No.

Japan International Cooperation Agency

Ministry of Energy and Mineral Resources
of the Republic of Indonesia

Master Plan Study for Geothermal Power Development in the Republic of Indonesia

Final Report

September 2007

West Japan Engineering Consultants, Inc.

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Preface

In response to the request from the Government of Republic of the Indonesia, the Government of Japan decided to conduct the Master Plan Study for Geothermal Power Development in Indonesia, and the study was implemented by Japan International Cooperation Agency (JICA).

JICA sent to the Indonesia the study team headed by Dr. Kan'ichi SHIMADA of West Japan Engineering Consultants, Inc. and organized by West Japan Engineering Consultants, Inc. seven times from March 2006 to September 2007.

The team held discussions with the officials concerned of the Government of Republic of Indonesia, and conducted related field surveys. After returning to Japan, the study team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the promotion of the geothermal power development in Indonesia to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Republic of Indonesia for their close cooperation throughout the study.

September 2007

Tadashi IZAWA
Vice President
Japan International Cooperation Agency

September 2007

Mr. Tadashi IZAWA
Vice President
Japan International Cooperation Agency

Letter of Transmittal

We are pleased to submit the final report of the Master Plan Study for Geothermal Power Development in the Republic of Indonesia. This study was implemented by West Japan Engineering Consultants, Inc. from March 2006 to September 2007 on the basis of the contract with your Agency.

In this project, the generation capacity of geothermal resources, future power demand and environmental constraints in each geothermal filed were studied throughout the country. Using the collected information, the master plan for geothermal power development until 2025 was prepared to realize the existing development targets of the Indonesian government. Moreover, promotion plans and political measures for geothermal power development were proposed for the accomplishment of the short-term and mid/long-term goals on the basis of geothermal development projects carried out through Public-Private Partnerships (PPP).

It is believed that the geothermal resources of this country can be used to the fullest extent possible for power and energy supply and can contribute to the mitigation of global warming, if geothermal power development in Indonesia is promoted smoothly along the lines indicated in the Master Plan. We are firmly convinced that the results of the Master Plan Study will contribute to the acceleration of geothermal development in Indonesia through the government-led program.

We wish to express our sincere gratitude to your Agency (Headquarters and Indonesia Office), the Japanese Embassy in Indonesia, and the Japan Bank for International Cooperation. We also wish to express our deep gratitude to the Ministry of Energy and Mineral Resources of the Republic of Indonesia.

Kan’ichi Shimada
Team Leader, Study Team of the Master Plan Study for Geothermal Power Development in the Republic of Indonesia.

Conclusion and Recommendation

Conclusion

The conclusions obtained by this study are as follows.

1. Understanding of the present status

- ✓ It is affirmed that the Indonesian government intends to develop the geothermal resources in this country, whose generating capacity has been inferred to be larger than 27,000MW in total. The legal framework has been prepared and a development goal (9,500MW in 2025; Road Map) has been set to realize the acceleration of geothermal power development in Indonesia.

- ✓ It is expected that geothermal power will be developed as an alternative energy source to fossil fuel. However, progress in the development of geothermal power in this country has been very slow-paced since the bi-millennium.

- ✓ The existence of a geothermal resource sufficient for the construction of geothermal power plants of 9,500MW by 2025 is affirmed by the resource evaluation in this study. Capacity calculated using data from the 50 geothermal fields is 9,076MW. Since geothermal resources in other fields can be expected, geothermal power plants of 9,500 MW could be constructed by 2025 from the viewpoint of geothermal resource capacity.

- ✓ In most geothermal fields investigated in this study, geothermal power development is considered to be possible without problems of environmental preservation in the surrounding areas. However, in some areas where a national park and protected forest area are included, it is necessary to reduce the development area of the fields.

- ✓ There is a large amount of CO_2 reduction effect when geothermal power generation is used as an alternative to fossil fuel. Atmospheric emissions of CO_2 of 50,122 x 10^3ton per year will be eliminated, if geothermal power plants of 8,200MW are constructed in 50 promising fields in the future.

- ✓ Contribution of multipurpose utilization of geothermal energy to social development in the regions where the geothermal power plants are to be constructed is clearly demonstrated in this study. In particular, application of multipurpose utilization to agriculture seems to be adequate in various geothermal fields in Indonesia. An appropriate business model is necessary for the introduction and expansion.

- ✓ It is concluded that geothermal resources should be developed as an alternative to fossil fuel as early as possible, because geothermal energy has various advantages and is an important indigenous and renewable source of energy in Indonesia.

2. Geothermal Development Master Plan

- ✓ Development plans that are appropriate for each geothermal field were made using information about environmental preservation, regulation, and electric power supply and demand, and the results of geothermal resource evaluation. Based on these development plans for each field, a Geothermal Development Master Plan of 9,500MW by 2025 was formulated.

- ✓ The amount of the geothermal generation capacity in the Master Plan cannot reach the Road Map target in the short-to-medium term, but can reach 9,500 MW by 2025.

- ✓ It is judged that the achieving the Road Map targets will be difficult under current government policies. To develop geothermal electric power of 9,500MW by 2025, it is clear that the establishment of a promotion system and support system for geothermal power development and the strengthening of the technology of the governmental research institute are necessary.

- ✓ It is clarified in the Master Plan that the geothermal fields where large-scale power development can be conducted are concentrated in Java Island and the Sumatra Island.

- ✓ According to the Master Plan, it is necessary to give priority to the construction of geothermal power plants in the developed fields on Java Island by 2016 as described in the Road Map for 2012-2016. Subsequently, the development of geothermal fields in Sumatra Island should be expanded. There are many fields where geothermal power plants of large capacity can be constructed at comparatively low cost on Sumatra Island.

- ✓ Since electric power is supplied by diesel generators in the many remote areas including the isolated islands and is costly, geothermal power is expected to be an economically promising alternative electric source to fossil fuel. However, considering the relatively inefficient economics of small geothermal power generation, it is advisable to promote geothermal power development by the central or the local government. A lot of attention to the development scale and electricity prices should be demanded if the private sector is to participate in the geothermal power business in the remote areas.

- ✓ The basic data and information for formulating the Master Plan have been integrated into the geothermal development data base. It is possible to use it for investigation of future development and private project investment. However, further resource study is indispensable for repletion of the database, because the quality and quantity of the current data in the database are not sufficient to conduct feasibility studies for the geothermal power projects or to judge the bidding conditions for geothermal development of each field.

- ✓ To accelerate the geothermal power development projects in the Master Plan, provision of resource data of sufficient quality and quantity by the government or government institute to the private sector is indispensable in Indonesia. The quality and quantity of the present data are not sufficient to allow geothermal development by the private sector.

- ✓ It is clarified that almost all geothermal power developments in this country could be CDM projects contributing to the promotion of business in this country. The CDM business for development in each field is expected to contribute to the improvement of project economics and to promote the development projects shown in the Master Plan. In the study, a model PDD (Project Design Document) is prepared, and the possibilities of CDM geothermal power development are presented.

- ✓ Two major barriers to development, namely resource development risk and large up-front investment requirements for geothermal power development projects were confirmed in Indonesia. The government should take measures to mitigate these barriers and to accelerate the geothermal power development projects in the Master Plan.

Table 1 Total power output in each island calculated on the bases of Geothermal Development Master Plan

Region	Development Rank	Number of Field	Installed Capacity (MW)	Development Plan by 2008 (MW)	Development Plan by 2012 (MW)	Development Plan by 2016 (MW)	Development Plan by 2020 (MW)	Development Plan by 2025 (MW)
Sumatra	A	8	2	10	530	915	1,715	2,995
	B	5	-	0	20	160	510	750
	C	6	-	0	0	0	420	725
	L	1	-	0	0	0	0	50
	N	12	-	0	0	0	0	200
	Total	**32**	**2**	**10**	**550**	**1,075**	**2,645**	**4,720**
Java-Bali	A	9	835	1,115	1,295	1,515	2,330	3,025
	B	3	-	0	0	165	340	480
	C	2	-	0	0	0	60	60
	L	2	-	0	0	0	0	70
	N	6	-	0	0	0	0	200
	Total	**22**	**835**	**1,115**	**1,295**	**1,680**	**2,730**	**3,835**
Nusa Tenggara	A	2	-	3	9	9	26	56
	B	1	-	0	0	10	20	20
	C	4	-	0	0	0	60	70
	N	1	-	0	0	0	0	0
	Total	**8**	**0**	**3**	**9**	**19**	**106**	**146**
Sulawesi	A	3	20	60	120	160	240	480
	C	2	-	0	0	0	90	255
	N	3	-	0	0	0	0	24
	Total	**8**	**20**	**60**	**120**	**160**	**330**	**759**
Maluku	C	2	-	0	0	0	40	40
	N	1	-	0	0	0	0	0
	Total	**3**	**0**	**0**	**0**	**0**	**40**	**40**
Total		**73**	**857**	**1,188**	**1,974**	**2,934**	**5,851**	**9,500**
The Road Map		-	857	2,000	3,442	4,600	6,000	9,500

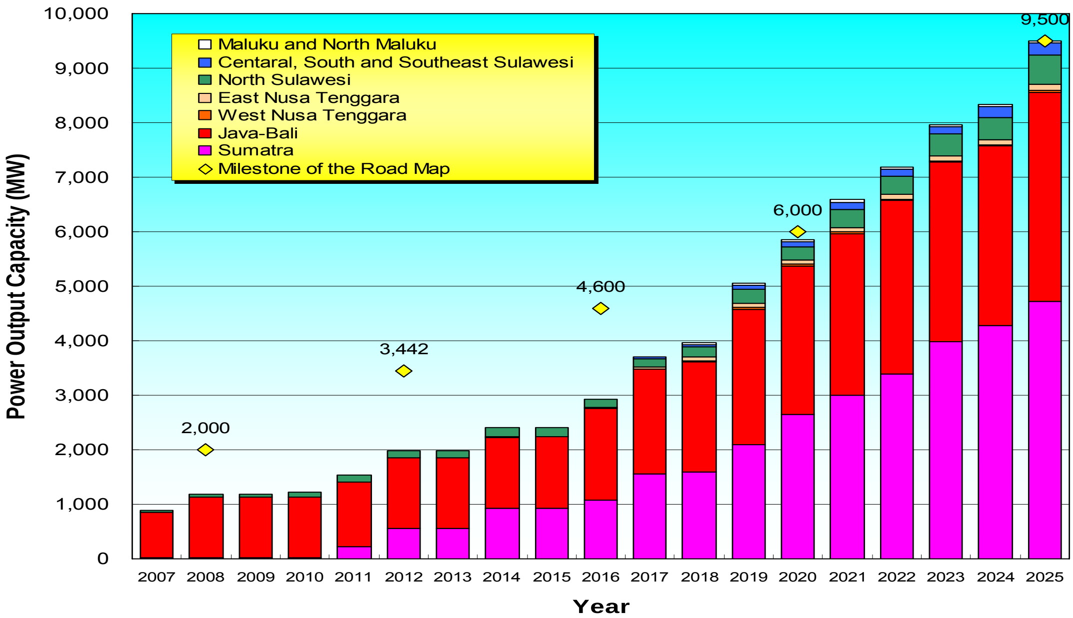


Fig. 2 Change of amount of geothermal power generation based on Master Plan

Table 2 Geothermal Development Master Plan in Each Region (1)

Sumatra

Region	No	Field name	Development Rank	Existing	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total(MW)
N.Sumatra	8	SARULA	A							300					110			110			110			630
N.Sumatra	9	SIBUAL BUALI	A																					
Lampung	27	ULUBELU	A						110			110					110			110				440
N.Sumatra	7	LAU DEBUK-DEBUK / SIBAYAK	A	2	8										30									40
Jambi	17	SUNGAI PENUH	A									55						110			110		80	355
S.Sumatra	25	LUMUT BALAI	A						110			110					110			110		180		620
Bengkulu	21	B. GEDUNG HULU LAIS	A									110						220			220		60	610
Bengkulu	22	TAMBANG SAWAH	A																220				80	300
Jambi	15	LEMPUR / KERINCI	B			T				20														20
W.Sumatra	13	MUARALABUH	B				T							55			55		55		75			240
Lampung	28	SUOH ANTATAI	B				T								110		110			110				330
Lampung	29	G. SEKINCAU	B				T							30		30								60
N.Sumatra	10	S. MERAPI - SAMPURAGA	B				T							55			45							100
Aceh	3	SEULAWAH AGAM	C					T							55			55		55		110		275
Lampung	30	RAJABASA	C					T							40		40		40					120
Lampung	31	WAI RATAI	C					T							40		40		40					120
S.Sumatra	24	MARGA BAYUR	C					T							55			55			60			170
Aceh	1	IBOIH - JABOI	C					T							10									10
W.Sumatra	14	G. TALANG	C					T							30									30
N.Sumatra	71	SIPAHOLON-TARUTUNG	L											T							20		30	50
Aceh	2	LHO PRIA LAOT	N																					
Aceh	4	G. GEUREUDONG	N																					
Aceh	5	G. KEMBAR	N																					
N.Sumatra	6	G. SINABUNG	N																					
N.Sumatra	11	PUSUK BUKIT - DANAU TOBA	N																					
N.Sumatra	12	SIMBOLON - SAMOSIR	N													T							200	200
Jambi	16	SUNGAI TENANG	N																					
Jambi	18	SUNGAI BETUNG	N																					
Jambi	19	AIR DIKIT	N																					
Jambi	20	G. KACA	N																					
Bengkulu	23	BUKIT DAUN	N																					
S.Sumatra	26	RANTAU DADAP - SEGAMIT	N																					
		TOTAL (MW)		2	8				220	320		385		140	480	30	510	550	355	385	595	290	450	
		Cumulative Capacity (MW)		2	10	10	10	10	230	550	550	935	935	1075	1555	1585	2095	2645	3000	3385	3980	4270	4720	4720
		Minimum Demand (MW)			1159.6	1234.4	1336	1425.6	3634.8	3754.8	3859.6	4002	4158.8	4318	4488.4	4662.4	4848	5005.2	5198.4	5418.8	5653.2	5903.6	6170.4	

Java-Bali

Region	No	Field name	Development Rank	Existing	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total(MW)
W.Java	32	KAMOJANG	A	140		60			60					60										320
W.Java	33	G. SALAK	A	380												60		60						500
W.Java	34	DARAJAT	A	145		110									75									330
W.Java	36	G. PATUHA	A							60				60			110			110			160	500
W.Java	37	G. WAYANG - WINDU	A	110		110									110		70							400
W.Java	38	G. KARAHA	A											30				55			110		110	305
W.Java	39	G. TELAGABODAS	A														55		40					95
C.Java	44	DIENG	A	60						60				60				110		110				400
Bali	52	BEDUGUL	A										10		55		55		55					175
W.Java	35	CISOLOK - CISUKARAME	B				T							55			55		70					180
C.Java	47	UNGARAN	B				T							55			55		70					180
E.Java	50	WILIS / NGEBEL	B				T							55			65							120
W.Java	40	TANGKUBANPERAHU	C						T							20								20
E.Java	51	IJEN	C						T							20		20						40
C.Java	46	TELOMOYO	L													T							50	50
Banten	42	CITAMAN - G. KARANG	L													T							20	20
Banten	41	BATUKUWUNG	N																					
Banten	43	G. ENDUT	N																					
C.Java	45	MANGUNAN	N													T							200	200
C.Java	48	G. SLAMET	N																					
E.Java	49	G. ARJUNO - WELIRANG	N																					
E.Java	72	IYANG ARGOPURO	N																					
		TOTAL (MW)		835		280			60	120			10	375	240	100	465	245	235	220	110		540	
		Cumulative Capacity (MW)		835	835	1115	1115	1115	1175	1295	1295	1295	1305	1680	1920	2020	2485	2730	2965	3185	3295	3295	3835	3835
		Minimum Demand (MW)			6803.2	7236	7810	8460.8	6925.2	7657.2	8444.8	9204.8	10130	10903.6	11882.8	12907.6	13986	15107.2	16054.4	17300.8	18626	20037.2	21542.8	

Red Font : exisiting geothermal development plan

Preliminary Study (Surface Survey by Government) | T Tendering | Exploration Stage | Exploitation Stage | **Blue Font** **Existing Working Area of PERTAMINA**

Table 2 Geothermal Development Master Plan in Each Region (2)

West Nusa Tenggara

W.Nusa Tenggara	53	HU'U DAHA	C						T							30								30
		TOTAL (MW)		0												30								
		Cumulative Capacity (MW)		0												30	30	30	30	30	30	30	30	30
		Minimum Demand (MW)			58.4	64.8	71.6	79.2	87.2	95.6	104.8	114	124	132.4	141.2	150.4	160.8	170.4	180.4	190.8	202	214	227.2	

East Nusa Tenggara

E.Nusa Tenggara	55	ULUMBU	A				6								10				10				10	36
E.Nusa Tenggara	56	BENA - MATALOKO	A		2.5										8								10	20
E.Nusa Tenggara	57	SOKORIA - MUTUBUSA	B				T							10		10								20
E.Nusa Tenggara	54	WAI SANO	C						T							10								10
E.Nusa Tenggara	58	OKA - LARANTUKA	C						T							10						10		20
E.Nusa Tenggara	60	ATADEI	C						T							10								10
E.Nusa Tenggara	59	ILI LABALEKEN	N																					
		TOTAL (MW)		0	3		6							10	18	40			10			10	20	
		Cumulative Capacity (MW)		0	3	3	9	9	9	9	9	9	9	19	36	76	76	76	86	86	86	96	116	116
		Minimum Demand (MW)			32.6	35.92	39.64	43.72	47.8	52.32	57.28	62.16	67.52	70.68	74.08	77.72	81.6	85.76	92.36	99.56	107.4	115.96	125.36	

North Sulawesi

N.Sulawesi	61	LAHENDONG	A	20	20	20		20	40								25		30		55		110	340
N.Sulawesi	63	TOMPASO	A																					
N.Sulawesi	62	KOTAMOBAGU	A									40					55		45					140
Golontaro	73	SUWAWA-GORONTALO	C									T				10					20		25	55
		TOTAL (MW)		20	20	20		20	40			40				10	80		75		75		135	
		Cumulative Capacity (MW)		20	40	60	60	80	120	120	120	160	160	160	160	170	250	250	325	325	400	400	535	535
		Minimum Demand (MW)			101.2	107.2	116	126	134.8	147.2	161.2	174	188	208	230.8	256	284	314.8	349.2	388	431.2	480	534.4	

Centaral, South and Southeast Sulawesi

C.Sulawesi	65	MERANA	C					T							40		40		60			60		200
C.Sulawesi	64	BORA	N																					
S.Sulawesi	66	BITUANG	N													T							24	24
SE.Sulawesi	67	LAINEA	N																					
		TOTAL (MW)		0											40		40		60			60	24	
		Cumulative Capacity (MW)		0											40	40	80	80	140	140	140	200	224	224
		Minimum Demand (MW)			252	268.8	289.6	312	332.8	354.8	378	402.4	428.4	466.4	497.2	530.4	565.2	599.2	636.8	676.8	719.2	764.4	812.4	

Maluku and North Maluku

Maluku	69	TULEHU	C						T							20								20
N.Maluku	70	JAILOLO	C						T							20								20
N.Maluku	68	TONGA WAYANA	N																					
		TOTAL (MW)		0												40								
		Cumulative Capacity (MW)		0		0	0	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40
		Minimum Demand (MW)			25.6	26.8	28.4	30.4	31.6	33.2	34.8	36.4	38	40.8	43.6	46.4	49.6	52.8	56.4	60.4	64.4	68.8	73.6	

Red Font : exisiting geothermal development plan

TOTAL (MW)

TOTAL (MW)	857	31	300	6	20	320	440	0	425	10	525	778	250	1,095	795	735	605	780	360	1,169	9,500
Cumulative Capacity (MW)	857	888	1,188	1,194	1,214	1,534	1,974	1,974	2,399	2,409	2,934	3,711	3,961	5,056	5,851	6,586	7,191	7,971	8,331	9,500	9,500
Total of Minimum Demand (MW)		8,433	8,974	9,691	10,478	11,194	12,095	13,040	13,996	15,135	16,140	17,358	18,631	19,975	21,335	22,568	24,135	25,803	27,584	29,486	
Milestone of the Road Map (MW)			2,000				3,442				4,600				6,000					9,500	
Shortage (MW)			813				1,469				1,667				149					0	

Preliminary Study (Surface Survey by Government) — T Tendering — Exploration Stage — Exploitation Stage — Blue Font: Existing Working Area of PERTAMINA

Recommendations

It is clarified that there are enough geothermal resources in Indonesia to accomplish the goals of planned geothermal power development (Road Map). However, the achievement of the Road Map is considered to be difficult under present circumstances. To develop geothermal electric power of 9,500MW by 2025, establishment of a promotion system and the support system for geothermal power development and the strengthening of the technology of the governmental research institute are necessary.

Resource development risk and large up-front investment requirements are two major barriers in the geothermal power development business. To promote geothermal power development in Indonesia, the following recommendations are made:

- ✓ In order to overcome the two barriers of resource risks and large up-front investment requirements, the geothermal development business requires an offer of adequate energy price from the buyer. However, the present purchase price of PLN, the single buyer of electric power in this country, is 5 cents/kwh or less (mostly 4.4-4.6 cents/kwh). In this situation, geothermal development of a green field by the private sector is thought to be extremely difficult, due mainly to the inefficient economy of the projects. Adequate financial support to geothermal developers by the government is indispensable.

- ✓ The extent of resource development risks is an important judgment factor when private companies decide whether they should enter the geothermal power business or not. The government needs to provide resource study data so that they can make an appropriate decision. However, the quality and quantity of the present data are insufficient to use for this judgment. It is necessary to collect data with a high degree of accuracy. The technical and financial capabilities of the governmental research institute (CGR) should be improved for these resource studies.

To accomplish this Master Plan, the proposed basic strategy is as follows:

- ✓ In Rank A fields, Geothermal Working Areas (WKP) have been designated and developers have been decided. In these fields, data for exploratory wells already exist, the resource risks are not major barriers, and each developer has a development plan. However, insufficient power purchase prices offered by PLN are discouraging many developers from proceeding with their development plans. Therefore, appropriate economic incentives are urgently required to promote the development of these fields.

- ✓ In Rank B and Rank C fields, Geothermal Working Areas (WKP) have not yet been designated. These fields can be judged as very promising fields based on surface geoscientific data. However, these fields are lacking exploratory well data.

Therefore, government promotion surveys are urgently required in these fields to set appropriate WKP and to attract private developers.

✓ Small scale geothermal development in remote islands is very important to promote rural electrification and to mitigate the high generation costs of diesel power plants. However, this small scale development is not attractive to private developers. Therefore, the government should play a key roll in promoting this small scale development.

To achieve the Master Plan, the following ten recommendations are also offered.

< Short-term policy >

1. Providing economic incentives: an appropriate combination of purchase price increase and government support measures affecting taxation and finance.
2. Establishment of an enforcement system for Geothermal Law: immediate enactment of rules and regulations of "Geothermal law" and reinforcement of the ability of central and local government to carry out these regulations.
3. Establishment of rules for coordination among the parties concerned: coordination between forestry reserves and national parks and geothermal development, etc.
4. Promotion of participation of private developers: improvement of the legal environment for investment protection, etc.

< Mid-term policy >

1. Promotion of geothermal resource surveys by government: implementation etc. of the promotion of surveys by government for resource risk reduction
2. Capacity building of geothermal engineers: capacity building of staffs of governmental institutes and upgrade of measurement instruments etc.
3. Promotion of reduction in development costs: financial support for possession of drilling rigs and procurement in geothermal well drilling, etc.
4. Securing financial resources for the government policy: study of special tax system for energy policy, etc.

< Long-term policy >

1. Promotion of human resources supply in higher education institutions: expansion of geothermal energy education at universities etc. and utilization of ODA program.
2. Nationalization of technologies and development of related industries: domestic production of devices related to geothermal steam production and generation facilities. Promotion of industries for multipurpose utilization of geothermal energy

In this Master Plan study, an intensive study was conducted for each field and for the whole country based on collected and existing geothermal data. However, as more new data accumulate, new interpretation of resources becomes possible. Therefore, it is desirable to revise this Master Plan periodically to take account of newly collected high-quality data and information in the future.

Summary

To achieve the Road Map (-2025), a Geothermal Development Master Plan was prepared for the promising fields of Indonesia. The study results are summarized below.

(1) Overview of Indonesian Energy and Geothermal Development Situation

Information concerning the present status of the energy sector and geothermal development in Indonesia was collected for use as fundamental information in preparing a geothermal development plan.

Indonesia suffered a large impact in the Asian economic crisis of July, 1997. However, the Indonesian economy has shown an improvement, with GDP growing by 4.5% in 2003, 5.1% in 2004, 5.6% in 2005, supported by strong personal consumption and the results of various policy reforms. Thus, the Indonesian economy is improving steadily, although there have been several large crises such as the Sumatra tidal wave disaster, the Bali hotel blast terrorism, and some large earthquakes disasters in the last few years.

In 2004, the total primary energy supply was 128,586 ktoe, and of this total, 45 percent was oil, 33 percent gas, 16 percent coal, with the remaining 5 percent supplied from other sources such as geothermal, hydro and new and renewable energy resources. Indonesia's final energy consumption in 2004 was 79,124 ktoe. The industry sector’s final energy consumption accounted for 39 percent of this total, the transport sector accounted for 29 percent, and the remaining 32 percent was consumed by the commercial/residential and other sectors.

Indonesia may have the highest geothermal power potential of any nation in the world. Trial calculation indicates that forty percent of the geothermal energy (equivalent of approximately 27,000 MW) in the earth’s crust is released in the Indonesian archipelago and neighboring areas. Although the generation capacity of Indonesia has reached 857MW, Indonesia is far from fully exploiting this huge potential of geothermal energy.

Geothermal development in Indonesia was strongly promoted in the 1990’s. However, many developers withdrew in the wake of the Asian economic crisis. In October 2003, the government enacted a Geothermal Law (No.27/2003) and clarified the procedures governing the participation of private developers. In September 2003, the government also relegated Pertamina to the state of PT. Pertamina (Persero), and transferred the geothermal business to PT. Pertamina Geothermal Energy (PGE), a subsidiary of Pertamina. Also the government declared that Pertamina should return geothermal development rights to the government for the areas where development has not yet started.

While proceeding with these reforms on the one hand, the Indonesian Government has decided to promote the development of renewable energy at the same time. For this purpose, in 2002, a National Energy Policy (NEP) was formulated. In 2006, "The Presidential Decree on the National Energy Policy" was issued. In this decree, the energy mix in 2005 is shown as a policy target and the percentage of geothermal energy is estimated as more than 5%. As a part of this development promotion, the Ministry of Energy and Minerals Resources worked out the "Road Map Development Planning of Geothermal Energy for 2004-2020", and announced officially that the target of geothermal energy development would be 6,000MW by 2020. This target was enhanced in 2005 to 9,500 MW by 2025.

(2) Nation-Wide Survey for Geothermal Resources

In the preliminary evaluation stage, processing, analysis and interpretation of the collected data for 73 geothermal fields were conducted. Geothermal structures are studied on the basis of existing data and the calculation of resource potential using the Stored Heat Method; in addition, simplified economic evaluations are carried out.

23 supplemental survey fields were selected based on their security and development stage in addition to the aforementioned resource and economic analysis. Geological and geochemical data obtained by supplemental surveys in 23 fields were analyzed and utilized to update the geothermal conceptual models.

