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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
(Summary Report)

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West Japan Engineering Consultants, Inc.

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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

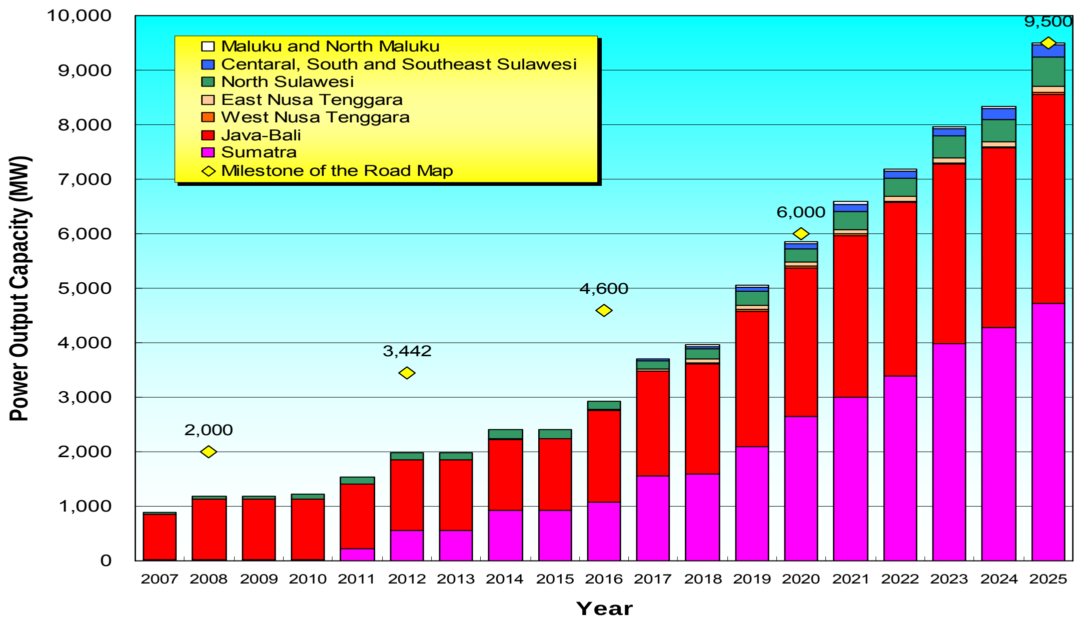


Fig. 2 Change of amount of geothermal power generation based on Master Plan

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.

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 demand in Indonesia in order to promote and accelerate geothermal energy exploitation for electric power generation in Indonesia.

1.2 Background of the Study

The utilization of geothermal energy already has a long history, and more than 8,000 MW of geothermal energy have been exploited around the world. Although it is one form of natural energy, geothermal energy production is extremely steady, with little fluctuation caused by weather or by seasonal conditions. Moreover, since it is domestically produced energy, geothermal energy greatly contributes to national energy security. In addition, since geothermal energy does not use fuel in its operation, it is not susceptible to fuel price increases caused by increases in international oil prices or falling currency exchange rates. From an environmental viewpoint, geothermal energy has little environmental impact, such as air pollution, because there is no combustion process in a geothermal power plant. Moreover, it helps to mitigate global warming because little CO_2 is exhausted from geothermal power plants.

It is said that Indonesia has the world’s greatest geothermal energy potential, which is estimated to be more than 27,000 MW and is thought to account for more than 40% of total world potential. Therefore, the development of geothermal power has been anxiously awaited in order to supply the increasing power demand and to diversify energy sources. Today, the total geothermal power generation capacity has reached 857 MW in Indonesia. (Table 1.2-1) However, although this capacity is the fourth largest by country in the world today, Indonesia has not fully utilized this huge geothermal potential yet.

The Indonesian government decided to diversify energy sources and to promote domestic energy sources in order to lower oil dependency. The government worked out a "National Energy Policy” (NEP) in 2002, and set a target of supplying 5% or more of the primary energy from renewable sources 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 presidential level policy. In addition, the government enacted a "Geothermal Law" for the first time in 2003 to promote the participation of the private sector in geothermal power generation. Moreover, in 2004 the Ministry of Energy and Mineral Resources worked out the "Road Map Development

Planning of Geothermal Energy" (hereinafter “Road Map") to materialize the national energy plan. In this Road Map, a high development target of 6,000 MW by 2020 and 9,500 MW by 2025 is set. (Fig. 1.2-1) Thus, a basic framework for geothermal energy development has been formulated and the government has started its efforts to attain these development targets.

However, neither the specific strategy for attaining the development targets nor the support measures for developers have yet been spelled out. Therefore, it is necessary to work out a nationwide geothermal energy development scenario which breaks down the Road Map into more detailed maps. Therefore, a "Geothermal Development Master Plan" comprising a nationwide development scenario and individual development scenarios in promising fields is needed.

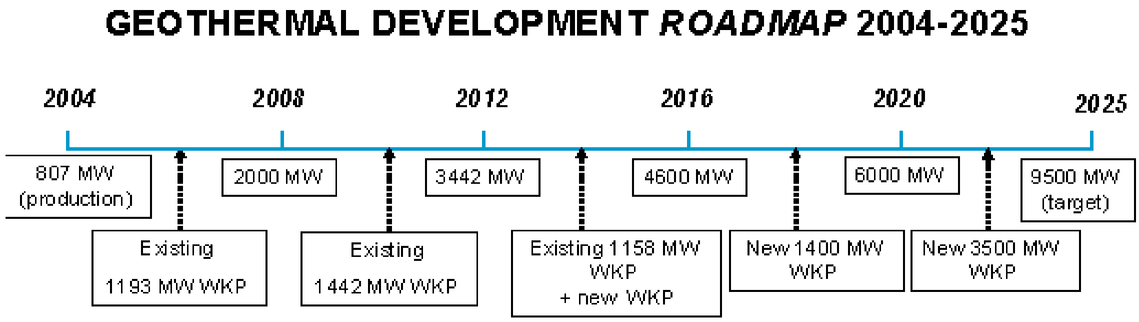


Fig. 1.2-1 Geothermal Development Roadmap 2004-2025

Table 1.2-1 Geothermal Resource Potential in each Island (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 capacitywas 807 MW as of 2004, and is 857 MW as of 2007.

Chapter 2 Outline and Process of Study

2.1 Research Area

Object Fields: seventy-three (73) prospective geothermal fields spread over the whole Indonesian archipelago（refer to Fig. 2.1-1）.

2.2 Basic Policy of Study

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

The Master Plan was scheduled to be carried 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 of the current problems.

The actual activities undertaken in the study divide into,

1) Data and information collection

2) Nationwide geothermal resource study

3) Natural and social environmental study

4) Master Plan formulation

The study proceeded with a priority on the survey of resources, and the environmental check of natural and social factors was considered in the site selection for development targets. Fig. 2.2-1 shows the flow of this study.

2.3 Methodology of Study

The work flow of the present master plan study is shown in Fig. 2.3-1. Activity details and methodology in this study are mentioned below.

(1) Collection of Data and Information

The collected information and the data provided from the Indonesian side were as follows:

governmental plans (development strategy, electric policy, laws and regulations, and structure charts for each organization) related to Indonesia geothermal promotion, specific data (regarding geothermal potential, development status, electricity demand and supply, distribution plans, generating cost), environmental guidelines, and so on.

(2) Nation-wide survey of geothermal resources ;

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

(3) Electric Sector Study

Power sector survey including the electricity distribution grid of all 73 fields

(4) Natural and Social Environmental Study

This activity was carried out to clarify the environmental protection condition of all 73 fields:

TOR for IEE based on discussion and interviews with the authorities concerned with the initial field work

IEE implementation following JICA’s guidelines for environmental and social considerations requires:

Determing scope of necessary items in AMDAL for geothermal power development project

IEE for environmental and social considerations at the master plan study stage

Calculation of green-house gas reduction and possibility of CDM projects in the promising fields

Data collection for project information note (PIN) was undertaken to proceed to project design document (PDD) preparation

(5) Formulation of Master Plan

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

i) Priority of the development of each geothermal field

Development priority was given to each geothermal field based on accepted evaluation standards regarding confirmation of geothermal steam, exploitable resource potentials, economy, balance of power demand and supply, access to the power transmission lines networks, natural/social and environmental impacts, and the present development status. Based on this prioritization, geothermal fields suitable for the objectives shown in the Road Map and National Power General Plan (Power Demand and Supply Plan) were selected, and the geothermal development plan for 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.

ii) Formulation of Action Plan

Integrated with present development status and acquired data, an action plan was prepared up to the start of plant operation for each field .

(6) Proposals for Geothermal Development Promotion

In parallel to the resource study, a study of challenges in geothermal development in Indonesia was done. In this study, the barriers to development and the necessity of government support were highlighted. Taking these results into consideration, some proposals were made to promote geothermal development in accordance with this master plan and to realize the goals of the Road Map in 2025.

2.4 Counterparts and Related Organizations

Counterparts and related organizations in this master plan study are as follows:

- Directorate General of Mineral, Coal and Geothermal, DGMCG
- Geological Agency, GA
- Directorate General of Electricity & Energy Utilization, DGEEU
- PT. PERTAMINA
- PT. PLN

・ National Development Planning Agency (BAPPENAS)
・ Badan Pengkajian dan Penerapan Teknology (BPPT)
・ Indonesia Geothermal Association (INAGA)

2.5 Technical Transfers and Workshops

Technical transfers related to the planning of geothermal power development in the master plan study were conducted mainly through OJT (On the Job Training in the field survey (geology, geochemistry, geophysics), environment and power sectors. Capacity development for almost all technologies applied to the master plan study was conducted during work in Indonesia.

in particular, the technology necessary to transfer to the Indonesian side was in the following fields.

- Electromagnetic survey（including analysis method）

- Geothermal reservoir calculation

- Database construction
- Master plan formulation (including economic evaluation)

In addition, the study results were explained and discussed at four workshops.

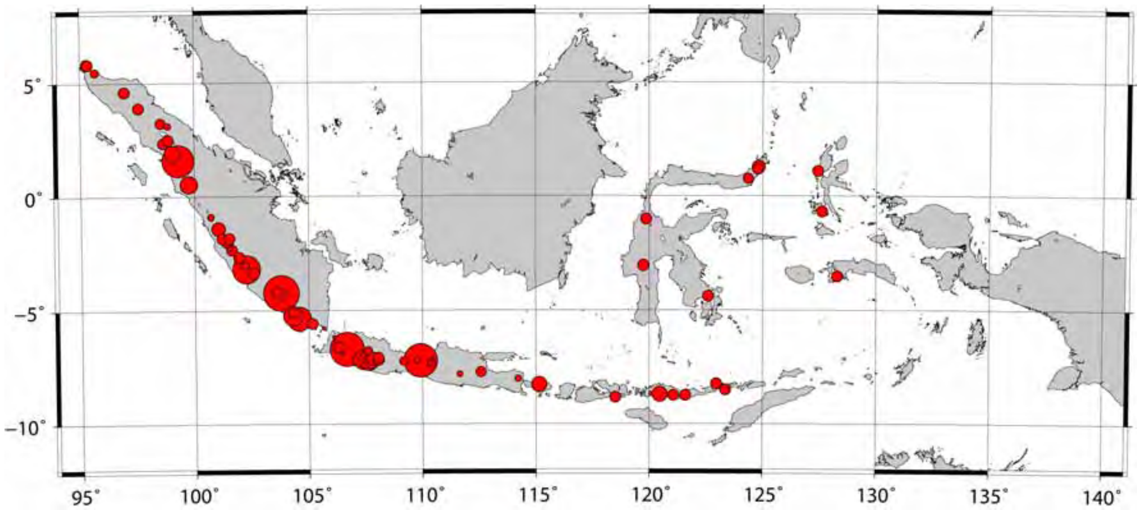


Fig. 2.1-1 Major Geothermal Fields in Indonesia (Muraoka 2005)

