt from Sumatera, Java, Bali, East Nusa Tenggara, Banda islands, to North Sulawesi. However, some are associated with non-volcanic environments

that mostly distributed in Bangka-Belitung, Sulawesi, Kalimantan and Papua islands.

Geothermal energy is known as sustainable energy and green energy, therefore its development appropriate with policy of Indonesia to reduce global emission. The factors can make geothermal energy to be priority for geothermal development in Indonesia. But in reality the development of geothermal energy has some barriers, until the current installed capacity of geothermal power plant (PLTP) has only reached 1,341 MWe.

II. TECTONIC SETTING OF INDONESIA

The position of the Indonesian archipelago is situated at the confluence of three major plates (Indian Australia - Aurasia - Pasifik) makes it have a complex tectonic structure, (figure 1). Subduction inter-continental and oceanic plates melting process produces a form of partial melting of magma in the mantle rocks and magma differentiation have on the way to the surface. The process forming pockets of magma which composition of acid to alkaline pathways that play a role in the formation of volcanoes known as the ring of fire.

The existence of a series of volcanoes in some parts of Indonesia and its tectonic activity as basis for the preparation of a conceptual model of the formation of geothermal system in Indonesia.

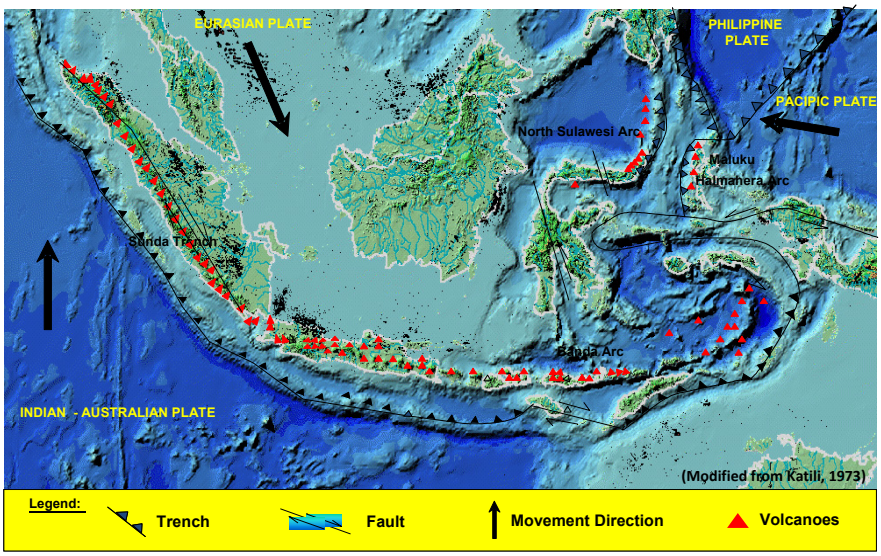

Figure 1. Tectonic setting of Indonesia, (Modified from Katili, 1973).

III. GEOTHERMAL SYSTEM IN INDONESIA

The picture below is a schematic cross-sectional model of a geothermal or hydrothermal system which is common along the Quaternary volcanic in Indonesia, such as Sumatera, Java, Bali, Nusa Tenggara, Maluku and North Sulawesi, (figure 2). While the next image is a schematic model of a geothermal system that occurred in the graben area with relatively flat topography, such as in parts of Sumatera are associated with the Great Sumatera Fault (GSF), (figure 3).

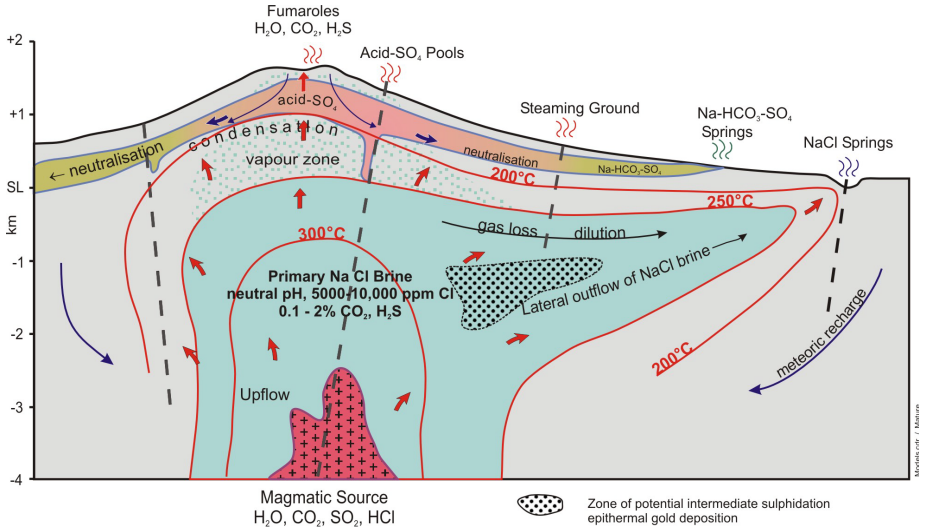

Figure 2. Cross-sectional schematic model of a geothermal or hydrothermal system which is common along the Quaternary volcanic.