After preliminary evaluation and supplemental surveys, resource evaluations of 49 fields were conducted.

Although uncertainty factors and standard values for geothermal resources were used for capacity estimation, the estimated capacity of 15859 MW is regarded as a certain target for future geothermal power development in Indonesia.

Two geothermal fields, Sokoria-Mutubus in Flores and Kotamobagu in Sulawesi were selected as object fields for geophysical survey （MT/TDEM）on the basis of the study results and the opinion of the counterparts. The geophysical survey was carried out smoothly in cooperation with counterparts from CGR and PERTAMINA. Acquired geophysical data provide detailed underground information related to geothermal activity. Based on these data, detailed geothermal structural models that allow the selection of drilling targets are constructed. Conducting geophysical surveys in these 2 fields has enabled work to proceed to the stage of exploratory well drilling.

For the formulation of a master plan, information about geothermal resources in each field, such as reservoir structure, heat source, reservoir extent and fluid chemistry, are compiled. This information is summarized as geoscientific maps and tables.

After interpretation of the geothermal structure in each field, geothermal resource potentials were calculated using the Stored Heat Method and Monte Carlo Analysis method. In the event, the resource potentials of 39 fields among 73 prospective fields were evaluated, because these fields are sufficiently well understood to allow the calculation of the resource potential. Fields under development were excluded from resource potential evaluation using the Stored Heat Method, and their planned power outputs, which were decided through detailed evaluation such as reservoir simulation study, were adopted as their resource potentials for this study.

After calculation of geothermal resource potentials, simplified economic evaluation was conducted for 49 fields, 38 of the 39 fields mentioned above together with 11 areas where exploration is at an advanced stage. In the simplified economic evaluation, the initial capital investment per kW, which is the cost per kW of constructing a geothermal power plant, was roughly estimated. The results of the calculation indicate that the initial capital investment per kW has a range from about 1,500 US$/kW to 2,300 US$/kW. We judged that the rough amount of initial capital investment estimated from the plant cost and well-drilling cost is an appropriate basis for comparing the economic aspects of each field in the formulation of a master plan.

The geothermal resource database was constructed using the existing database prepared by the Center for Geological Resouces (CGR), an Indonesian counterpart.

The database was updated in collaboration with CGR, and the functionality to compile information concerning "characteristics of geothermal reservoir and reservoir evaluation" and "production data from well" has been newly added to the revised database.

Information concerning geology, geochemistry, geophysics, well study and resource potential collected and analyzed during the study, are input into the data base.

Compiled and classified geoscientic data for each geothermal field input into the geothermal resource database are utilized to determine which geothermal fields have the highest potential for electricity development.

The construction of a geothermal resource database for Indonesia has permitted the compilation of various kinds of information for each field that facilitate the identification, assessment and characterization of geothermal reservoirs., Possible fields worthy of exploitation are evaluated for future development in consideration of their reservoir potentials, chemical features and stage of development.

(3) Electric Power Sector

Information concerning the present status and future plans for electric power supply and transmission lines has been collected in preparing a geothermal development plan.

The power demand of Indonesia (sales amount of electric power) in 2004 was 100,097 GWh, and the maximum power demand was 18,896 MW. To meet this demand, 120,161Gwh of electric power was generated by power plants with a capacity of 21,882 MW. The breakdown of the power plant capacity is 6,900 MW of steam power plants (31.5%), 6,561 MW of gas combined cycle power plants (30.0%), 3,199 MW of hydro power plants (14.6%), 2,921 MW of diesel power plants (13.4%), 6,900 MW of gas turbine plants (6.8%), and 807 MW[1] of geothermal power plants (3.7%) . The electricity demand for all Indonesia will be 450,000 GWh in 2025 (annual average growth rate of 7.2% from 2004), and the maximum electric power demand will reach 79,900 in 2025 (ditto 6.8%).

The power generated by the 73 prominent geothermal power development sites can be transmitted to Indonesian power systems (transmission lines or distribution lines) directly. Each connection to existing power systems involves determining the exact point of connection and the method of connection, in consideration of the various generation capacities, the transmission line construction cost and the convenience of system operation.

(4) Natural and social environment study

The environmental impacts of projects proposed under this master plan study were evaluated . The conceivable environmental impacts are categorized into three (3) grades of magnitude: serious impact, some impact and unknown impact; in addition each impact is evaluated as either positive or negative. The scope of conceivable impacts is evaluated at each project stage: the planning -F/S stage, the construction stage and the operation stage. Some negative impacts of pollution and impacts on the natural environment are evident in the planning and Planning-F/S stage as a result of surface surveys and test well drilling. Serious impacts of pollution, impacts on the natural environment and geographical features, and the impact of involuntary resettlement are expected in the construction stage as a result of geothermal well drilling, and construction of power facilities and the geothermal fluid transportation system. Serious impacts of pollution and impacts on the natural environment are expected in the operation stage due to geothermal brine and non-condensable gas emission. On the other hand, positive impacts are expected to enhance the local economy by increasing employment opportunities, improving livelihoods , etc. Because GHG emissions from a geothermal plant are less than those from other thermal power plants, a positive impact of GHG emission reduction is expected.

The objectives of the natural and social environmental study are to conduct an IEE study at the master plan study stage, and to predict and assess the environmental and social impacts caused by geothermal exploration and geothermal power development. The natural and

[1] As of 2007, the capacity of geothermal power plants is 857MW.

social environment study includes investigation of the legal framework for environmental preservation and of the disincentive effects on geothermal power development of environmental regulations in the 73 prospective fields.. Information concerning the social environment, natural environment, pollution, noise/vibration, grand subsidence, etc. has been collected in this study. These collected data are used as fundamental data which can be provided to the geothermal developer to assist further data collection and the preparation of a development plan for promising fields.

Based on the initial environmental examination, an environmental impact assessment of 18 fields (as planned 16 fields), where supplemental geological and geochemical studies were carried out, was conducted following the *JICA Guidelines for Environmental and Social Considerations* with reference to the *JBIC Guidelines for Confirmation of Environmental and Social Considerations* as follows.

These assessments were carried out in order to provide data for prioritizing prospect fields at the master plan-making stage. Therefore, a simple investigation was carried out, consisting of collecting existing data and confirming a geographic relation between the prospect field and the residence/protection area by field reconnaissance of prospect fields etc. It is recommended that environmental data for prospect fields for which there are no existing data for assessment be collected and evaluated as development progresses in the future.

(5) Formation of the Master Plan

The Master Plan for geothermal development was constructed from the data and information collected through the various kinds of studies. The Master Plan is comprises mainly the development priority and development implementation plan for each the field. An outline of each process involved in the formulation of the Master Plan is described below.

The currently planned geothermal development projects and future expansion projects are given top priority for development. Based on the various surveys and studies of resource characteristics, the geothermal prospects are ranked according to the likelihood of the presence of an exploitable geothermal reservoir in the field, and the exploitable resource potential of each field is estimated. Since geothermal power development within the area of national parks is prohibited in Indonesia at present, the exploitable resource potential is reduced according to the ratio of national park area within the inferred geothermal reservoir area. Moreover, taking account of the future increase in power demand, an upper limit of the geothermal development scale for each field is estimated according to the minimum demand of 2025 in the power grid. Regarding geothermal development of the appropriate output capacity estimated from resource potential, the assumed power plant project in each field is economically evaluated, and the fields having a high FIRR are given high priority for development. For development projects classified into the same rank of project IRR, the development priority of projects that need longer T/L construction is lowered.

From the results of the various evaluations mentioned above, the development priority and the development scale of future projects in each field are determined. Based on the proposed power plant capacity, a development plan for each field is designed. A schedule and estimated cost for the development is also represented. Compiling the development plans for each field, the Master Plan for geothermal development (development scenario) for the whole of Indonesia, which aims at a total installed capacity of 9,500MW in 2025, was worked out. Based on the Master Plan for geothermal development, the electric power development plan for Indonesia, including other power sources, was consulted.

The determined rank of each field is shown in Table 1 as 'Development Priority'. The ranks are classified into A, B, C, L and N in decreasing order of priority. At the right end of the table, regardless of the development priority, some fields were marked as fields where small-scale geothermal development is desirable for local electrification on remote islands and/or for alternative energy development in place of diesel power or other sources. The total exploitable resource potential of the fields classified in ranks A, B, C and L is 9,076MW. In addition, the total minimum exploitable resource potential is estimated to be 1,050MW for the fields classified into rank N, and 2,853MW for the rest of fields in the whole of Indonesia

According to the determined development scale, a geothermal development plan for each of the 50 fields was drawn up. For the fields classified into ranks B, C and L, where no development plan exists at present, we created a development plan including recommended type and number of power units in consideration of resource characteristics and power demand of the field. Additionally, we drew up development schedules corresponding to the plans and estimated the development cost for the fields, including those classified into rank A.

From the results of various studies and considerations, we constructed the Master Plan for geothermal development (development scenario) for the whole of Indonesia up to 2025. The Master Plan is a realistic development plan based on actual resource, technical and social conditions, and should be treated as a target for future development.

The final goal of the Master Plan is to develop 9,500MW capacity in total by 2025 as indicated in the Geothermal Development Roadmap. In the formation of the Master Plan, we placed the timing of commencement of development and power plant operation in consideration of the forecasted power demand in each grid as well as the development schedules for each field. Since the time for preliminary surveys and tender preparation does not seem to be sufficient for the tender of many Working Areas at the same time, we also constructed a Master Plan of 'practical case' in which the timing of commencement of development (the tender) is postponed one or two year(s) for some fields of rank B and C

(Table 2). In this scenario, the development of the fields of rank B and C is launched from fields having a higher development priority, and the tenders for 23 fields are carried out over three years with seven or eight fields per year.

The Master Plan of 'practical case' for each region (power grid) is shown in Table 3. Regarding development in the fields of rank N, since the development capacity of each field cannot be determined at present, the development capacity is arbitrarily assumed to be 200MW in Sumatra, 200MW in Java-Bali and 24MW in Central and South Sulawesi. Although the developed fields are concentrated in Java-Bali at present, future development would be centered on the fields in Sumatra in order to achieve large capacity development. The development capacity in other remote island regions would be relatively small because of the small power demand in these regions.

The "National Electricity Development Plan (RUKN) (2005)" shows a necessary electric power development plan based on a forecast of electricity demand. This plan is formulated based on the philosophy of the "Least Cost Policy on the supply side." It is envisaged that geothermal energy will account for only 3.7% of electric power and 1.2% of primary energy. Accordingly, in this case, the accomplishment of an energy mix based on the "Presidential Decree on National Energy Policy (No. 5, 2006)" will be very difficult. Therefore, we have formulated an alternative electric power development plan which is compatible with the Master Plan for geothermal development. In this process, the basic philosophy has been changed to an "Energy Mix Policy".

Studies of the economy and the role of each type of electric power plant in a large-scale system such as Java-Bali or Sumatra system will lead to the construction of sophisticated, large-scale 600 MW class thermal power plants. In such a large-scale system, geothermal power plants are less economic than large-scale coal power plants. However, from the perspective of "Energy Mix Policy", geothermal power plants should be used as base load suppliers as well as coal power plants. In a small-scale system, since small-scale 50 MW class power plants will be built, the economy of geothermal power plants surpasses that of coal power plants, and it is recommended that geothermal power plants be used as base load suppliers.

Based on these studies, the power plant development plan of RUKN (2005) was adjusted to accommodate the Master Plan for geothermal development. It is thought that the suggested energy mix of the "Presidential Decree on National Energy Policy (PD No. 5 / 2005), namely to have 5% or more of primary energy supplied by geothermal energy, will be achieved by 2025.

(6) Geothermal Development Database

In order to promote geothermal power development in Indonesia it is indispensable to prepare a database to manage information necessary for geothermal power development. Accordingly, a geothermal development database was developed to manage and integrate information concerning 1) geothermal resources, 2) the Social and Natural Environment, and 3) Transmission lines. Items of information that can be managed using this database are as follows.

	General Information	Geothermal Resources	Policy, Social and Natural Environment	Utility and Transmission Lines
Whole Indonesia	How to use the Database	a. Resource Potentials b. Geothermal Power Plant c. Prospective Area d. Development Process e. Business Scheme f. Investigation Status g. Load Map and Action Plan	a. Geothermal Law b. Environmental Assessment c. National park and Protected Forest d. Registration, Standards, and Regulations	a. Power Demand b. Power System c. Existing Power voltage d. Future Grid program
Individual Field	a. Area Code b. Latitude, Longitude c. Working Area d. Concession	a. Reservoir Conceptual Model b. Chemical Condition c. Well Productivity d. Resource Potential	a. Social and Economic Conditions b. Residence Precipitations c. Flora and Fauna d. Climate Condition e. Land use	a. Transmission Line (T/L) Voltage b. T/L Length c. T/L Connection d. T/L Diagram e. Others

This database, which incorporates detailed information about individual geothermal prospect areas in addition to information about the whole of Indonesia, was tentatively installed into a server at the Center for Geological Resources (CGR). Information about 73 geothermal prospect fields, which was collected through the Master Plan Study, had already been input into the database. Methods of operation and maintenance of the database were transferred to the staff of CGR so that they can manage and update the information in the database by themselves. The operation manual of the database is attached as another document.

In this database check boxes for defining “open information” or “closed information” were provided so that the database can be easily used as an “open database” in the future, which should open information to the public. In addition, another function for editing the contents of information open to the public was also provided so that the quality and quantity of the information can be controlled before being made public

(7) Application of CDM project

The potential for CDM projects in Indonesia is estimated in terms of emission reductions achievable through oil substitution, based on the amount of possible additional geothermal development by 2025 that excludeexisting and planned geothermal power projects.

The annual CO_2 emission reduction achieved by a 10MW geothermal power plant is 61 (kt-co_2/year). If the new geothermal plants are constructed as CDM projects, an emission reduction of 50,122 (kt-co_2/year) is expected. If the value of CER is 10 (US$/t-$CO_2$) under the emission factor 0.819(t-CO_2/MWh), earnings of about 0.8(cent/kW) are obtained when geothermal power generation is executed as CDM business in Indonesia. This is a clear incentive for geothermal power development.

The model PDD’s were drawn up for a 55MW geothermal power generation in Muaralabuh field in Sumatra and a 10MW small-scale geothermal power station in Sukoria in Flores, which indicates that all of the geothermal power development projects in Indonesia can be CDM projects.

Geothermal power generation produces low concentrations of CO2 and CH4 in NCG (non-condensable gas) with the geothermal vapor. It is necessary to pay attention to the concentration of NCG because, the higher the concentration of CO2 and CH4, the lower the GHG emission reduction effect. When the concentration of CO2 goes up to 10w%, the amount of emission reduction falls to zero. The average CO2 concentration at existing geothermal power plants is around 1w%, indicating that an adequate emission reduction effect can be anticipated. The concentrations of CH4 should be carefully checked because, although their concentration is lower than 1/100, their GHG effect is 21 times that of CO2.

(8) Multi-purpose Utilization of Geothermal Energy

Considerations affecting the introduction of a project for multi-purpose geothermal utilization in Indonesia are as follows.

- ✓ Since multipurpose geothermal utilization contributes to a reduction in the consumption of fossil fuel and to global environmental protection, it is positively advanced in developed countries.

- ✓ Industry driven by multipurpose geothermal utilization can be introduced for the development of rural areas in Indonesia.

- ✓ It is suitable to plan for multipurpose geothermal utilization in combination with the geothermal power development, because geothermal energy securing accompanies the risk.

- ✓ Studies of multipurpose geothermal utilization have been carried out in Indonesia and multipurpose geothermal utilization projects are functioning in Kamojang and Lahendong.

- ✓ Legislation concerning geothermal applications and multipurpose geothermal utilization is insufficient at present. Legislation that better suits the current state of the country is necessary.

- ✓ The study of multipurpose geothermal utilization is mainly advanced by BPPT. It is expected that BPPT will play the key role in the promotion of multipurpose geothermal utilization in the future.

- ✓ It is necessary to solve technical problems and to study the economics of projects and distribution and markets to encourage the dissemination and expansion of multipurpose geothermal utilization, and to establish a business model.

It is advisable that technical assistance concerning multipurpose geothermal utilization be obtained from developed countries that have the requisite experience and know-how in geothermal development. In addition, the business model should be established through a pilot project in cooperation with a developed country. Incorporating the project for multipurpose geothermal utilization into the geothermal power development plans would appear to be effective for promoting the expansion of multipurpose geothermal utilization.

(9) The barriers to geothermal development and necessity of government support

The barriers to geothermal development and the necessity of government support are studied by using a price model of geothermal power generation. In general, there are two barriers to geothermal development: resource development risks and a large up-front investment. In Indonesia, geothermal developers have great difficulty overcoming these two barriers because the purchase price of electricity from geothermal power plants is very low. To change this situation for the better, an increase in purchase price, package of incentives, and use of ODA finance such as Yen Loans is necessary.

A price model of a 55 MW model geothermal power plant was constructed.

An analysis using this price model demonstrated that (i) resource characteristics have a remarkable influence on the profitability of geothermal projects, and (ii) the large up-front investment and long lead-time for geothermal development increase the selling price of electricity. This result shows that resource development risks and the large up-front investment required are important barriers to geothermal development.

In Indonesia, PLN purchases electricity from IPPs at a price of less than 5 cents/kWh. There is no discrimination among the types of energy sources, and, as a result, the purchase price of electricity from geothermal power plants and from coal power plants is at almost the same level.. This policy aims to keep electric tariffs at a low level and to achieve a sound financial base for PLN. It is understandable from these viewpoints. However, based on this purchase price, the economics of geothermal power generation is so seriously degraded that no geothermal developers will have the motivation to develop geothermal energy at all in Indonesia In order to promote geothermal energy development to the levels foreseen in the Master Plan, it is necessary to raise PLN's purchase price to the level where developers can recover a return from their investment. When that is difficult, it is necessary for the government to offer a policy package of economic incentives to geothermal development to bridge the gap between the selling price and purchase price

This section discusses the effect of various government incentives: increase in PLN's purchase price, tax incentives, preliminary survey by government, low-interest loans at the development stage, low-interest loans at the construction stage, subsidies of construction costs, and the use of ODA finance such as Yen Loans. It has become clear that each incentive has the effect of decreasing the selling price by almost 0.3 cents/kWh. It is also demonstrated that the use of Yen Loans has the largest effect, reducing the selling price by about 2 cents/kWh, and is one of the strongest measures.

Moreover, it is understood that a purchase price of at least 10 cents/kWh is necessary for private developers when there are no government incentives. A purchase price of at least 8 cents/kWh is necessary to promote development of Pertamina fields when there are no incentives from government. If the purchase price cannot be raised enough, a government incentive package is needed to fill the price gap.

It is also demonstrated that CDM payments of 5$/ton have the effect of reducing the selling price by about 0.4 cents/kWh. An increase in drilling costs of 1m$ per well has the effect of increasing the selling price by about 1 cent/kWh.

(10) Proposal for Geothermal Development Promotion

To describe the basic strategy for geothermal development, the 73 fields studied are categorized, considering the progress of development, resource capacity and so on, into 5 ranks : Rank-A, B, C, N and L.

In rank A fields, the Geothermal Working Area (WKP) has already been designated and the developer has also been decided. Each developer has its development plan in the WKP. However, the development has not progressed well, although the development plan exists. A common factor disturbing the smooth development of many fields is the lack of attractiveness in PT.PLN's buying price for geothermal electricity. Because of this low buying price, many developers are facing difficulty in envisioning the success of their projects and are hesitant to promote the project. The resources of rank A fields account for almost all the development targets for 2012. It is indispensable to resolve this problem and to promote development in rank A fields to accomplish the targets of 2012. To promote rank A fields, economic incentive policies bridging the gap between the buying price which PLN offers and the selling price which the developer requests should be offered. Moreover, it is recommended that ODA financing, such as the Yen Loans for the projects of Pertamina, GeoDipa, and/or PT. PLN, be used, as the effect of ODA funding is considerable.

Currently no working area (WKP) has been set in rank B and rank C fields. Moreover, surveys with exploration drillings have not been done in these fields. Therefore, rank B and rank C fields involve larger resource development risks than rank A fields, although the surface data indicate the existence of promising resources

As rank B fields account for about 30 percent of the development targets between 2012 and 2016, promotion of development in these fields is indispensable to reach the targets of 2016. Also, as rank C fields play the key role in the targets of 2020 and 2025, the development of these fields is also expected from a long-term viewpoint. In order to develop these fields, the working areas (WKP) should first be set. For this, an adequate survey of resources by the government is necessary to set appropriate working areas. It is true that the working areas may be set from the results of surface surveys alone, but precise information on the existence of resources is more desirable when inviting private developers into the development of the area.

There are some geothermal fields on remote islands in rank A, B, and C. In these fields, the development of geothermal resources will be small-scale because the power demand in the system is not so large. In such small systems, geothermal power plants are the most economically advantageous power source. Therefore, geothermal development in such small systems should be positively promoted in order to decrease generation costs. Moreover, geothermal development is also desirable for promoting rural electrification on such small islands, as the National Energy Plan aims at achieving 90% of nationwide electrification or more by 2020. However, in such remote islands, development by private developers cannot be expected because the project scale is too small for private business. In such remote islands, where the private sector is unlikely to participate, the government should play a central role in development. In such fields, as the development scale is small, there is a possibility of converting successful exploration wells into production wells. Therefore, the construction of a small power plant by PT. PLN or by a local government company may be easy, if the government succeeds in drilling steam wells in the survey and transfers the wells to the power plant operator. Governmental surveys are highly anticipated in these fields

The following proposals are directed toward the accomplishment of the Geothermal Development Master Plan.

<Short-term Policies>
Proposal 1 Providing economic incentives
Proposal 2 Establishment of enforcement system for Geothermal Law
Proposal 3 Establishment of rules for coordination among the parties concerned
Proposal 4 Promotion of participation of private developers

<Mid-term Policies>
Proposal 5 Promotion of resource surveys by the government
Proposal 6 Building the capacity of geothermal engineers
Proposal 7 Promotion of reduced development costs
Proposal 8 Securing financial resources to implement government policy

<Long-term Policies>
Proposal 9 Promotion of human resources supply in higher education institutions
Proposal 10 Nationalization of technologies and development of related industries

It is highly recommended that these proposals be implemented without delay.

Table 1 Exploitable Resource Potential and Development Priority of the Promising Field

Region	No	Field Name (underline: Existing W/A)	Expansion and Existing Development Plan	Reservoir Existence Possibility *	Economy ***	T/L Length km	Resouce Potential (MW)	Limited by National Park (MW)	Limited by demand (MW)	Installed Capacity (MW)	Expansion and Existing Development Plan	Possible Add./New Capacity (MW)	Development Priority****	Small Scale Develop.
N.Sumatra	8 9	SARULA SIBUAL BUALI	○	1	E1	21	660	630	630	0	300	330	A	
Lampung	27	ULUBELU	○	1	E1	19	440	440	440	0	220	220	A	
W.Java	32	KAMOJANG	○	1	E1	10	320	320	320	140	120	60	A	
W.Java	33	G. SALAK	○	1	E1	1	500	500	500	380	0	120	A	
W.Java	34	DARAJAT	○	1	E1	3	330	330	330	145	110	75	A	
W.Java	36	G. PATUHA	○	1	E1	19	500	500	500	0	120	380	A	
W.Java	37	G. WAYANG - WINDU	○	1	E1	15	400	400	400	110	110	180	A	
W.Java	38 39	G. KARAHA G. TELAGABODAS	○	1	E1	9	400	400	400	0	30	370	A	
C.Java	44	DIENG	○	1	E1	4	400	400	400	60	120	220	A	
N.Sulawesi	61 63	LAHENDONG TOMPASO**	○	1	E1	11	380	380	340	20	100	220	A	
Bali	52	BEDUGUL	○	1	E2	6	330	175	175	0	175	0	A	
N.Sumatra	7	LAU DEBUK-DEBUK / SIBAYAK	○	1	E3	6	160	40	40	2	8	30	A	
E.Nusa Tenggara	55	ULUMBU	○	1	E3	14	150	150	36	0	6	30	A	○
E.Nusa Tenggara	56	BENA - MATALOKO	○	1	E4	8	30	30	20	0	2.5	18	A	○
Jambi	17	SUNGAI PENUH	○	2	E1	5	355	355	355	0	55	300	A	
S.Sumatra	25	LUMUT BALAI	○	2	E1	50	620	620	620	0	220	400	A	
Bengkulu	21 22	B. GEDUNG HULU LAIS TAMBANG SAWAH	○	2	E2	44	910	910	910	0	110	800	A	
N.Sulawesi	62	KOTAMOBAGU	○	2	E2	2	220	160	140	0	40	100	A	
Jambi	15	LEMPUR / KERINCI		1	E4	32	60	20	20	0	0	20	B	
W.Sumatra	13	MUARALABUH		2	E1	7	240	240	240	0	0	240	B	
Lampung	28	SUOH ANTATAI		2	E1	18	600	330	330	0	0	330	B	
W.Java	35	CISOLOK - CISUKARAME		2	E1	4	180	180	180	0	0	180	B	
C.Java	47	UNGARAN		2	E1	2	180	180	180	0	0	180	B	
Lampung	29	G. SEKINCAU		2	E2	19	300	60	60	0	0	60	B	
E.Java	50	WILIS / NGEBEL		2	E2	5	120	120	120	0	0	120	B	
N.Sumatra	10	S. MERAPI - SAMPURAGA		2	E3	23	500	100	100	0	0	100	B	
E.Nusa Tenggara	57	SOKORIA - MUTUBUSA		2	E4	20	90	40	20	0	0	20	B	○
Aceh	3	SEULAWAH AGAM		3	E1	4	600	275	275	0	0	275	C	
Lampung	30	RAJABASA		3	E2	8	120	120	120	0	0	120	C	
Lampung	31	WAI RATAI		3	E2	16	120	120	120	0	0	120	C	
S.Sumatra	24	MARGA BAYUR		3	E2	29	170	170	170	0	0	170	C	
C.Sulawesi	65	MERANA		3	E2	40	200	200	200	0	0	200	C	
Golontaro	73	SUWAWA-GORONTALO		3	E3	24	130	130	55	0	0	55	C	
Aceh	1	IBOIH - JABOI		3	E4	5	20	20	10	0	0	10	C	○
W.Sumatra	14	G. TALANG		3	E4	7	30	30	30	0	0	30	C	
W.Java	40	TANGKUBANPERAHU		3	E4	16	20	20	20	0	0	20	C	
E.Java	51	IJEN		3	E4	5	120	40	40	0	0	40	C	
W.Nusa Tenggara	53	HU'U DAHA		3	E4	15	110	110	30	0	0	30	C	○
E.Nusa Tenggara	54	WAI SANO		3	E4	17	50	50	10	0	0	10	C	○
E.Nusa Tenggara	58	OKA - LARANTUKA		3	E4	10	90	90	20	0	0	20	C	○
E.Nusa Tenggara	60	ATADEI		3	E4	12	50	50	10	0	0	10	C	○
Maluku	69	TULEHU		3	E4	12	50	40	20	0	0	20	C	○
N.Maluku	70	JAILOLO		3		14	40	40	20	0	0	20	C	○
C.Java	46	TELOMOYO		Low	E4	19	50	50	50	0	0	50	L	
N.Sumatra	71	SIPAHOLON-TARUTUNG		Low	E4	19	50	50	50	0	0	50	L	
Banten	42	CITAMAN - G. KARANG		Low	E4	8	20	20	20	0	0	20	L	
Aceh	2	LHO PRIA LAOT		NE		3						0	N	
Aceh	4	G. GEUREUDONG		NE		11						0	N	
Aceh	5	G. KEMBAR		NE		59						0	N	
N.Sumatra	6	G. SINABUNG		NE		38						0	N	
N.Sumatra	11	PUSUK BUKIT - DANAU TOBA		NE		18						0	N	
N.Sumatra	12	SIMBOLON - SAMOSIR		NE		3						0	N	
Jambi	16	SUNGAI TENANG		NE		83						0	N	
Jambi	18	SUNGAI BETUNG		NE		32						0	N	
Jambi	19	AIR DIKIT		NE		35						0	N	
Jambi	20	G. KACA		NE		29						0	N	
Bengkulu	23	BUKIT DAUN		NE		14						0	N	
S.Sumatra	26	RANTAU DADAP - SEGAMIT		NE		25						0	N	
Banten	41	BATUKUWUNG		NE		6						0	N	
Banten	43	G. ENDUT		NE		13						0	N	
C.Java	45	MANGUNAN		NE		19						0	N	
C.Java	48	G. SLAMET		NE		20						0	N	
E.Java	49	G. ARJUNO - WELIRANG		NE		3						0	N	
E.Nusa Tenggara	59	ILI LABALEKEN		NE		15						0	N	
C.Sulawesi	64	BORA		NE		16						0	N	
S.Sulawesi	66	BITUANG		NE		4						0	N	
SE.Sulawesi	67	LAINEA		NE		53						0	N	
N.Maluku	68	TONGA WAYANA		NE		37						0	N	
E.Java	72	IYANG ARGOPURO		NE		26						0	N	
		TOTAL					11,405	9,635	9,076	857	1,847	6,373		