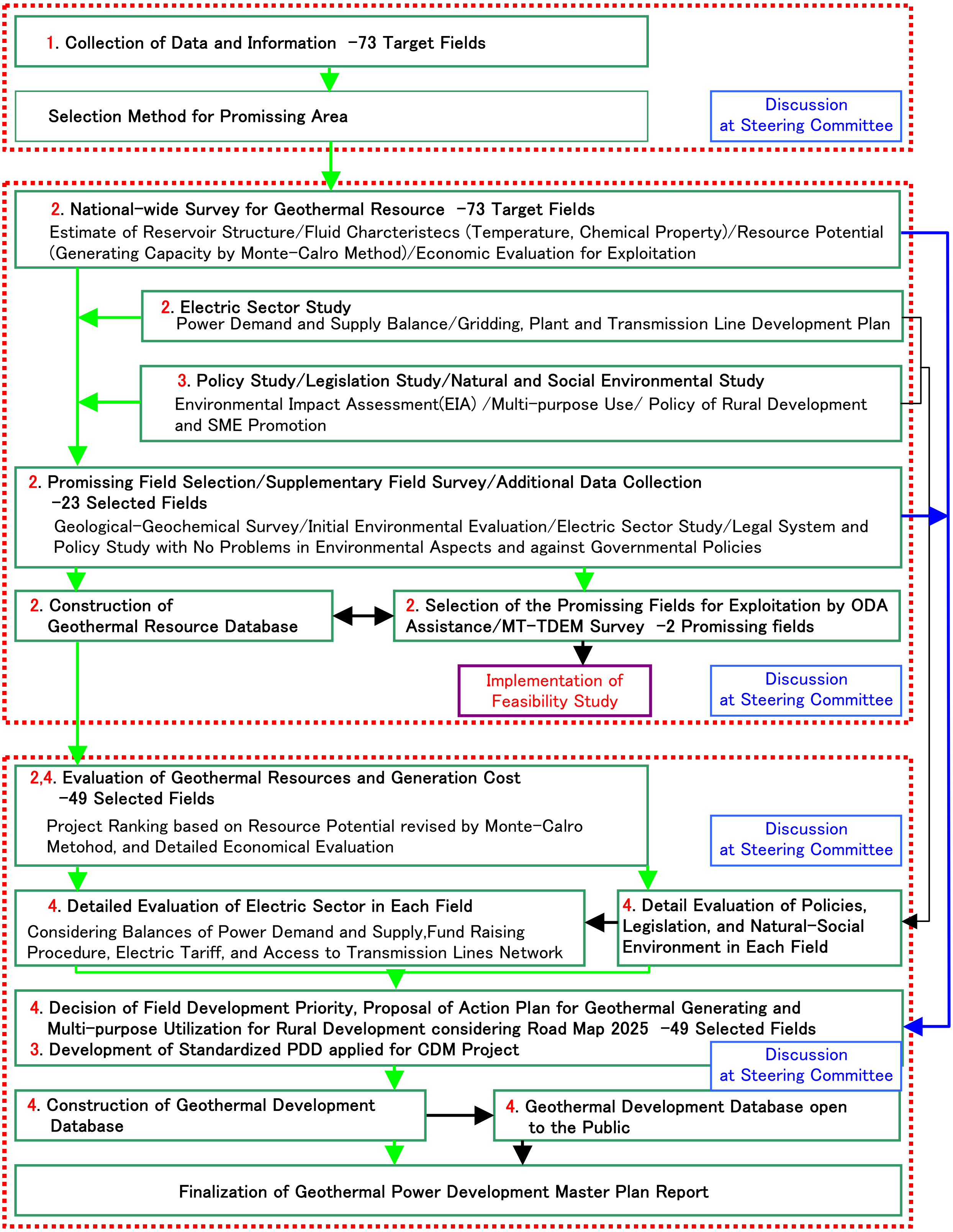


Fig. 2.2-1 Flow of Geothermal Master Plan Study in Indonesia

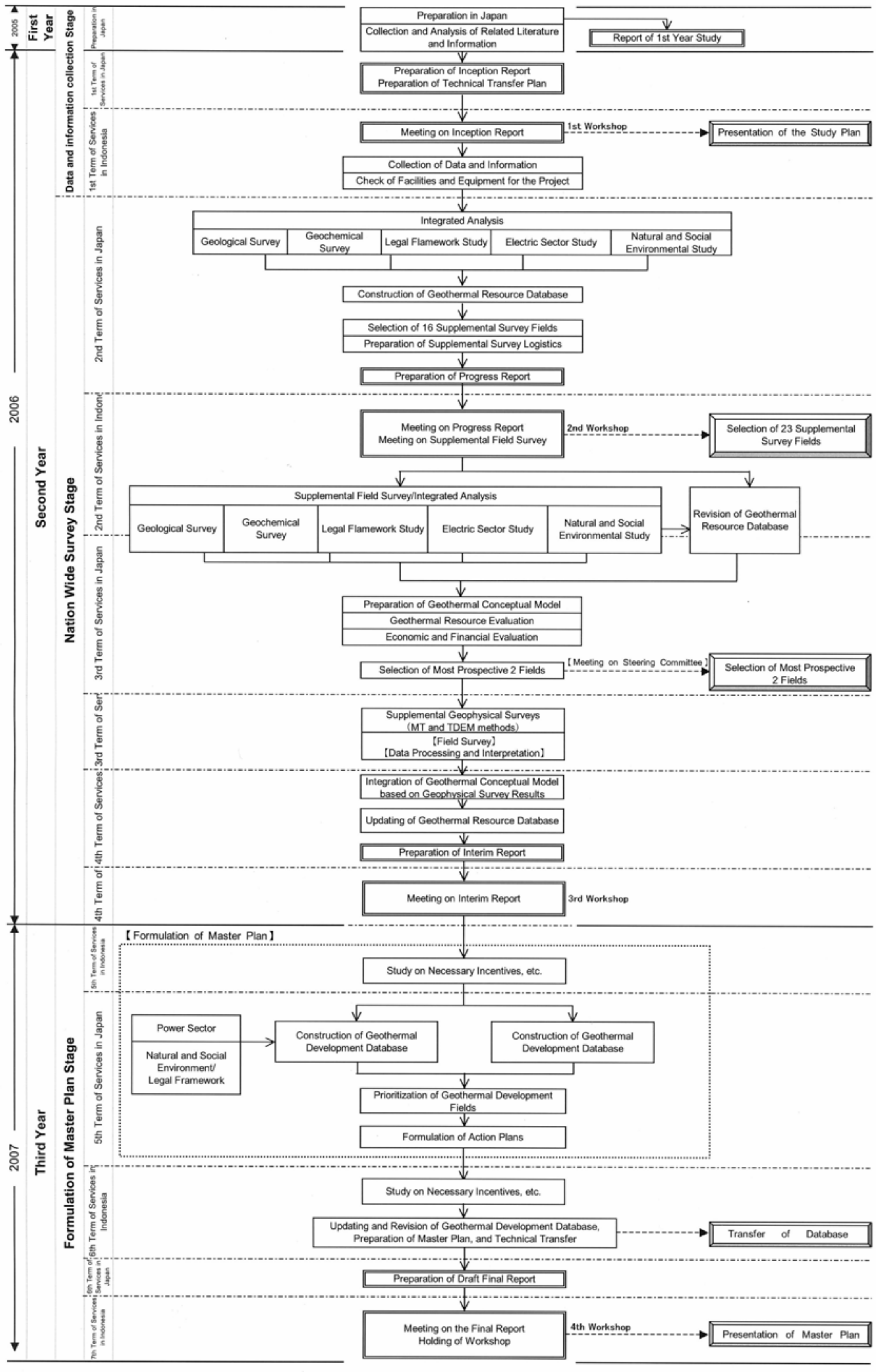


Fig. 2.3-1 Geothermal Master Plan Study in Indonesia

Chapter 3 Overview of Indonesian Energy and Geothermal Development Situation

3.1 Overview of Indonesian Economy and Energy Situation

Indonesia suffered a large impact in the Asian economic crisis that began in July, 1997. However, the Indonesian economy has shown an improvement, with GDP growing by 4.5% in 2003, 5.1% in 2004, and 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 earthquake disasters in the last few years.

In 2004, total primary energy supply was 128,586 ktoe, of which 45 percent was oil, 33 percent gas, 16 percent coal, and 5 percent was other energy 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, the transport sector accounted for 29 percent, and the remaining 32 percent was consumed by the commercial/residential and other sectors.

3.2 Geothermal Development Situation and Geothermal Development Policy

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. (Table 3.2-1, Table 3.2-2) Although the generation capacity of Indonesia has reached 857MW, Indonesia is far from fully exploiting this huge potential of geothermal energy. (Table 3.2-3)

Geothermal development in Indonesia was much promoted in 1990’s. However, many developers withdrew during the turmoil of the Asian economic crisis. In October 2003, the government enacted the Geothermal Law (No.27/2003) and clarified the procedures for private developers’ participation. 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. In addition the government declared that Pertamina should return the geothermal development rights to the government for the areas where development had 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 "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. (Fig.3.2-1)

Table 3.2-1 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 3.2-2 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)

Table 3.2-3 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 Java	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) ")

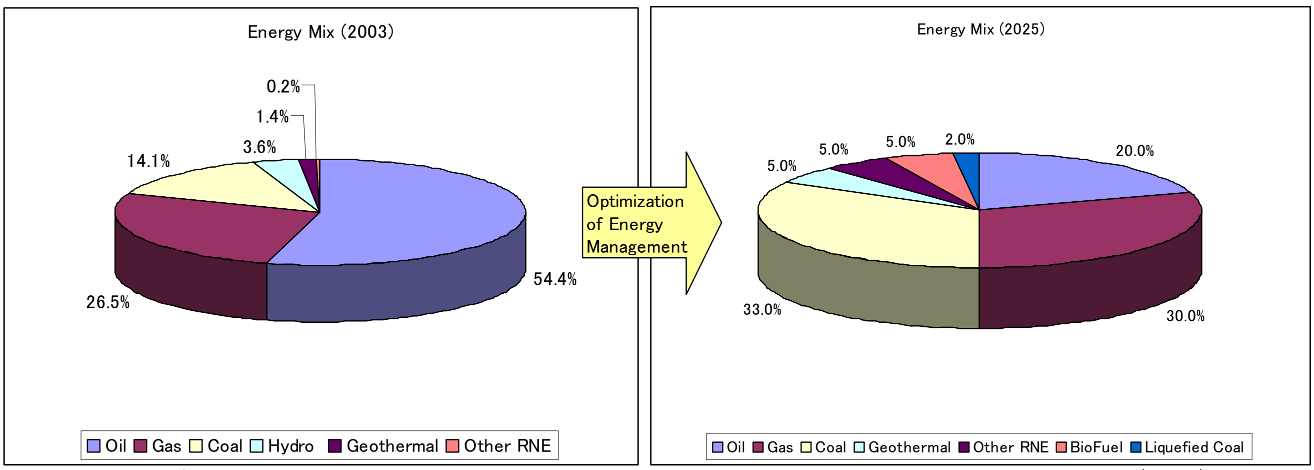
(Note) *1 Chevron took over Unocal (Union Oil Company of California), who was the original developer of Salak on Aug. 2005 .

*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



(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. 3.2-1 Energy Mix Target in 2025

Chapter 4 Nation-Wide Survey for Geothermal Resources

4.1 Preliminary Evaluation of 73 Geothermal Fields and Selection of Supplemental Survey Fields

In the preliminary evaluation stage, processing, analysis and interpretation of the collected data for 73 fields were conducted. Following a request from the Indonesian side, three additional fields, Sipaholon in North Sumatra, Iyan Argopuro in East Java and Suwawa in Gorontaro, were added to 70 initial target areas. Based on the existing data, geothermal structures were studied and calculation of resource potential using the Stored Heat Method and simplified economic evaluation were carried out. 23 supplemental survey fields were selected based on security and development stage in addition to these resource and economic analyses (Table 4.1-1).

4.2 Supplemental Survey Fields and Geothermal Conceptual Model

4.2.1 Supplemental Geological and Geochemical Field Survey

Twenty three fields, which were considered to be good prospects and worth investigating in detail, were included in the nationwide study (supplemental geological and geochemical surveys). Rock sample analysis and chemical and isotopic analyses of hot spring waters and fumarolic gases were carried out. Supplemental survey information was utilized for evaluation of geothermal resources. Fig. 4.2.1-1 and Table 4.2.1-1 shows an example of a compiled map and table of resource study results.

Geological and geochemical data obtained from the supplemental surveys in 23 fields were analyzed and utilized to update the geothermal conceptual models.

After preliminary evaluation and supplemental survey, 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-Mutubusa 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 views of the counterparts.

4.2.2 Supplemental Geophysical Survey

After the discussion of resource potentials, social-environmental aspects and future development plans among DGMCG, CGR, PERTAMINA and the JICA study team, the Sokoria-Mutubusa field (East Nusa Tenggarah) and the Kotamobagu field (North Sulawesi) were selected for the supplemental geophysical survey (MT/TDEM method). The survey results are summarized as follows:

(1) Sokoria geothermal field (refer to Fig. 4.2.2-1)

Based on the survey results, three resistivity discontinuities (Rs1, Rs2 and Rs3) were detected. Considering the geological study results, resistivity discontinuity Rs1 probably reflects a Caldera rim, and resistivity discontinuity Rs2 is likely to reflect a fault structure. In the central portion of resistivity discontinuity Rs2, a low resistivity zone of less than 5ohm-m probably reflects low-temperature hydrothermal-alteration minerals (smectite etc) acting as the cap-rock of the reservoir.

In addition, underlying the low resistivity zone along discontinuity Rs2, a relatively higher resistivity zone of greater than 30ohm-m possibly reflects high temperature alteration products such as illite and/or chlorite. Hence the area along resistivity discontinuity Rs2 at depth is possibly indicative of a higher temperature zone at depth. Therefore it is highly probable that the central portion of resistivity discontinuity Rs2 reflects a part of the fault-like structure where geothermal fluid may circulate at depth in the Sokoria field.

Based on these facts, the zone along resistivity discontinuity Rs2 is likely to be a promising zone for geothermal development in the Sokoria field.

(2) Kotamobagu geothermal filed (refer to Fig. 4.2.2-2)

Based on the survey results, three resistivity discontinuities (Rk1, Rk2 and Rk3) probably reflecting fault-like structures were detected. A low resistivity zone of less than 5ohm-m probably reflecting low-temperature hydrothermal-alteration minerals (smectite etc) acting as the cap-rock of the reservoir is widely distributed in the northwestern, central and southeastern portions of the survey area roughly around depths of 500m and 750m.

In addition, underlying the low resistivity zone, a relatively high resistivity zone of greater than 25ohm-m possibly reflecting high temperature alteration products such as illite and/or chlorite is detected around the western portion of Rk2 and around the northern portion of Rk3. Hence these areas around the west of Rk2 and around the north of Rk3 at depth are possibly indicative of higher temperature zones at depth. Therefore it is highly probable that the northern portion of resistivity discontinuity Rk3 and the western portion of the resistivity discontinuity Rk2 reflect fault-like structures where geothermal fluid may circulate at depth in the Kotamobagu field.

Based on these facts, the zone around stations 9, 10, 12 and 13 including the intersection of resistivity discontinuities Rk2 and Rk3, is likely to be a promising zone for geothermal development in the Kotamobagu field.

4.2.3 Geothermal Conceptual Model

For the formulation of a master plan, interpretations of a geothermal structural model of each field are conducted by analyzing geoscientific information such as reservoir structure, heat source, reservoir extent and fluid chemistry. Interpretations of the geothermal conceptual model are carried out at each study stage. Initially, the interpretation is carried out at the preliminary evaluation stage based on existing data analysis. After completion of the supplemental geological and geochemical survey of 23 fields and the geophysical survey of 2 fields, geothermal structural models were re-interpreted and updated based on the acquired information. This information is summarized as geoscientific maps and tables for the formulation of the master plan (Fig. 4.2.3-1).

4.3 Geothermal Resource Database

The geothermal resource database was constructed by utilizing the existing database prepared by Center for Geological Resouces (CGR), an Indonesian counterpart.
In collaboration with CGR the database was updated, with the compiling function regarding "characteristics of geothermal reservoir and reservoir evaluation" and "well production data" newly added to the database.

Information concerning geology, geochemistry, geophysics, well study and resource potential, which was collected and analyzed during the study, was incorporated into the data base.
Compiled and classified geoscientific data for each geothermal field incorporated in the geothermal resourse database are utilized for the evaluation of geothermal fields which have a high potential for electricity development.

4.4 Calculation of resource potential and Simplified economical evaluation

After the interpretation of geothermal structure, the geothermal resource potential was calculated using the Stored Heat Method and Monte Carlo Analysis method. The resource potential of 38 fields among the 73 prospective fields was evaluated, because these fields yielded enough data to calculate the resource potential. The fields under development were excluded from resource potential evaluation using the Stored Heat Method, and their planned power outputs, which were decided through detailed evaluations such as reservoir simulation study, were adopted as their resource potentials for this study.

After the interpretation of geothermal structure and completion of geothermal resource calculation, simplified economic evaluation was conducted for 49 fields, the 38 fields mentioned above and 11 advanced-explored areas. In the simplified economic evaluation, the initial capital investment per kW, which is the cost per kW required for 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. (Table 4.4-1). Properly speaking, we should note that the initial capital investment actually increases because it is necessary to consider the construction costs of access roads, pipelines, and transmission lines in addition to the plant cost and well-drilling cost. However, we judged that the general values of initial capital investment estimated from the plant cost and well-drilling cost is adequate to compare the economicl aspects of each field for the formulation of a master plan.

4.5 Prospective geothermal fields

To devise an adequate plan to promote the utilization of geothermal resources in Indonesia, it is necessary to understand the present situation with respect to geothermal capacity of each area. Through the construction of a database of geothermal resources in Indonesia, various kinds of information concerning each field were compiled with the aim of identifying, assessing and characterizing geothermal reservoirs. Taking into consideration reservoir potentials, chemical features and development stages, possible fields worth exploiting were evaluated for future development. The following fields are recommended for development in consideration of the present status of power development（Table 4.5-1）.