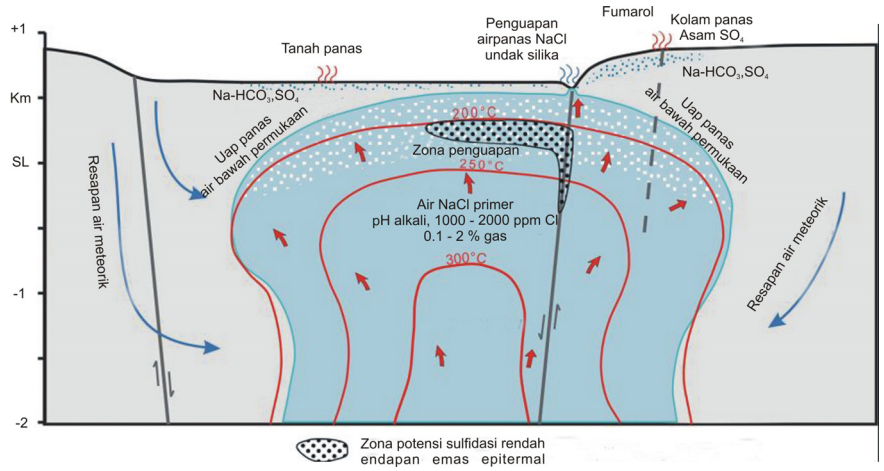

Figure 3. Sectional schematic of a geothermal or hydrothermal system on the graben (Lawless et al. 1995).

Based on the association of the order of geology, geothermal systems in Indonesia can be grouped into three (3) main types: volcanic, graben (volcano-tectonic) and non-volcanic. This type of grouping can be used as a guide in estimating the initial size of the potential energy in a geothermal system.

The following table 1. shows the relationship between a geothermal system to estimate the potential energy it contains, it appears that a great potential are generally owned by a complex and caldera volcanoes types.

Table 1. Relationship type geothermal systems in Indonesia and the estimated potential energy

Type		**Temperature**	**Potency of Energy**	**Example**
Volcanic	Strato volcano single	High ~ 250 °C	Intermediate 50 – 100 MW	Tampomas and Ungaran
	Complex volcano	High ~ 250 °C	Large > 100 MW	Salak, Wayang Windu and Lawu
	Caldera	High ~ 250 °C	Large > 100 MW	Kamojang, Drajat, Ulumbu and Sibayak
Volcano - tectonic	Graben	Intermediate to high 200 - ~ 250 °C	Intermediate to large 50 - > 100 MW	Sarula, Bonjol, Ranau lake and Sipaholon
Non-volcanic	Intrusive	Low to intermediate ~ 200 °C	Small to intermediate ~ 50 MW	South Sulawesi, Central Sulawesi, South East Sulawesi and Buru

IV. GEOTHERMAL ENERGY DEVELOPMENT IN INDONESIA

Distribution of geothermal resources in Indonesia is largely attended a line of volcanoes on the island of Sumatera, Java, Bali, Nusa Tenggara, Sulawesi, Maluku and North Maluku. Geothermal resources are also found in some non-volcanic regions such as Bangka-Belitung, Kalimantan, Sulawesi, Buru, Seram and Papua islands. Until the December 2012, has identified 299 geothermal areas

throughout Indonesia with a total potential area reached 28,635 MWe (figure 4). The amount is updated annually in line with the discovery of geothermal areas of new or activities in order to improve the status of a preliminary survey into a detailed survey to the drilling of exploration. The data is then used as initial data in determining the working area of geothermal (WKP).