* Reservoir Existing Possibility:
- 1 : Confirmed by well(s)
- 2 : Infered mainly by geothermometer
- 3 : Infered by some geoscientific data
- Low : Low possibility or low temp.
- NE : Not enough data for evaluation

** No.63 TOMPASO: Reservoir possibility in TOMPASO is 2.

*** Economy: Classification of Project IRR — E1, E2, E3, E4

****Development Priority
- A Existing Power Plant or Existing Expansion/Development Plan
- B High Possibility of Existing Geothermal Reservoir
- C Medium Possibility of Existing Geothermal Reservoir
- L Low Possibility of Existing Geothermal Reservoir
- N Not Enough Data for Evaluation

Table 2 Geothermal Development Master Plan (Practical Case)

Region	No	Field name	Development Rank	Existing	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total (MW)
N.Sumatra	8	SARULA	A							300					110			110			110			630
N.Sumatra	9	SIBUAL BUALI	A																					
Lampung	27	ULUBELU	A						110			110					110			110				440
W.Java	32	KAMOJANG	A	140		60			60					60										320
W.Java	33	G. SALAK	A	380												60		60						500
W.Java	34	DARAJAT	A	145		110									75									330
W.Java	36	G. PATUHA	A							60				60			110			110			160	500
W.Java	37	G. WAYANG - WINDU	A	110		110									110		70							400
W.Java	38	G. KARAHA	A											30				55			110		110	305
W.Java	39	G. TELAGABODAS	A														55		40					95
C.Java	44	DIENG	A	60						60				60				110		110				400
N.Sulawesi	61	LAHENDONG	A	20	20	20		20	40								25		30		55		110	340
N.Sulawesi	63	TOMPASO	A																					
Bali	52	BEDUGUL	A										10		55		55		55					175
N.Sumatra	7	LAU DEBUK-DEBUK / SIBAYAK	A	2	8										30									40
E.Nusa Tenggara	55	ULUMBU	A				6								10				10				10	36
E.Nusa Tenggara	56	BENA - MATALOKO	A		2.5										8								10	20
Jambi	17	SUNGAI PENUH	A									55						110			110		80	355
S.Sumatra	25	LUMUT BALAI	A						110			110					110			110		180		620
Bengkulu	21	B. GEDUNG HULU LAIS	A									110						220			220		60	610
Bengkulu	22	TAMBANG SAWAH	A																220				80	300
N.Sulawesi	62	KOTAMOBAGU	A									40					55		45					140
Jambi	15	LEMPUR / KERINCI	B			T				20														20
W.Sumatra	13	MUARALABUH	B				T							55			55		55		75			240
Lampung	28	SUOH ANTATAI	B				T								110		110			110				330
W.Java	35	CISOLOK - CISUKARAME	B				T							55			55		70					180
C.Java	47	UNGARAN	B				T							55			55		70					180
Lampung	29	G. SEKINCAU	B				T							30		30								60
E.Java	50	WILIS / NGEBEL	B				T							55			65							120
N.Sumatra	10	S. MERAPI - SAMPURAGA	B				T							55			45							100
E.Nusa Tenggara	57	SOKORIA - MUTUBUSA	B				T							10		10								20
Aceh	3	SEULAWAH AGAM	C					T							55			55		55		110		275
Lampung	30	RAJABASA	C					T							40		40		40					120
Lampung	31	WAI RATAI	C					T							40		40		40					120
S.Sumatra	24	MARGA BAYUR	C					T							55			55			60			170
C.Sulawesi	65	MERANA	C					T							40		40		60			60		200
Golontaro	73	SUWAWA-GORONTALO	C									T				10					20		25	55
Aceh	1	IBOIH - JABOI	C					T							10									10
W.Sumatra	14	G. TALANG	C					T							30									30
W.Java	40	TANGKUBANPERAHU	C						T							20								20
E.Java	51	IJEN	C						T							20		20						40
W.Nusa Tenggara	53	HU'U DAHA	C						T							30								30
E.Nusa Tenggara	54	WAI SANO	C						T							10								10
E.Nusa Tenggara	58	OKA - LARANTUKA	C						T							10						10		20
E.Nusa Tenggara	60	ATADEI	C						T							10								10
Maluku	69	TULEHU	C						T							20								20
N.Maluku	70	JAILOLO	C						T							20								20
C.Java	46	TELOMOYO	L													T							50	50
N.Sumatra	71	SIPAHOLON-TARUTUNG	L											T							20		30	50
Banten	42	CITAMAN - G. KARANG	L													T							20	20
Aceh	2	LHO PRIA LAOT	N																					
Aceh	4	G. GEUREUDONG	N																					
Aceh	5	G. KEMBAR	N																					
N.Sumatra	6	G. SINABUNG	N																					
N.Sumatra	11	PUSUK BUKIT - DANAU TOBA	N																					
N.Sumatra	12	SIMBOLON - SAMOSIR	N																					
Jambi	16	SUNGAI TENANG	N																					
Jambi	18	SUNGAI BETUNG	N																					
Jambi	19	AIR DIKIT	N																					
Jambi	20	G. KACA	N																					
Bengkulu	23	BUKIT DAUN	N													T							424	424
S.Sumatra	26	RANTAU DADAP - SEGAMIT	N																					
Banten	41	BATUKUWUNG	N																					
Banten	43	G. ENDUT	N																					
C.Java	45	MANGUNAN	N																					
C.Java	48	G. SLAMET	N																					
E.Java	49	G. ARJUNO - WELIRANG	N																					
E.Java	72	IYANG ARGOPURO	N																					
E.Nusa Tenggara	59	ILI LABALEKEN	N																					
C.Sulawesi	64	BORA	N																					
S.Sulawesi	66	BITUANG	N																					
S.Sulawesi	67	LAINEA	N																					
N.Maluku	68	TONGA WAYANA	N																					
		TOTAL (MW)		857	31	300	6	20	320	440	0	425	10	525	778	250	1,095	795	735	605	780	360	1,169	9,500
		Cumulative Capacity (MW)		857	888	1,188	1,194	1,214	1,534	1,974	1,974	2,399	2,409	2,934	3,711	3,961	5,056	5,851	6,586	7,191	7,971	8,331	9,500	9,500
		Total of Minimum Demand (MW)			8,433	8,974	9,691	10,478	11,194	12,095	13,040	13,996	15,135	16,140	17,358	18,631	19,975	21,335	22,568	24,135	25,803	27,584	29,486	
		Milestone of the Road Map (MW)				2,000				3,442				4,600				6,000					9,500	
		Shortage (MW)				813				1,469				1,667				149					0	

Red Font : exisiting geothermal development plan

Preliminary Study (Surface Survey by Government) | T Tendering | Exploration Stage | Exploitation Stage | Blue Font Existing Working Area of PERTAMINA

Table 3 Geothermal Development Master Plan in Each Region (1)

Sumatra

Region	No	Field name	Development Rank	Existing	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total(MW)
N.Sumatra	8	SARULA	A							300					110			110			110			630
N.Sumatra	9	SIBUAL BUALI	A																					
Lampung	27	ULUBELU	A						110			110					110			110				440
N.Sumatra	7	LAU DEBUK-DEBUK / SIBAYAK	A	2	8										30									40
Jambi	17	SUNGAI PENUH	A									55						110			110		80	355
S.Sumatra	25	LUMUT BALAI	A						110			110					110			110		180		620
Bengkulu	21	B. GEDUNG HULU LAIS	A									110						220			220		60	610
Bengkulu	22	TAMBANG SAWAH	A																220				80	300
Jambi	15	LEMPUR / KERINCI	B			T				20														20
W.Sumatra	13	MUARALABUH	B				T							55			55		55		75			240
Lampung	28	SUOH ANTATAI	B				T								110		110			110				330
Lampung	29	G. SEKINCAU	B				T							30		30								60
N.Sumatra	10	S. MERAPI - SAMPURAGA	B				T							55			45							100
Aceh	3	SEULAWAH AGAM	C					T							55			55		55		110		275
Lampung	30	RAJABASA	C					T							40		40		40					120
Lampung	31	WAI RATAI	C					T							40		40		40					120
S.Sumatra	24	MARGA BAYUR	C					T							55			55			60			170
Aceh	1	IBOIH - JABOI	C					T							10									10
W.Sumatra	14	G. TALANG	C					T							30									30
N.Sumatra	71	SIPAHOLON-TARUTUNG	L											T							20		30	50
Aceh	2	LHO PRIA LAOT	N																					
Aceh	4	G. GEUREUDONG	N																					
Aceh	5	G. KEMBAR	N																					
N.Sumatra	6	G. SINABUNG	N																					
N.Sumatra	11	PUSUK BUKIT - DANAU TOBA	N																					
N.Sumatra	12	SIMBOLON - SAMOSIR	N													T							200	200
Jambi	16	SUNGAI TENANG	N																					
Jambi	18	SUNGAI BETUNG	N																					
Jambi	19	AIR DIKIT	N																					
Jambi	20	G. KACA	N																					
Bengkulu	23	BUKIT DAUN	N																					
S.Sumatra	26	RANTAU DADAP - SEGAMIT	N																					
		TOTAL (MW)		2	8				220	320		385		140	480	30	510	550	355	385	595	290	450	
		Cumulative Capacity (MW)		2	10	10	10	10	230	550	550	935	935	1075	1555	1585	2095	2645	3000	3385	3980	4270	4720	4720
		Minimum Demand (MW)			1159.6	1234.4	1336	1425.6	3634.8	3754.8	3859.6	4002	4158.8	4318	4488.4	4662.4	4848	5005.2	5198.4	5418.8	5653.2	5903.6	6170.4	

Java-Bali

Region	No	Field name	Development Rank	Existing	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total(MW)
W.Java	32	KAMOJANG	A	140		60			60					60										320
W.Java	33	G. SALAK	A	380												60		60						500
W.Java	34	DARAJAT	A	145		110									75									330
W.Java	36	G. PATUHA	A							60				60			110			110			160	500
W.Java	37	G. WAYANG - WINDU	A	110		110									110		70							400
W.Java	38	G. KARAHA	A											30				55			110		110	305
W.Java	39	G. TELAGABODAS	A														55		40					95
C.Java	44	DIENG	A	60						60				60				110		110				400
Bali	52	BEDUGUL	A										10		55		55		55					175
W.Java	35	CISOLOK - CISUKARAME	B				T							55			55		70					180
C.Java	47	UNGARAN	B				T							55			55		70					180
E.Java	50	WILIS / NGEBEL	B				T							55			65							120
W.Java	40	TANGKUBANPERAHU	C						T							20								20
E.Java	51	IJEN	C						T							20		20						40
C.Java	46	TELOMOYO	L													T							50	50
Banten	42	CITAMAN - G. KARANG	L													T							20	20
Banten	41	BATUKUWUNG	N																					
Banten	43	G. ENDUT	N																					
C.Java	45	MANGUNAN	N													T							200	200
C.Java	48	G. SLAMET	N																					
E.Java	49	G. ARJUNO - WELIRANG	N																					
E.Java	72	IYANG ARGOPURO	N																					
		TOTAL (MW)		835		280			60	120			10	375	240	100	465	245	235	220	110		540	
		Cumulative Capacity (MW)		835	835	1115	1115	1115	1175	1295	1295	1295	1305	1680	1920	2020	2485	2730	2965	3185	3295	3295	3835	3835
		Minimum Demand (MW)			6803.2	7236	7810	8460.8	6925.2	7657.2	8444.8	9204.8	10130	10903.6	11882.8	12907.6	13986	15107.2	16054.4	17300.8	18626	20037.2	21542.8	

Red Font : exisiting geothermal development plan

Preliminary Study (Surface Survey by Government) | T Tendering | Exploration Stage | Exploitation Stage | Blue Font: Existing Working Area of PERTAMINA

Table 3 Geothermal Development Master Plan in Each Region (2)

West Nusa Tenggara

W.Nusa Tenggara	53	HU'U DAHA	C						T							30								30
		TOTAL (MW)		0												30								
		Cumulative Capacity (MW)		0												30	30	30	30	30	30	30	30	30
		Minimum Demand (MW)			58.4	64.8	71.6	79.2	87.2	95.6	104.8	114	124	132.4	141.2	150.4	160.8	170.4	180.4	190.8	202	214	227.2	

East Nusa Tenggara

E.Nusa Tenggara	55	ULUMBU	A				6								10				10				10	36
E.Nusa Tenggara	56	BENA - MATALOKO	A		2.5										8								10	20
E.Nusa Tenggara	57	SOKORIA - MUTUBUSA	B				T							10		10								20
E.Nusa Tenggara	54	WAI SANO	C						T							10								10
E.Nusa Tenggara	58	OKA - LARANTUKA	C						T							10						10		20
E.Nusa Tenggara	60	ATADEI	C						T							10								10
E.Nusa Tenggara	59	ILI LABALEKEN	N																					
		TOTAL (MW)		0	3		6							10	18	40			10			10	20	
		Cumulative Capacity (MW)		0	3	3	9	9	9	9	9	9	9	19	36	76	76	76	86	86	86	96	116	116
		Minimum Demand (MW)			32.6	35.92	39.64	43.72	47.8	52.32	57.28	62.16	67.52	70.68	74.08	77.72	81.6	85.76	92.36	99.56	107.4	115.96	125.36	

North Sulawesi

N.Sulawesi	61	LAHENDONG	A	20	20	20		20	40								25		30		55		110	340
N.Sulawesi	63	TOMPASO	A																					
N.Sulawesi	62	KOTAMOBAGU	A									40					55		45					140
Golontaro	73	SUWAWA-GORONTALO	C									T				10						20	25	55
		TOTAL (MW)		20	20	20		20	40			40				10	80		75		75		135	
		Cumulative Capacity (MW)		20	40	60	60	80	120	120	120	160	160	160	160	170	250	250	325	325	400	400	535	535
		Minimum Demand (MW)			101.2	107.2	116	126	134.8	147.2	161.2	174	188	208	230.8	256	284	314.8	349.2	388	431.2	480	534.4	

Centaral, South and Southeast Sulawesi

C.Sulawesi	65	MERANA	C					T							40		40		60			60		200
C.Sulawesi	64	BORA	N																					
S.Sulawesi	66	BITUANG	N													T							24	24
SE.Sulawesi	67	LAINEA	N																					
		TOTAL (MW)		0											40		40		60			60	24	
		Cumulative Capacity (MW)		0											40	40	80	80	140	140	140	200	224	224
		Minimum Demand (MW)			252	268.8	289.6	312	332.8	354.8	378	402.4	428.4	466.4	497.2	530.4	565.2	599.2	636.8	676.8	719.2	764.4	812.4	

Maluku and North Maluku

Maluku	69	TULEHU	C						T							20								20
N.Maluku	70	JAILOLO	C						T							20								20
N.Maluku	68	TONGA WAYANA	N																					
		TOTAL (MW)		0												40								
		Cumulative Capacity (MW)		0		0	0	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40
		Minimum Demand (MW)			25.6	26.8	28.4	30.4	31.6	33.2	34.8	36.4	38	40.8	43.6	46.4	49.6	52.8	56.4	60.4	64.4	68.8	73.6	

Red Font : exisiting geothermal development plan

TOTAL (MW)

TOTAL (MW)	857	31	300	6	20	320	440	0	425	10	525	778	250	1,095	795	735	605	780	360	1,169	9,500
Cumulative Capacity (MW)	857	888	1,188	1,194	1,214	1,534	1,974	1,974	2,399	2,409	2,934	3,711	3,961	5,056	5,851	6,586	7,191	7,971	8,331	9,500	9,500
Total of Minimum Demand (MW)		8,433	8,974	9,691	10,478	11,194	12,095	13,040	13,996	15,135	16,140	17,358	18,631	19,975	21,335	22,568	24,135	25,803	27,584	29,486	
Milestone of the Road Map (MW)			2,000				3,442				4,600				6,000					9,500	
Shortage (MW)			813				1,469				1,667				149					0	

Preliminary Study (Surface Survey by Government) | T Tendering | Exploration Stage | Exploitation Stage | Blue Font Existing Working Area of PERTAMINA

Table 4 Fields to be Promoted Urgently by Providing Economic Incentives (Rank A Fields)

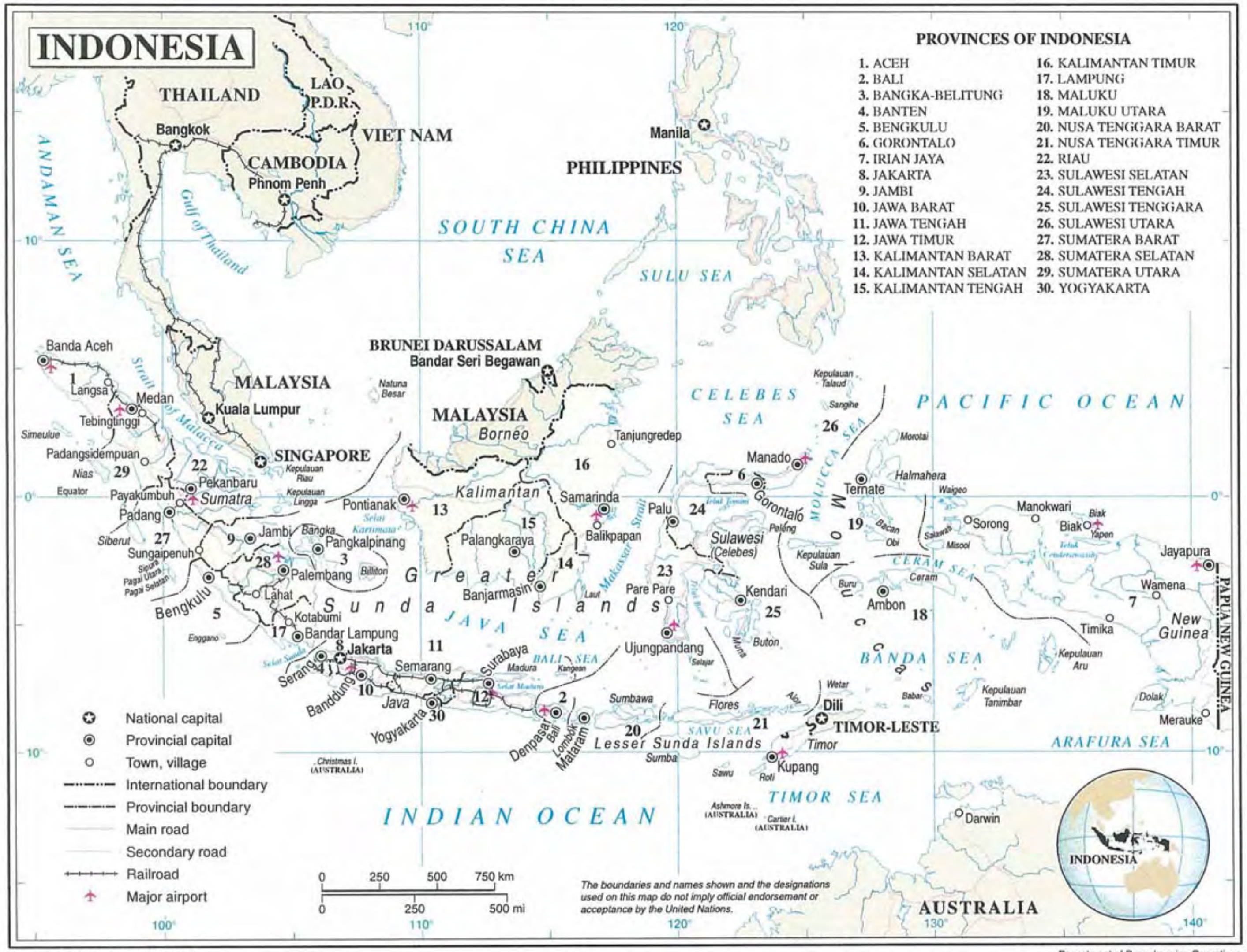
	Region	No	Field name	WKP	Concession	Developer
1	N.Sumatra	7	LAU DEBUK-DEBUK / SIBAYAK	O	Pertamina	Pertamina
2	N.Sumatra	8	SARULA	O	PLN	MEDCO/C.ITHO
3	N.Sumatra	9	SIBUAL BUALI	O	PLN	MEDCO/C.ITHO
4	Jambi	17	SUNGAI PENUH	O	Pertamina	Pertamina
5	Bengkulu	21	B. GEDUNG HULU LAIS	O	Pertamina	Pertamina
6	Bengkulu	22	TAMBANG SAWAH	O	Pertamina	Pertamina
7	S.Sumatra	25	LUMUT BALAI	O	Pertamina	Pertamina
8	Lampung	27	ULUBELU	O	Pertamina	Pertamina
9	W.Java	32	KAMOJANG	O	Pertamina	Pertamina
10	W.Java	33	G. SALAK	O	Pertamina	Cheveron
11	W.Java	34	DARAJAT	O	Pertamina	Amoseas
12	W.Java	36	G. PATUHA	O	Pertamina	Geo Dipa
13	W.Java	37	G. WAYANG - WINDU	O	Pertamina	MNL
14	W.Java	38	G. KARAHA	O	Pertamina	KBC
15	W.Java	39	G. TELAGABODAS	O	Pertamina	
16	C.Java	44	DIENG	O	Pertamina	Geo Dipa
17	Bali	52	BEDUGUL	O	Pertamina	Bali Energy
18	E.Nusa Tenggara	55	ULUMBU	O	PLN	MEMR
19	E.Nusa Tenggara	56	BENA - MATALOKO	O	PLN	MEMR
20	N.Sulawesi	61	LAHENDONG	O	Pertamina	Pertamina
21	N.Sulawesi	62	KOTAMOBAGU	O	Pertamina	Pertamina
22	N.Sulawesi	63	TOMPASO	O	Pertamina	Pertamina

Table 5 Fields to be Promoted Urgently by Governmental Survey (Rank B and Rank C fields)

	Region	No	Field name	Rank
1	Jambi	15	LEMPUR / KERINCI	B
2	W.Sumatra	13	MUARALABUH	B
3	Lampung	28	SUOH ANTATAI	B
4	W.Java	35	CISOLOK - CISUKARAME	B
5	C.Java	47	UNGARAN	B
6	Lampung	29	G. SEKINCAU	B
7	E.Java	50	WILIS / NGEBEL	B
8	N.Sumatra	10	S. MERAPI - SAMPURAGA	B
9	E.Nusa Tenggara	57	SOKORIA - MUTUBUSA	B
10	Aceh	3	SEULAWAH AGAM	C
11	Lampung	30	RAJABASA	C
12	Lampung	31	WAI RATAI	C
13	S.Sumatra	24	MARGA BAYUR	C
14	C.Sulawesi	65	MERANA	C
15	Golontaro	73	SUWAWA-GOLONTALO	C
16	Aceh	1	IBOIH - JABOI	C
17	W.Sumatra	14	G. TALANG	C
18	W.Java	40	TANGKUBANPERAHU	C
19	E.Java	51	IJEN	C
20	W.Nusa Tenggara	53	HU'U DAHA	C
21	E.Nusa Tenggara	54	WAI SANO	C
22	E.Nusa Tenggara	58	OKA - LARANTUKA	C
23	E.Nusa Tenggara	60	ATADEI	C
24	Maluku	69	TULEHU	C
25	N.Maluku	70	JAILOLO	C

Table 6 Fields to be Promoted by Government from the Viewpoint of Rural Electrification

	Region	No	Field name	Remarks
1	E.Nusa Tenggara	55	ULUMBU	Rank A
2	E.Nusa Tenggara	56	BENA - MATALOKO	Rank A
3	E.Nusa Tenggara	57	SOKORIA - MUTUBUSA	Rank B
4	Aceh	1	IBOIH - JABOI	Rank C
5	W.Nusa Tenggara	53	HU'U DAHA	Rank C
6	E.Nusa Tenggara	54	WAI SANO	Rank C
7	E.Nusa Tenggara	58	OKA - LARANTUKA	Rank C
8	E.Nusa Tenggara	60	ATADEI	Rank C
9	Maluku	69	TULEHU	Rank C
10	N.Maluku	70	JAILOLO	Rank C



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Department of Peacekeeping Operations
Cartographic Section

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Acronyms and Abbreviations

ADB	: Asian Development Bank
AIST	: National Institute of Advanced Industrial Science and Technology
AMDAL	: Analysis Mengenai Dampak Lingkungan
API/INAGA	: Asosiasi Panasbumi Indonesia / Indonesia Geothermal Association
BAPPENAS	: National Development Planning Agency
BOO	: Build-Operate-Own
BOT	: Build-Operate-Transfer
BPPT	: Badan Pengkajian dan Penerapan Teknologi
CDM	: Clean Development Mechanism
CER	: Certified Emission Reduction
CGR	: Center for Geological Resources
CO_2	: Carbon dioxide
DGEEU	: Directorate General of Electricity & Energy Utilization
DGMCG	: Directorate General of Mineral, Coal and Geothermal
EIA	: Environmental Impact Assessment
EIRR	: Economic Internal Rate of Return
ESC	: Energy Sales Contract
FIRR	: Financial Internal Rate of Return
FS	: Feasibility Study
GA	: Geological Agency
GDP	: Gross Domestic Product
IBT	: Eastern part of Indonesia
ICP	: Inductively Coupled Plasma Emission Spectrometry
IEE	: Initial Environmental Evaluation
IPP	: Independent Power Producer
IRR	: Internal Rate of Return
IUP	: Geothermal Energy Business Permit
ITB	: Institute of Technology Bandung
JBIC	: Japan Bank International Cooperation
JICA	: Japan International Cooperation Agency
JOC	: Joint Operation Contract
K-Ar	: Potassium-Argon

LA	: Loan Agreement
MEMR	: Ministry of Energy and Mineral Resources
MT	: Magneto-Telluric
NCG	:Non Condensable Gas
NEDO	: New Energy and Industrial technology Development Organization
O&M	: Operation & Maintenance
ODA	: Official Development Assistance
OJT	: On-the Job-Training
PDD	: Project Design Document
PERTAMINA	: PT. PERTAMINA (Persero)
PIN	: Project Information Note
PGE	: PT. PETRAMINA Geothermal Energy
PLN	: PT. Perusahaan Listrik Negara (Persero)
PNOC-EDC	: Philippine National Oil Company – Energy Development Corporation
RPS	: Renewable Portfolio Standard
RUKN	: Rencana Umum Ketenagalistrikan Nasional
RUPTL	: Rencana Usaha Penyediaan Tenaga Listrik
TDEM	: Time Domain Electro Magnetic
TL	: Thermoluminescence
TOE	: Ton of Oil Equivalent
UGM	: Gadjiah Mada University
UI	: University of Indonesia
VAT	: Value Added Tax
WACC	: Weighted Average Cost of Capital
WKP	: Working Area for Geothermal Development
WS	: Work shop

Unit

Prefixes

k	: kilo-	$=10^3$
M	: mega-	$=10^6$

Units of Length

m	: meter
km	: kilometer

Units of Area

m^2	: square meter
km^2	: square kilometer

Units of Volume

m^3	: cubic meter
l	: liter
kl	: kilolitor

Units of Mass

kg	: kilogram
t	: ton (metric)

Units of Energy

kWh	: kilowatt-hour
MWh	: megawatt-hour
MJ	: megajoule
TOE	: ton of oil equivalent (1TOE = 10^7 kcal)

Units of Temperature

℃	: degree Celsius

Units of Electricity

W	: watt
kW	: kilowatt
MW	: megawatt
Ah	: ampere-hour
V	: volt
kV	: kilovolt
kVA	: kilovolt-ampere

MVA	: megavolt- ampere

Units of Currency

Rp	: Indonesian Rupiah
US$	: US Dollar
¥	: Japanese Yen

Exchange Rate : Rp. 9,125/US dollars (As of the end of march 2007)
: ¥ 118/US dollars (- ditto -)

Chapter 1　Introduction

Chapter 1 Introduction

1.1 Objective of the Study

The objective of this study is to make a nationwide geothermal energy development master plan (hereinafter "Geothermal Development Master Plan" or "Master Plan") based on the amount of geothermal resources in promising areas and electricity power demands in Indonesia in order to promote and accelerate geothermal energy exploitation for electric power generation in Indonesia.