(1) Sumatra

Iboih-Jaboi, Seulawah Agam, Lau Debuk-Debuk/Sibayak, Sarulla, Sibual Buali, S. Merapi-Sampuraga, Muaralabuh, Lempur/Kerinci, Sungai Penuh, B. Gedung Hulu Lais , Tambang Sawah, Marga Bayur, Lumut Balai, Ulubelu, Suoh Antatai, G. Sekincau, Rajabasa, Wai Ratai

(2) Java-Bali

Kamojang, G. Salak, Darajat, Cisolok-Cisukarame, G. Patuha, G. Wayang-Windu, G. Karaha, G. Telagabodas, Dieng, Ungaran, Wilis-Ngebel, Bedugul,

(3) Sulawesi and East Indonesia

Hu'u Daha, Wai Sano, Ulumbu, Bena-Mataloko, Sokoria-Mutubusa, Oka-Larantuka, Atadei, Lahendong, Kotamobagu, Tompaso, Tulehu, Jailolo

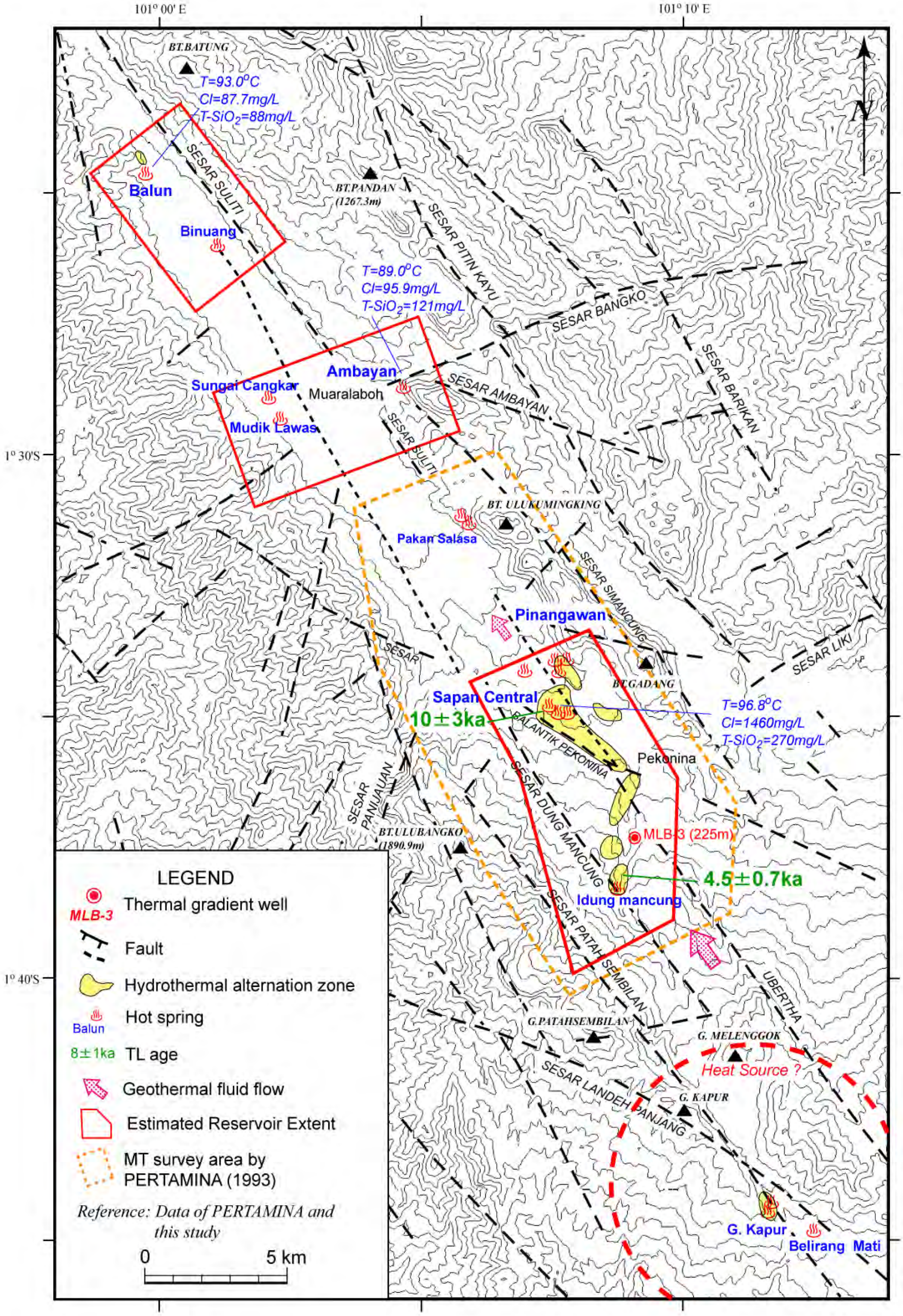


Fig. 4.2.1-1 Compiled map of Geoscientific Study Results (No.13 MUARALABUH)

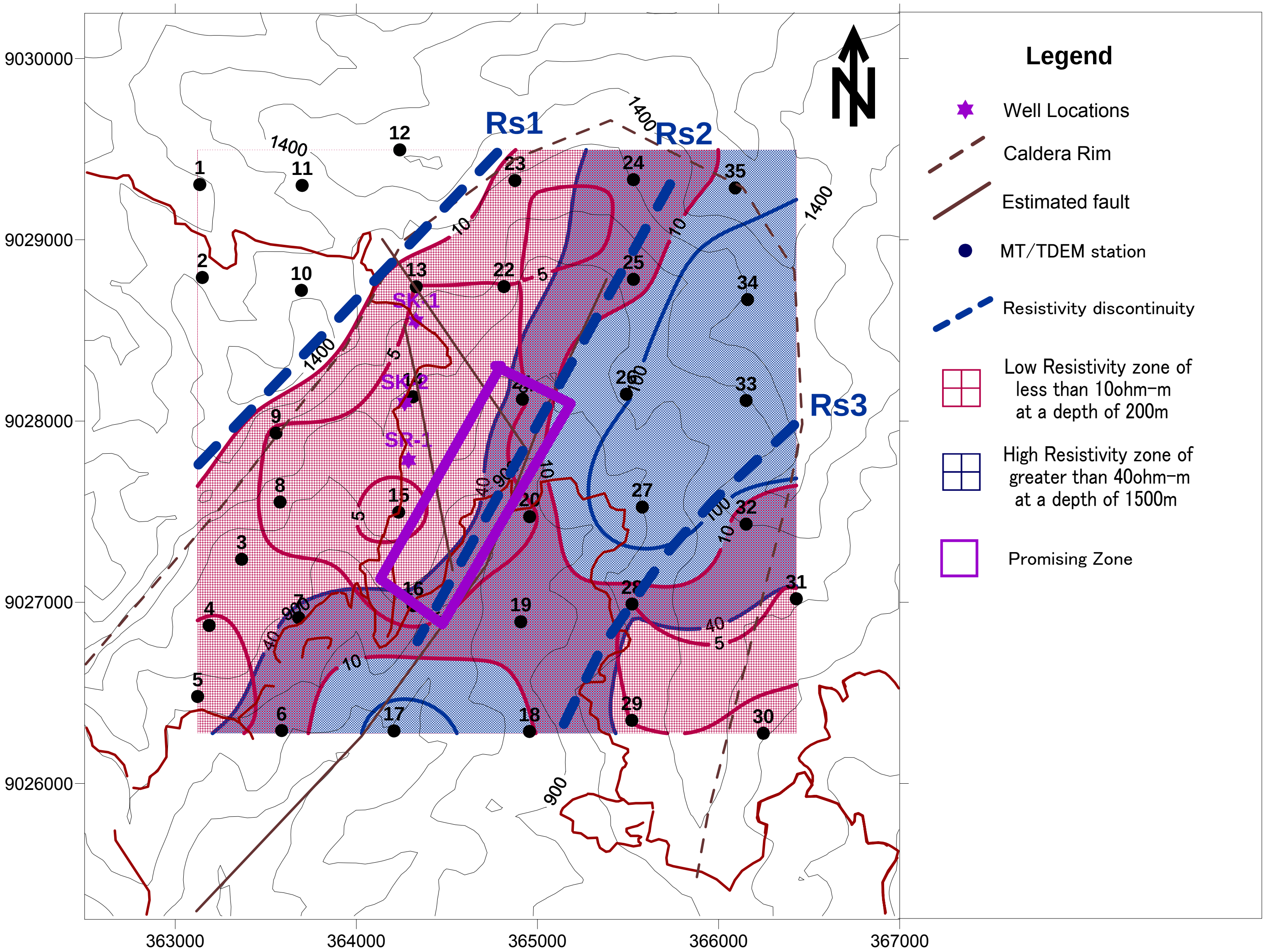


Fig. 4.2.2-1 Synthetic Resistivity Structure Map in the Sokoria geothermal field

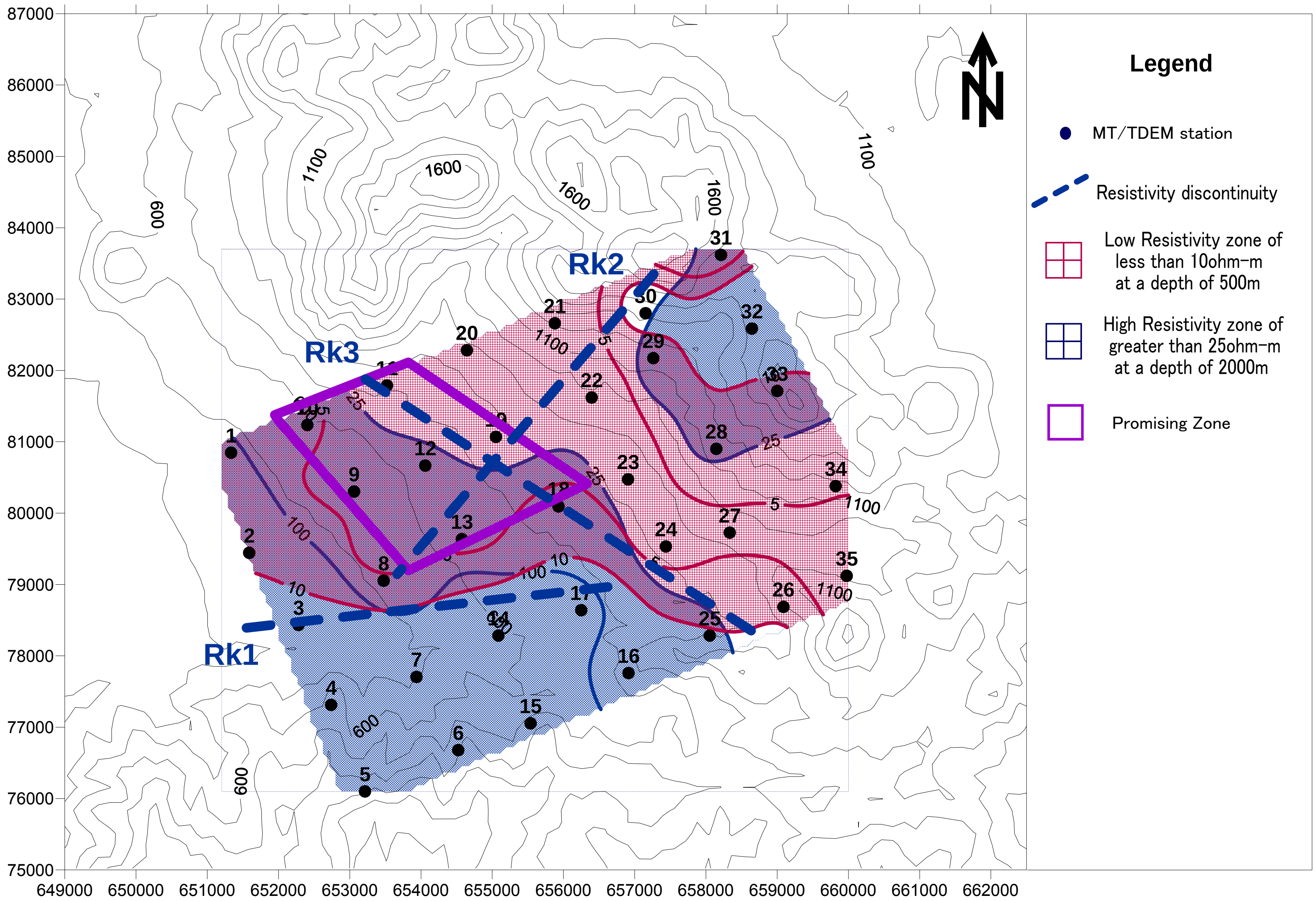


Fig. 4.2.2-2 Synthetic Resistivity Structure Map in the Sokoria geothermal field

Table 4.2.2-1 Location of Supplementary Survey Fields

Region	Field
North Sumatera	・ PUSUK BUKIT - DANAU TOBA (No.11) ・ SIMBOLON – SAMOSIR (No.12) ・ SIPAHOLON – TARUTUNG (No.71)
West Sumatera	・ MUARALABUH (No.13) ・ G. TALANG (No.14)
Jambi	・ SUNGAI PENUH (No.17)
Bengkulu	・ B. GEDUNG HULU LAIS (No.21) ・ TAMBANG SAWAH (No.22)
South Sumatera	・ MARGA BAYUR (No.24)
Lampung	・ SUOH ANTATAI (No.28) ・ G. SEKINCAU (No.29) ・ RAJABASA (No.30)
West Java	・ CISOLOK – CISUKARAME (No.35) ・ TANGKUBANPERAHU (No.40)
Banten	・ CITAMAN - G. KARANG (No.42)
Central Java	・ TELOMOYO (No.46) ・ UNGARAN (No.47)
East Java	・ WILIS / NGEBEL (No.50) ・ IJEN (No.51)
East Nusa Tenggara	・ SOKORIA – MUTUBUSA (No.57)
North Sulawesi	・ KOTAMOBAGU (No.62) ・ TOMPASO (No.63)
Gorontalo	・SUWAWA-GORONTALO (No.73)

Table 4.4-1 General Estimate of The Initial Capital Investiment Per KW of Each Geothermal Field.