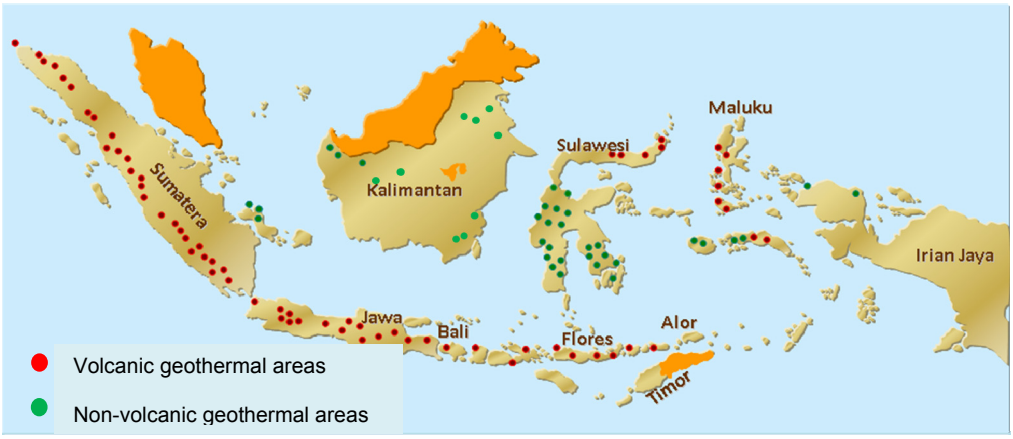

Figure 4. Distribution of geothermal areas in Indonesia,
(Geological Agency of Indonesia, As of December 2012).

Indonesia's geothermal energy potential will change from time to time based on the results of investigations carried out either by the government or other parties. Status of geothermal energy potential of Indonesia until December 2012 are presented in the table 2.

Table 2. Geothermal potential of Indonesian islands.

No	ISLAND	NUMBER OF LOCATION	POTENCY OF GEOTHERMAL ENERGY (MMe)					Total Potency	Installed (MWe)
			Resources		Reserves				
			Speculative (MWe)	Hyphotetic (MWe)	Possible (MWe)	Probable (MWe)	Proven (MWe)		
1	Sumatera	90	3089	2427	6867	15	380	12778	122
2	Jawa	71	1710	1826	3708	658	1815	9717	1134
3	Bali-Nusa Tenggara	28	360	417	1013	0	15	1805	5
4	Kalimantan	12	145	0	0	0	0	145	
5	Sulawesi	65	1323	119	1374	150	78	3044	80
6	Maluku	30	545	97	429	0	0	1071	
7	Papua	3	75	0	0	0	0	75	
	Total	299	7247	4886	13391	823	2288	28635	1,341
			12,133		16,502				
			28,635						

The Indonesian government expects the development of geothermal energy in Indonesia to run well so that geothermal can act as a pillar of national energy security. This is evident through the establishment of Presidential Regulation. 5 Year 2006 on National Energy Policy. The government targets in the regulation of geothermal energy contribution in 2025 amounted to 5% of national energy consumption, equivalent to 9500 MWe (figure 5).

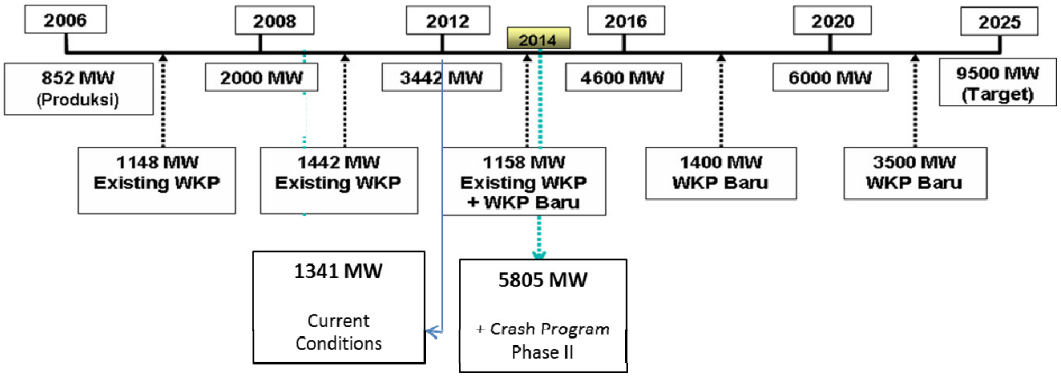

Figure 5. Road map of geothermal energy development in Indonesia 2006 – 2025.