In addition, the technical transfer of the resource evaluation technology and other related technology through the implementation of this study is also included in the objective.

1.2 The Study Areas

The study areas are seventy three (73) promising geothermal fields in Indonesia.

1.3 Background of the Study

1.3.1 Significance of Geothermal Energy Development

The utilization of geothermal energy has already a long history and more than 8,000 MW capacity of geothermal energy has been exploited in the world. Notwithstanding one form of natural energy, geothermal energy production is extremely steady with less fluctuation caused by weather or by seasonal condition. Moreover, since it is a domestically produced energy, geothermal energy greatly contributes to the national energy security. In addition, in a country which largely depends on imported energy, the exploitation of geothermal energy favorably contributes to the national economy through the saving of the foreign currency. In a country which exports energy, the exploitation of geothermal energy also contributes to the national economy through acquisition of foreign currency in payment. In addition, since geothermal energy does not use fuel in its operation, it is insusceptible to the fuel price increase caused by increase of international oil price or depreciation of currency exchange rate. From environmental viewpoint, geothermal energy has little environmental impact such as air pollution because there is no combustion process in geothermal power plant. Moreover, it is a global-environmentally friendly energy because the CO_2 exhaust is also extremely little from geothermal power plant. Additionally, geothermal energy can contribute to regional development through utilization of hot water from the power plant. The development of geothermal energy has a great significance for the national economy and the people's life.

1.3.2 Current State of Geothermal Energy Development in Indonesia

It is said that Indonesia has the world-biggest geothermal energy potential, which is estimated as more than 27,000 MW and is though to account for more than 40% of world total potential. Therefore, the development of geothermal power has been strongly expected in order to supply energy to the increasing power demand and to diversify energy sources. Today, geothermal power plants exist in seven fields in Indonesia, i.e. Kamojang, Darajat, Wayang-Windu, Salak in west Java, Dieng in Central Java, Sibayak in north Sumatra, and Lahendong in north Sulawesi. The total power generation capacity reaches 857 MW. However, although this capacity is the forth largest in the country-ranking in the world, Indonesia has not fully utilized this huge geothermal potential yet.

Indonesian economy has showed a good recovery from the Asian economic crisis, and has been continuously expanding in these years. Accordingly the domestic energy demand is also expanding. On the other hand, the oil supply has decreased due to depletion of existing oilfields or aging of the production facilities. As a result, Indonesia changed its status form an oil-export country to an oil-import country in 2002.

Having been urged by such situation, Indonesian government decided to diversify energy sources and to promote domestic energy sources in order to lower oil dependency. The government worked out "National Energy Policy" (NEP) in 2002, and set a target of supplying 5% or more of the primary energy by renewable energy by 2020. In addition, the government promulgated the "Presidential Decree on the National Energy Policy" (PD No.5/2006) in 2006, and enhanced the NEP from ministerial level policy to the presidential level policy. On the other hand, the government enacted "Geothermal Law" for the first time in 2003 to promote the participation of private sector in geothermal power generation. Moreover, Ministry of Energy and Mineral Resources worked out "Road Map Development Planning of Geothermal Energy" (hereafter "Road Map") to materialize the national energy plan in 2004. In this Road Map, a high development target of 6,000 MW by 2020 and 9,500 MW by 2025 is set. Thus, a basic framework for geothermal energy development has been formulated and the government has started its efforts to attain these development targets.

1.3.3 Challenges of Geothermal Energy Development in Indonesia and the Necessity of Master Plan

Indonesia has started its positive geothermal energy development promotion. However, there remain several challenges against the achievement of the development targets.

In general, similar to oil and gas development business, geothermal energy development business has big resource development risks. These development risks are peculiar to the business of underground resource development. Even though the surface survey has been fully carried out, important information of resources is still unknown until development actually finishes. Among this information, there are many kinds of information which greatly influence the economy of the geothermal power generation business. The business profitability deteriorates if the resource productivity turns to be worse than originally expected. Oppositely, the profitability improves if the resource productivity turns to be more excellent than original expectation. This difference is very large and it is at the last stage of development that the developers can know the result is favorable one or not. This fact is a very big risk for enterprise management.

The second problem of geothermal energy development is that this business needs a large amount of up-front investment and a long lead time of development. Geothermal energy developers need to disburse a large amount of money for survey and development of resources. They also need to invest a large amount of capital in construction of steam facilities and power plant. It is after a long development period ends that developers can obtain income of energy sales. Therefore the geothermal energy development business should endure a large amount of up-front investment for a long time.

In order to deal with these problems and to advance geothermal energy development widely, the positive participation of government is definitely required. Specifically the positive support from the government is needed to overcome two barriers of geothermal development; i.e. the resource development risks and the large amount of up-front investment burden which exceeds private developer’s ability. For implementation of this governmental support policy, a clear and overall ground design of geothermal development vision is necessary.

As already mentioned, a strong will of the Indonesian government to develop geothermal energy is confirmed by Presidential Decree of the national energy policy and Road Map. Moreover, a legal frame for geothermal energy development has been well worked out by Geothermal Law. However, neither the specific strategy to attain development targets nor the support measures for developers have yet spelled out. Therefore, it is necessary to work out a nationwide geothermal energy development scenario which breakdowns Road Map into detail maps. This scenario will work as a guideline to create a consensus of geothermal development among governmental agencies. Also this scenario will work as a tool to guide geothermal energy developers for a direction of effective and efficient geothermal energy development. Besides this nationwide scenario, individual development scenarios which show concrete development images in each promising field are also needed. These individual scenarios contribute to form consensus of development among related organizations. Therefore, "Geothermal Development Master Plan", which consists of a nationwide development scenario and individual development scenarios in promising fields, is needed.

1.3.4 Justification of Supporting Indonesia's Geothermal Energy Development

Japan is blessed with abundant geothermal energy as well as Indonesia, and has a long history of geothermal energy utilization of 40 years or more. The technologies for geothermal energy exploration and utilization, which have been developed during this period in Japan, have established a worldwide evaluation. For instance, steam turbines and generators of Japanese manufacturers are utilized in many geothermal power plants in the world. Moreover, exploration technology and resource evaluation technology has a high accuracy, and has supported geothermal development in many domestic and oversees geothermal fields. In addition, the technology for geothermal hot water utilization has been variously developed for agricultural, forestry, and fisheries use. The government also has a long history of geothermal energy development policy to make use of this indigenous energy to enhance national energy security. Therefore there are enough technology, knowledge, experience, and human resources of geothermal energy development in Japan, and it can be justified as an appropriate project to use such affluent resources for the support of Indonesian geothermal energy development. It can be said as an intellectual contribution to the international society from Japan.

Moreover, if the geothermal energy development of Indonesia is promoted by this study, more domestic energy demand will be supplied by domestically-produced energy. As a result, Indonesia will be able to export more oil, natural gas, and coal to the international society and Japan will be one of the beneficiaries of this energy export expansion. It can be said that this is a big meaning of this study for the stable supply of energy for Japan.

In addition, geothermal power generation hardly exhausts carbon dioxide. Moreover, geothermal power generation can supply a large amount of energy. Therefore, geothermal power generation project is expected as an extremely promising CDM project. As the efforts to decrease carbon dioxide emission in domestic economic activities make slow progress, a lot of attention is paid to oversee CDM projects. Supporting geothermal energy development of Indonesian will contribute to formulate a lot of promising CDM projects and will expand the opportunities for Japanese investors to invest in such CDM projects.

Therefore, supporting geothermal energy development in Indonesia can be justified from various viewpoints as a project of great significance not only for Indonesia but also for Japan.

1.3.5 Request and S/W of this Study

With these backgrounds, Indonesian government requested this study to Japanese government in August 2004, and JICA dispatched S/W mission in October 2005, and S/W for this study was concluded between both the governments in December 2005.

1.4 Basic Policy of Study

To make a master plan in the geothermal energy development corresponding to Road Map, this study was executed according to the following basic policy and the procedure.

As for Master Plan, it was scheduled to carry out in the following order:

"Evaluation study on geothermal resource potential (location, natural and social environment, and economics of development)",

"Study on electric power supply and demand", and

"Study on political assistance and guidelines for geothermal development" with consideration on the current problems.

The actual activities in the study was divided into,

1) Data and information collection

2) Nationwide geothermal resource study

3) Natural and social environmental study

4) Master Plan formulation

The study proceeded by the priority on the survey of resources, and the environmental check on natural and social side was considered in the site selection for development target. Fig. 1.4-1 shows the flow of this study.

First of all, the evaluation from geothermal resource potential side was executed by collecting existing data information in 73 regions including the request from Indonesian side and a simple economics study was done using these data. In addition, the study from the natural and social environment was done to check whether each project has some potential problem, or if it is necessary for electric demand and supply. Collected data and information was converted into electronic data for database software.

As the next step, target regions, which can be promptly developed or should be developed, was selected by using the previous database. The collected in-depth data was processed by using evaluation software, and amount of the resource and scale (output) was evaluated. In addition, the development economics was also examined. By adding examination to these results from electric power supply and demand, from environmental consideration, and from the policy side, the development priority level was decided. Following, the content of each development work (scale, corporate structure, multipurpose use, and business scheme at time) for the Road Map achievement was examined. After that, these data was compiled as a geothermal development Master Plan. For two promising fields, which were desired to implement the geophysical survey, accurate resource data was collected by subsurface resistivity survey by MT/TDEM method. These survey results are reflected in the database.

The data was compiled in a database for convenience use and for public disclosure in the future. As for the database, geothermal resource database and geothermal development database was made. In addition, the database for disclosure to the public was also made. As mentioned in the below-chapter, a former database was updated in utilizing the existing software, which CGR had already introduced and a later one was newly prepared by West JEC. Standard PDD was made for making the geothermal development business as CDM business.

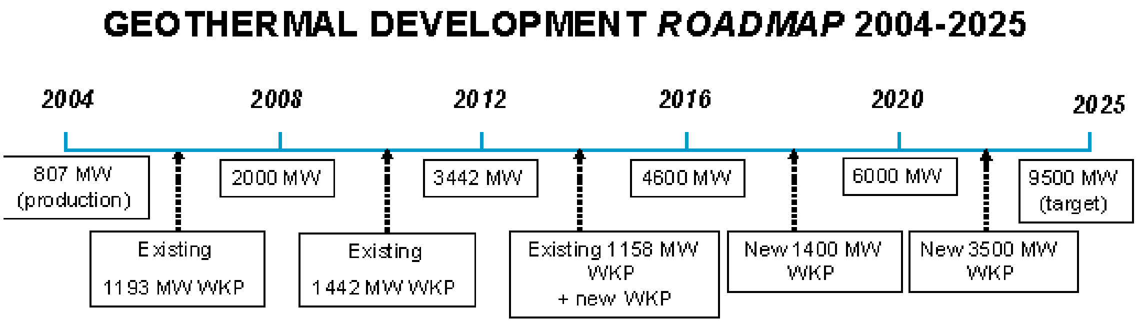


Fig. 1.3-1 Geothermal Development Road Map

Table 1.3-1 Geothermal Resources in Indonesia (Nasution, 2004)

LOCATION	RESOURCES (MWe)		RESERVE (MWe)			INSTALLED CAPACITY
	SPECULATIVE	HYPOTETIC	POSSIBLE	PROBABLE	PROVEN	
SUMATRA	5,705	2,433	5,419	15	499	2
JAVA - BALI	2,300	1,611	3,088	603	1,727	785
NUSA TENGGARA	150	438	631	-	14	
SULAWESI	1,000	125	632	110	65	20
MALUKU / IRIAN	325	117	142	-	-	
KALIMANTAN	50	-	-	-	-	
Total 251 locations	9,530	4,714	9,912	728	2,305	Total 807 MWe
	14,244		12,945			
	Total : 27,189					

（Note） Installed capacity is 807 MW as of 2004, and is 857 MW as of 2007.

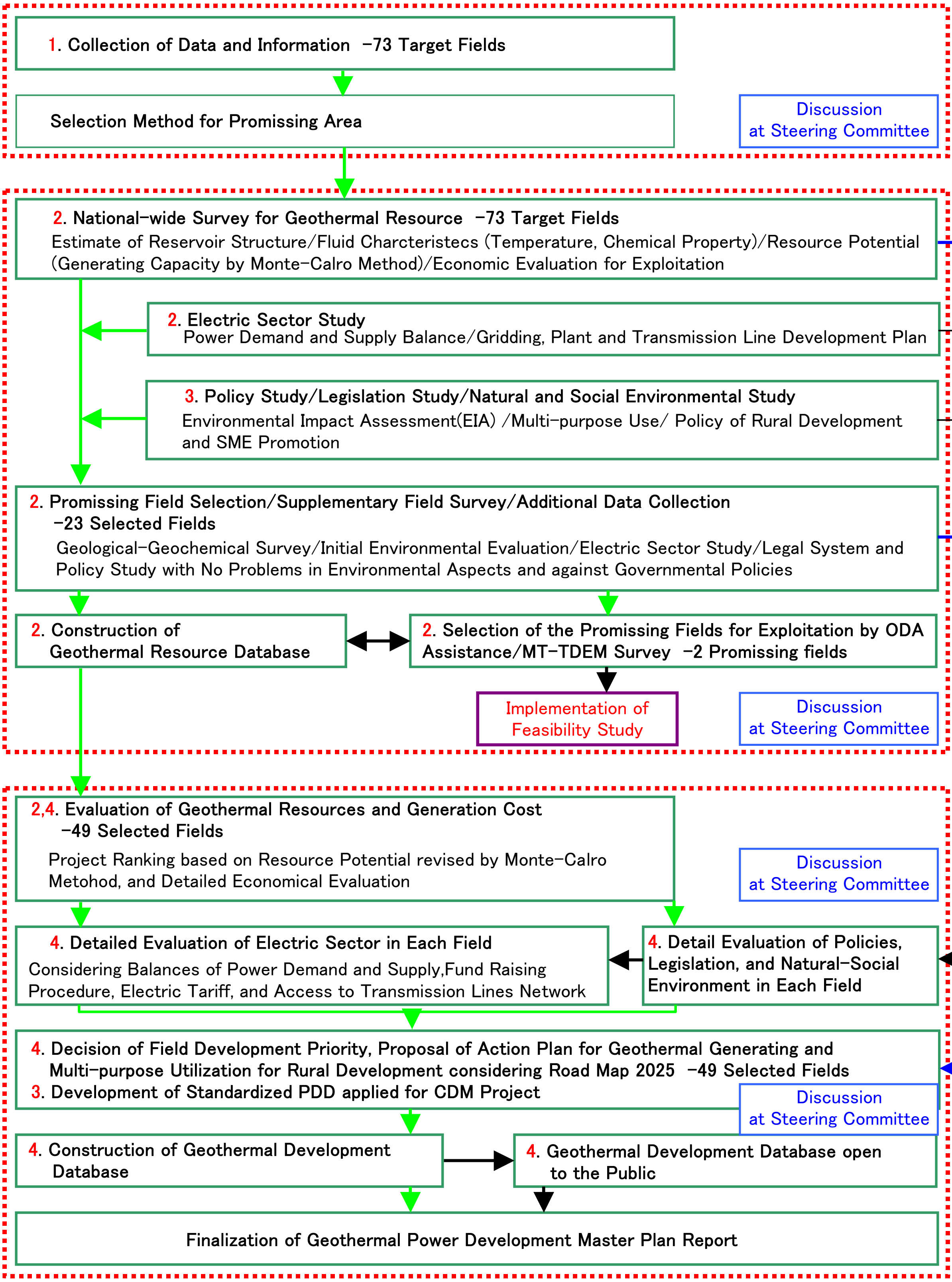


Fig. 1.4-1 Method of Executing Geothermal Development Master Plan Study

Chapter 2　Outline and Process of Study

Chapter 2 Outline and Process of Study

2.1 Activities by Study Team and Methodology

Work flow of the present master plan study is shown to Fig. 2.1-1. Activity contents and methodology in this study are mentioned below.

2.1.1 Collection of Data and Information

This activity was done in the period from March to May in 2006. The collected information and data provided from Indonesian side were as follow: governmental plans (development strategy, electric policy, laws and regulations, and structure chart of each organization) related to Indonesia geothermal promotion, each data (geothermal potential, developing status, electric demand and supply, distribution plan, generating cost), and environmental guidelines, etc.

In addition, information of local sub-contractor selection and necessary equipment obtained in Indonesia were also collected for the implementation of geophysical MT-TDEM survey on the sites.

2.1.2 Nation-wide Survey for Geothermal Resource

This activity was done in the period from June in 2006 to March in 2007. Database was prepared on the basis of collected data and information of the 73 fields. Using the database and considering present status of geothermal development of each field, 16 fields ware scheduled to select mainly from the viewpoint of geothermal resource potential. Actually, adjacent fields were picked up as promising in several areas. In addition, some fields were recommended from Indonesian side so that 23 fields were finally selected as field survey target field. In these 23 fields, supplementary surveys such as geological, geochemical and environmental studies were conducted and the study results was added in the database. Compiled with these field survey data and newly acquired data, geothermal model of 34 fields were prepared and upgraded. Furthermore, the geothermal resource capacities of remaining 50 fields were also calculated with simplified method in consideration of master plan preparation and milestone target production by Road Map. Integrated with these results, economical evaluation of 49 fields was done.

Software for the database of the project was newly prepared based on existing software constructed by CGR, one of Indonesian counterparts. Resource evaluation and economic analyses was conducted through the construction of price model of geothermal generating.

Study items in this stage are summarized as follows.

- Preliminary analysis of the 73 prospective fields
- Selection of the 16 supplemental survey fields
- Supplemental geological survey in the 23 selected fields
- Supplemental geochemical al survey in the 23 selected fields
- Study of specification of geothermal resource database
- Study of electric sectors related to the 73 selected fields
- Resource evaluation of the geothermal field (detailed study of the 34 field and concise study of the remaining 15 fields)
- Economy evaluation of the geothermal field development projects (detailed study of the 49 field and concise study of the remaining fields)
- Supplemental geophysical surveys of magneto telluric (MT) and time domain electromagnetic (TDEM) methods in the appropriate geophysical survey 2 fields

The result of resource capacity calculation, economical evaluation and geophysical MT-TDEM analysis surveyed at two fields was presented, discussed and approved at the Steering Committee in February, 2007. In addition, technical transfer to Indonesian experts was undertaken in the fields of geoscientific survey/analysis (in particular, model construction of geothermal system and resistivity analysis by MT-TDEM method), reservoir calculation, database construction, etc. through the capacity building by on-the-job-training and opening of workshop.

2.1.3 Electric Sector Study

Power sector survey including electricity distribution-grid of all 73 fields was implemented in the period of 2nd term of service in Indonesia from August to October 2006.

The gathered data and information on power demand-and-supply balance, existing power equipments and power grids, power plant and transmission line development plan, and generation cost by competitive energy against geothermal power was organized and analyzed with respect to each power grid and objective. The prospective 73 fields of geothermal power were divided into four areas of Sumatra, Java-Bali, Sulawesi and other islands (Lesser Sunda Islands, Moluccas Islands), and the data and information on each power demand-and-supply plan, existing and future plan of power equipments etc. was organized. Particularly, the survey of electricity distribution-grid system including 23 supplemental survey fields was planned to visit each branch office of PT. PLN for collection of detailed data.

Moreover, the information of competitive energy generation cost against geothermal generation was collected, but in fields where the gathered data was not good enough, the estimate was made under other various data. The data was available to make the project priority decision and CDM scheme.

The results of study about the electric sector was summarized, and they were added to the database for evaluation of the 73 geothermal development candidate fields.

2.1.4 Natural and Social Environmental Study

This activity was done for understanding of environmental protection condition in the period of 2nd term of service in Indonesia from August to October 2006.

Contents of environmental impact assessment (IEA) called as Analysis Dampak Lingkungan (hereafter AMDAL) are defined by the environmental impact assessment government regulation (No.51, 1993). Environmental conditions and impacts in the objected area of the geothermal power project, whose capacity is more than 55MW, should be checked by application of AMDAL. In geothermal power projects in and around the following legally protected areas, it lies under an obligation to prepare AMDAL, even if its capacity is less than 55MW.

- Forest protection areas
- Peat areas
- Water catchment’s areas
- Coastal edges
- River edges
- Areas surrounding lakes and reservoirs
- Areas surrounding springs
- Nature conservation areas (including nature reserves, wildlife reserves, tourism forests, genetic protection areas, and wildlife refuges)
- Marine and freshwater conservation areas (including marine waters, fresh water bodies, coastal areas, estuaries, coral reefs and atolls which have special features such as high diversity or a unique ecosystem)
- Coastal mangrove areas
- National parks
- Recreation parks
- Nature parks
- Cultural reserve and scientific research areas (including karsts areas, areas with special cultural features, archaeological sites or sites with high historical value)

Areas susceptible to natural hazards

Ministry of forestry published maps of the protected areas in Indonesia in December 1993 (Protected Area in Indonesia as of December 2003, Ministry of Forestry, Directorate General of Forest Protection and Nature Conservation). Geothermal developing areas are ranged keeping out of these protected areas. Geographical relationship between the area of geothermal exploitation and the protected area in each field was evaluated, in consideration of generation capacity of the designated exploitation area. Information regarding the environmental constrain was described in the geothermal resource database.

TOR for IEE was specified and the field study for IEE was programmed, based on collected existing data, and the results of discussion and interview with the authorities concerned at first work in Indonesia. After preparing TOR for IEE, the field study was conducted efficiently in collaboration with experienced local consultants in natural and social environmental study.

- Initial Environmental Evaluation (IEE) is not obligated to carry under environmental impact assessment system in Indonesia. This master plan study is categorized, as “B” by JICA’s guideline for environmental and social considerations requires. Then IEE was conducted at the second work in Indonesia in this study. To achieve the study object, scope of necessary items in AMDAL for geothermal power development project including exploration of resources and development of power plant was conducted at this stage.

- Terms of reference (TOR) of IEE for environmental and social considerations at the master plan study stage was discussed with counterparts and experts of the ministry of environment of Indonesia.

- For calculation of green-house gas reduction and possibility of CDM project in the promising fields, data of project information note (PIN) was collected to proceed to project design document (PDD) preparation.

In addition, technical transfer to Indonesian experts was undertaken in the fields of geothermal environmental survey, possibility of CDM project, preparation of PIN and PDD through the capacity building by on-job-training.

2.1.5 Formulation of Master Plan

Integrated with evaluation and analysis undertaken by 2006, a master plan for the geothermal development in Indonesia was prepared by the following contents: 1) geothermal development database, 2) advisable order of development priority of fields, and 3) action plan of study and development of each field.

(1) Design and formulation of the geothermal development database

Geothermal development database was made by integrating and managing data of the geothermal resources, economical evaluations, power transmission lines and information of social and environmental impacts, which had been collected through this project. In addition, the database for opening information on the web site was made through discussion with MEMR in Indonesia. Operation and management of these databases developed in this project was technically transferred to Indonesian side so that they can update and improve the system with the data by themselves.

The geothermal development database includes the following contents.

(a) Geothermal resources data of 73 fields

(1) Distribution of geothermal resources and potentials,

(2) Estimates of steam cost (only 49 fields due to the luck data in the remaining fields,as mentioned in the later chapter)

(b) Power demand and supply in the promising fields

(1) Balances of power demand and supply,

(2) Power development plan including power plants and transmission lines,

(3) Access to the power transmission lines,

(4) Estimates of geothermal power generation costs and their competitive power generation costs.

(c) Social and environmental data in the promising fields

(1) Relationship between the geothermal fields and environmental protected area where are defined by the law No.11 of the Ministry of Environment in Indonesia in 1994,

(2) Initial stage of the environmental impacts investigation,

(3) Estimate of the effects to the green house gas emission

(2) Priority of the development of each geothermal field

1) Business plans and detailed economical evaluation on each geothermal prospective field

Considering the geothermal resources, geothermal reservoir distributions, reservoir properties such as chemical characteristics of the geothermal fluids and natural, social environmental impacts, power demand and supply, and transmission line networks, economical evaluation, business style, political advices and enhancements for the development analyzed in this study, development plans of geothermal in the promising fields generation were formulated. The required duration and development procedure was included in the these plans from the initial exploration stage to start of plant operation.

Detailed economical evaluation was conducted by applying internal return rate (IRR) in addition to the generation cost that could be calculated using the resource evaluation and generation cost calculation systems. Financial evaluation was conducted using the amount of IRR, the return rate of selling electric power, which is equivalent to the business cost (investment cost and operation cost). In order to fairly evaluate the prospect of the finance for each field, same calculation conditions of fund raising procedure, opportunity cost, selling rate of electric power, repayment plan, and operation maintenance cost etc. were used. Because these calculation conditions were different depending on the business style, final evaluation was conducted through case studies, which was carried out considering the business type that could be classified depending on the generation cost. Concerning the important parameters such as business cost, selling rate of the electric power, interest, loading factor of power plant etc., sensitivity study was conducted to analyze their effects to the results of financial evaluation.