Region	No	Names of the 70 fields in this Survey	Temperature(°C)			Grid.		Demand	Resources		Reserves			Potential (MW)	Power Plant (MW)	Single Well Productivity			Single Well Injectivity		Required Number of Well			Drilling Costs (million US$)	Plant Costs (million US$)	Initial Capital Investment (million US$)	Initial Capital Investment for Drilling (US$/kW)	Initial Capital Investment for Plant (US$/kW)	Initial Capital Investment Per kW (US$/kW)
			Surface	Geotherm	Measured	T/L	D/L	(MW).	Speculative	Hypothesis	possible	Probable	Proven			Depth(m)	MW	Water Flow (t/h)	Depth(m)	capacity (t/h)	Success Rate	Production	Reinjection						
Aceh	1	IBOIH - JABOI	100	170-290			X	10			15			15	10	1500	6	180	1000	200	70%	3	3	8.3	12.0	20	825	1,200	2,025
Aceh	2	LHO PRIA LAOT	101	170-220			X	10																					
Aceh	3	SEULAWAH AGAM	95	180-300		X		3,000			900			900	900	1500	6	180	500	200	70%	215	193	460.9	1,080.0	1,541	512	1,200	1,712
Aceh	4	G. GEUREUDONG	69			X		3,000																					
Aceh	5	G. KEMBAR	89	>190		X		3,000																					
SumUta	6	G. SINABUNG				X		3,000																					
SumUta	7	LAU DEBUK-DEBUK / SIBAYAK	116		302	X		3,000		70	131		39	170	170	2000	10	230	1000	200	70%	25	28	85.8	204.0	290	505	1,200	1,705
SumUta	8	SARULA	101			X		3,000		100	147		133	280	280	2000	6	190	1000	200	70%	67	64	217.8	336.0	554	778	1,200	1,978
SumUta	9	SIBUAL BUALI	72			X		3,000					80	80	80	2000	10	190	1000	200	70%	12	11	38.5	96.0	135	481	1,200	1,681
SumUta	10	S. MERAPI - SAMPURAGA	99	<290		X		3,000			700			700	700	2000	6	190	1000	200	70%	167	159	542.3	840.0	1,382	775	1,200	1,975
SumUta	11	PUSUK BUKIT - DANAU TOBA	90	<290		X		3,000																					
SumUta	12	SIMBOLON - SAMOSIR	43	>170		X		3,000																					
SumBar	13	MUARALABUH	104	180-270		X		3,000		250	250			250	250	1500	6	180	1000	200	70%	60	54	158.4	300.0	458	634	1,200	1,834
SumBar	14	G. TALANG	98	<290		X		3,000			25			25	25	2000	6	190	1000	200	70%	6	6	19.8	30.0	50	792	1,200	1,992
Jambi	15	LEMPUR / KERINCI	97	210-290		X		3,000			20		15	35	35	1500	6	180	500	200	70%	9	8	19.3	42.0	61	550	1,200	1,750
Jambi	16	SUNGAI TENANG	96			X		3,000																					
Jambi	17	SUNGAI PENUH	102	200-250		X		3,000			600			600	600	1500	6	190	500	200	70%	143	136	310.8	720.0	1,031	518	1,200	1,718
Jambi	18	SUNGAI BETUNG	30			X		3,000																					
Jambi	19	AIR DIKIT	98			X		3,000																					
Jambi	20	G. KACA	41			X		3,000																					
Bengkulu	21	B. GEDUNG HULU LAIS	95	180-290		X		3,000			1,000			1,000	1000	1500	6	180	1000	200	70%	239	215	630.9	1,200.0	1,831	631	1,200	1,831
Bengkulu	22	TAMBANG SAWAH	95	>230		X		3,000			400			400	400	1500	4	160	1000	200	70%	143	115	362.5	480.0	842	906	1,200	2,106
Bengkulu	23	BUKIT DAUN	95			X		3,000																					
SumSel	24	MARGA BAYUR	96	180-250		X		3,000			130			130	130	1500	4	180	1000	200	70%	47	43	124.9	156.0	281	960	1,200	2,160
SumSel	25	LUMUT BALAI	98			X		3,000			820			820	820	1500	9	220	1000	200	70%	131	143	373.5	984.0	1,357	455	1,200	1,655
SumSel	26	RANTAU DADAP - SEGAMIT	96			X		3,000																					
Lampung	27	ULUBELU	99			X		3,000			580			580	580	1500	9	220	1000	200	70%	93	101	264.6	696.0	961	456	1,200	1,656
Lampung	28	SUOH ANTATAI	99	230-300		X		3,000			920			920	920	1500	9	220	1000	200	70%	147	161	419.7	1,104.0	1,524	456	1,200	1,656
Lampung	29	G. SEKINCAU	98	260-300		X		3,000			380			380	380	1500	9	220	1000	200	70%	61	66	173.3	456.0	629	456	1,200	1,656
Lampung	30	RAJABASA	99	200-280		X		3,000			170			170	170	1500	6	180	1000	200	70%	41	36	107.3	204.0	311	631	1,200	1,831
Lampung	31	WAI RATAI	92	220-290		X		3,000			180			180	180	1500	6	180	1000	200	70%	43	39	113.9	216.0	330	633	1,200	1,833
JavaBar	32	KAMOJANG	96		252	X		20,000				73	227	300	300	1500	6	5	1000	200	80%	63	2	106.2	360.0	466	354	1,200	1,554
JavaBar	33	G. SALAK			280	X		20,000			115		485	600	600	2000	10	230	1000	200	80%	75	87	260.7	720.0	981	435	1,200	1,635
JavaBar	34	DARAJAT	77		245	X		20,000					362	362	362	2000	6	5	1000	200	80%	76	2	169.4	434.4	604	468	1,200	1,668
JavaBar	35	CISOLOK - CISUKARAME	98	>250		X		20,000			400			400	400	1500	6	190	1000	200	70%	96	91	258.5	480.0	739	646	1,200	1,846
JavaBar	36	G. PATUHA	89		245	X		20,000		65	247		170	417	417	1500	6	5	1000	200	80%	87	3	146.9	500.4	647	352	1,200	1,552
JavaBar	37	G. WAYANG - WINDU	50		270	X		20,000		75		135	250	385	385	1500	9	220	1000	200	80%	54	60	155.1	462.0	617	403	1,200	1,603
JavaBar	38	G. KARAHA	95			X		20,000		50	70	100	30	200	200	1500	9	220	1000	200	80%	28	31	80.3	240.0	320	402	1,200	1,602
JavaBar	39	G. TELAGABODAS	92			X		20,000		75	120	80		200	200	1500	9	220	1000	200	70%	32	35	91.3	240.0	331	457	1,200	1,657
JavaBar	40	TANGKUBANPERAHU	96	>170		X		20,000			20			20	20	1500	4	160	1000	200	70%	8	6	19.8	24.0	44	990	1,200	2,190
Banten	41	BATUKUWUNG	52			X		20,000																					
Banten	42	CITAMAN - G. KARANG	94	>180		X		20,000		50	25			25	25	1500	4	160	1000	200	70%	9	7	22.6	30.0	53	902	1,200	2,102
Banten	43	G. ENDUT	84			X		20,000																					
JavaTen	44	DIENG	94		368	X		20,000		200	185	115	280	580	580	2000	10	260	1000	200	80%	73	95	265.1	696.0	961	457	1,200	1,657
JavaTen	45	MANGUNAN	46			X		20,000																					
JavaTen	46	TELOMOYO		>190		X		20,000			90			90	90	1500	4	160	1000	200	70%	33	27	84.2	108.0	192	935	1,200	2,135
JavaTen	47	UNGARAN	86	180-320		X		20,000			230			230	230	1500	6	190	1000	200	70%	55	52	148.0	276.0	424	643	1,200	1,843
JavaTen	48	G. SLAMET	51			X		20,000																					
JavaTim	49	G. ARJUNO - WELIRANG	70			X		20,000																					
JavaTim	50	WILIS / NGEBEL	93	190-250				20,000			180			180	180	1500	6	190	1000	200	70%	43	41	116.1	216.0	332	645	1,200	1,845
JavaTim	51	IJEN	57					20,000			130			130	130	1500	4	160	1000	200	70%	47	38	119.4	156.0	275	918	1,200	2,118
Bali	52	BEDUGUL	32		285	X		20,000		75	245		30	275	275	2500	9	220	1500	200	80%	39	43	178.2	330.0	508	648	1,200	1,848
NTB	53	HU'U DAHA	86				X	10			190			190	10	1500	4	160	1000	200	70%	4	4	11.0	12.0	23	1,100	1,200	2,300
NTT	54	WAI SANO	92	>250		X		30			70			70	30	1500	6	180	500	200	70%	8	7	17.1	36.0	53	568	1,200	1,768
NTT	55	ULUMBU	96		240	X		30					175	175	30	1000	7	220	500	200	70%	7	7	11.6	36.0	48	385	1,200	1,585
NTT	56	BENA - MATALOKO	95	270-300		X		30					20	20	20	1000	6	200	500	200	70%	5	5	8.3	24.0	32	413	1,200	1,613
NTT	57	SOKORIA - MUTUBUSA	97	180-320		X		30			150			150	30	1500	6	190	500	200	70%	8	7	17.1	36.0	53	568	1,200	1,768
NTT	58	OKA - LARANTUKA	90				X	30			145			145	30	1500	4	160	500	200	70%	11	10	23.7	36.0	60	788	1,200	1,988
NTT	59	ILI LABALEKEN					X	30																					
NTT	60	ATADEI	97				X	30			90			90	30	1500	4	160	1000	200	70%	11	10	29.2	36.0	65	972	1,200	2,172
SulUta	61	LAHENDONG	99		356	X		200		125		95	80	175	175	2000	10	230	1000	200	80%	22	26	77.0	210.0	287	440	1,200	1,640
SulUta	62	KOTAMOBAGU	98	<320		X		200			260			260	200	2000	6	190	1000	200	70%	48	45	155.1	240.0	395	776	1,200	1,976
SulUta	63	TOMPASO	98	>250		X		200			400			400	200	1500	6	180	1000	200	70%	48	43	126.5	240.0	367	633	1,200	1,833
SulTen	64	BORA	81			X		500																					
SulTen	65	MERANA	90			X		500			380			380	380	1500	4	160	1000	200	70%	136	109	344.3	456.0	800	906	1,200	2,106
SulSel	66	BITUANG	98			X		500																					
Sul SE	67	LAINEA	85			X		500																					
MalUta	68	TONGA WAYANA	60				X	10																					
Maluku	69	TULEHU	92	>230			X	30			25			25	25	1500	4	160	1000	200	70%	9	7	22.6	30.0	53	902	1,200	2,102
MalUta	70	JAILOLO	97				X	20		320																			
SumUta	71	SIPAHOLON-TARUTUNG	47	>170		X		3,000			85			85	85	1500	4	180	1000	200	70%	31	27	80.9	102.0	183	951	1,200	2,151
JavaTim	72	Iyang Agropuro	65																										
Golontaro	73	SUWAWA-GOLONTALO	83	>130		X		200			210			210	200	1500	4	160	1000	200	70%	72	58	182.6	240.0	423	913	1,200	2,113

Table 4.5-1 (1) Geothermal Resource Areas in Sumatra Island

Region	No	Names of the 70 fields in this Survey	Reservoir Volume (x 10^9 m^3)			Temperature(°C)			Surface Water Type (Hot Spring)			Potential (MW)					Stage of Develoment
			Min.	Most Likely	Max.	Surface	Geotherm	Measured	pH	Major Anion	Cl max (ppm)	Spec.	Hypo.	Possible	Probable	Proven	
Aceh	1	IBOIH - JABOI	3.4	5.1	6.8	100	170-290		2.4-7.5	SO4, HCO3, Cl-SO4	1353			15			S2
Aceh	2	LHO PRIA LAOT				101	170-220		6.5	Cl	5312						S1
Aceh	3	SEULAWAH AGAM	118	177	236	100	180-300		6.5-7.0	Cl-SO4	2399			900			S2
Aceh	4	G. GEUREUDONG				69											RE
Aceh	5	G. KEMBAR				89	>190		7.8	Cl-SO4	828						S1
SumUta	6	G. SINABUNG															RE
SumUta	7	LAU DEBUK-DEBUK / SIBAYAK	2	3.975	6.6	116		302	6.7	HCO3	110		70	131		39	OP
SumUta	8	SARULA	15.1	22.65	30.2	101		310	3.1-9.3	SO4, HCO3, Cl-HCO3, Cl-SO4	1310		100	147		133	F2
SumUta	9	SIBUAL BUALI	7.1	10.65	14.2	72		267	7.5-7.9	HCO3, Cl-HC	288					80	F1
SumUta	10	S. MERAPI - SAMPURAGA	89	133.5	178	119	<290		1.8-7.7	SO4, HCO3, mixed, Cl-HCO3	933			700			S2
SumUta	11	PUSUK BUKIT - DANAU TOBA				90	<290		2.8-3.7	SO4, Cl-SO4	394						S1
SumUta	12	SIMBOLON - SAMOSIR				91	>170		3.4-8.4	SO4, HCO3	479						S1
SumUta	71	SIPAHOLON-TARUTUNG	14.2	21.3	28.4	65	>170		6.2-7.2	SO4, HCO3, mixed, Cl-HCO3	277			85			S1
SumBar	13	MUARALABUH	80.3	120.45	160.6	106	180-270		2.0-8.5	SO4, HCO3, C	1532		250	250			S2
SumBar	14	G. TALANG	3.4	5.1	6.8	98	<290		2.2-8.6	SO4, HCO3	198			25			S2
Jambi	15	LEMPUR / KERINCI	4.5	6.75	9	97	210-290		2.8-7.2	SO4, HCO3 (Cl: well)	9 (1440: well)			20		15	F1
Jambi	16	SUNGAI TENANG	33.8	77.1	138	96			8.0	Cl-SO4	392						S1
Jambi	17	SUNGAI PENUH	69	103.5	138	102	200-250		7.0-8.9	Cl-HCO3	584			600			S2
Jambi	18	SUNGAI BETUNG				30											S1
Jambi	19	AIR DIKIT				98			2.5	SO4	3						S1
Jambi	20	G. KACA				41											S1
Bengkulu	21	B. GEDUNG HULU LAIS	128	192	256	95	180-290		2.1-7.2	SO4, HCO3, Cl-SO4, Cl-HCO3, Cl	3155			1,000			S2
Bengkulu	22	TAMBANG SAWAH	60.6	90.9	121.2	99	>230		6.1-8.9	SO4, HCO3, Cl	3411			400			S2
Bengkulu	23	BUKIT DAUN				95			2.3	SO4	47						S1
SumSel	24	MARGA BAYUR	21	31.5	42	98	180-250		1.7-7.6	SO4, HCO3	16			130			S2
SumSel	25	LUMUT BALAI	70	105	140	98			2.5	SO4	80			820			S2
SumSel	26	RANTAU DADAP - SEGAMIT				96											S1
Lampung	27	ULUBELU	50	75	100	99			2-neutral		900			580			F1
Lampung	28	SUOH ANTATAI	77.6	116.4	155.2	99	230-300		7.0-7.2	Cl-SO4, Cl	1326			920			S2
Lampung	29	G. SEKINCAU	37.3	55.95	74.6	98	260-300		7.5-7.6	HCO3, Cl	1370			380			S2
Lampung	30	RAJABASA	20.1	30.15	40.2	100	200-280		6.0-6.5	HCO3, Cl-HCO3, Cl	6830			170			S2
Lampung	31	WAI RATAI	18.8	28.2	37.6	92	220-290		5.9-7.4	Cl-HCO3, Cl	2589			180			S2
Sub-Total in Sumatra													420	7,453		267	

Table 4.5-1 (2) Geothermal Resource Areas in Java-Bali region

Region	No	Names of the 70 fields in this Survey	Reservoir Volume (x 10 ^{9} m^{3})			Temperature(^{o}C)			Surface Water Type (Hot Spring)			Potential (MW)					Stage of Develoment
			Min.	Most Likely	Max.	Surface	Geotherm	Measured	pH	Major Anion	Cl max (ppm)	Spec.	Hypo.	Possible	Probable	Proven	
JavaBar	32	KAMOJANG	11.2	18.9	28	96		252	2.9-8.2	SO4, HCO3	17				73	227	OP
JavaBar	33	G. SALAK	22.1	33.15	44.2			280						115		485	OP
JavaBar	34	DARAJAT	13.3	19.95	28.6	77		245	3.0-5.0	SO4	14					362	OP
JavaBar	35	CISOLOK - CISUKARAME	50.4	75.6	100.8	99	>250		6.8-8.7	SO4, mixed, Cl-SO4, Cl-HCO3	560			400			F1
JavaBar	36	G. PATUHA				89		245					65	247		170	F2
JavaBar	37	G. WAYANG - WINDU	25.4	63.675	119	50		270					75		135	250	OP
JavaBar	38	G. KARAHA	79.1	118.65	158.2	95			6.6	SO4	11		50	70	100	30	F2
JavaBar	39	G. TELAGABODAS				92							75	120	80		S2
JavaBar	40	TANGKUBANPERAHU	3.4	5.1	6.8	96	>170		2.5-7.4	SO4, HCO3, Cl-SO4, Cl-HCO3, Cl	1581			20			S2
Banten	41	BATUKUWUNG				52											S2
Banten	42	CITAMAN - G. KARANG	4	6	8	94	>180				(150)		50	25			F1
Banten	43	G. ENDUT				84											RE
JavaTen	44	DIENG	6.5	14.55	25.8	94		368					200	185	115	280	OP
JavaTen	45	MANGUNAN				46											S2
JavaTen	46	TELOMOYO	15.1	22.65	30.2	37	>190		7.6	HCO3 (SO4, mixed: well)	180			90			S2
JavaTen	47	UNGARAN	24.5	36.75	49	86	180-320		6.0-8.0	HCO3, Cl-HCO3, Cl	5339			230			S2
JavaTen	48	G. SLAMET				51			7.9	HCO3	26						S2
JavaTim	49	G. ARJUNO - WELIRANG				70			6.7	HCO3	334						S1
JavaTim	50	WILIS / NGEBEL	20.8	31.2	41.6	93	190-250		6.6-7.0	Cl (Cl-HCO3: well)	4627			180			S2
JavaTim	51	IJEN	21.2	31.8	42.4	57			6.5-8.3	HCO3	152			130			S2
JavaTim	72	Iyang Agropuro				65			7.4	HCO3	26						S1
Bali	52	BEDUGUL				32		285					75	245		30	F2
Sub-Total in Java-Bali													590	2,057	503	1,834	