In terms of stages of geothermal activity, the Act No. 27 stipulates that operational geothermal activity consists of five (5) phases, namely the Preliminary Survey, Exploration, Feasibility Study, Exploitation and Utilization. Stages of this activity is actually a means of supervisory control to the business actor. Preliminary Survey and Exploration is actually part of the exploration in a broad sense, but that the government should be given flexibility when drilling does not have the funds, then the beginning of exploration in the form of an integrated survey geo science surface of at least the government should do. To distinguish the Preliminary Survey, the stage of exploration operations is a geothermal drilling. In general the flow of geothermal exploitation activities are as shown below (figure 6).

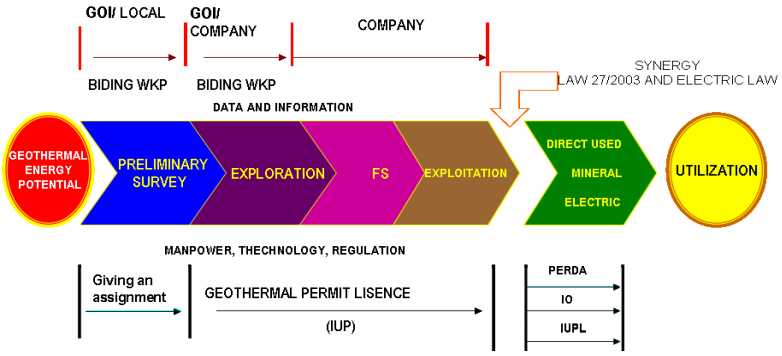

Figure 6. Chart of geothermal development based on Law No. 27/2003.

Efforts to reach the targets set out in the National Energy Policy and carry out this plan as stated in the road map is to encourage geothermal electricity production increases from existing and establish WKP new one to be developed. In pursuing the goal of adopting the new WKP, Government and / or Local Government conduct preliminary surveys or geothermal exploration in all parts of Indonesia. In accordance with their mandate, Geological Agency of Indonesia was appointed as the party that represents the government in the conduct of research, survey and exploration in an effort to improve the quality and quantity of data geothermal to reduce the risk of investment in the upstream sector. To improve the achievement of the implementation of geothermal preliminary surveys, the government may also assign the implementation of a preliminary survey of geothermal to other parties or who is often called the assignment of a preliminary survey of geothermal energy. Through this mechanism, the government commissioned a preliminary survey of geothermal energy to businesses that are interested in providing some privileges at the time the results of the preliminary survey assignment tendered.

Data and information geo science outcome of the investigation together with other data (especially land) will be used as the basis for the preparation and determination WKP. Procedures for determining the WKP is set up government through the Minister of Energy and Mineral Resources Regulation Number 11 of 2008 which requires that the data is already geo science can provide a preliminary description of geothermal systems. List of Indonesian geothermal WKP as of December 2012 are presented in appendix A (existing WKP) and appendix B (new WKP).

V. CRASH PROGRAME PHASE II

In addition to the preparation, adoption and new WKP auction, to accelerate the development of geothermal energy also accelerated program of 10,000 MW phase II project, which is based on Presidential Decree No. 4 of 2010. Presidential Regulation provides the basis for the accelerated development of power plants that use renewable energy, coal and gas until 2014. Geothermal energy as one of the categories included in the 3977 MW of renewable energy has a role in the acceleration power projects. Geothermal development plan to speed up the

construction of 10,000 MW power plant Phase II as set out in the Minister of Energy and Mineral Resources No. 01 of 2012 are presented in Appendix C.

VI. CONCLUSIONS

Some conclusions of this paper are given as follows:

- Indonesia has geothermal resources are large (28,635 MWe), but their utilization for electricity generation is still very small (1,341 MWe or 4.6 % from total resources).
- The Indonesian government policy in accelerating the development of geothermal energy other than through the preparation, adoption and new auctions WKP, also one of them with the Program to Accelerate Development of 10,000 MW Power Plant Phase II where geothermal energy can contribute about 4,925 MWe.

VII. ACKNOWLEDGEMENTS

The authors wish to express thanks to Geological Agency to publish this paper.