2) Decision of development priority and discussion on the development procedure

i) Formulation of evaluation standards of geothermal fields

Evaluation standards were formulated considering the geothermal resources potentials, competitive energy's potentials and economy against geothermal energy, balances of power demand and supply, access to the power transmission lines networks, economy of the development business, natural/social and environmental impacts, and the present development status. The priority of development was finalized to consider these standards and development plan of each field. Each evaluation standard was decided, considering the opinions of the authorities concerned in Indonesia as well as the results of the surveys.

ii) Evaluation of the geothermal fields based on the evaluation standards and development procedure

Each geothermal field was evaluated and classified using the geothermal resources database. It was discussed whether or not the geothermal fields conformed to the evaluation standards. Probability of resource existence was judged from the collected data and the field with proven steam reserve was evaluated at high priority. The economy was evaluated based on the power generation cost and IRR. The geothermal resources were evaluated along the needs of power demands and political advices for the developments. The conditions of location and environmental aspects were evaluated in terms of the development constraints and predicted environmental impacts.

iii) Decision of development priority to the geothermal fields

Development priority was given to each geothermal field based on the confirmed evaluation standards regarding confirmation of geothermal steam, exploitable resources potentials, economy, balances of power demand and supply, access to the power transmission lines networks, natural/social and environmental impacts, and the present development status. Based on the priority given, the geothermal fields suitable for the objectives shown in the Road Map were selected, and then geothermal development plan in Indonesia was formulated.

This proposed development plan was considered so that Road Map of the Indonesian could be realized by this master plan study, but the plan could not but prepare in a condition to include some policy support because there were many problems that it should have solved under the present conditions. Initially, we thought that a suitable development plan for each field could be prepared from the conditions such as economy or the resources distribution, but just described the recommended plan as reference information because of no good result of economical evaluation.

3) Formulation of Action Plan

The action plan of the geothermal master plan in Indonesia was mentioned in Chapter 7 of this report. Though referring to milestone target of each year of Road Map, it was prepared based on the development process collected from the developers because of actually delay toward the target until 2016. In the fields closed to regional electricity distribution grid, an action plan was particularly regarded as generation source of a base load in response to growth of the electricity demand.

2.1.6 Policy Advice for Geothermal Development Promotion

Compiled with evaluation result of this study, actual performance and future plan by PT. PERTAMINA, PT. PLN and private entities, the extraction of the problems and policy support to overcome was considered for the realization of the goal of Road Map 2025. Predicted these effects quantitatively, several policy advises was prepared for geothermal development promotion in Indonesia.

2.2 Member List of Study Team

The list of the member who engaged in this master plan study and its organization are shown to Table 2.2-1 and Fig.2.2-1, respectively.

2.3 Counterpart and Related Organization

2.3.1 Counterpart Personnel

Counterparts of this master plan study were the following organization under the Ministry of Energy and Mineral Resources, Indonesia.

(1) Directorate General of Mineral, Coal and Geothermal, DGMCG

Director General: Simon F. Sembilin

Director: Sugiharto Harsoprayitno, MSc

(2) Geological Agency, GA

Head: Bambang Dwiyanto

Director of Center of Geo-Resources, CGR: Hadiyanto

(3) Directorate General of Electricity & Energy Utilization, DGEEU

Director General: Yogo Pratomo, M. Sc.

Director: Emy Perdanahari, M. Sc.

2.3.2 Cooperative Organization and The Personnel

On this master plan study, the cooperative organizations were as follows.

(1) PT. PERTAMINA

Suroto (Geothermal Resource & Technology Manager)

(2) PT. PLN

Udibowo Ciptomulyono (Senior Officer for Primary Energy Management

Darmawati (Division of Power System Planning outside Java-Bali)

(3) National Development Planning Agency (BAPPENAS)

Gumilang Hardjakoesoema, M.Sc. (Director of Directorate of Energy, Telecommunication and Informatics)

(4) Badan Pengkajian dan Penerapan Teknology (BPPT)

Suyanto, M.Sc (Energy Conversion & System)

Taufan Surana

(5) Indonesian Geothermal Association (INAGA)

Aliming Ginting

In addition, technical advice and support of this study in the Japanese side was received from following agency.

(6) National Institute of Advanced Industrial Science and Technology, Japan （AIST）

Dr. Hirofumi Muraoka (Leader, Geothermal Resource Research Group)

Dr. Keiichi Sakaguchi (Senior Research Scientist, Geothermal Resource Research Group)

Dr. Masaaki Takahashi (Senior Research Geochemist, Research Center for Deep Geological Environments)

2.4 Capacity Building

Technical transfer related to planning of geothermal power development in the master plan study was conducted mainly OJT (On the Job Training)-base in the sectors of field survey (geology, geochemistry, geophysics), environment and power sector. Capacity development about almost all technologies applied to the master plan study was conducted during works in Indonesia.

Particularly, the technology necessary to transfer to Indonesian side particularly was the following fields.

- Electromagnetic survey（including analysis method）
- Geothermal reservoir calculation
- Database construction
- Master plan formulation (including economy evaluation)

The technology transfer was done by a one-to-one method through OJT in the local field survey and the joint analysis in Bandung. The latest analysis technology for underground structure extraction was provided in electromagnetic survey. In the field of geothermal reservoir calculation, integrated analysis technology for appropriate evaluation of the power output of the early development stage was advised based on the geothermal structure model, using data of geological survey, geochemical analysis, geophysical evaluation and well testing.

In addition, a geothermal resource database to each working area and another geothermal development database including information of economy evaluation, environmental assessment, electricity supply and demand situation were updated and transferred to Indonesian side.   Furthermore, technical transfer of feasibility consideration and approval procedure of the CDM project was carried out through collaboration (refer to Table 2.4-1).

2.5 Opening of Workshop

Because this master plan study was deeply related with “Geothermal Law” and “Road Map”, which showed the development policy of Indonesia, and had a possibility to give a big impact to future geothermal development strategy, private enterprises and foreign financial supporting organizations paid attention to this study as well as Indonesian geothermal related authorities.

Therefore, JICA held the workshop enough to recognize the findings in the study to Indonesian concerned personnel at each stage, submitted reports, and asked the steering committee, which Indonesian side set up, to get approval.

The workshop/steering committee in the first field work was opened at DGMCG in May, 2006.   In this meeting, JICA explained the scope of works of this study and Indonesian side understood and approved it.   During this first field work, JICA made several meetings with each counterpart organization to fully understand the content of this master plan study.

In the second field work, JICA held the second workshop/steering committee in August, 2006 and explained the contents of the progress report and discussed how to lead the later studies. The principal summary of progress report was accepted by the Indonesian side, but regarding JICA proposed supplement survey fields, which had been originally planned to implement at 16 fields, Indonesian side requested to add several fields.   In this subject, an ad-hoc technical meeting was held in September, 2006 between JICA study team and Indonesian concerned personnel.

In this technical meeting, JICA explained the details of the method of resources evaluation, the economic evaluation and how to select supplementary survey fields.   Furthermore, JICA team evaluated the additional fields proposed from Indonesian side and chose the prospect fields where are worthy of the survey.   Finally, 23 fields were selected.

After the whole field survey including data acquisition from additional fields was finished, JICA held a counterpart meeting to decide the candidate sites of geophysical (MT/TDEM) survey in October, 2006.   DGMCG, CGR and PETAMINA participated in this meeting and discussed with JICA team. As a result, all participants agreed to decide two fields and JICA team began the adjustment of the field work.

The third steering committee/workshop was held in February, 2007 at the period of the fourth field work. JICA explained the interim report and finalized it after discussion with Indonesian side. Furthermore, JICA explained the following study contents and master plan formulating method to each counterpart and got the consent of them.

In the sixth field work, JICA will explain the draft final report at the final workshop/steering committee after the adjustment with each Indonesian counterpart. Regarding the data disclosure, it will be necessary to get permission from each concerned organization through the check the content of report. JICA team will also hold an open workshop to public/private geothermal entities about the proposed master plan formulated in this study, together with the geothermal development policy of the Ministry of Energy and Mineral Resources (MEMR).

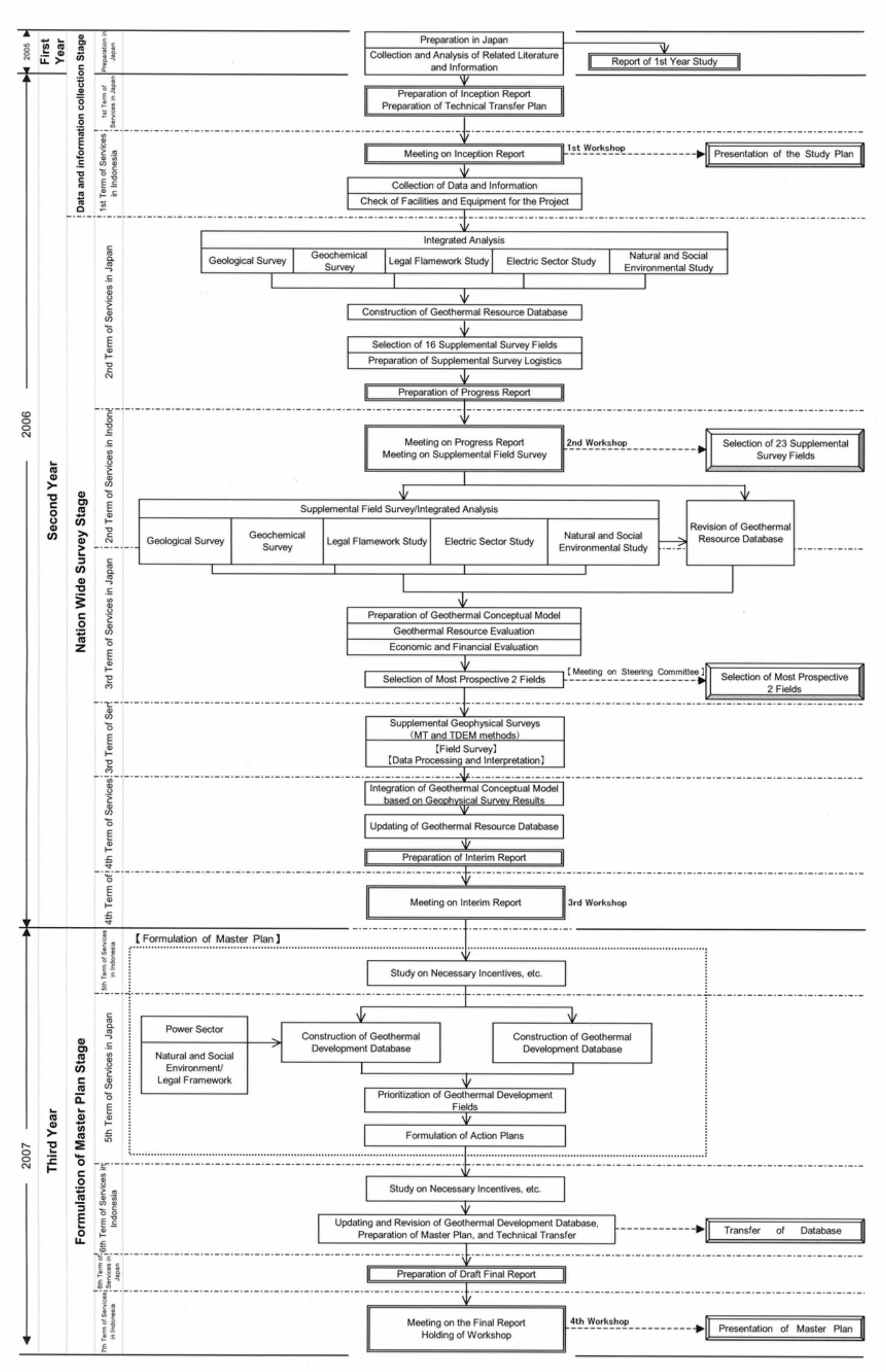


Fig. 2.1-1 Work Flow of the Master Plan Study

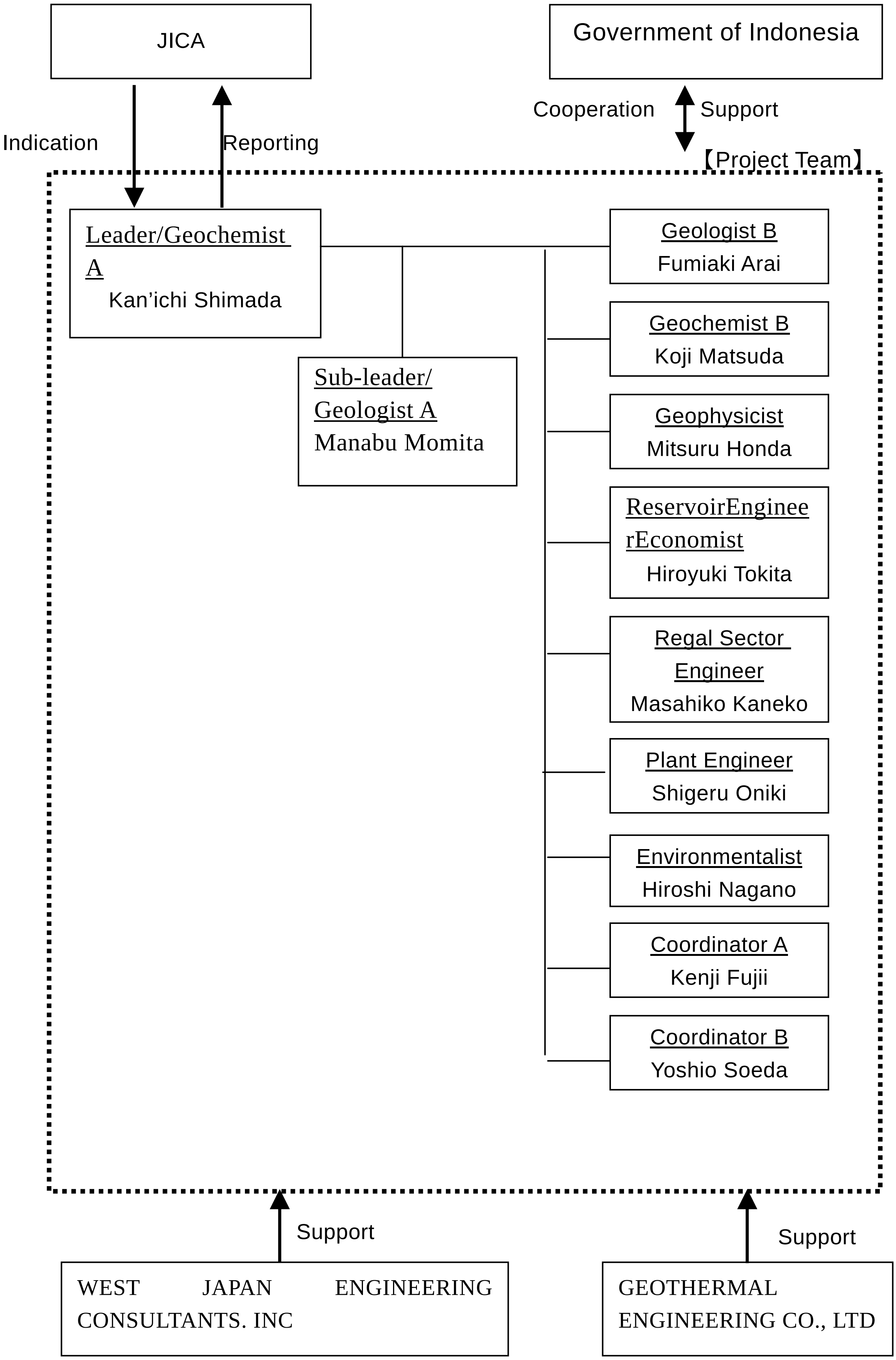


Fig. 2.2-1 Organization of Study Team

Table 2.2-1 Member List of the Study Team

Name	Charge	Contents
Kan'ichi SHIMADA	Team Leader / Geochemical A	Supervise of study, Technological management, Master Plan compilation, and Geochemical survey
Manabu MOMITA	Sub-leader / Geological survey A	Assistance to Leader, Geological survey, Geothermal structure study, and Evaluation of resource
Fumiaki ARAI	Geological survey B	Assistance to geological survey
Koji MATSUDA	Geochemical survey B	Assistance to geochemical survey, Geochemical analysis, Geothermal resource evaluation, and Evaluation of resource
Mitsuru HONDA	Geophysical survey	Geophysical survey, Geophysical analysis, and Geothermal structure study
Hiroyuki TOKITA	Resource Data Base Economy evaluation	Geothermal resource data base, Geothermal development data base, Economy evaluation
Masahiko KANEKO	Policy study / Legislation study	Policy study, Legislation study, Master Plan compilation
Shigeru ONIKI	Power demand / Power transmission system	Power demand and power transmission system survey
Hiroshi NAGANO	Environmental and social survey / CDM study	Natural and social environmental survey, CDM study, Financial evaluation, and Master Plan compilation
Kenji FUJII	Logistic coordinator	Logistic coordination
Yoshio SOEDA	Logistic coordinator	Logistic coordination, Assistance to field survey (geological study) Accountant

Table 2.4-1 Items of Capacity Building

Sector	Content	Procedure	Period
Geological Study	Technical transfer of recent geological technology connected to modelling of geothermal system and	-On the job training through joint study activities -Explanation and discussion at Workshop	May in 2006 Aug. - Oct. in 2006 March in 2007 Sep. in 2007
Geochemical Study	Technical transfer of recent technology regarding geochemical model and generating application condition of geothermal fluids	-On the job training through joint study activities -Explanation and discussion at Workshop	May in 2006 Aug. - Oct. in 2006 March in 2007 Sep. in 2007
Geophysical Study	Technical transfer of recent MT/TDEM technology connected to modelling of geothermal system, in particular quality control of	-On the job training through joint study activities -Explanation and discussion at Workshop	Dec. in 2006 - March in 2007 Sep. in 2007
Model Construction	Technical transfer of integration of all geoscientific information, modelling of geothermal system and selection of promissing fields	-On the job training through joint study activities -Explanation and discussion at Workshop	May in 2006 Aug. - Oct. in 2006 March in 2007 Sep. in 2007
Reservoir Engineering	Technical transfer regarding reservoir potential calculation based on geothermal conceptual model	-On the job training through joint study activities -Explanation and discussion at Workshop	May in 2006 Aug. - Oct. in 2006 March in 2007 Sep. in 2007
Database Construction	Technical transfer regarding construction/update of geothermal resource database and geothermal development	-On the job training through joint study activities -Explanation and discussion at Workshop	May in 2006 Aug. - Oct. in 2006 March in 2007 Sep. in 2007
Master Plan Formulation	Technical transfer regarding formulation of action plan for geothermal development promotion	-On the job training through joint study activities -Explanation and discussion at Workshop	June - July in 2007 Sep. in 2007
Environmental Assessment (including CDM procedure)	Technical transfer regarding environmental impact assessment Explanation of JICA Environmental Guideline and standardized CDM-PDD	-On the job training through joint study activities -Explanation and discussion at Workshop	May in 2006 Aug. - Oct. in 2006 March in 2007 Sep. in 2007

Chapter 3 Overview of Indonesian Energy and Geothermal Development Situation

Chapter 3 Overview of Indonesian Energy and Geothermal Development Situation

3.1 Overview of Indonesian Economy and Energy Situation

3.1.1 Indonesian Economy Situation

(1) Overview

Indonesia is an archipelago comprised of 17,508 large and small islands near the equator with a total area of 1,861 thousand square kilometers. The population in 2005 is about 221 million. (Table 3.1.1-1) Indonesia suffered the largest impact among ASEAN and South Korea in the Asian economic crisis in July, 1997, and the GDP growth rate in 1998 became negative growth of ▲13.1%. After that, Indonesia's economy has shown an improvement, with GDP growing by 4.5% in 2003, 5.1% in 2004, 5.6% in 2005, supported by the strong personal consumption power and the results of various policy reforms. Thus, the Indonesian economy is improving steadily although there were big anxiety elements such as the Sumatra tidal wave disaster, the Bali hotel blast terrorisms, and some large earthquake disasters in these several years. (Fig.3.1.1-1)

In the real economy, the strength of personal consumption attracts attention. The number of sales of cars, such as the two-wheeled vehicle and four-wheeled vehicles, and home electric appliances, such and air conditioner, refrigerators and washing machines, has expanded greatly thanks to the rise of payment. The lending for consumption from banks is also expanding, and it is another factor to support strong consumption. The governmental expenditure and export became other engines of economic growth in 2005 and in 2006. (Fig. 3.1.1-2) The government had expended a large amount of subsidiaries in the past to suppress the price of oil fuel in domestic market. However, these subsidiaries have been heavy burdens to worsen the governmental finance balance in the background of recent international high oil price situation. Therefore, the government announced the reduction of the subsidiaries and the increase of domestic fuel prices in August, 2005. After that, the government raised the price of gasoline and kerosene by 127% on the average in October, 2005. Therefore, the year of 2005 became an abnormal year in which the consumer prices rose by 17.1%. (Fig. 3.1.1-3)

A present challenge in macro economy is to improve unemployment rate. The number of unemployed workers is continuously increasing since the economic crisis in 1997. As approximately 2.5 million of new people are estimated to join in labor market every year, it is estimated that the economic growth with annual rate of more than 6% is needed to create new jobs and to prevent from worsening the unemployment rate. To attain this high economic growth, the conversion of the economy, which is driven by the personal consumption, is needed towards the economy driven by the investment. Moreover, the promotion of the foreign direct investment is indispensable for Indonesian economy to maintain the internationally competitive power in the changing international economic environment where the international free trading framework such as FTAs are being developed and the Chinese economic power is rising. For this purpose, it is necessary for the government to address squarely to the challenges such as improving economic infrastructure, increasing the social securities, modernizing the relationship between employers and employees, developing the judicial system, and eradicating the corruptions.

Although the primary engine of Indonesian economic growth is non-energy sector, the sector of fossil energy resources, such as oil, natural gas and coal, played still important roles in the economy not only as domestic energy suppliers and also as foreign exchange earners. Oil and gas sector contributed to obtain US$15.2 billion or 23.8% of total export earnings and about 18% of government budget in 2003. And coal contributed to obtain US$2.5 billion of export earning. In 2004, Indonesia's oil and natural gas reserves slightly decreased to around 641 MCM and 2,770 BCM respectively, while that of coal remained at 4,968 Mt.

The project was started in March 2006 in Japan from preparation work, and in May, 1st Workshop/Steering Committee was held at Directorate General of Mineral Coal and Geothermal (DGMCG)

Collection and compiling of data of 73 prospective geothermal fields, which had been selected previously or recommended by the counterparts were carried out

(2) Gross Domestic Production

Gross domestic product (GDP) has been continuously and steadily growing up after the recovery from the economic crisis in the second half of 1990's. Since 2000, the annual growth rate of GDP remains roughly about 5%. The growth of GDP in the first half of 2006 was 5.0% with several factors such as the rise of international energy prices and the domestic fuel price increase after the reduction of fuel subsidiaries.

In 2005, real gross domestic product (GDP) was US$ 175.0 billion and per capita GDP was about US$ 1,300. Since 1991 manufacturing has been the major contributor to Indonesian economy, and it accounted for 28.1% of the real GDP, while trade, hotel and restaurant contributed around 16.8%. Agriculture and livestock, forestry & fishery contributed 14.5%. Mining and querying contributed about 9.3%, financial ownership & business services 9.3%, service 9.2%, transportation and communication 6.3%, and construction 5.9% (Fig.3.1.1-4). In terms of growth by sectors, the highest growth was seen in the transportation and communication sector with the increase of 13.0%. This growth was attributed to the good business in the airline industry (15.6% increase of domestic airlines and 7.5% increase of international airlines) and in the marine transportation industry (11.7% increase of passengers and 8.4% increase of freight transportation). Moreover, the trade, hotel and restaurant sector increased by 8.6%, reflecting the boom of good business. In addition, the construction sector increased by 7.3% with the construction rush of shopping malls and commercial buildings. The financial sector, the electric, gas and water sector and the service sector followed with the increase of 7.1%, 6.5%, and 5.2% respectively. (Table 3.1.1-2)

(3) Market

The exchange rate of rupiah to US dollars depreciated and exceeded 10,000 rupiah for the first time in 2001. The rate rose to 8,500 rupiah level again in 2003, however, it depreciated again afterwards. This depreciation was reportedly attributed to the factors such that a large amount of dollar demand was generated in the payment for imported oil by PERTAMINA in light of international oil price increase, and that the market felt the anxiety to the large amount of fuel subsidiaries and to the consequent deterioration of governmental financial balance. (Fig.3.1.1-5)

To stabilize the exchange market, the Indonesian government restricted the transaction of rupiah in the offshore market. Moreover, the government introduced the policy target interest rate in July, 2005, and raised the interest rate, which had been in 8% level, up to 12.8% by the end of 2005. As a result, the overseas short-term capital was attracted by the high interest rate and began to flow into the market, and the exchange rate of rupiah began to rise. The exchange rate is about Rp.9,100 per US dollar at the time of March, 2007.

Financial markets are increasingly confident about financial stability and macroeconomic prospects. The exchange rate has been less volatile with trading between Rp.9,000 and Rp.9,500 for months and stocks have been traded at historic highs (Fig. 3.1.1-6). Bond yields have fallen in all maturities to the 2004-year end level (Fig.3.1.1-7). The declines in these long-term yields also reflect improving market sentiments, with short-term yields affected by policy interest rates.

In light of recent improvements in Indonesia's macroeconomic situation (including improvements in debt indicators) and political stability, major rating agencies upgraded ratings of Indonesia Moody's began the most recent upgrades in May (from B2 to B1) followed by Standard & Poors in July (from B+ to BB-). A Japanese ratings firm (R&I)followed in October (from BB- to BB). Although these ratings are still below the investment grade, these upgrade of ratings reflects and supports rising market confidence.

(4) Foreign Trade

The current balance of Indonesia has been deteriorating since 2004 due to the increase of oil importation. The current balance in 2005 has decreased to 340 million US dollars.

(Fig.3.1.1-8)

(5) Inflation and Financial Policy

The inflation rate, the increase rate of consumer price index from the corresponding month in the previous year, had been in the high level of around 10% since 2000. The rate once decreased to 5.1% in 2003 but began to increase again and is in the high level of 17.1% in 2005, reflecting the price hike of fuels.

However, tight monetary policy, exchange rate appreciation, and a slowdown in economic activity contained inflation pressure. Overall inflation has decelerated to 14.5 percent (yoy) in September 2006 and second round impacts have been contained. Core inflation (excluding easily changeable food and administrative prices) has fallen from 10.2 percent in February to 9.1 percent in September 2006.

After increasing policy interest rates between Match and December 2005, Bank of Indonesia began to cautiously lower them in May 2006. Bank of Indonesia lowered its policy interest rate (SBI 1 month) to 10.75 percent in October. Real interest rate (adjusted by cote inflation) also fell from a peak of 3.3 percent in December 2005 to 2.1 percent in September 2006. As signs of inflationary pressure recede Bank of Indonesia has room for additional policy interest cuts.

(6) Employment

According to the statistics of Central Statistics Bureau, the work force population of 2005 increased by 1.82 million (1.76%) from the previous year, and became 158 million. The completely unemployed workers were 10.85 million and increased by 602 thousand (5.9%) from the previous year. The unemployment rate deteriorated by 0.3%, and reached to 9.7%.