Table 4.5-1 (3) Geothermal Resource Areas in Sulawesi and East Indonesia

Region	No	Names of the 70 fields in this Survey	Reservoir Volume (x 10^9 m^3)			Temperature(°C)			Surface Water Type (Hot Spring)			Potential (MW)					Stage of Develoment
			Min.	Most Likely	Max.	Surface	Geotherm	Measured	pH	Major Anion	Cl max (ppm)	Spec.	Hypo.	Possible	Probable	Proven	
NTB	53	HU'U DAHA	30.4	45.6	60.8	86			2.2-6.7	SO4, HCO3, Cl-SO4	1555			190			S2
NTT	54	WAI SANO	9.1	13.65	18.2	92	>250		5.7-7.1	SO4, HCO3, Cl-HCO3, Cl	20000			70			S2
NTT	55	ULUMBU	17	25.5	34	96		240	3.0-4.4	SO4	36					175	F2
NTT	56	BENA - MATALOKO	3	4.5	6	95	270-300		2.5-6.4	SO4	18					20	F2
NTT	57	SOKORIA - MUTUBUSA	16.4	24.6	32.8	97	180-320		1.9-8.0	SO4, HCO3, Cl-SO4, Cl-HCO3	1560			150			S1
NTT	58	OKA - LARANTUKA	23.9	35.85	47.8	90			2.6-8.6	SO4, HCO3, Cl-HCO3, Cl-SO4, Cl	4994			145			S1
NTT	59	ILI LABALEKEN															RE
NTT	60	ATADEI	14.9	22.35	29.8	97			8.1	HCO3	10			90			F1
SulUta	61	LAHENDONG	9.9	14.85	19.8	99		356	8.7	mixed	290		125		95	80	OP
SulUta	62	KOTAMOBAGU	30	45	60	98	<320		2.0-7.8	SO4, HCO3, mixed, Cl-SO4, Cl-HCO3	869			260			S2
SulUta	63	TOMPASO	39.9	59.85	79.8	98	>250		2.2-7.8	SO4, mixed, Cl-SO4	280			400			S2
Golontaro	73	SUWAWA-GOLONTALO	33.9	50.85	67.8	94	>130		7.4-7.8	SO4, Cl-SO4	923			210			S2
SulTen	64	BORA				81											RE
SulTen	65	MERANA	63.3	94.95	126.6	90			6.8-8.8	HCO3, mixed, Cl-HCO3, Cl-SO4, Cl	3569			380			S1
SulSel	66	BITUANG				98											RE
Sul SE	67	LAINEA				85											RE
MalUta	68	TONGA WAYANA				60											S1
Maluku	69	TULEHU	4.4	6.6	8.8	92	>230		6.5-7.7	HCO3, Cl-HCO3, Cl-SO4, Cl	14300			25			S2
MalUta	70	JAILOLO	44.3	66.45	88.6	97			7.2-7.8	HCO3, Cl-HCO3, Cl-SO4, Cl	6954		320				S2
Sub-Total in Sulawesi and East Indonesia													445	1,920	95	275	
Grand-Total in Indonesia													1,455	11,430	598	2,376	

Chapter 5 Electric Power Sector

5.1 Outlook of Future Electric Power Supply and Demand for Geothermal Development Plan

The power demand of Indonesia (amount of electric power sold) in 2004 was 100,097 GWh, and the maximum demand for power was 18,896 MW. To meet this demand, electric power of 120,161GWh was generated by power plants with a total 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%) (Fig.5.1-1). The electricity demand for all Indonesia will reach 450,000 GWh in 2025 (annual average growth rate of 7.2% from 2004), and the maximum electric power demand will reach 79,900 MW in 2025 (ditto 6.8%). (Fig. 5.1-2)

5.2 Required transmission lines and substation facilities on construction of geothermal power plants

The service voltages of transmission lines in Indonesia are 500kV, 275kV (design but 150kV operation), 150kV and 70kV, and 20kV for distribution lines. Java has the most developed power system. Next is Sumatra, and others including Sulawesi and Kalimantan have separate power systems in each urban area. The power generated by the 73 prominent geothermal power development sites will be able to be transmitted to Indonesian power systems (transmission lines or distribution lines) directly. Each connection to the power systems has been reviewed with reference to the exact point of connection and the method of the connection in consideration of the generation capacity, the transmission line construction cost and the convenience of system operation.

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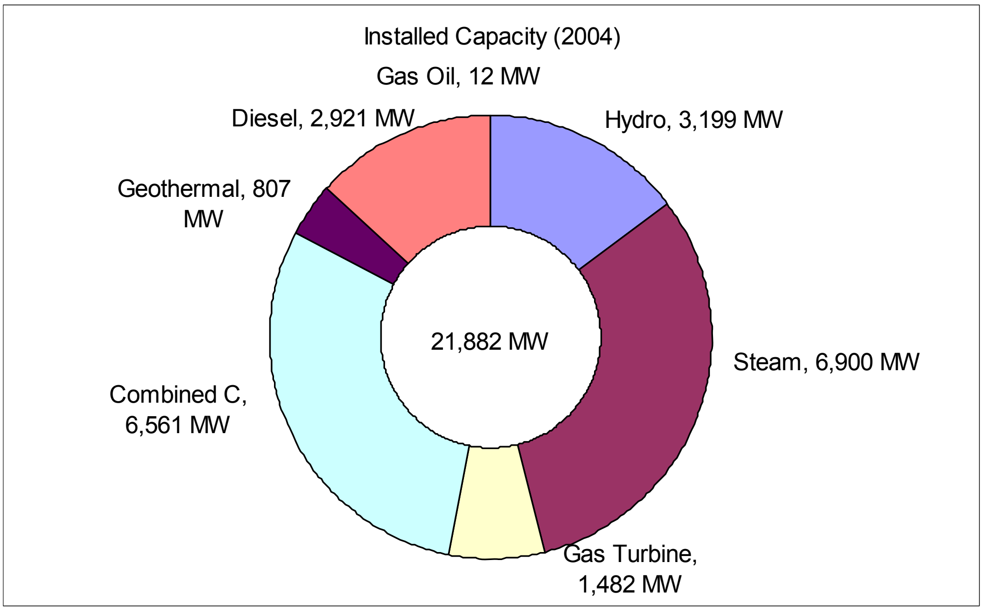
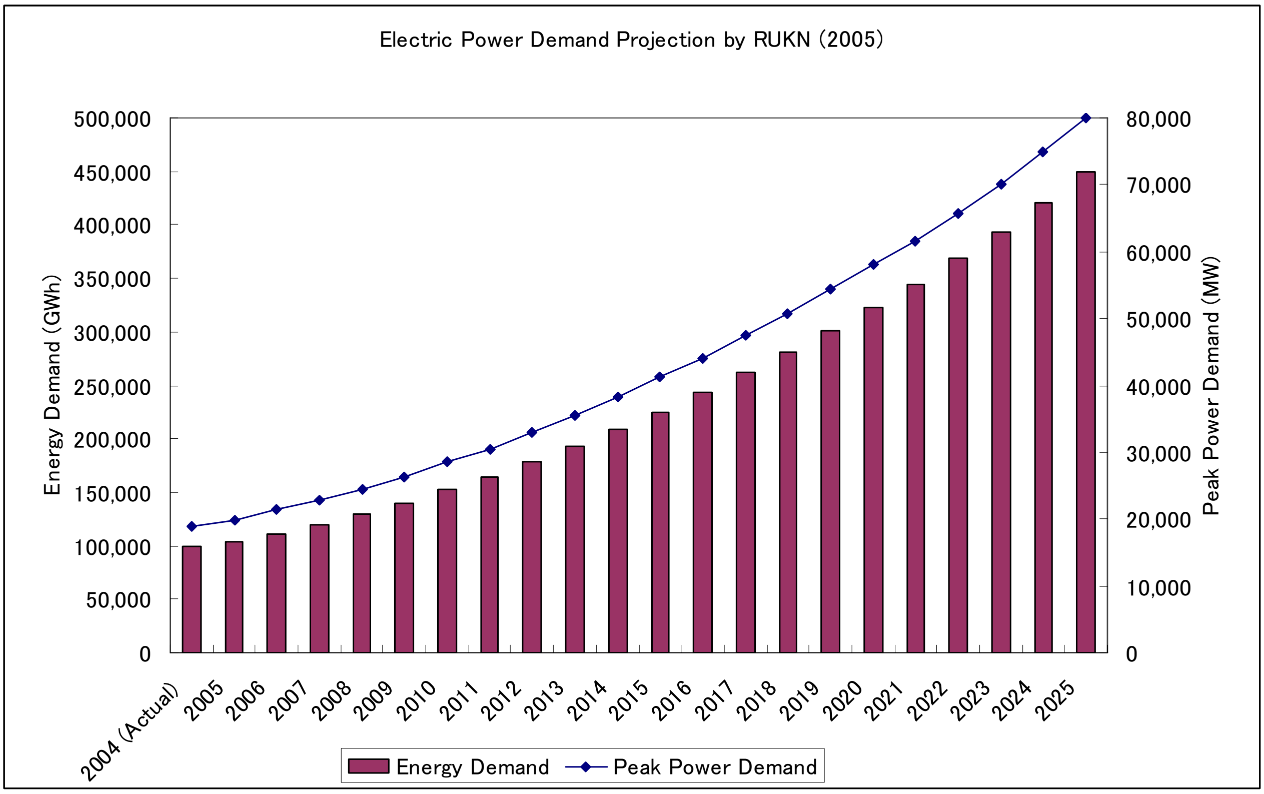
1 As of 2007, the capacity of geothermal power plants is 857MW.



(Source) PLN Statistics (2004)

Fig. 5.1-1 Installed Power Plant Capacity (2004)



(Source) RUKN (2005)

Fig. 5.1-2 Projection of Electric Power Demand (All Indonesia)

Chapter 6 Natural and Social Environmental Study

6.1 Expected environmental impact of project implementation

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, and each impact is evaluated to be either positive or negative. The scope of conceivable impacts is evaluated for each project stage: the planning -F/S stage, the construction stage and the operation stage. The study results are shown in Table 6.1-1.

Some negative impacts of on the natural environment, such as surface survey and test well drilling, are considered at the planning and Planning-F/S stage . Serious impacts of pollution, impacts on the natural environment and geographical features, and involuntary resettlement are expected at the construction stage, arising from geothermal well drilling, construction of power facilities and the geothermal fluid transportation system. Serious impacts of pollution and impacts on the natural environment are expected at the operation stage due to geothermal brine and non-condensable gas emissions.   On the other hand, positive impacts are expected to enhance the local economy byincreasing employment opportunities, improving livelihoods, etc.   Because the GHG emissions from geothermal plants are less than those from other thermal power plants, reduction of GHG emissions is expected to be another positive impact.

6.2 Natural and social environmental study

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

6.2.1   Initial environmental study

The natural and social environmental study includes investigation of the legal framework of environmental preservation and the disincentive effects on geothermal power development of environmental regulation in the 73 prospective fields..   Information concerning the social environment, the natural environment, pollution, noise/vibration, grand subsidence, etc. was collected in this study. These collected data are used as fundamental inputs for the geothermal developer in collecting data and preparing a development plan for promising fields.

6.2.2 Envirommental Impact Assesment

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. The results are shown in Table 6.2.2-1. 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.

Table 6.1-1 Scope of Environmental and Social Considerations

Items	Overall Rating	Planning-F/S	Construction	Operation
Air Pollution	-A	-B	-B	-A
Water Pollution	-A	-B	-B	-A
Soil Pollution	-B	-B	-B	
Waste	-B	-B	-B	-B
Noise and Vibration	-B	-B	-B	-A
Ground Subsidence	-A			-A
Offensive Odors	-B	-B	-B	-B
Geographical Features	-A	-B	-A	-B
Bottom Sediment				
Biota and Ecosystem	-A	-B	-A	-A
Water Usage	-B	-B	-B	-B
Accidents	-B	-B	-B	-B
Global Warming				+A
Involuntary Resettlement	-A	-B	-A	
Local Economy (such as employment, livelihood, etc.)	+A	+B	+A	+A
Land Use and Utilization of Local Resources	+B	+B	+B	+B
Social Institutions (such as social infrastructure and local decision-making institutions)	C			C
Existing Social Infrastructures and Services	＋B		+B	+B
The poor, Indigenous Ethnic People	C			C
Misdistribution of Benefit and Damage	C			C
Local Conflict of Interests	C			C
Gender				
Children's Rights				
Cultural Heritage	-B		-B	
Infectious Diseases such as HIV/AIDS and others				

+ : positive impact -: negative impact

A : Serious impact is expected B : Some impact is expected

C : Extent of impact is unknown

No Mark : No impact is expected

Table 6.2.1-1 Summary of Initial Environmental Examination

Category	Environmental Item	No3	No14	No17	No21	No24	No28	No29	No36	No40	No42	No46	No47	No50	No51	No57	No63	No71	No73
		Muara Labuh	G. Talan	Sungai Penuh	B. Gedung Hulu Lais	Marga Bayur	Suoh Antatai	G. Sekicau	Cisolok - Cisukarame	Tangkuban Perahu	Citaman - G. Karang	Telomoyo	Ungaran	Wilisngebel	Ijen	Sokoria - Mutubusa	Tompaso	Sipaholon - Tarutun	Swawa - Gorontalo
Mitigation Measures	(1) Air Quality	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
	(2) Water Quality	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
	(3) Wastes	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
	(4) Soil Contamination	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
	(5) Noise and Vibration	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
	(6) Subsidence	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
	(7) Odor																		
Natural Environment	(1) Protected Areas	-B	-B	-B	-B	-A	-B	-A	-B	-B	-B	-B	-B	-B	-A	-B	-B	-B	-B
	(2) Ecosystem	C	C	-B	C	C	C	C	-B	-B	C	C	C	C	C	C	C	C	C
	(3) Hydrology	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
	(4) Topography and Geology	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Social Environment	(1) Resettlement																		
	(2) Living and Livelihood	+B	+B	+B	+B	+B	+B	+B	+B	+B	+B	+B	+B	+B	+B	+B	+B	+B	+B
	(3) Heritage																		
	(4) Landscape																		
	(5) Ethnic Minorities and Indigenous Peoples																		

+ : positive impact -: negative impact   A : Serious impact is expected B : Some impact is expected C : Extent of impact is unnkown   No Mark : No impact is expected

Chapter 7 Formation of the Master Plan

7.1 Master Plan for Geothermal Development

In this chapter, the Master Plan for geothermal development constructed from the data and information collected through the various kinds of studies will be discussed. The Master Plan comprises mainly the development priority and development implementation plan for each the field.

7.1.1 Process for Formation of the Master Plan

The process flow for formation of the Master Plan for geothermal development is shown in Fig. 7.1.1-1. An outline of each process of formation of the Master Plan is given 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 possible existence of an exploitable geothermal reservoir in the field, and the exploitable resource potential in 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.
- Taking account of the future increase in power demand, an upper limit of the geothermal development scale in 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.

7.1.2 Expansion and Existing Projects

The current practical plans for geothermal development/expansion projects were confirmed through interview to developers (PERTAMINA, PLN, etc.) during a mission trip to Indonesia in June 2007. Most of the existing plans for development/expansion are for projects in the existing Working Area and are proposed by PERTAMINA or other private companies. The other projects in two fields have been planned by PLN as small-scale developments in remote areas. The total installed capacity of the existing plans reaches 1,847MW. A future expansion plan is assumed in the G. Salak field.