VIII. REFERENCES

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Appendix A: List of Existing WKP (Pre the Law No. 27/ 2003)

NO.	NAME OF WKP	GEOTHERMAL PERMIT HOLDERS (IUP)	FIELD	DEVELOPER/ COMPANY	POTENCY (MWe)	INSTALLED (MWe)
1	Sibayak-Sinabung	PT. PGE	Sibayak	PT. PGE	124	12
2	Cibeureum - Parabaktl (Gn. Salak)	PT. PGE	Gn. Salak	JOC - CGS, Ltd	952	377
3	Pengalengan (Wayang windu)	PT. PGE	Wayang Windu	JOC - Star Energy Geothermal Wayang Windu	400	227
			Patuha	PT. Geo Dipa Energi	706	-
4	Kamojang-Darajat	PT. PGE	Kamojang	PT. PGE	855	200
			Darajat	JOC - CGI, Ltd	610	270
5	Dieng	PT. PGE	Dieng	PT. Geo Dipa Energi	780	60
6	Lahendong-Tompaso	PT. PGE	Lahendong	PT. PGE	358	80
7	Sibual-Buali	PT. PGE	Sarulla	JOC – SOL	1146	-
8	Hululais - Tambang Sawah	PT. PGE	Hulu Lais	PT. PGE	873	-
9	Lumut Balai	PT. PGE	Lumut Balai	PT. PGE	1066	-
10	Sungaipenuh	PT. PGE	Sungai Penuh	PT. PGE	208	-
11	Ulubelu	PT. PGE	Ulubelu	PT. PGE	556	110
12	Karaha-Cakrabuana	PT. PGE	Karaha Bodas	PT. PGE	725	-
13	Buyan Bratan (Bedugul)	PT. PGE	Bedugul	JOC - Bali Energy, Ltd	276	-
14	Ulumbu	PT. PLN (Persero)	Ulumbu	PT. PLN (Persero)	199	5
15	Tulehu	PT. PLN (Persero)	Tulehu	PT. PLN (Persero)	100	-
16	Cibuni	KJK Teknosa	Cibuni	KJK Teknosa	140	-
17	Iyang-Argopuro	PT. PGE	Iyang Argopuro	PT. PGE	295	-
18	Kotamobagu	PT. PGE	Kotamobagu	PT. PGE	410	-
19	Clater	PT. Wahana Sembada Sakti	Clater	PT. Wahana Sembada Sakti	90	-
Total					**10,869**	**1,341**

Appendix B: List of New WKP (Based on the Law No. 27/ 2003)

No	Nama WKP	Provinsi	Potensi (MWe)	Pemegang IUP
1	Jaboi	NAD	50	Sabang Geothermal Energy
2	Seulawah Agam	NAD	180	
3	Sorik Marapi-Roburan-Sampuraga	Sumatera Utara	200	Sorik Marapi Geothermal Power
4	Sipoholon Ria	Sumatera Utara	75	
5	Simbolon-Samosir	Sumatera Utara	195	
6	Gunung Talang	Sumatera Barat	36	
7	Bukit Kili	Sumatera Barat	83	
8	Lidi Pinangawan Muaralaboh	Sumatera Barat	400	Supreme Energy
9	Bonjol	Sumatera Barat	200	
10	Rantau Dedap	Sumatera Selatan	105	Supreme energy
11	Kepahiang	Bengkulu	180	
12	Gunung Rajabasa	Lampung	91	Supreme Energy
13	Suoh Sekincau	Lampung	230	Chevron Geothermal Suoh Sekincou
14	Danau Ranau	Lampung	210	
15	Wai Ratai	Lampung	185	
16	Kaldera Danau Banten	Banten	115	PT. Sintesa Banten Geothermal
17	Gunung Endut	Banten	80	
18	Tangkuban Parahu	Jawa Barat	100	Tangkuban Parahu Geothermal
19	Tampomas	Jawa Barat	50	WIKA Jabar Power
20	Cisolok - Cisukarame	Jawa Barat	30	Jabar Rekind Geothermal
21	Gunung Ciremai	Jawa Barat	150	
22	Ungaran	Jawa Tengah	100	Giri Indah Sejahtera
23	Baturaden	Jawa Tengah	175	PT. Sejahtera Alam Energy
24	Guci	Jawa Tengah	79	PT. Spring Energi Sentosa
25	Candi Umbul Telomoyo	Jawa Tengah	72	
26	G.Lawu	Jawa Tengah-Jawa Timur	195	
27	Ngebel - Wilis	Jawa Timur	120	PT. Bakrie Darmakarya Energi
28	Blawan - Ijen	Jawa Timur	270	Medco Cahaya Geotermal
29	Hu'u - Daha	Nusa Tenggara Barat	65	Pacific Geo Energy
30	Sembalun	Nusa Tenggara Barat	100	
31	Sokoria	Nusa Tenggara Timur	30	Sokoria Geothermal Indonesia
32	Atadei	Nusa Tenggara Timur	40	Westindo Utama Karya
33	Mataloko	Nusa Tenggara Timur	63	
34	Ileange	Nusa Tenggara Timur	40	
35	Marana	Sulawesi Tengah	36	
36	Bora-Pulu	Sulawesi Tengah	123	
37	Suwawa	Gorontalo	110	
38	Jailolo	Maluku Utara	75	Star Energy Geothermal Halmahera
39	Songa Wayaua	Maluku Utara	140	