Because of violent competition with imported products from China, the textile industry and the timber industry fell in the serious slumps, and a lot of the factory close and the dismissal of employees was observed. In addition, because of interruption of construction projects by the price hike of fuels in October 2005, the dismissal of the worker was also observed in construction industry. These factors are thought to increase the unemployment rate (Fig.3.1.1-9).

(7) The National Medium-term Development Plan

The Yudoyono administration announced the Medium-term Development Plan (MTDP)(2004-2009) in January 2005. While the MTDP appreciated what the previous five-year plan (PROPENAS 1999-2004) had achieved, it spells out that further reform would be needed for (i) "establishing democracy and justice for all," (ii) "creating an

Indonesia that is safe and peaceful," and (iii) "improving prosperity" economically and socially, and thus it set those three goals as main agendas for the MTDP.

More specifically, first of all, to establish democracy and justice in Indonesia, the MTDP aims at intensifying efforts to improve the judicial systems, establish the rule of law, and eliminate corruption, and thus to establish government trusted by the people. Secondly, to create a safe and peaceful society, the MTDP aims at eradicating regional conflicts, conventional crimes, smuggling, and terrorism, fostering public awareness to protect the safety and peace of civil society, and strengthening state institutions maintaining law and order such as the police and military forces. Finally, to build an economically and socially prosperous country, the MTDP aims at further expansion of investment and exports, which have been sluggish so far, and of economic growth together with job creation and poverty reduction. As an issue commonly associated with these three agendas in the MTDP, the Yudoyono administration intends to strengthen the role of civil society (the private sector) in politics, the policy-making processes, and economic activities.

Particularly in the third agenda, that is building an economically and socially prosperous country, the government will decisively implement policies for macroeconomic stability, including the reduction of the fiscal deficit, while it will also strengthen industrial competitiveness and promote investment and exports, in order to achieve economic growth with enough job creation. The government, considering that economic growth must be accompanied by poverty reduction, will also implement measures to reduce poverty over the medium and long term.

The MTDP, with these policy targets, aims at achieving an annual economic growth rate of between 6% and 7% and reducing the unemployment rate and poverty rate from their respective current 10% and 16% to 5% and 8% in 2009. To achieve these goals, the economic policies in the MTDP focus on (i) macro-economic stability, (ii) the improvement of the business climate, and (iii) the revitalization of the agriculture, forestry, and fisheries industry, while enhancing social policies in the area of education and health.

More specific goals for the economic policies, especially for macro-economic stability and the improvement of the business climate, are as follows:

(1) Macro-economic Stability

(i) Inflation: to stay at around 5%.

(ii) Fiscal policy: to achieve a balanced budget by 2009 and reduce the public debt to 32% of GDP by 2009

(iii) Reform of the financial sector: to establish a prudential supervisory agency (OJK) and a deposit insurance scheme and to foster non-bank financial institutions (e,g., mutual funds, pensions, and insurance companies)

(2) Improvement of business climate

(i) The reduction in the transaction costs for doing business and barriers to entry

(ii) To reduce the time period for duty and VAT rebates with a view to promoting exports

(iii) To foster small/medium-sized enterprises: to improve access of small/medium-sized enterprises to credit and technical assistance

(iv) Labor market reform: the improvement of costly labor regulations and the improvement of regulations related to labor disputes

(v) The development of infrastructure: water supplies, transportation (roads, railroads, ports, and airports), and energy supplies

(3) Revitalization of the agriculture, forestry, and fisheries industry

(i) Support for farmers: to facilitate access to financial resources

(ii) Development of rural infrastructure: roads, irrigation, etc.

(iii) Development of agro-business: removal of entry barriers

3.1.2 Energy Situation of Indonesia

(1) Primary Energy Supply

In 2004, total primary energy supply was 128,586 ktoe. of this total, 45 percent was oil, 33 percent gas, 16 percent coal, and 5 percent for other energy such as geothermal, hydro and new and renewable energy resources. (Table 3.1.2-1)

Most of Indonesia's proven oil reserves are located onshore in the Duri and Minas fields in central Sumatra. Other significant production fields are located in offshore north-western Java, East Kalimantan and the Natuna Sea. During the last decade, crude oil production in Indonesia ranged between 1.3 and 1.4 million bbl/d. But as fields were continuously developed and reserves were depleted, crude oil production started to decline in the recent years. Thus, in 2003, Indonesia was only able to produce crude oil at an average rate of 1.1 million bbl/d, further declining to 966,000 bbl/d in 2004. In total, oil production declined from 457 billion barrels in 2002, to 419 billion barrels in 2003 and 401 billion barrels in 2004. Aside from oil, Indonesia also produces about 131,000 bbl/d of natural gas liquids and condensate in 2002, 2003 and 2004.

Besides relying on its domestic oil production, Indonesia also imports crude oil and refinery products to support its domestic oil requirements. Prior to 2002, Indonesia has been an energy exporter, exporting oil, gas, and coal. But in 2002, because of increased demand and depleting reserves, Indonesia (for the first time) became a "net oil importer". It has exported 185.9 million barrels of crude oil and 42 million barrels of refinery products, but imported 124 million barrels of crude oil and 106.9 million barrels of fuel oil. In total, Indonesia's net oil imports reached 3 million barrels in 2002.

Net oil import increased to 30 million barrels in 2004. Indonesia is however optimistic that it will immediately recover and get out of its current status as a "net oil importer" when new oil resources are discovered and developed in the next few years. BP Migas, the Indonesian upstream oil and gas regulatory body, has set up a target to increase the oil production into 1.3 million barrel by 2009.

In 2004, Indonesia's natural gas production reached around 3,030 BCF, a decrease of 4.0 percent from its 2003 production of 3,155 BCF. About 46 percent of Indonesia's natural gas production was converted to LNG for export, while the rest was used to supply the domestic demand and exported through pipeline. In the domestic market, about 47 percent are utilized by industry and electricity, while 39 percent are used for gas injection and fuel on the field. The rest of the domestic supply is utilized either as city gas (9 percent), or in refineries (3 percent). About 90 percent of the gas exported is exported as LNG, 4 percent as LPG and 6 percent as piped gas. Of the exported LNG, around 69 percent went to Japan, 19 percent to Korea and 12 percent to Chinese Taipei. Despite the availability of natural gas in Indonesia, its domestic use is still relatively under-developed.

As for coal, Indonesia’s total recoverable reserves are estimated at 4,968 million tones. More than half of them is lignite (about 57 percent), 27 percent is sub-bituminous, 14 percent bituminous and less than 0.5 percent is anthracite. Based on a recent assessment of Indonesia's coal reserves, 10 more coal basins were identified which contain 336 tcf of Coal Bed Methane (CBM). The major coal reserves in Indonesia are located in the islands of Sumatra, and Kalimantan, while some reserves are also found in West Java and Sulawesi. Indonesian coal generally has a heating value ranging between 5,000 - 7,000 kcal/kg, with low ash and sulfur levels. The sulfur content of Indonesian coal is below 1 percent. In 2004, Indonesia has produced about 132 million tones of coal, an increase of 16 percent from its production in 2003 of 114 million tons. Most or about 70 percent of production was exported, about 70 percent to Japan, South Korea and Chinese Taipei. Indonesia plans to double its coal production, eyeing other economies in East Asia and India as potential markets.

Indonesia has 21,882 MW of installed generating capacity in 2004, of which it has generated about 120,161 GWh of electricity. Most of the electricity generated came from thermal (86.4 percent), while the rest were supplied by hydro (8.1 percent) and geothermal and others (5.6 percent).

(2) Final Energy Consumption

Indonesia's final energy consumption increased to 79,124 ktoe in 2004 from 65,741 ktoe in 2003. The increase was mainly because of greater consumption in industry, and moderate consumption in the transport sector compared with that of 2003. The industry sector’s final energy consumption accounted for 39 percent of final energy consumption in 2004, an increase of 63 percent compared with 2003. The increased energy consumption in industry sector was mainly because of new investment in the industry sector and completion and operation of new coal fired power plants. Likewise energy consumption in the transport sector accounted for 29 percent of final energy consumption in 2004, 7 percent higher than 2003. The remaining 32 percent was consumed by the commercial/ residential and other sectors.

The most important end use fuel was oil, accounting for 60 percent of consumption, followed by gas at 18 percent, electricity at 11 percent and coal at 9 percent. Despite many efforts to reduce oil consumption, Indonesia oil consumption in 2004 increased by 22% to reach 48,138 ktoe from 39,434 ktoe in 2003.

3.2 Geothermal Development Situation and Geothermal Development Policy

3.2.1 Current Situation and Trend of Geothermal Development

Indonesia may have the highest geothermal power potential of any nation in the world. Trial calculation indicates that forty percent of geothermal energy (equivalent of approximately 27,000 MW) in the earth’s crust is released in Indonesian archipelago and neighboring areas. (Table 3.2.1-1, Table 3.2.1-2)

The development of the geothermal power has been strongly expected to meet the increasing electric power demand and the viewpoint of the diversification of the energy source. Today, geothermal power development has been promoted in seven (7) fields such as Kamojang, Darajat, Wayang-Windu, Salak in western Java, Dien in central Java, Sibayak in north Sumetra, and Lahendong in north Sulawesi. The generation capacity has reached 857MW. (Fig.3.2.1-1, Table3.2.1-3, Fig.3.2.1-2) Although this development is the fourth largest one in the world, Indonesia is far behind from well exploiting this huge potential of geothermal energy. (Table 3.2.1-4)

It is only 30 years since the first development of geothermal energy was performed. In 1974, the Indonesian Government issued Presidential Decree No.16/1974 to bestow the right of geothermal development on PERTAMINA. In 1981, PERTAMINA was allowed to develop geothermal energy in a new form of partnership with private companies (Joint Operation Contract (JOC) system) by the issuance of Presidential Decree No.22/1981. This JOC contract system enabled domestic and overseas private companies to enter geothermal development in Indonesia. Furthermore, in 1991, the government issued Presidential Decree No.22/1981 to allow PERTAMINA to expand its business to the downstream power generation business in JOC system. This measure substantially paved the way for private company to participate in the electric power generation business as Independent Power Producer (IPP). In order to support this private participation in geothermal development from the financial sides, President Decree No.49/1991 was issued to reduce tax rate in geothermal power generation business from 46 % to 34%.

This measure remarkably accelerated the geothermal development in 1990s. In addition to the above mentioned measure, there were other favorite factors such as: (1) the selling price of electricity was on a relatively high level, (2) sales were done on US dollar base, and (3) there were the payment guarantee of government. However, in the turmoil of Indonesian Rupee fall and the financial difficulties of PLN after the crisis of Asian currency, the IPP contracts of geothermal development were reconsidered and renegotiated. As a result, the buying price of PLN was greatly reduced, and in this process many IPP enterprises have withdrawn from Indonesia.

Through this renegotiation process, the government concluded that it is not appropriate to allow PERTAMINA to monopolize geothermal development, and issued Presidential Decree No.76/2000 (The presidential decree on the use of geothermal energy for power generation) in July 2000. This Presidential decree abolished Presidential Decree No.45/1991 and annulled JOC development system between PERTAMINA and private company except the already signed contract. Also, in October 2003, the government enacted ‘Geothermal Law’ and stipulated that geothermal energy is a national asset and government/regional governments shall control its development. The law also clarified the procedures for private enterprises to participate in geothermal energy development.

As for PERTAMINA which is responsible for development of wide range of energies such as petroleum, natural gas and geothermal energy, the government recognized that the organization and business range of PERTAMINA had become too large to carry out efficient management. With the enforcement of new Oil and Gas Law, No.31/2001, in September 2003, Indonesian Government relegated PERTAMINA to the state of PT. PERTAMINA (Persero). As a part of this reorganization, geothermal business is transferred to PT. PERTAMINA Geothermal Energy (PGE), a subsidiary company of PERTAMINA. As the Presidential Decree No.76/2000 goes into effect, PERTAMINA became one of the developers. Also, it is declared that PERTAMINA should return the geothermal development right to the government for the areas where the development is not yet started.

While preceding these reforms on the one hand, Indonesian Government has decided to promote the development of renewable energies on the other hand. For this purpose, in 2002, National Energy Policy (NEP) is formulated, and it was decided that the energy supply by renewable energy be made more than 5%. And in 2006, “The Presidential Decree on the National Energy Policy” is issued and the national energy policy is enhanced as the high-leveled national policy. In this decree, energy mix in the year of 2005 is shown as a policy target and the percentage of geothermal energy is estimated as more than 5%. In 2004, the Ministry of Energy and Minerals Resources worked out “Road Map Development Planning of Geothermal Energy for 2004- 2020”, and announced officially that the target of geothermal energy development is 6,000MW by 2020. This target was enhanced in 2005 to 9,500 MW by 2025.

3.2.2 The National Energy Policy (NEP)

Stable energy supply is essential for achieving social and economic development in any nations. In most countries including Indonesia, domestic energy demand is met mostly from fossil energy sources, particularly for oil while proven reserve of oil is limited in the world. In Indonesia, the contribution of oil was approximately 88% in 1970.   Although the share of oil has gradually decreased to 54% in 2002, the total oil consumption is relatively high with the growth rate of 6.1% per year. This higher growth is attributed to the economic growth and population growths. However, the per capita energy consumption was relatively low or about 311.6 KOE (kilo gram of Oil Equivalent) per capita, while the energy intensity is 108.3 KOE/thousand US$ (at 1995 US$). On the other hand, the renewable energy of Indonesia has very big potential. However, the development is not well developed compared to this big potential.

Realizing present energy condition, the government launched the National Energy Policy (NEP) in 2002.   The vision of this policy is “to guarantee the sustainable energy supply to support national interest”; while the missions are:

(a) guaranteeing domestic energy supply,

(b) improving the added value of energy sources,

(c) managing energy ethically and sustainable way and considering prevention of environment function,

(d) proving affordable energy for the poor, and

(e) developing national capacity.

The targets of NEP are:

(a) improving the role of energy business toward market mechanism to increase added value,

(b) achieving electrification ration of 90% by the year 2020,

(c) reaching renewable energy (non large hydro) energy shares in energy mix at least 5% by 2020,

(d) realizing energy infrastructure, which enable to maximize public access to energy and energy use for export,

(e) increase strategic partnership between national and international energy companies in exploring domestic and export energy resources,

(f) decrease energy intensity by 1% per year therefore to the elasticity to be 1 by 2020, and

(g) increase the local contents and improving the role of national human resources in the energy industries.

To reach this energy targets, strategy have to be taken namely:

(a) restructuring energy sector,

(b) implementing market based economy,

(c) developing regional empowerment in energy sector,

(d) developing energy infrastructures

(e) improving energy efficiency,

(f) improving the role of national energy industry,

(g) improving national energy supporting activities (service and industries), and

(h) empowering community.

To ensure the achievement of the targets, the policy measures to be pursued are:

(a) intensification measure is taken to increase the availability of energy in parallel with the national development and population growth,

(b) diversification measure is taken to increase coal and gas shares, which have a larger potential than oil and to increase renewable energy shares, which has a huge potential and clean ,

(c) conservation measures is taken to improve energy efficiency by developing and using energy saving technology both in upstream and down stream sides.

In line with the strategies, several action plan have to be done:

(a) upstream side(oil, gas, coal, geothermal, hydro power, other renewable energy resource, nuclear energy, other new energy resources),

(b) downstream side (petroleum, gas pipeline, gas fuel, and LPG, electricity),

(c) energy utilization (household, and commercial sector, industry sector, transportation sector) ,

(d) human resources development ,

(e) research and development , and

(f) community development in supplying energy to empower the local society.

3.2.3 Presidential Decree on "National Energy Policy" (PD No.5 / 2006)

In 2006, the above-mentioned National Energy Policy was enhanced to be a higher level of national policy by Presidential Decree. Specifically, the President of Indonesia issued the Presidential Decree of "The National Energy Policy (PD No.5/2006)" on 25, January, 2006, in order to "guarantee the stable energy supply to the domestic market for sustainable socio economic development".

This Presidential Decree clarifies the concrete target of national energy policy such as :

(a) Energy elasticity (the ratio between the rate of energy consumption increase and the rate of economic growth) should be less than 1 by the year of 2025. (Fig.3.2.3-1)

(b) Achievement of the following energy mix in 2025 (Fig.3.2.3-2)

1) Oil 20% or less

2) Gas 30% or more

3) Coal 33% or more

4) Bio-fuel 5% or more

5) Geothermal 5% or more

6) Other new and renewable energy (especially, biomass, nuclear power, hydro power, photovoltaic, wind power etc.)

5% or more

7) Liquefied coal 2% or more

Moreover, the decree states that this policy target will be achieved by the main policies and the support policies, and that the main policies are:

(a) Energy supply policies to secure stable energy supply to domestic market and to optimize energy production, etc.

(b) Energy utilization policy to improve energy efficiency and to diversify energy sources,

(c) Energy price policy to aim at economic price (although some support to the poor people will be considered.), and

(d) Environmental policy to apply sustainable development principle.

As for the supporting policies, the decree indicates the following four policies (Article 3):

(a) Energy infrastructure development,

(b) Partnership between government and business society,

(c) Empowerment to people, and

(d) Research & development and educational & training.

In addition, the decreed states that the government may support the development of the specified alternative energy sources and may grant the incentives to the developers of the energy sources (Article 6).

The setting of clear target in the level of presidential decree provides the people concerned to geothermal energy with high expectations for further development of geothermal energy in Indonesia.

3.2.4 The Geothermal Energy Law (Law No.27/2003)

Today, Indonesia becomes a pure oil importing country because of the rapid increase of domestic energy demand led by economic recovery and social development. Moreover, it is estimated that the remaining oil production period might be about ten years if the present oil production level continues. Therefore, the government is promoting the national energy policy which aims at diversifying energy resource form oil dependency system to multi-source supply system. Among many energy sources, geothermal energy is;

(a) domestically produced energy,

(b) stable power supply which shows a high availability,

(c) the energy source which exists in local areas, and is indispensable energy source necessary for local development,

(d) environmentally-friendly energy, and

(e) the energy source which contributes to regional society and local industries through supplying hot water for multi purpose usage.

However, Indonesian geothermal development had been promoted without sufficient legal base. Therefore, it became widely understood that Indonesia needs a legal base to attract more private investors in geothermal development activities in the future. On October 23, 2003, the Indonesian government enacted "Geothermal Energy Law (No.27/ 2003)" which consisted of 44 Articles in 15 Chapters.

This regulation provide certainty of law to the industry because the huge potentials of Indonesia’s geothermal resources and its vital role to ensuring Indonesia’s strategic security of energy supply, and its ability to add value as an alternative energy to the fossil fuel for domestic use. This law regulates the upstream of geothermal business. The downstream business that engages in electric power generation is to be subject to the Electric Law No. 20/2002.

This law has the following Vision, Mission and Objectives:

<Vision>

Geothermal energy plays an important role as a renewable natural resource of choice among the variety of national energy resources to support sustainable development and to help bring about a prosperous society.

<Mission>

To manage geothermal energy resource development as mandated by the law:

To encourage and stimulate geothermal energy activities for the sustainable fulfillment of national energy needs.

To reduce dependency on oil-based fuels, thereby conserve oil reserves

<Objectives>

control the utilization of geothermal energy business activities to support sustainable development and provide overall added value

Increase revenue for state and the public to support national economy growth for the sake of increased public prosperity and welfare.

It is thought that the enactment of this geothermal power law has the following meaning.

(a) The procedure of the geothermal development is clarified, and becomes transparent in the following actions:

(i) Designation of the Working Area for geothermal development,

(ii) Issuance of Geothermal Energy Business Permit (IUP), and

(iii) Tendering for Working Areas etc.

(b) The system to spur development is built-in in the following actions:

(i) Setting the period of IPU,

(ii) Obligation to return IPU in case that the development does not finish within a certain period after obtaining IPU, and

(iii) Obligation to report the development plan to the authority and the administrational order to change the development plan if necessary by the authority etc.

(c) The role of state government and regional government is clarified in such areas:

(i) Management of geothermal resources and geothermal data,

(ii) Management of balance between the amount of resource and the amount of development,

(iii) Preparatory investigations,

(iv) Issuance of IUP, and

(v) The possibility of participation in geothermal development by state-run enterprises

These clarifications are very important from the viewpoint to invite private company's participation. The good administrational management to secure the policy intention is expected. One of the most remarkable regulations in this new law is the obligation of preliminary survey by the state government. Article 10-1 of the law classifies the geothermal development activity into the following five stages: (i) Preliminary survey, (ii) Exploration, (iii) Feasibility Study, (iv) Development, and (v) Utilization. Among these activities, Article 10-2 states that state government or the regional government are to execute preliminary survey in their jurisdictions. Namely, state government will execute preliminary survey which shows the potential of the area and thus attracts private companies to take part in. Especially as state government (Ministry of Mineral Resources and Energy) has a responsibility of designate the geothermal working areas, information should be gathered for a promising region by the Ministry. The Ministry therefore needs to carry out preliminary survey which includes 2 to 3 of test wells. By this preliminary survey by the government, the geothermal development working area, which is the base of this new law, will be set appropriately. Additionally, an initial resource development risks will be greatly reduced. As this result, private companies can be expected to participate. (By the way, both the private sector and the public sector can carry out the business after exploration stage. This can be understood that there is some room where the public sector can carry out geothermal development in areas necessary to develop from the view point of national interest.(Fig.3.2.4-1)

3.2.5 "Geothermal Development Target" and "Road Map Development Planning of Geothermal Energy”

With the setting of National Energy Policy and the enactment of Geothermal Law, the Indonesian government set the development target for geothermal energy in the future. In the National Energy Policy, it is mentioned that "5% or more of the power generation will be made from renewable energy sources by 2020". As the development of large-scale hydro power is renounced due to environmental reasons, geothermal energy is requested to play the most important role to achieve the renewable energy development target. Ministry of Mineral Resources and Energy set the target of "6,000MW of geothermal development by 2020" from such a background.

And, the Ministry compiled the "Road Map Development Planning of Geothermal Energy for 2004-2020” to achieve this development target in June, 2004. This road map aims at the development of 6,000MW by 2020. It also describes the problems and measures to achieve this target. According to this road map, the governmental survey to grasp and to evaluate the amount of the resources is pointed out as one of important issues. As for the development target, the government has enhanced the target to be "9,500MW of geothermal development by 2025" in 2005 (Table3.2.5-1).

3.2.6 Establishment of "Directorate General of Minerals, Coal and Geothermal” and “Geological Agency” in Ministry of Mineral resources and Energy

The Indonesian government has worked out new geothermal policy one after another in these 2 to 3 years. In addition to this, the government modified the organization of Ministry of Mineral Resources and Energy. The Ministry started new organization, “Directorate General of Minerals, Coal and Geothermal”, which takes the responsibility for the geothermal development policy as well as coal development policy. This new organization replaces the old Directorate General of Geology & Mineral Resources. Moreover, the Ministry changed “Directorate of Geology Environment & Mining Area” into the new organization of "Directorate of Geothermal & Groundwater". Moreover, a new organization, which is responsible to carry out the geological survey by the government, was also established as "Geological Agency" in the Ministry. This organization change was nominally done in December, 2005. However, the actual administration work has substantially started since May, 2006. By these newly established authorities, a consistent, effective, efficient and powerful geothermal development policy is expected. (Fig.3.2.6-1)

As for PERTAMINA, the government has decided to split the company into three independent companies of oil, gas and geothermal development business and to establish the holding company of these companies so as to optimize workforce and to clarify each responsibility. It is a result of implementing the new Oil and Gas Law (No. 22/2001) and Government Regulation No.31/2003. According to the Governmental Regulation, PERTAMINA has to transfer the commercialization of geothermal energy to its subsidiary company. As a result, the establishment of PT. PERTAMINA Geothermal Energy (PT. PGE), as its subsidiary company, was declared in December, 2006.

In addition, BAPPENAS organized the meeting comprised of related ministries (Steering Committee) to support geothermal development in 2005. BAPPENAS is planning to support geothermal development through this official and unofficial meeting.

Thus, the geothermal development in Indonesia has newly started with a series of policy announcements. The expectation for geothermal energy development in Indonesian Government is rising today.

3.2.7 Electric Sector Reform in Indonesia

In Indonesia, the electricity business had been regulated by Electricity Law No. 15/1985. Under the Law, PLN was charged with the exclusive task of undertaking electricity supply to the public although they could co-operate with other parties after receiving the Energy Minister's consent. The initial step in restructuring power market began in 1994 through the conversion of PLN corporate status from states owned agency with a social purpose to a Limited Liability Company. Restructuring efforts continued in 1995 through the unbundling of PLN's Java-Bali generation, distribution and transmission assets. Generation assets were unbundled into two generation companies, called PJB and Indonesia Power. A distribution unit was separated into four distribution units (East, West and Central Java and Jakarta). Each distribution units operates as semi- autonomous, where they receive funds allocation to cover their operational expenses in order to meet performance as set out in contract with headquarter. Java-Bali transmission is transfer to Java-Bali Electricity Transmission unit and load dispatch center as a subsidiary of generation unit. Structure market becomes a single buyer market, where PLN transmission unit buy the power from PLN generators and IPPs. Outside Java and Bali islands, restructuring takes place in form of decentralization of PLN.

To precede electric power sector reform, Indonesia government promulgated new Electricity Law No. 20 in 2002. Under this new law, the private investors will be allowed to enter electricity sector. With this new law, Indonesian government planed to liberate the electricity market by 2007. To supervise the electricity market, the Government of Indonesia established a Power Market Supervisory Agency called BAPETAL (Badan Pengatur Tariff Listrik). The power industry watchdog would determine which province in the economy is ready for market competition, and which would remain under government control. The supervisory body would be in charge of ensuring fair market competition for mid size and large size consumer and determining power prices for small users. Java, Madura, Bali (Jamali) and Batam islands would become the first areas open market competition will be applied.

However, in December 2004, the Indonesian Constitution Court annulled the Electricity Law No. 20/2002 on the basis that the law contravened the Indonesian Constitution by permitting full competition in the electricity business. The Court referred to Article 33 of the constitution which are state that "economic sector which are important to the state and crucial for the welfare of the people are controlled by the state and must be developed to give the maximum benefit to the people". The Court re-instated the defunct Electricity Law No.15/1985 to maintain legal certainty following the annulment of the 2002 law. However, any contracts made by the government under the 2002 law remains in effect.

Under such situation, the government issued Governmental Regulation No. 3/2005 (GR 3/2005) on 16 January 2005, and announced that there would be a new electricity law in the near future. The GR 3/2005 is formally an amendment to Governmental Regulation No 10/1989 of the 1985 law, but is substantially able for the private sector to enter the electric power business.

3.2.8 Private Participation Method to Power Sector

Governmental Regulation (No.3/2005) confirms that electricity supply is controlled by the State and is managed by a state-owned enterprise appointed based on a Government Regulation as the holder of the Electricity Business Operation Authority (PKUK) in supplying electricity for the public use. The Minister determines the business area for the PKUK (Article 3). The GR3/2005 also states that the electricity power supply and usage is based on the Comprehensive National Electricity Plan (RUKN), which is to be determined by the Minister (Article 2). Article 7 of the GR 3/2005 states that the holder of PKUK should secure electricity supply in their business areas (Article 11 (2)).

Regarding the private participation in the power sector, the GR 3/2005 stipulates the following articles (Fig.3.2.8-1);

- As long as it does not infringe the benefit of sates, the Electricity Business Operation License for the Public Use (PIUKU) or the Electricity Business Operation License for the Own Use (IUKS) may be issued to any entity. The eligible entity includes corporative, local public entities, private enterprises and individuals. (Article 6 (1) – (3)).