7.1.3 Geothermal Resource Evaluation

(1) Development Priority Based on Likelihood of Reservoir Presence

The geothermal resource characteristics were assessed in each of the 73 promising fields. However, because of a lack of sufficient geoscientific data, only 50 fields among the 73 fields could be evaluated in terms of resource characteristics and capacity.
For geothermal resource evaluation relating to development priority, the evaluated fields were classified into 4 ranks, listed below according to the likelihood of reservoir presence.

- 1 : The reservoir is ascertained by well drilling(s). (including already developed fields)
- 2 : The existence of a reservoir is inferred mainly from appropriate geothermometry using chemical data about hot springs and fumarolic gases. The likelihood of reservoir presence is extremely high.
- 3 : The existence of a reservoir is inferred from a variety of geoscientific information, including geological and geophysical survey data and the occurrence of high temperature manifestations.
- Low : The likelihood of reservoir presence is low; or only a low temperature reservoir may exist. (However, there is a possibility of power plant project utilizing low enthalpy fluids.)

In addition to these four ranks, geothermal fields where insufficient geoscientific data is available, were classified as ‘NE’.

(2) Estimated Resource Potential

Geothermal resource potential for each field was estimated as a resource capacity that is thought to be technically possible to exploit, based on the results of the Stored-heat method calculation. The estimation was based on the resource potential having some range, which results from the calculation adopting Monte Carlo analysis and taking account of the values estimated by the Government of Indonesia (CGR, MEMR) and PERTAMINA in the past.

The resource potential of the 50 fields was estimated to be 11,405MW in total. The minimum exploitable resource potential of 23 fields out of the 73 study fields was calculated to be 1,050 MW in total. Moreover, the minimum potential of all geothermal fields in Indonesia excluding the 73 fields was calculated to be 2,853 MW in total.

7.1.4 Natural/Social Environmental Evaluation (National Park Restrictions)

At present, geothermal power development within the area of national parks is prohibited in Indonesia (but directional well drilling from the outside into a national park is permitted). Development of all the resource existing in the field, therefore, is not possible at geothermal prospects where some part of the area is national park. In such a case, the exploitable resource potential is reduced according to the ratio of national park area within the inferred geothermal reservoir area.

At the fields listed below, the exploitable resource potential was significantly reduced from the actually existing potential because of a large ratio of national park area within the inferred geothermal reservoir area.

Sumatra: Seulawah Agam, Lau Debuk-Debuk/Sibayak, S. Merapi - Sampuraga, Lempur/Kerinci, G. Sekincau

Java-Bali: Ijen, Bedugul

7.1.5 Power Sector Evaluation (Power Demand Restrictions)

Since a geothermal power plant is operated basically for base load and not for peak load, the geothermal power plant capacity that should be developed in a certain field is restricted by the minimum power demand in the power grid where the field is located. In this study, taking account of the future increase in power demand, an upper limit of the geothermal development scale in each field is assumed according to the minimum demand of 2025 in the power grid.

The estimated potential for each region is tabulated below.

Region	Installed Capacity	Existing Plan	Possible New/Additional Plan	Total Resource Potential
Sumatra	2	913	3,605	4,520
Java-Bali	835	785	2,015	3,635
Nusa Tenggara	0	9	138	146
Sulawesi	20	140	575	735
Maluku	0	0	40	40
Total (MW)	857	1,847	6,373	**9,076**

The geothermal resource potential (possible development capacity) specified above is considered to be the maximum exploitable resource potential in the 50 fields up to 2025. The locations of the 50 fields with their evaluated potential are shown in Fig. 7.1.5-1.

7.1.6 Economic Evaluation of Resources for Geothermal Power Generation

The economic values of resources for geothermal power generation are evaluated based on the estimated development scale and the resource characteristics in 49 fields where sufficient geoscientific data has been available as presented in Chapter 4. The resource capacity in each field is assumed to be the amount to be developed by 2025. Resource characteristics such as depth of reservoir, steam production and brine flow per well, and reinjection capacity per well are assumed from the geothermal conceptual models presented in Chapter 4. The other conditions for economic evaluation are assumed to be similar to the model project shown in Chapter 8.

The profitability of the project (a financial internal rate of return: FIRR) is calculated at the electricity purchase price of 5 cents/kWh. Profitability is classified into E1, E2, E3, and E4, in order of decreasing profitability. The calculated profitability reflects the resource potential such as steam production per well and the scale of the reservoir, i.e. the extent of scale merit advantage.

7.1.7 Transmission Line Length for Power Plant Project

The necessary T/L length was treated as a supplemental factor for ranking the development priority. For fields where a development/expansion plan currently exists or where fields have been given the rank of NE, the necessary T/L length was ignored for evaluation. For the ranking of fields by project economy, priority was given to the classification by profitability. When the necessary T/L length is less than 20km, the development priority of the field remains unchanged.

The development priority of two fields, Marga Bayur and Merana, which were classified as rank 3 by resource potential and as rank E2 by profitability, were ranked lower due to the longer T/L length.

7.1.8 Determination of Development Priority and Proposed Plant Capacity

From the results of evaluations mentioned above from 7.1.2 to 7.1.7, the development priority and the development scale of future projects in each field is determined.

The determined rank is shown in Table 7.1.6-1 as ‘Development Priority’ with other parameters and information. The ranks are classified into A, B, C, L and N in decreasing order of priority, but fields classified as N could be re-evaluated and possibly ranked higher than rank L in accordance with results of further resource assessment in future. 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 in 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

7.1.9 Development Plan for Each Field

According to the determined development scale (power plant capacity), a geothermal development plan for each field was made for the 50 fields. For the fields classified into ranks B, C and L, where no development plan exists at present, we drew up a development plan including recommendable power unit and number of the units in consideration of the resource characteristics of and power demand on the field. Additionally, we created development schedules corresponding to each plan and estimated the development cost for the fields, including ones classified into rank A. The development plans for each of the 50 fields were summarized in a sheet with the results of various kinds of evaluations.

7.1.10 Formation of the Master Plan

Based on the results of various studies and considerations mentioned from 7.1.2 to 7.1.9, 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. Note that the Master Plan does not consider the actual participation of developers necessary for realizing the plan.

The final goal of the Master Plan is to develop 9,500MW of 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 (refer to Chapter 5) as well as the development schedules for each field described in the previous section. 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 7.1.10-1). 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 7.1.10-2.

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.

7.1.11 An Electric Power Development Plan compatible with the Geothermal Development Master Plan

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 (Table 7.1.11-1).

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. About 30% of power suppliers will be peak load suppliers, about 30% will be middle load suppliers, and about 40% will be base load suppliers in a large-scale system, while the composition of a small-scale system will be about 40% peak load suppliers, about 40% middle load suppliers, and about 20% base load suppliers (Table 7.1.11-2, Figs. 7.1.11-1 and 7.1.11-2).

Based on these studies, the power plant development plan of RUKN (2005) was adjusted to accommodate the Master Plan for geothermal development (Table 7.1.11-3). 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 (Table 7.1.11-4, Figs. 7.1.11-3 and 7.1.11-4).

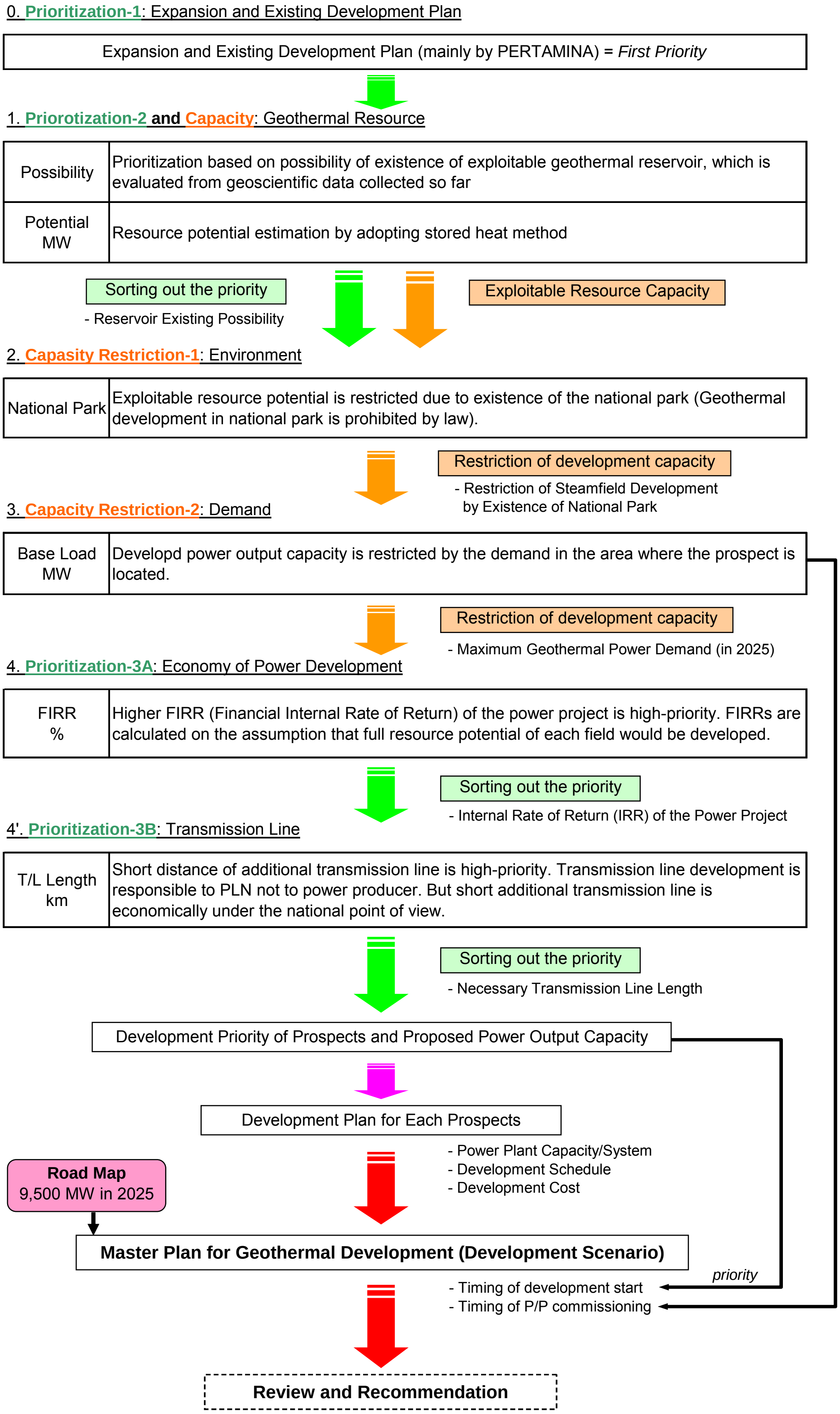


Fig. 7.1.1-1 Methodological Flow for Formation of Master Plan for Geothermal Development

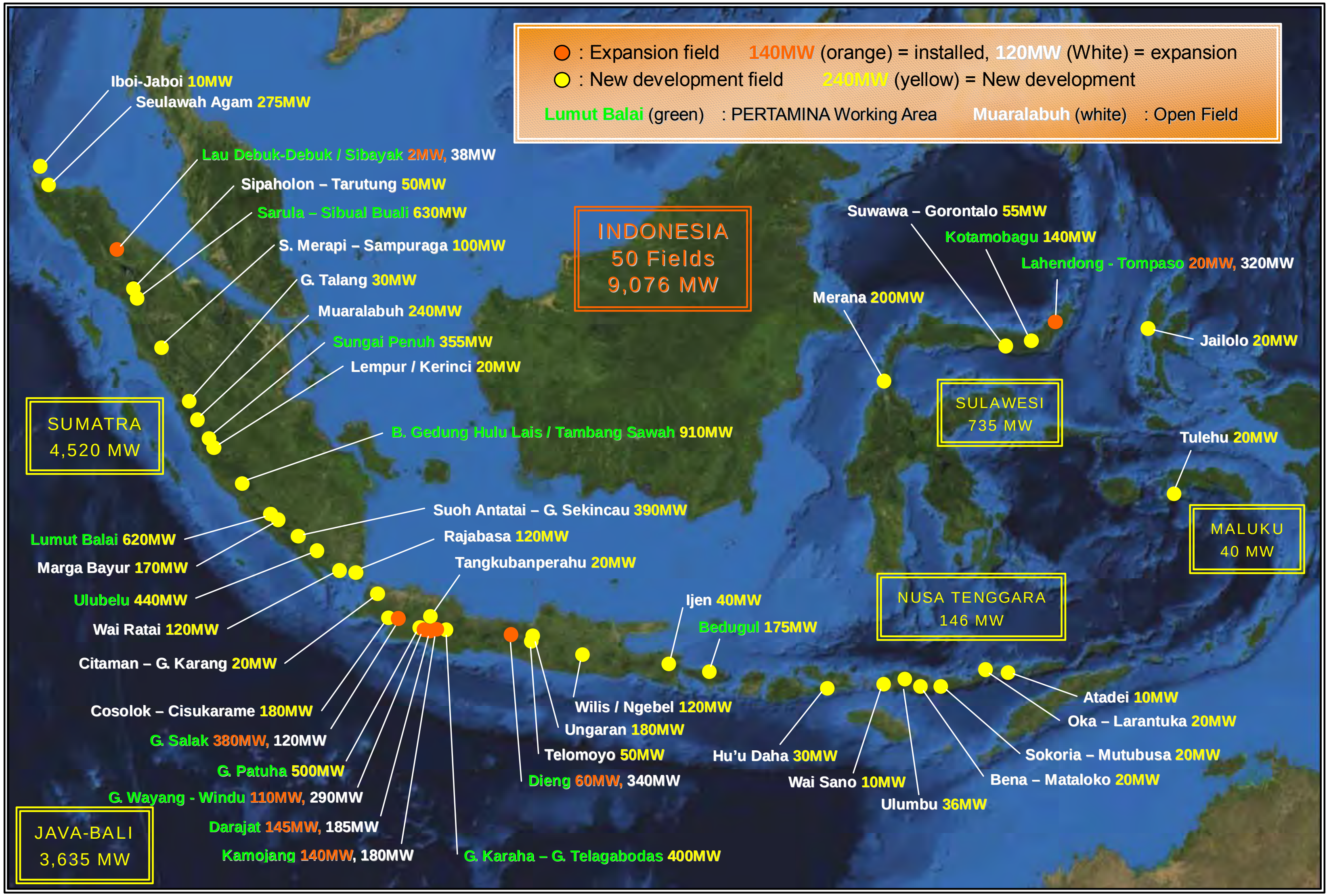


Fig. 7.1.5-1 Map Showing the Possible Development/Expansion Capacity in Promising Geothermal Fields

Table 7.1.8-1 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	40	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 7.1.10-1 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 7.1.10-2 (1) 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 7.1.10-2 (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
		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 7.1.11-1 Power Plant Mix in 2025 by RUKN

Power Plant	MW	Existing (2004) (a) (*1)		New Plant (2005-2025) (b) (*2)		Total (as of 2025) (c) (*3)	
Hydro Power	MW	3,199	(14.6%)	2,666	(3.5%)	5,865	(6.3%)
Gas Turbine	MW	1,494	(6.8%)	6,235	(8.2%)	7,285	(7.8%)
Combined cycle	MW	6,561	(30.0%)	16,665	(21.9%)	21,756	(23.3%)
Steam	MW	6,900	(31.5%)	36,637	(48.1%)	41,982	(45.0%)
Geothermal	MW	807	(3.7%)	1,429	(1.9%)	2,286	(2.5%)
Diesel	MW	2,921	(13.4%)	583	(0.8%)	2,089	(2.2%)
Nuclear	MW	0	(0.0%)	12,000	(15.7%)	12,000	(12.9%)
Total	MW	21,882	(100.0%)	76,214	(100.0%)	93,263	(100.0%)

(Source) *1 from PLN Statistics 2004, Pertamina Geothermal Energy Boucher
*2 from RUKN (2005)
(Note) *3 (C) is not equall to (a)+(b) due to decommission of power plants.