Total potensi: 4.758 MWe

Appendix C: List of geothermal fields for acceleration of geothermal development projects 10,000 MWe phase II (Based on Ministerial Regulation of Energy and Mineral Resources No. 01/ 2012)

No.	Filed	Province	Estimated Capacity	
1	PLTP Sungai Penuh	Jambi	2x55	110
2	PLTP Hululais	Bengkulu	2x55	110
3	PLTP Kotamobagu 1 dan 2	Sulawesi Utara	2x20	40
4	PLTP Kotamobagu 3 dan 4	Sulawesi Utara	2x20	40
5	PLTP Sembalun	Nusa Tenggara Barat	2x10	20
6	PLTP Tulehu	Maluku	2x10	20
7	PLTP Tangkuban Perahu I	Jawa Barat	2x55	110
8	PLTP Kamojang 5 dan 6	Jawa Barat	1 x30 1 x60	90
9	PLTP Ijen	Jawa Timur	2x55	110
10	PLTP Ungaran Argopuro	Jawa Timur	1x55	55
11	PLTP Wilis Nganjuk	Jawa Timur	3x55	165
12	PLTP Guntung Seulah	Banten	1 x55	55
13	PLTP Rawa Dano	Banten	1 x 110	110
14	PLTP Cibuni	Jawa Barat	1x 10	10
15	PLTP Cisolok-Cisukarame	Jawa Barat	1 x50	50
16	PLTP Karaha Bodas	Jawa Barat	1 x30 2x55	140
17	PLTP Pangka	Jawa Barat	3x60	180
18	PLTP Tampomas	Jawa Barat	1 x45	45
19	PLTP Tangkuban Perahu II	Jawa Barat	2x30	60
20	PLTP Wayang Windu Unit 3 dan 4	Jawa Barat	2x 110	220
21	PLTP Guntung Ciremai	Jawa Barat	2x 55	110
22	PLTP Baturaden	Jawa Tengah	2x 110	220
23	PLTP Dieng	Jawa Tengah	1 x55 1 x60	115
24	PLTP Gunung Ungaran	Jawa Tengah	1 x55	55
25	PLTP Ungaran	Jawa Tengah	1 x55	55
26	PLTP Seulawah Agam	Nanggroe Aceh Darussalam	1X55	55

No.	Filed	Province	Estimated Capacity	
27	PLTP Jaboi	Nanggroe Aceh Darussalam	2x5	10
28	PLTP Sarulla 1	Sumatera Utara	3x 110	330
29	PLTP Sarulla 2	Sumatera Utara	2x55	110
30	PLTP Ungaran Telomoyo	Jawa Tengah	1 x55	55
31	PLTP Simbolon Samosir	Sumatera Utara	2x55	110
32	PLTP Simbolon Ria-Ria	Sumatera Utara	1 x55	55
33	PLTP Sorik Marapi	Sumatera Utara	240 (Total)	240
34	PLTP Muaralaboh	Sumatera Barat	2x 110	220
35	PLTP Bonjol	Sumatera Barat	3x55	165
36	PLTP Lumut Balai	Sumatera Selatan	4x55	220
37	PLTP Rantau Dedap	Sumatera Selatan	2x110	220
38	PLTP Rajabasa	Lampung	2x110	220
39	PLTP Ulubelu 3 dan 4	Lampung	2x55	110
40	PLTP Suoh Sekincau	Lampung	4x55	220
41	PLTP Wai Ratai	Lampung	1 x55	55
42	PLTP Danau Ranau	Lampung	2x55	110
43	PLTP Lahendong 5 dan 6	Sulawesi Utara	2x20	40
44	PLTP Bora	Sulawesi Tengah	1 x5	5
45	PLTP Marana Masaingi	Sulawesi Tengah	2x10	20
46	PLTP Mataloko	Nusa Tenggara Barat	2x10	20
47	PLTP Atadei	Nusa Tenggara Timur	2 x2.5	5
48	PLTP Sokoria	Nusa Tenggara Timur	3x5	15
49	PLTP Mataloko	Nusa Tenggara Timur	1 x5	5
50	PLTP Jailolo	Maluku Utara	2x5	10
51	PLTP Songa Wayaua	Maluku Utara	1 x5	5
		Total installed:		4,925 MW