- The PIUKU and/or IUKS are to be issued only in the following cases (Article 6 (7));

    - The holder of PKUK or PIUKU can not supply the electricity in the area, or

    - The holder of PIUKS will supply electricity more economically.

- The holder of PKUK or PIUKU may purchase electric power and/or rent networks from other properly licensed enterprise after the consent of Minister or the Governor of the Region (Article 11 (3), (4)).

- This purchase and/or rent should be done through a public tender

(Article 11 (5)).

- However, the purchase of electricity can be done by a direct appointment in the case of purchases from generation using renewable energy source, marginal gas, coal at mine mouth and other local energy resources, purchases of excess electricity, and in case of a critical power supply situations (Article 11 (6)). (To clarify the term of renewable energy, Ministerial Regulation No. 9 / 2005 is issued and it states that the renewable energy includes mini/micro hydro, geothermal, biomass, wind-power, solar power. (Article 16 of MR No. 9/2005))

- The purchasing price and/or rent fee should be in terms of Rupia. The price and/or rent fee can be adjusted by the changes of cost factors. The price and/or rent fee should be approved by Minister, Governor of the Region (Article 32 A),

According to these series of Government Regulations and Ministerial Regulations, an enterprise which intends to sell electric power generated by geothermal source can enter a negotiation of Power Purchase Agreement with PLN without being chosen in the open bidding procedure. Ministerial Regulation No.9/2005 stipulates that PLN can propose an electric power purchasing plan to Minister with reasons. It also states that the geothermal power generation enterprise can propose the electric power sales plan to PLN (Article 16). The MR No.9/2005 states that Power Purchase Agreement including the price of electricity should be negotiated within 90 days (Article 17).

The power generation project implementable without tendering is called “unsolicited project”. On the other hand, the project of which investor is decided by the open tendering is called “solicited project”. In Indonesia, a lot of unsolicited projects had been carried out during 1990's. And the electric power price of many of them turned to be expensive after the economic crisis in 1997. Therefore, Government of Indonesia deems that these uncontrolled unsolicited projects had been one of the reasons of PLN’s financial deterioration. To avoid the same situation happen, Government Regulation No.3/2005 intends to control the number of unsolicited projects in which private investors will participate. The GR No.3/2005 also expects to secure the transparency of selecting investors through open tendering. Moreover, it expects that the electric power price will become lower through the tendering process. By the way, in the process of open tendering for the solicited projects, the highest bidder is decided in consideration of its financial base, its technological ability, the proposal electric power sales price, and the construction schedule etc. It is assumed that the negotiation of electric power sales price and the conditions of Power Purchase Agreement should end within 90 days.

Regarding the price of electricity purchase, the Ministerial Regulation No. 9/2005 further states that the price of electric generated from a certain capacity of renewable energy source will be determined by Ministerial Regulation (Article 19, MR No.5/2005). Based on this regulation, Ministerial Regulation No. 2/2006 is issued.

3.2.9 Investment Environment of Indonesia

As for the private investment in electric power sector, the general investment regulations are applied in addition to the regulations related to electric power business. The general regulations for foreign direct investment are as follows.

(1) Legal Aspect

There are several legal aspects to be considered. They are;

(a) Foreign Capital Investment Law (Law No. 1 / 1967)

Foreign Direct Investment (FDI), further referred to as Penanaman Modal Asing (PMA), is a status of doing business and governed primarily by the Foreign Capital Investment Law No. 1 of 1967, as amended by Law No. 11 of 1970. Based on the law the government has been introducing various policies and measures on FDI where now great efforts are given to promoting FDI in Indonesia.

The PMA company is granted a period of 30 years to operate after its legal formation. If within the said period of time it commits an additional investment (expansion of its project), another 30 years of time is granted for the expansion project. This period can be extended for another 30 years.

(b) Domestic Capital Investment Law (Law No. 6 / 1968)

Domestic Direct Investment, further referred to as Penanaman Modal Dalam Negeri(PMDN), is a status of doing business for entirely owned by Indonesian capital either jointly between company(ies) or individual(s) governed primarily by the Domestic Capital Investment Law No. 6 of 1968, as amended by Law No. 12 of 1970.

(c) Corporate Law (Law No. 1/ 1995)

The most common legal entity to business community is a Corporate Company, Perseroan Terbatas (PT), no matter whether they are foreign direct investments or domestic direct investments.

(d) The Government Regulation No. 20 of 1994 on Share Ownership.

In general a PMA company is established as a joint venture between foreign and Indonesian partners. The partnership may involve legal entities (corporations) or individual persons.

In case of infrastructure projects such as ports, generation and transmission as well as distribution of electricity for public use, telecommunications, shipping, airlines, potable water, public railways and nuclear electric power generation, PMA company should be established by way of joint ventures between foreign and Indonesian state-owned enterprise. Therefore, a enterprise which intends to carry out geothermal development needs to form a joint venture with a state company.

In general case other than the above-mentioned PMA companies, there is no requirement on the minimum amount of investment (equity plus loan). The amount is for the parties concerned to determine, based on their economies of scale and business considerations. A PMA company may be established as a straight investment, or 100 % foreign ownership. It is required, however, that not later than 15 years of commercial operation, the company starts to be divested by selling some of its shares to Indonesian individual(s) and/or business entities, through direct placement and/or indirectly through domestic stock exchange provided that the Indonesian share is maintained at least 5 %.

(2) Taxation

(a) Income Tax

Income tax in Indonesia is progressive and applied to both individual(s) and enterprises. A self-assessment method is used to calculate the tax.

Tax Rates for Enterprise(ies)

Taxable annual income	Tax rate
Up to Rp. 50 million	10%
Over Rp. 50 million to Rp. 100 million	15%
Over Rp. 100 million	30%

In Indonesia, the 34% of tax rate has been applied to geothermal business.

(b) Losses

Basically the government provides a loss carried forward facility for a period of 5 (five) years.

(c) Depreciation and Amortization Rates

Depreciation cost on assets is deductible from the income before tax. Depreciable assets are grouped into four categories depending on the useful life of the assets. Investors may choose either the straight line method (for periods of less than 20 years) or the fast declining balance method (except for buildings) Depreciation rate is determined according to the useful life and utilization such as :

Physical (Tangible) Asset	Useful Life (Years)	Method of Calculation	
		Straight Line (%)	Double Declining Balance (%)
I. Non Building :			
Group 1	4	25	50
Group 2	8	12.5	25
Group 3	16	6.25	12.5
Group 4	20	5	10
II. Building :			
Permanent	20	5	
Non Permanent	10	10	

(d) Value Added Tax and Sales Tax on Luxury Goods

In normal cases, 10 % Value Added Tax (VAT) is applied to imports, manufactured goods and most services. In addition, there is also sales tax on luxury goods ranging from 10 % to 75 %.

(e) Land & Building Tax

Land & building tax is payable annually on land, buildings and permanent structures. The effective rates are nominal, typically not more than one tenth of one percent per annum (0.1%) of the value of property.

(3) Incentives

(a) Import Duties

All investment projects of PMA as well as PMDN projects which are approved by the Investment Coordinating Board or by the Office of Investment in the respective districts, including existing PMA and PMDN companies expanding their projects to produce similar product(s) in excess of 30% of installed capacities or diversifying their products, will be granted the incentive of import duty relief so that the final tariffs become 5 % for the importation of capital goods namely machinery, equipments, spare parts and auxiliary equipments.

As for the equipment necessary for the geothermal development, Minister of Finance announced the incentive measures of import tax exemption for geothermal power plant machines and equipments which will be imported by July, 2006 on April, 2005. (No.26/PMK.010/2005) The entity eligible for this import duty exemption is PERTAMINA and entities who obtain the geothermal development permission.

(b) Tax Allowance

The government has introduced a Tax Bill No's 16, 17, 18, 19 and 20 of 2000 and applied since January 1, 2001. Based on this tax law, the domestic and foreign investors will be granted tax allowances in certain sector and/or area as follows :

- An Investment Tax Allowance in the form of taxable income reduction as much as 30 % of the realized investment spread in 6 (six) years.
- Accelerated depreciation and amortization
- A loss carried forward facility for period of no more than 10 (ten) years.
- A 10 % income tax on dividends, and possibly being lower if stipulated in the provisions of an existing particular tax treaty.

The government has also introduced provisions No's 146 of 2000 of 2000 and 12 of 2001 on the importation and/or delivery of Selected Taxable Goods, and or the provision of Selected Taxable Services as well as the importation and or delivery of Selected Strategic Goods which are exempted from Value Added Tax

(c) Export Manufacturing

- There are many incentives provided for exporting manufacture products. Some of these incentives are as follows;
- Restitution (drawback) of import on the importation of goods and materials needed to manufacture the exported finished products.
- Exemption from Value Added Tax and Sales Tax on Luxury goods and materials purchased domestically, to be used in the manufacturing of the exported products.
- The company can import raw materials required regardless of the

availability of comparable domestic products.

Table 3.1.1-1 Key Data and Economic Profile of Indonesia

key Data		Energy Reserves(*4)	
Land Area (km^2) (*1)	1,860,360	Oil (MCM)	641.1
Population（million）(*2)	220.6	Gas (BCM)	2,770
GDP（billion US$）(*2)	287.2	Coal (Mt)	4,968
GDP per capita（US$）(*3)	1,302		

（Reference : *1　As of 2004　Statistical Year Book of Indonesia 2004; BPS
*2　As of 2005　Indonesia at a Glance; World Bank, 2005
*3　calculated from *2
*4　As of 2004　APEC Energy Overview 2006; IEEJ）

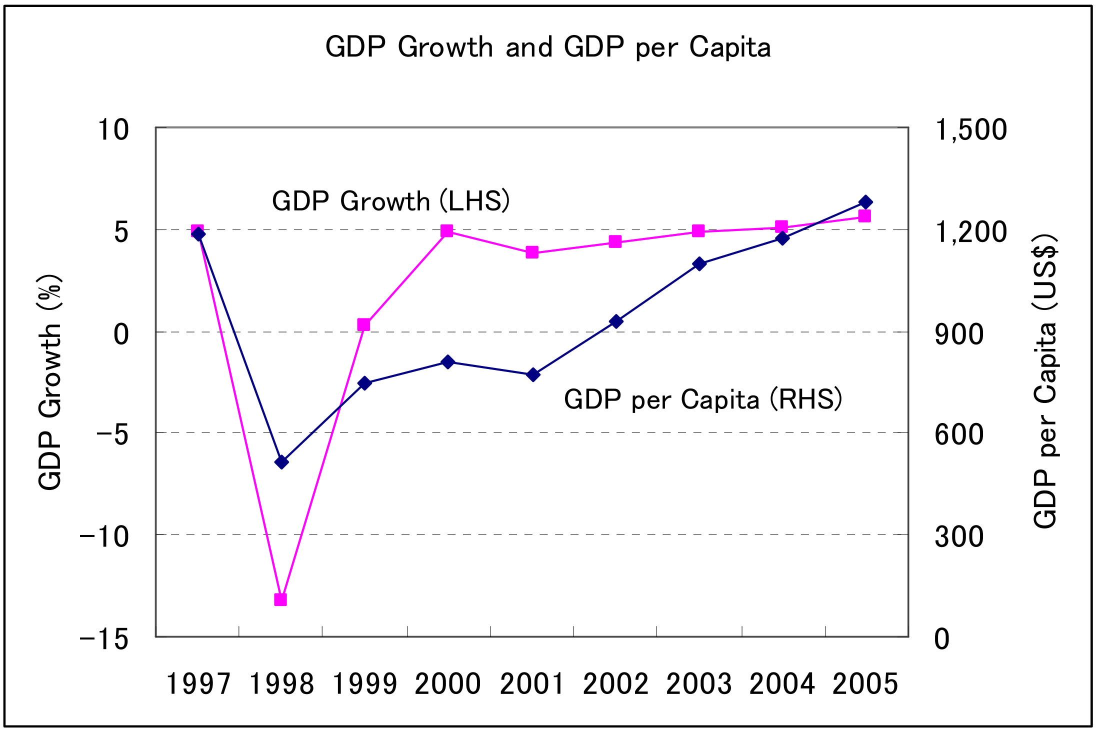


Fig. 3.1.1-1 Growth of GDP

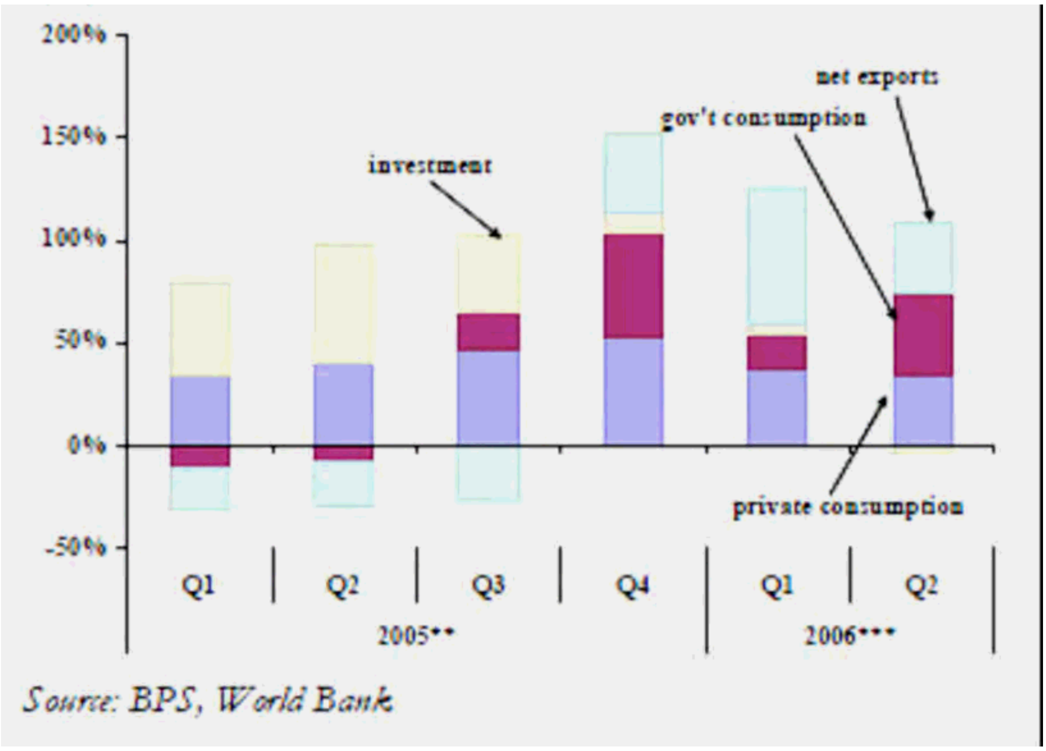
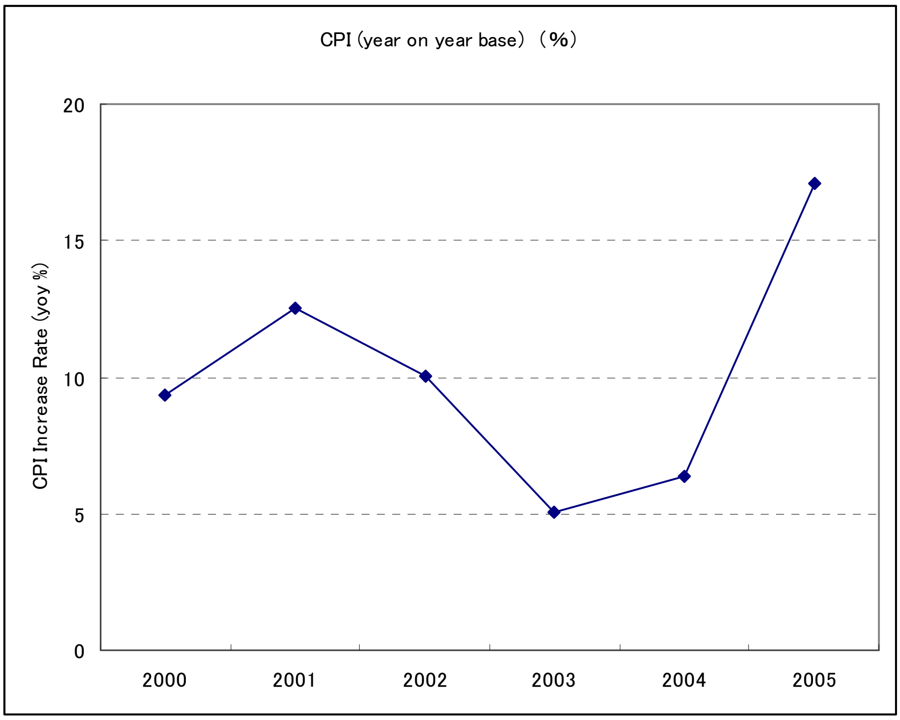
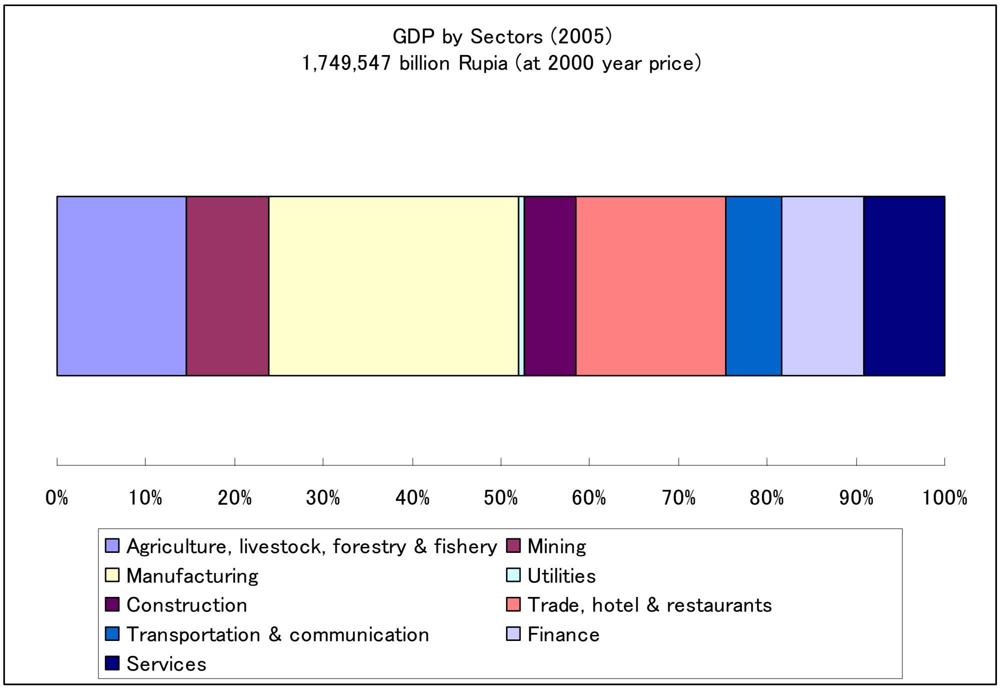


Fig. 3.1.1-2 Source of Growth (year of year growth rate, %)



(Source: BPS)

Fig. 3.1.1-3 Consumer Price Index Increase (year on yea)



(Source: BPS)

Fig. 3.1.1-4 GDP by Sectors (2005)

Table 3.1.1-2 Growth by Sector and Category

	2003	2004	2005	2006 (H1)
Tradable	**3.8%**	**3.5%**	**3.5%**	**3.7%**
Agriculture	4.3%	4.1%	2.5%	4.5%
Mining	-0.9%	-4.6%	1.6%	4.5%
Manufacturing	5.3%	6.2%	4.6%	3.1%
Non-Tradable	**6.2%**	**7.1%**	**8.0%**	**6.3%**
Construction	6.7%	8.2%	7.3%	7.7%
Finance	7.0%	7.7%	7.1%	5.2%
Transport & Commu.	11.6%	12.7%	13.0%	12.2%
Utility	5.9%	5.9%	6.5%	5.7%
Trade, Hotel & Restaurant	5.3%	5.8%	8.6%	4.7%
Services	3.9%	4.9%	5.2%	5.7%
Total	**4.9%**	**5.1%**	**5.6%**	**5.0%**

(Source: Economic and Social Update, World Bank)

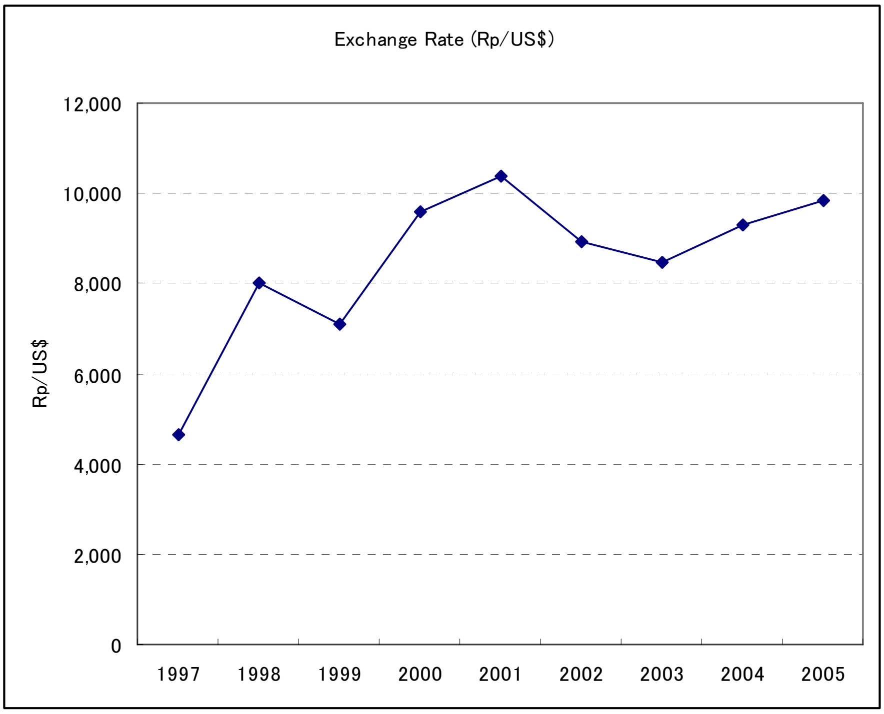


Fig. 3.1.1-5 Exchange Rate of Rupia (to US Dollar)

Fig. 3.1.1-6 Market Confidence is back (Rupia exchange rate and stock index)

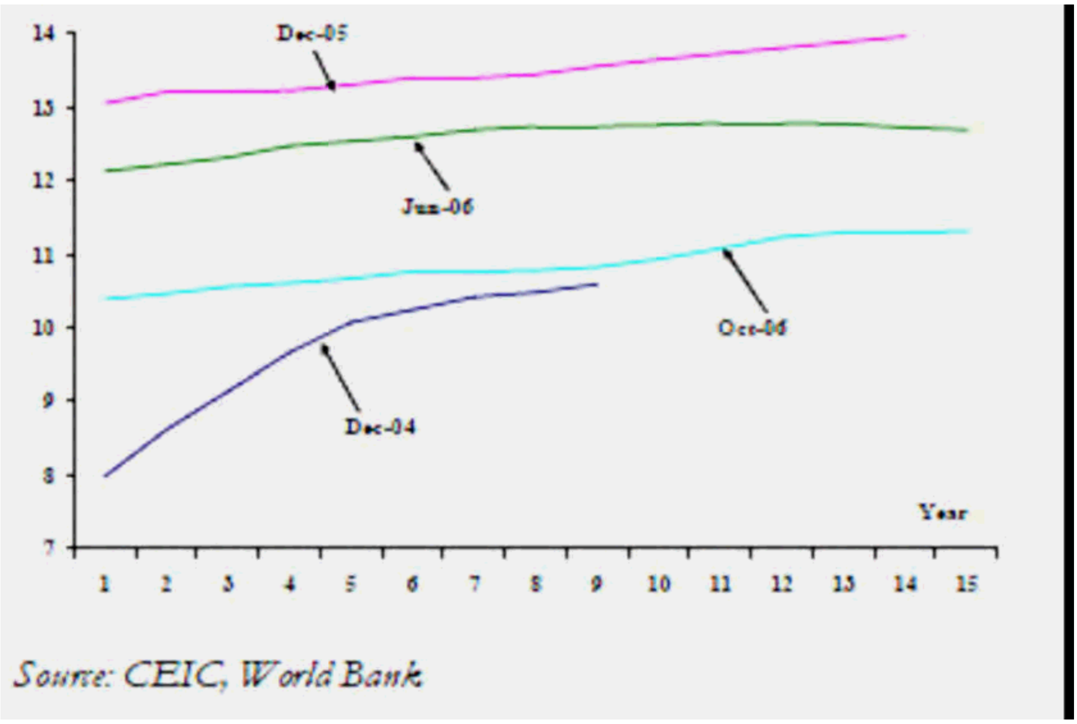
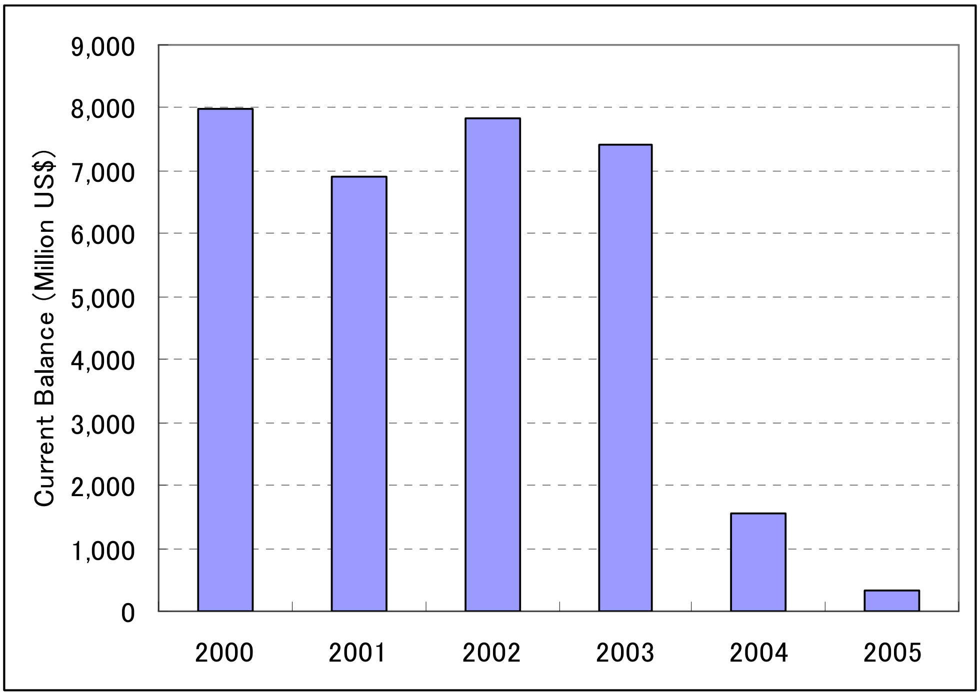


Fig. 3.1.1-7 Declining Interest Rates (Domestic bond yield curve, percent)



(Source: JETRO data base)