Table 7.1.11-2 Model Power Plant Specification of various Energy Sources

Power Source	Plant Capacity (MW)	Initial Investment (m$)	Unit Cost ($/kW)	Construction Years (Yrs.)	Plant Factor (%)	Fuel Price ($/MMBTU)	Heat rate (%)	Remarks
Geothermal	55	136	2,500	5	85	-	-	
Coal	600	510	850	3	85	1.8 (35$/t)	38	include port, coal yard, ash disposal pond etc.
	50	79	1,580					
Natural Gas CC	600	300	500	3	85	8.6 (50$/B)	50	not include gas pipeline
	50	60	1,200					
Diesel	10	16	1,550	2	85	12.9 (50$/B)	38	
Hydropower	20	44	2,200	4	60	-	-	

(Note) Initial investment does not include Interest during Construction (IDC).

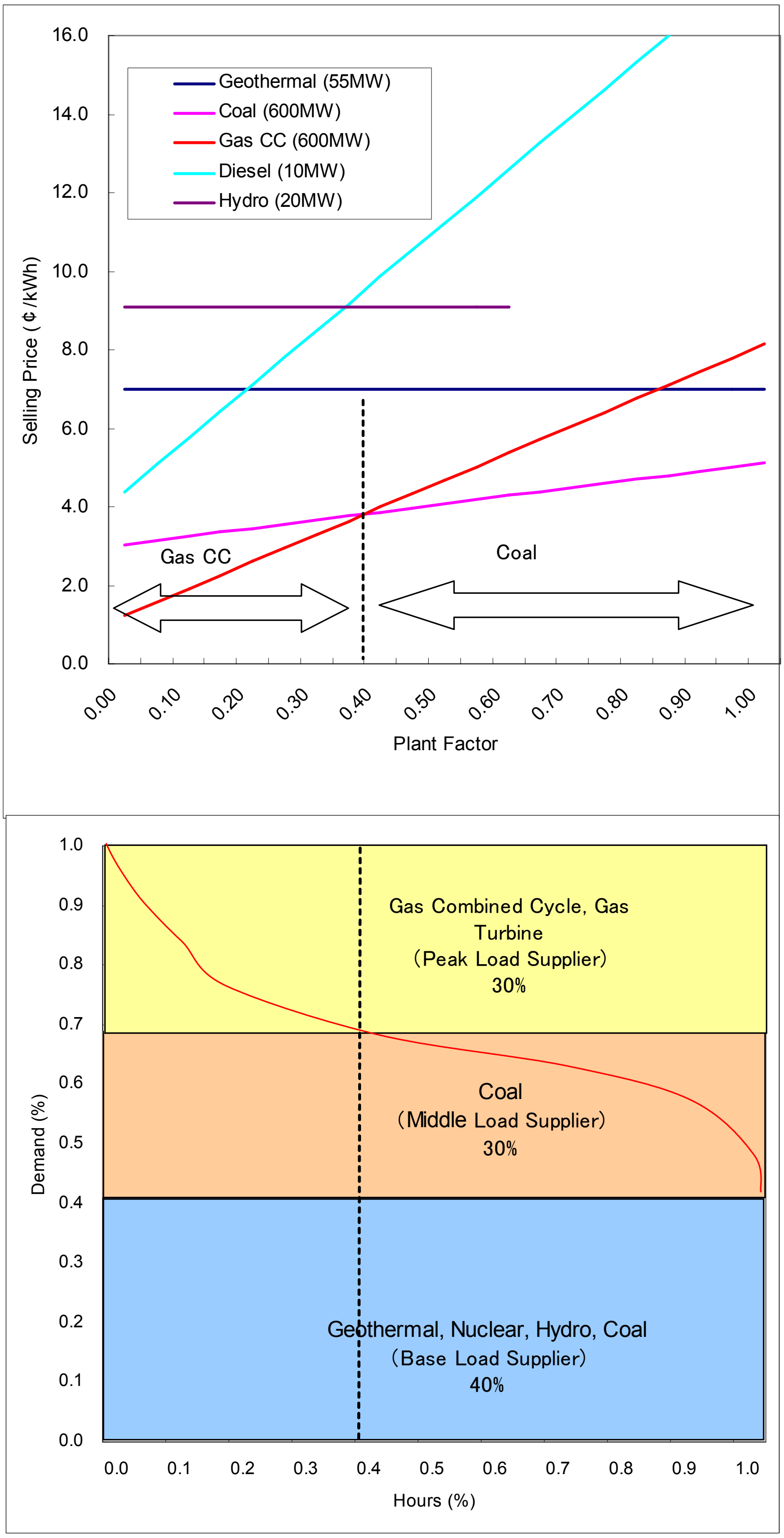
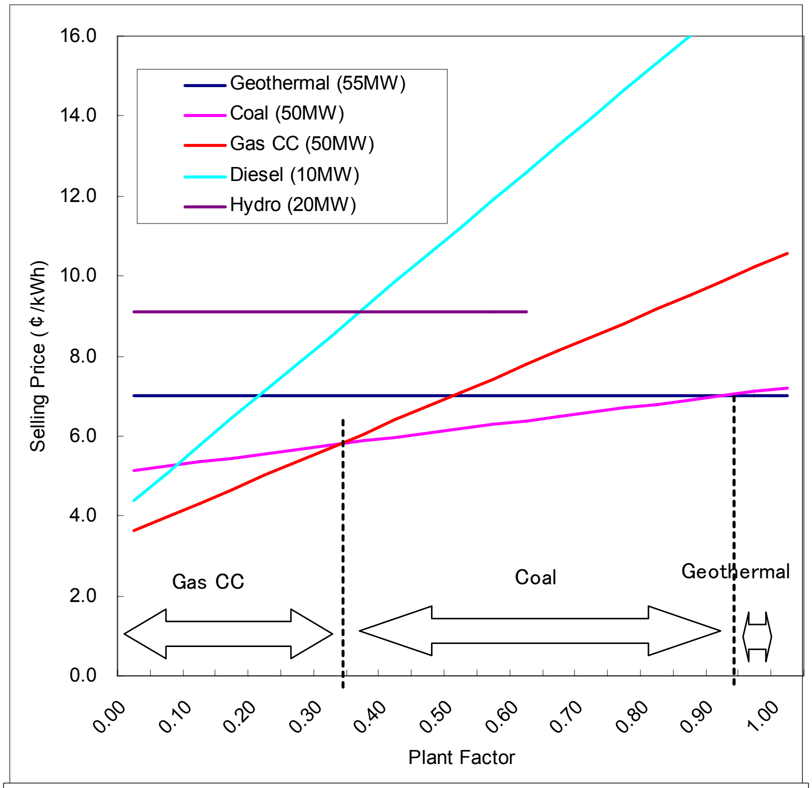


Fig. 7.1.11-1 The Role of Power Plant and Composition in Java-Bali System



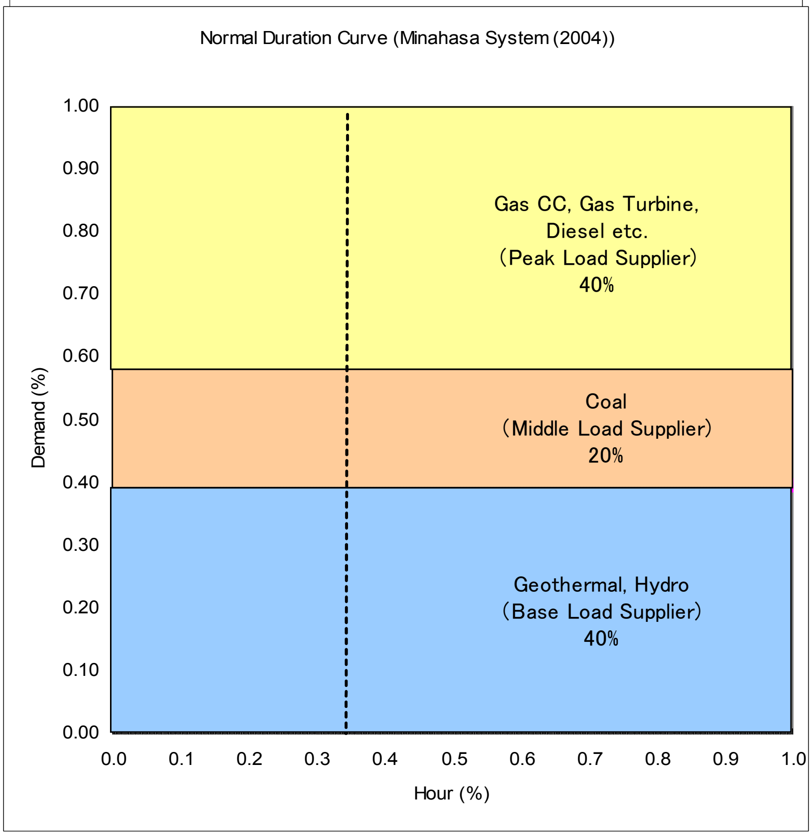


Fig. 7.1.11-2 The Role of Power Plant and Composition in Small-Scale System
(Minahasa System Example)

Table 7.1.11-3 Power Plant Mix in Geothermal Development Scenario in Master Plan

(MW)

System	Existing (2004) (a) (*1)		New Plant (2005-2025) (b) (*2)		Total (as of 2025) (C) (*3)		RUKN (2025) (d)		Difference (c)-(d)
Sumetra									
Peak Demand	2,531		-		10,176		10,176		-
Minimum Demand	1,012		-		6,170		6,170		-
Power Plant	3,352	(100%)	10,357	(100%)	12,530	(100%)	12,530	(100%)	0
Hydro Power	566	(17%)	1,062	(10%)	1,628	(13%)	1,628	(13%)	0
Gas Turbine	377	(11%)	1,080	(10%)	1,297	(10%)	1,297	(10%)	0
Combined cycle	818	(24%)	900	(9%)	1,372	(11%)	1,372	(11%)	0
Steam	745	(22%)	2,597	(25%)	3,027	(24%)	7,195	(57%)	-4,168
Geothermal	2	(0%)	4,718	(46%)	4,720	(38%)	552	(4%)	4,168
Diesel	844	(25%)	0	(0%)	486	(4%)	486	(4%)	0
Nuclear	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0
Java-Bali									
Peak Demand	14,310		-		59,107		59,107		-
Minimum Demand	5,724		-		21,543		21,543		-
Power Plant	15,908	(100%)	54,555	(100%)	68,092	(100%)	68,092	(100%)	0
Hydro Power	2,409	(15%)	1,000	(2%)	3,409	(5%)	3,409	(5%)	0
Gas Turbine	927	(6%)	2,800	(5%)	3,550	(5%)	3,550	(5%)	0
Combined cycle	5,683	(36%)	14,015	(26%)	18,616	(27%)	18,616	(27%)	0
Steam	6,000	(38%)	23,740	(44%)	28,598	(42%)	28,938	(42%)	-340
Geothermal	785	(5%)	3,000	(5%)	3,835	(6%)	1,495	(2%)	2,340
Diesel	103	(1%)	0	(0%)	84	(0%)	84	(0%)	0
Nuclear	0	(0%)	10,000	(18%)	10000	(15%)	12000	(18%)	-2,000
Surawesi & Gorontalo									
Peak Demand	242		-		1,336		1,336		-
Minimum Demand	97		-		534		534		-
Power Plant	344	(100%)	1,540	(100%)	1,661	(100%)	1,661	(100%)	0
Hydro Power	61	(18%)	50	(3%)	111	(7%)	111	(7%)	0
Gas Turbine	0	(0%)	290	(19%)	290	(17%)	290	(17%)	0
Combined cycle	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0
Steam	0	(0%)	645	(42%)	645	(39%)	950	(57%)	-305
Geothermal	20	(6%)	515	(33%)	535	(32%)	230	(14%)	305
Diesel	263	(77%)	40	(3%)	80	(5%)	80	(5%)	0
Nuclear	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0
S_Sulawesi									
Peak Demand	490		-		2,031		2,031		-
Minimum Demand	196		-		812		812		-
Power Plant	464	(100%)	2,181	(100%)	2,399	(100%)	2,399	(100%)	0
Hydro Power	129	(28%)	370	(17%)	499	(21%)	499	(21%)	0
Gas Turbine	123	(26%)	465	(21%)	498	(21%)	498	(21%)	0
Combined cycle	0	(0%)	240	(11%)	240	(10%)	240	(10%)	0
Steam	25	(5%)	826	(38%)	833	(35%)	1,057	(44%)	-224
Geothermal	0	(0%)	224	(10%)	224	(9%)	0	(0%)	224
Diesel	187	(40%)	56	(3%)	106	(4%)	106	(4%)	0
Nuclear	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0
NTB									
Peak Demand	105		-		568		568		-
Minimum Demand	42		-		227		227		-
Power Plant	148	(100%)	585	(100%)	679	(100%)	679	(100%)	0
Hydro Power	0	(0%)	1	(0%)	1	(0%)	1	(0%)	0
Gas Turbine	0	(0%)	140	(24%)	140	(21%)	155	(23%)	-15
Combined cycle	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0
Steam	0	(0%)	367	(63%)	367	(54%)	367	(54%)	0
Geothermal	0	(0%)	30	(5%)	30	(4%)	0	(0%)	30
Diesel	147	(100%)	47	(8%)	140	(21%)	155	(23%)	-15
Nuclear	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0
NTT									
Peak Demand	62		-		313		313		-
Minimum Demand	25		-		125		125		-
Power Plant	128	(100%)	329	(100%)	374	(100%)	374	(100%)	0
Hydro Power	0	(0%)	12	(4%)	12	(3%)	12	(3%)	0
Gas Turbine	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0
Combined cycle	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0
Steam	0	(0%)	114	(35%)	114	(30%)	221	(59%)	-107
Geothermal	0	(0%)	116	(35%)	116	(31%)	9	(2%)	107
Diesel	128	(100%)	87	(26%)	132	(35%)	132	(35%)	0
Nuclear	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0
Maluku									
Peak Demand	78		-		184		184		-
Minimum Demand	31		-		74		74		-
Power Plant	170	(100%)	202	(100%)	258	(100%)	258	(100%)	0
Hydro Power	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0
Gas Turbine	0	(0%)	20	(10%)	20	(8%)	40	(16%)	-20
Combined cycle	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0
Steam	0	(0%)	92	(46%)	92	(36%)	92	(36%)	0
Geothermal	0	(0%)	40	(20%)	40	(16%)	0	(0%)	40
Diesel	170	(100%)	50	(25%)	106	(41%)	126	(49%)	-20
Nuclear	0	(0%)	0	(0%)	0	(0%)	0	(0%)	0
Total									
Peak Demand	17,818		-		73,715		73,715		-
Minimum Demand	7,127		-		29,486		29,486		-
Power Plant	20,512	(100%)	69,749	(100%)	85,993	(100%)	85,993	(100%)	0
Hydro Power	3,166	(15%)	2,495	(4%)	5,661	(7%)	5,661	(7%)	0
Gas Turbine	1,427	(7%)	4,795	(7%)	5,796	(7%)	5,830	(7%)	-35
Combined cycle	6,501	(32%)	15,155	(22%)	20,228	(24%)	20,228	(24%)	0
Steam	6,770	(33%)	28,381	(41%)	33,675	(39%)	38,819	(45%)	-5,144
Geothermal	807	(4%)	8,643	(12%)	9,500	(11%)	2,286	(3%)	7,214
Diesel	1,841	(9%)	279	(0%)	1,133	(1%)	1,169	(1%)	-35
Nuclear	0	(0%)	10,000	(14%)	10,000	(12%)	12,000	(14%)	-2,000

(Note) *1 from PLN Statistics 2004, Pertamina Geothermal Energy Boucher

*2 Geothermal capacity is increased according to development plan.