Fig. 3.1.1-8 Current Balance

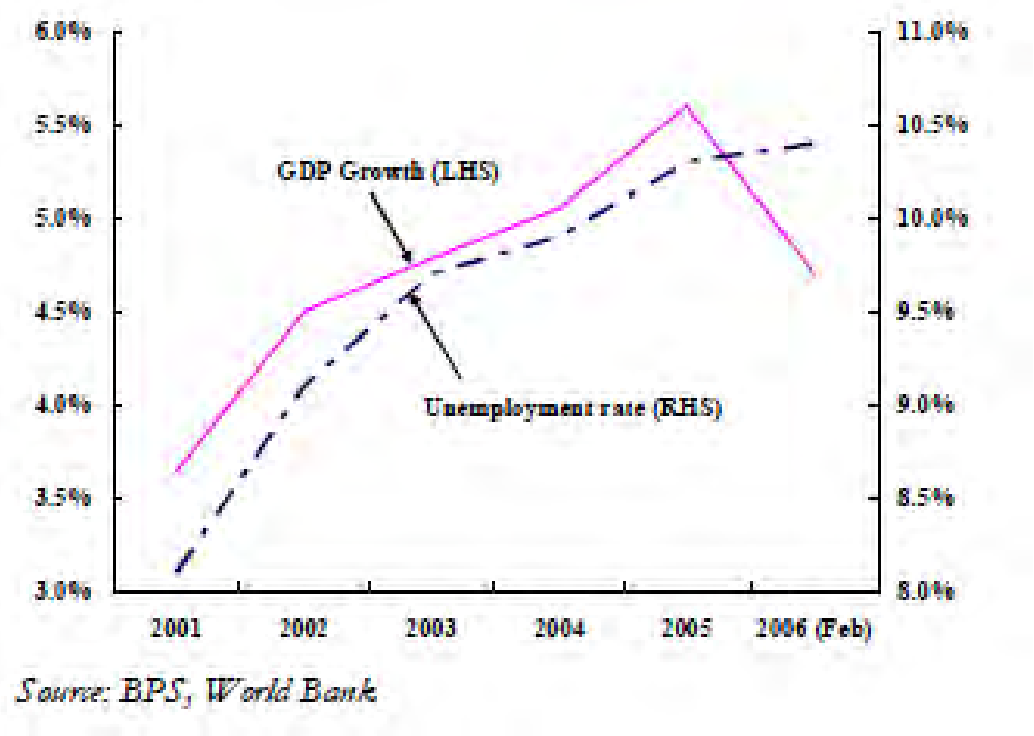


Fig. 3.1.1-9 Rising Unemployment Rate (Growth rate and unemployment rate)

Table 3.1.2-3 Energy Supply and Consumption in 2004

Primary Energy Supply (kTOE)			Final Energy Consumption (kTOE)			Power Generation (GWh)	
Domestic Production		201,596	Industry Sector		31,444	Total	120,161
Net Import & others		- 72,740	Transport Sector		22,623	Thermal	103,812
Total PES		128,856	Other Sectors		25,057	Hydro	9,674
Break Down	Coal	20,983	Total FEC		79,124	Nuclear	—
	Oil	58,570	Break Down	Coal	7,186	Others	6,675
	Gas	42,478		Oil	48,138		
	Others	6,555		Gas	14,682		
	Total	128,856		Electricity &others	9,117		
				Total	79,124		

(Source : Energy Data and Modeling Center, IEEJ (http://www.ieej.or.jp/egeda/database-top.html))

Table 3.2.1-1 Indonesia Geothermal Potential

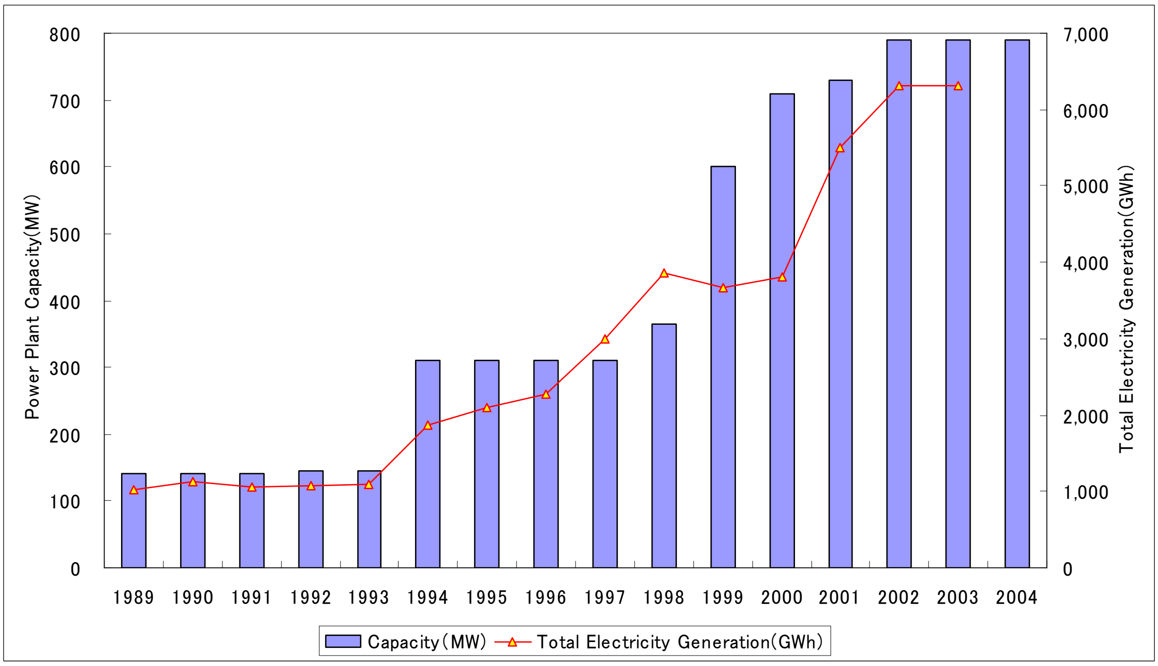
Location	Resources (MWe)		Reserve(MWe)			Installed Capacity
	Speculative	Hypothetic	Possible	Probable	Proven	
Sumatra	5,705	2,433	5,419	15	499	2
Java-Bali	2,300	1,611	3,088	603	1,727	835
Nusa Tenggara	150	438	631	–	14	–
Sulawesi	1,000	125	632	110	65	20
Maluku/Irian	325	117	142	–	–	–
Kalimantan	50	–	–	–	–	–
Total	9,530	4,714	9,912	728	2,305	857
	14,244		12,945			
251Location	Total 27,189					

(Source : "Current State of Geothermal Development in Indonesia", Dr. Dwipa SJAFRA,)

Table 3.2.1-2 Energy Resources in Indonesia and the World

Energy	Resource	Share in the World	Proven Resource (R)	Annual Production (P)	Remarks
Oil	321 Billion Brr	1.20%	5 Billion Brr	500 Million Brr	R/P = 10 years Exportable
Natural Gas	507 TSCF	3.30%	90 TSCF	3 TSCF	R/P = 30 years Exportable
Coal	50 Billion Tones	3%	5 Billion Tones	100 Million Tones	R/P = 50 years Exportable
Hydro	75,000MW	0.02%	75,000MW	4,200 MW	No development of large scale hydro power plant
Geothermal	27,000MW	40%	2,305MW	857 MW	

(Source : Road Map Development Planning of Geothermal Energy for 2004-2020; MEMR)



(Source: PERTAMINA Geothermal Development)

Fig. 3.2.1-1 Plant Capacity and Electricity Generation of Geothermal Energy in Indonesia

Table 3.2.1-3 Geothermal Power Plant in Indonesia and its Development Scheme

Power Plant	Location	Unit No.	Capacity(MW)	Start of Operation	Steam Developer	Power Generator
Kamojang	West Jawa	Unit- 1	30MW	1983	Pertamina	PLN
		Unit- 2	55MW	1988		
		Unit-3	55MW			
Salak	West Java	Unit-1	60MW	1994(*5)	Pertamina/ Chevron Geothermal of Indonesia (*1)	PLN
		Unit-2	60MW			
		Unit-3	60MW			
		Unit-4	66.7MW	1997(*5)	Pertamina / Chevron Geothermal of Indonesia(*1)	
		Unit-5	66.7MW			
		Unit-6	66.7MW			
Darajat	West Java	Unit-1	55MW	1994	Pertamina/Amoseas Indonesia Inc.(AI)(*2)	PLN
		Unit-2	90MW	1999	Pertamina / Amoseas Indonesia Inc.(AI) (*2)	
Lahendong	North Sulawesi	Unit-1	20MW	2001	Pertamina	PLN
Sibayak	North Sumatra	Unit-1	2MW	2000	Pertamina	
Wayng-Windu	West Java	Unit-1	110MW	2000	Pertamina / Magma Nusantara Ltd (MNL) (*3)	
Dieng	Central Java	Unit-1	60MW	2002	Geo Dipa (*4)	
Total			857MW	（Break Down）	PLN Power Plant（395MW） IPP Power Plant （462MW）	

（Source：Pertamina; "Pertamina Geothermal Development（Resource & Utilization）"）

(Note) *1 Chevron took over Unocal (Union Oil Company of California), who was the original developer of Salak on Aug. 2005 .

*2 Amoseas Indonesia Inc. is a subsidiary of U.S.-based Chevron Texaco.

*3 Magma Nusantara is a wholly owned subsidiary of Star Energy. Star Energy acquired W'ayang-Windu in Nov. 2004.

*4 Dien Plant was transfer to PT Geo Dipa from California Energy, who was the original developer, through Government of Indonesia in 2002. PT Geo Dipa is a joint venture of Pertamina and PLN.

*5 Renovated in 2005

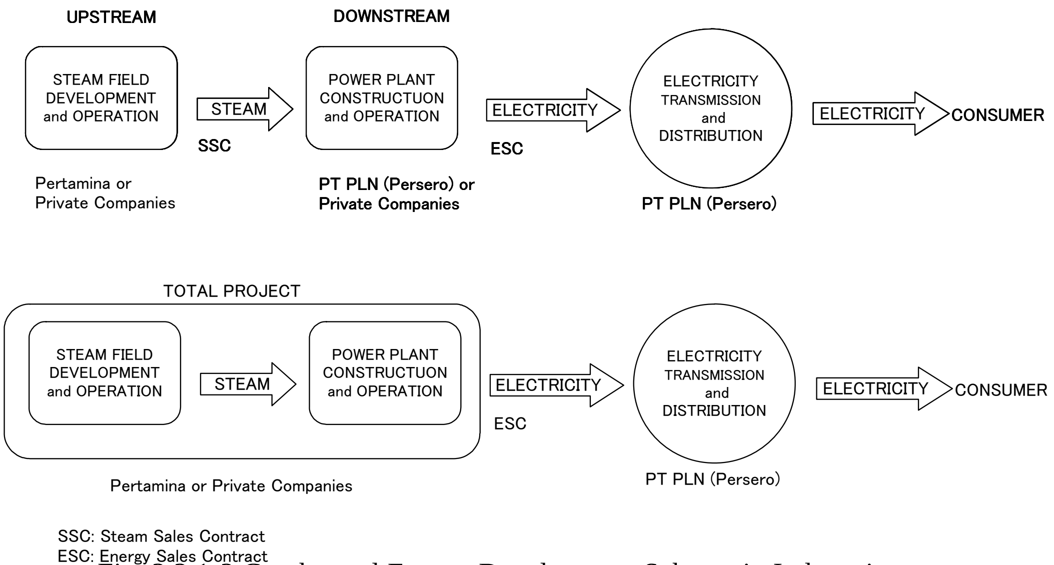
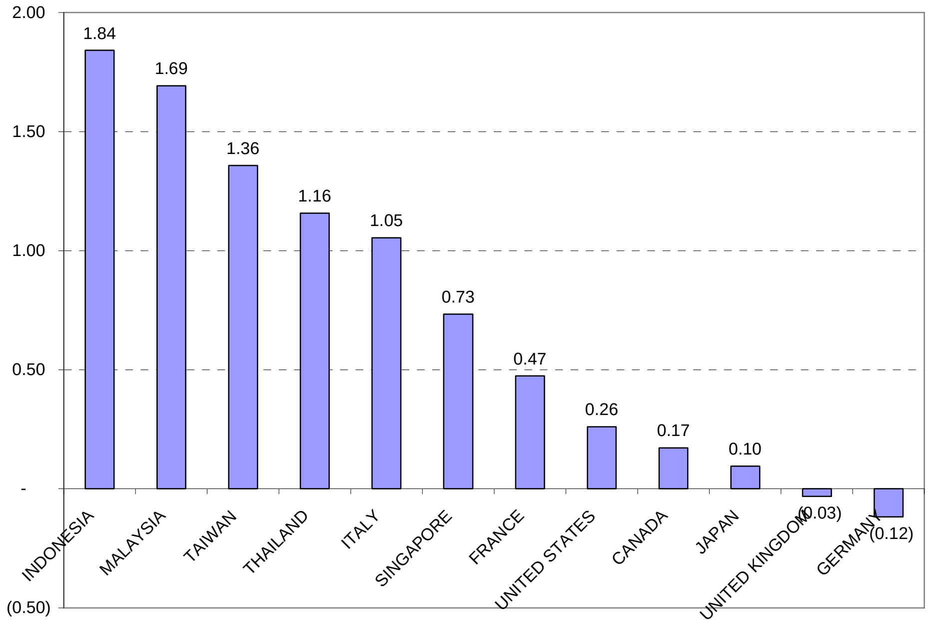


Fig. 3.2.1-2 Geothermal Energy Development Scheme in Indonesia

Table 3.2.1-4 Geothermal Power Generation Capacity in the World (2003)

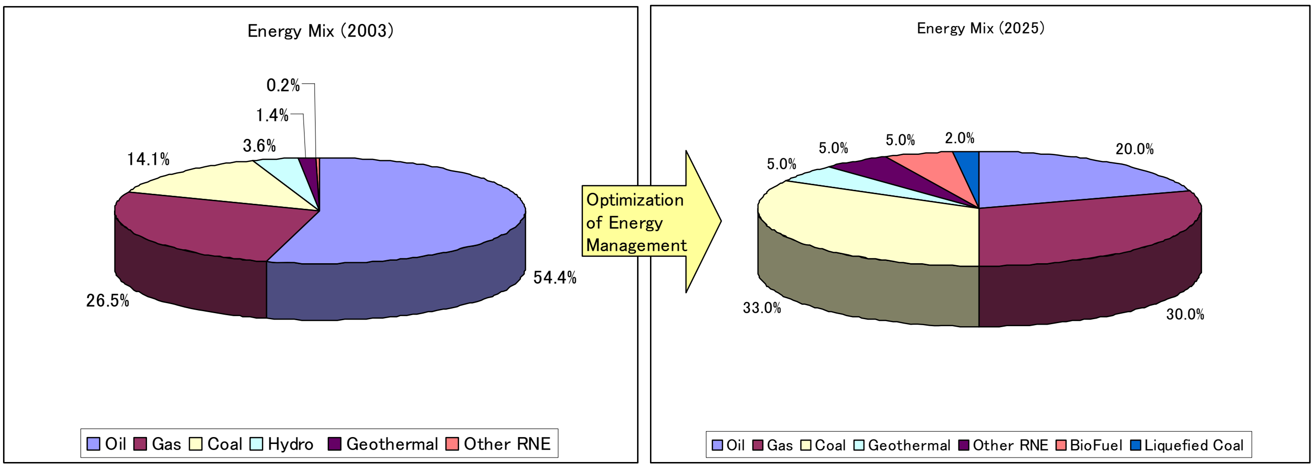
Country	Capacity (MW)
United States of America	2,228.0
Philippines	1,909.0
Mexico	855.0
Indonesia	807.0
Italy	785.0
Japan	546.9
New Zealand	437.0
Iceland	172.1
El Salvador	161.0
Costa Rica	142.5
Nicaragua	70.0
Kenya	45.0
Guatemala	33.4
China	29.2
Russia	23.0
Turkey	20.4
Portugal	16.0
Ethiopia	8.5
Guadeloupe	4.2
Thailand	0.3
Australia	0.2
Total	8,293.7

(Source: Pertamina Geothermal Development 2003)



(Note : Data is processed from BP Statistical Review of World Energy 2004 and IMF World Monetary Outlook 2004) (Source : "National Energy Management Blue Print (2005)")

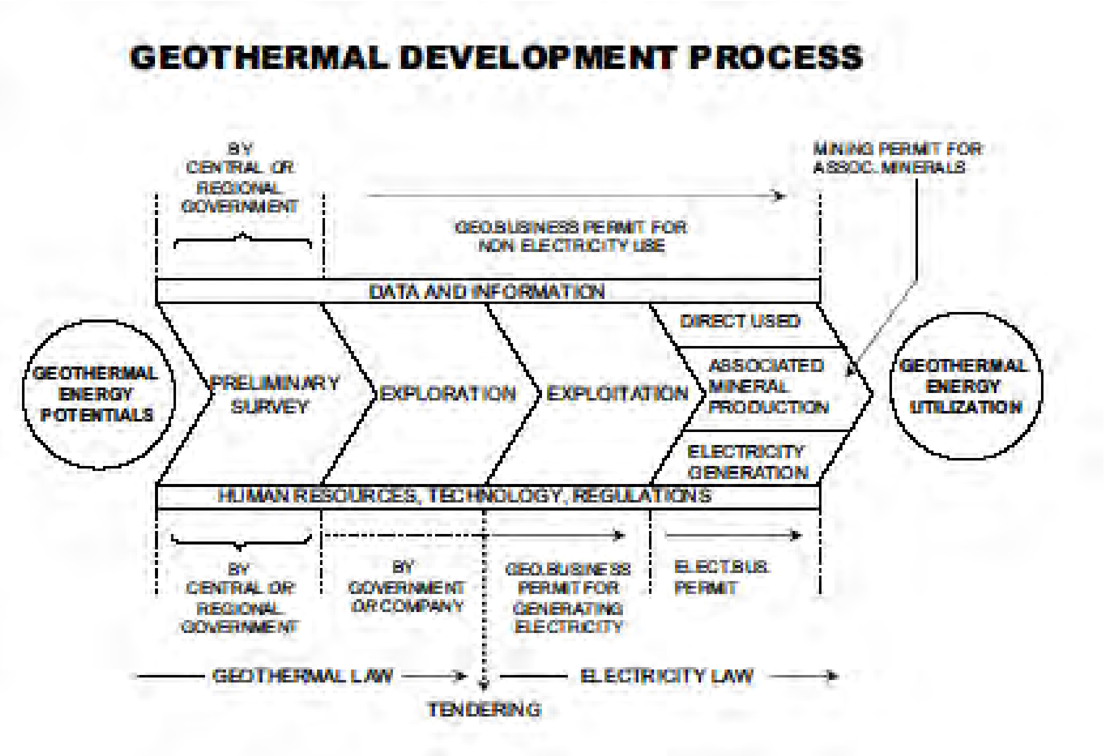
Fig. 3.2.3-1 Energy Elasticity in Main Countries (1998－2003)



(Note : Energy Mix in 2003 is based on "National Energy Management Blue Print (2005).

Energy Mix in 2025 is based on "Presidential Decree No.5 /2006.)

Fig. 3.2.3-2 Energy Mix Target in 2025



（資料：Dr. Dwipa SJAFRA,“Geothermal Resource & Development in Indonesia”）

Fig. 3.2.4-1 Geothermal Development Process in Indonesia

Table 3.2.5-1 Existing Working Area and Development Plan in the Road Map

No.	Geothermal Field	Developer	Production as of 2004 (MWe)	Development Planning Up to 2008 (MWe)	Development Planning Up to 2012 (MWe)
1	Sibayak	Pertamina	2	10	40
2	Sibual-Buali (Sarula)	PLN		220	220
3	Sungaipenuh	Pertamina			55
4	Hululais-Tambang Sawah	Pertamina			55
5	Lumit Balai	Pertamina		110	110
6	Waypanas (Ulu Belu)	Pertamina		110	110
7	Cibeureum-Parabakti (Salak)	Unocal	330	80	110
8	Pangalengan				
	- Kawah Cibuni	Yala teknosa		10	
	- Gunug Patuha	Geodipa		120	60
	- Wayang Windu	MNL	110	110	110
9	Kamojang-Darajat				
	- Kamojang	Pertamina	140	60	60
	- Darajat	Amoseas	145	110	75
10	Karaha, Cakrabuana	KBC		55	55
11	Dtt. Dieng	Geodipa	60	120	60
12	Iyang, Argopuro	Pertamina			55
13	Tabanan, Bali (Bedugul)	Bali Energy		10	110
14	Lahendong	Pertamina	20	60	40
15	Kotamobagu	Pertamina			60
16	Tulehu	PLN			16
17	Mataloko	PLN		2	6
18	Ulumbu	PLN		6	
Total		Additional	807	1,193	1,442
		Cumulative	807	2,000	3,442

(Source : "Current State of Geothermal Development in Indonesia", Dr. Dwipa SJAFRA,) Organization of Ministry of Energy and Mineral Resources

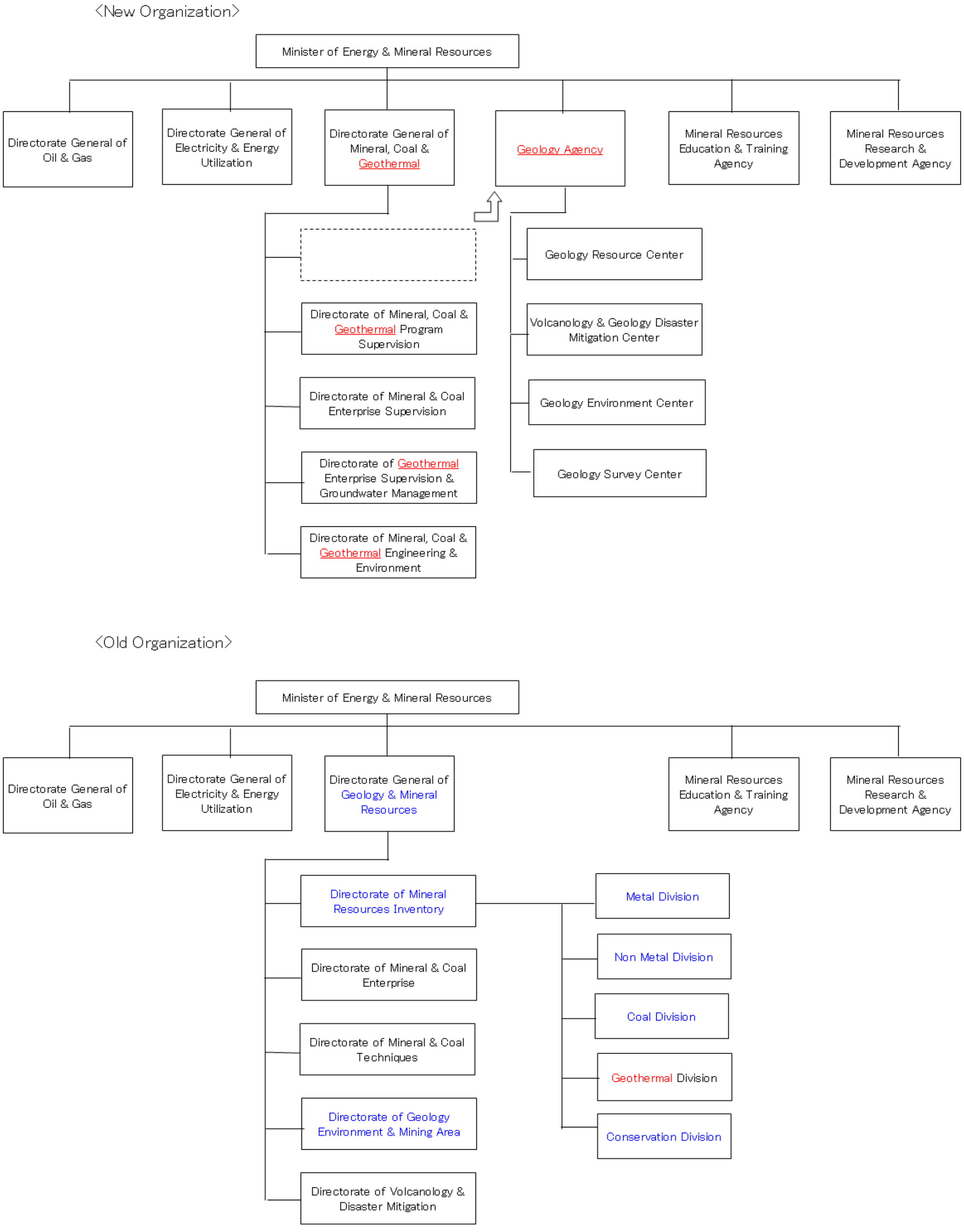


Fig. 3.2.6-1 Organization of Ministry of Energy and Mineral Resources（December, 2005）

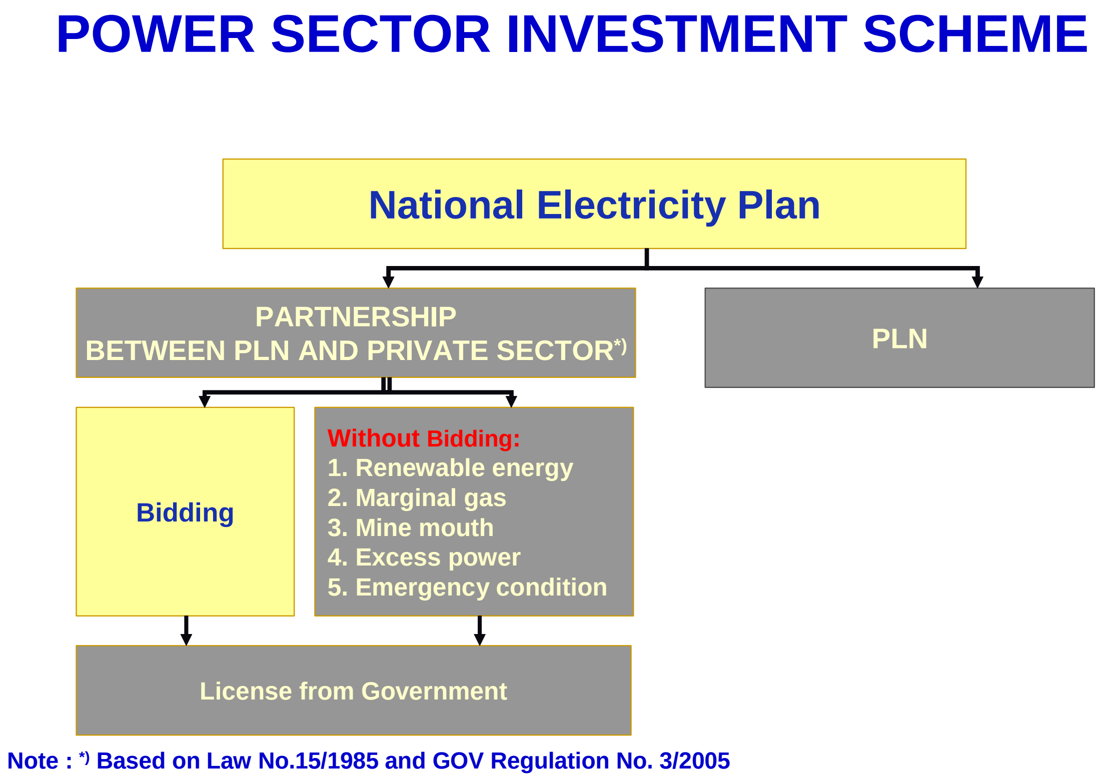


Fig. 3.2.8-1 Power Sector Investment Scheme