Other power plant capacities are adjusted considering the role of plant type.

*3 (C) is not equal to (a)+(b) due to decommission of power plants.

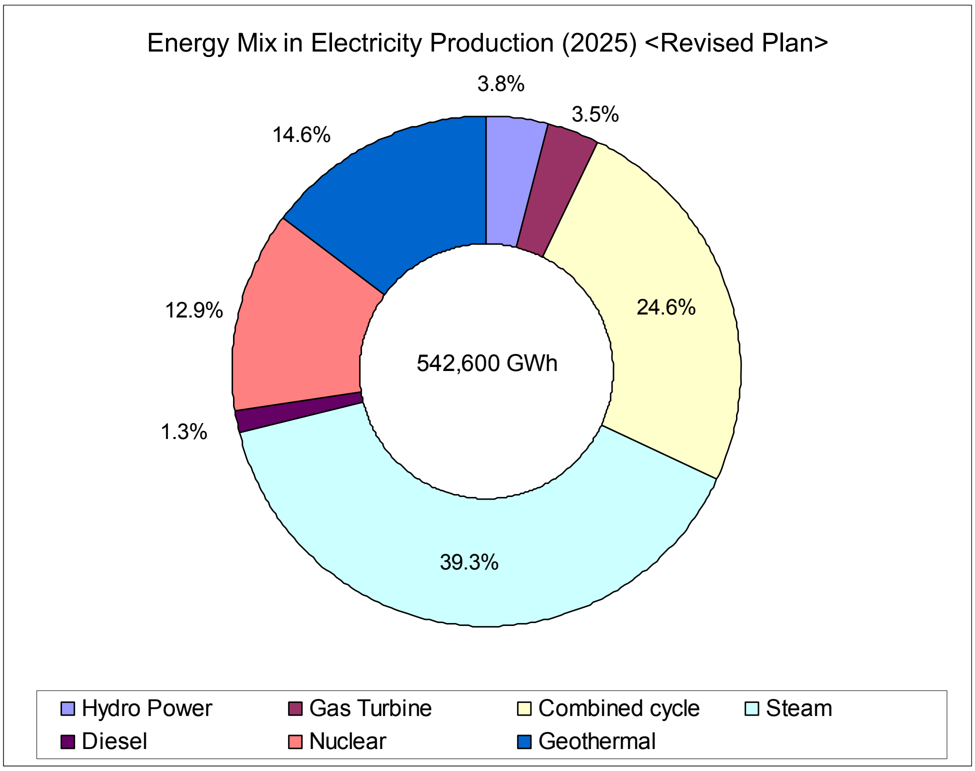


Fig. 7.1.11-3 Energy Mix in Electricity Production in 2025 by Geothermal Development Scenario

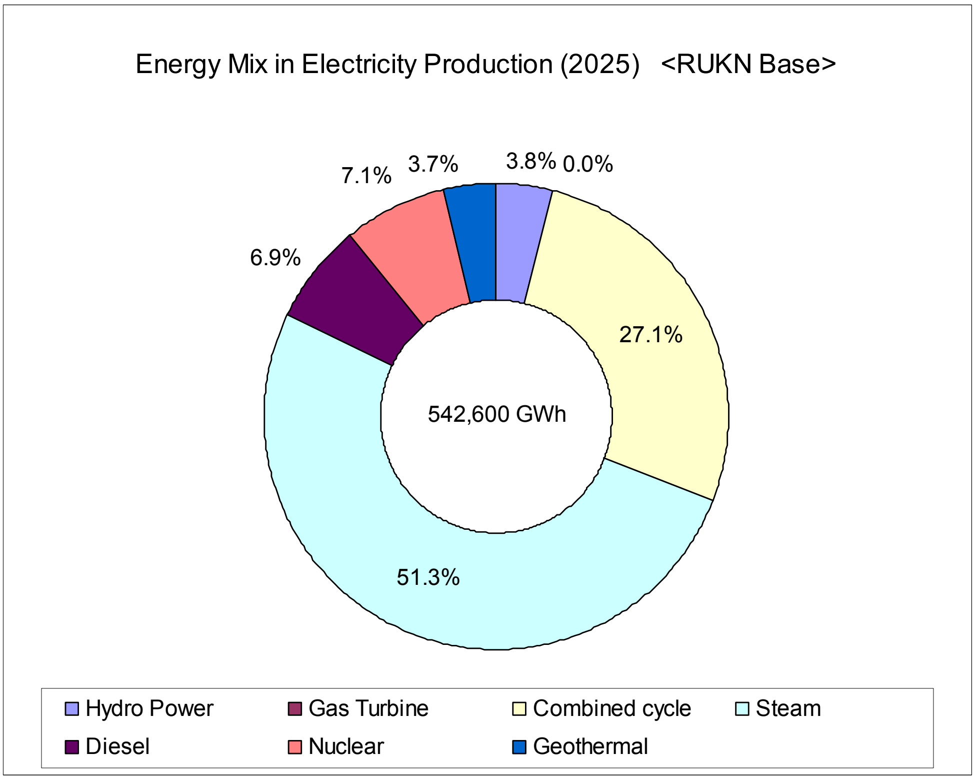


Fig. 7.1.11-4 Energy Mix in Electricity Production in 2025 by RUKN

Table 7.11-4 Power Plant Mix in Geothermal Development Scenario in Master Plan (2025)

Power Plant	MW	Existing (2004) (a) (*1)		New Plant (2005-2025) (b) (*2)		Total (as of 2025) (c) (*3)		RUKN (2025)		Difference
Hydro Power	MW	3,199	(14.6%)	2,666	(3.5%)	5,865	(6.3%)	5,865	(6.3%)	0
Gas Turbine	MW	1,494	(6.8%)	6,200	(8.1%)	7,251	(7.8%)	7,285	(7.8%)	-35
Combined cycle	MW	6,561	(30.0%)	16,665	(21.9%)	21,756	(23.3%)	21,756	(23.3%)	0
Steam	MW	6,900	(31.5%)	31,493	(41.3%)	36,838	(39.5%)	41,982	(45.0%)	-5,144
Geothermal	MW	807	(3.7%)	8,643	(11.3%)	9,500	(10.2%)	2,286	(2.5%)	7,214
Diesel	MW	2,921	(13.4%)	547	(0.7%)	2,054	(2.2%)	2,089	(2.2%)	-35
Nuclear	MW	0	(0.0%)	10,000	(13.1%)	10,000	(10.7%)	12,000	(12.9%)	-2,000
Total	MW	21,882	(100.0%)	76,214	(100.0%)	93,263	(100.0%)	93,263	(100.0%)	0

(Note) *1 from PLN Statistics 2004, Pertamina Geothermal Energy Boucher

*2 Geothermal capacity is increased according to development plan.

Other power plant capacities are adjusted considering the role of plant type.

*3 (C) is not equal to (a)+(b) due to decommission of power plants.

7.2 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 Conditions c. Well Productivity d. Resource Potential	a. Social and Economic Conditions b. Residence Precipitations c. Flora and Fauna d. Climate Conditions 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 prospective 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 for 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.

7.3 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 (Table 7.3-1). 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 PDD (Project Design Document) of Darajat Ⅲ geothermal power development project in Indonesia was registered with the CDM executive board on December 11, 2006. This is a geothermal power development project with an installed capacity of 110MW in the central Java island. 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 CO_2 and CH_4 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 CO_2 and CH_4, the lower the GHG emission reduction effect. Fig. 7.3-1 shows the relation between CO_2 concentrations in steam and CO_2 emissions. When the concentration of CO_2 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 CH_4 should be carefully checked because, although their concentration is lower than 1/100, their GHG effect is 21 times that of CO_2.

Table 7.3-1 CO_2 Emission Reduction Effect

Region	No	Names of the 70 fields in this Survey	Additional Power Plant (MW)	Annual Generation (GWh/year)	Annual CO2 Reduction (10^3 t-CO_2/year)
Aceh	1	IBOIH - JABOI	10	74	61
Aceh	3	SEULAWAH AGAM	275	2,048	1,677
SumUta	7	LAU DEBUK-DEBUK / SIBAYAK	38	283	232
SumUta	8	SARULA	330	2,457	2,012
SumUta	9	SIBUAL BUALI	300	2,234	1,829
SumUta	10	S. MERAPI - SAMPURAGA	100	745	610
SumBar	13	MUARALABUH	240	1,787	1,464
SumBar	14	G. TALANG	30	223	183
Jambi	15	LEMPUR / KERINCI	20	149	122
Jambi	17	SUNGAI PENUH	355	2,643	2,165
Bengkulu	21	B. GEDUNG HULU LAIS	455	3,388	2,775
Bengkulu	22	TAMBANG SAWAH	455	3,388	2,775
SumSel	24	MARGA BAYUR	170	1,266	1,037
SumSel	25	LUMUT BALAI	620	4,617	3,781
Lampung	27	ULUBELU	440	3,276	2,683
Lampung	28	SUOH ANTATAI	330	2,457	2,012
Lampung	29	G. SEKINCAU	60	447	366
Lampung	30	RAJABASA	120	894	732
Lampung	31	WAI RATAI	120	894	732
JavaBar	32	KAMOJANG	180	1,340	1,098
JavaBar	33	G. SALAK	120	894	732
JavaBar	34	DARAJAT	185	1,378	1,128
JavaBar	35	CISOLOK - CISUKARAME	180	1,340	1,098
JavaBar	36	G. PATUHA	500	3,723	3,049
JavaBar	37	G. WAYANG - WINDU	290	2,159	1,768
JavaBar	38	G. KARAHA	200	1,489	1,220
JavaBar	39	G. TELAGABODAS	200	1,489	1,220
JavaBar	40	TANGKUBANPERAHU	20	149	122
Banten	42	CITAMAN - G. KARANG	20	149	122
JavaTen	44	DIENG	340	2,532	2,073
JavaTen	46	TELOMOYO	50	372	305
JavaTen	47	UNGARAN	180	1,340	1,098
JavaTim	50	WILIS / NGEBEL	120	894	732
JavaTim	51	IJEN	40	298	244
Bali	52	BEDUGUL	175	1,303	1,067
NTB	53	HU'U DAHA	30	223	183
NTT	54	WAI SANO	10	74	61
NTT	55	ULUMBU	36	268	220
NTT	56	BENA - MATALOKO	20	149	122
NTT	57	SOKORIA - MUTUBUSA	20	149	122
NTT	58	OKA - LARANTUKA	20	149	122
NTT	60	ATADEI	10	74	61
SulUta	61	LAHENDONG	200	1,489	1,220
SulUta	62	KOTAMOBAGU	140	1,042	854
SulUta	63	TOMPASO	120	894	732
SulTen	65	MERANA	200	1,489	1,220
Maluku	69	TULEHU	20	149	122
N.Maluku	70	JAILOLO	20	149	122
SumUta	71	SIPAHOLON-TARUTUNG	50	372	305
Golontaro	73	SUWAWA-GOLONTALO	55	410	335
		TOTAL	8219	61,199	50,122

Existing Power Plant (Nos. 7, 33, 34, 37, 44, 61)

Existing Project (Nos. 8, 9, 17, 21, 22, 25, 27, 32, 36, 38, 39, 52, 55, 56, 62, 63)

Emission Factor (t-CO_2/MWh) = 0.819

Load Factor = 85%

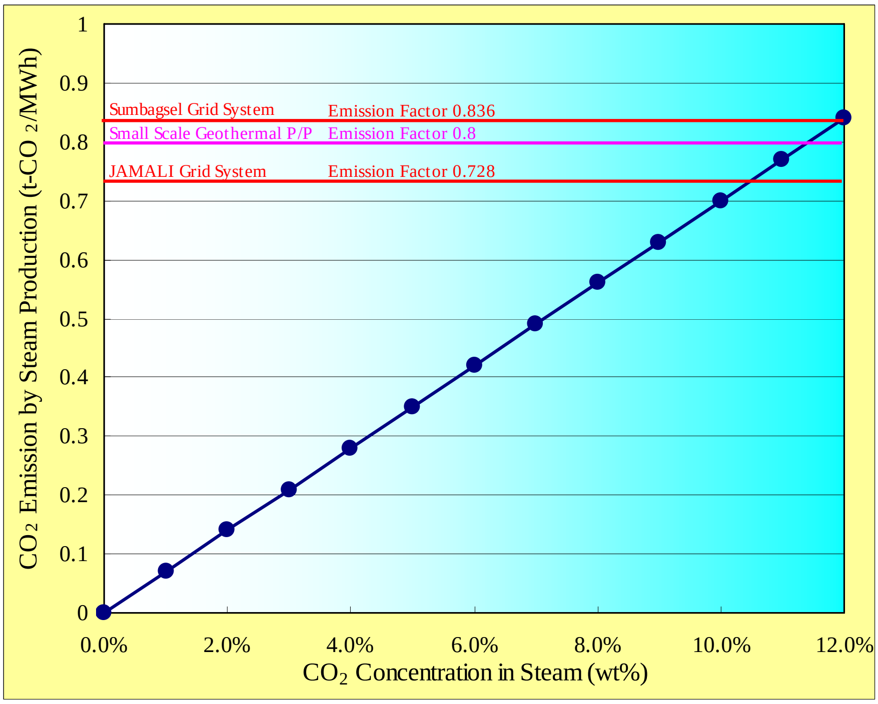


Fig. 7.3-1 CO_2 Emission by Steam Production

7.4 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 toglobal 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.

Chapter 8 The barriers to geothermal development and necessity of government support

8.1 Methodology

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.

8.2 Characteristics of geothermal energy and barriers to its development

A price model of a 55 MW model geothermal power plant was constructed. (Table 8.2-1, Table 8.2-2, Fig.8.2-1) 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. (Fig.8.2-2, Fig.8.2-3, Fig. 8.2-4) .

8.3 Challenges in development of geothermal energy in Indonesia

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. (Table 8.3-1) 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 (Fig.8.3-1). 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 (Table 8.3-1, Fig.8.3-2).

8.4 Discussions of government support to geothermal development

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. (Table 8.4-1) 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. (Table 8.4-2, Fig.8.4-1 and Fig.8.4-2).

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. (Fig. 8.4-1 – Fig.8.4-4, Table 8.4-2, Table 8.4-3)..

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.

Table 8.2-1 Development Cost for 55MW Model Geothermal Plant

Stage	Content	Cost (m$)
1. Surface Survey	Wide-area Surface Survey	2
2. Exploratory	2 Exploratory Wells (success rate 50%) etc.	10
3. Cinfirmation (Development	3 Production Wells (success rate 70%) etc.	10
4. Construction		
4.1 Steam Field	7 Production Wells (success rate 80%), P/L et	42
4.2 Power Plant	Power Plant	65
5. Others		7
Total		136

Table 8.2-2 Condition of Cost Analysis

Field Condition	Production Well Drilling Cost (m$/well)	3
	Steam Productivity (MW/well)	8
Plant Condition	Plant Life (Years)	30
	Plant Factor (%)	85
	Axially rate (%)	6
Financing Condition	Interest rate (%)	8.5
	Repayment (Years)	12
	Grace Period (Year)	3
Business Condition	Depreciation Method	Straight line
	Depreciation Period - Wells	7
	- Machinery	15
	Tax rate (%)	34

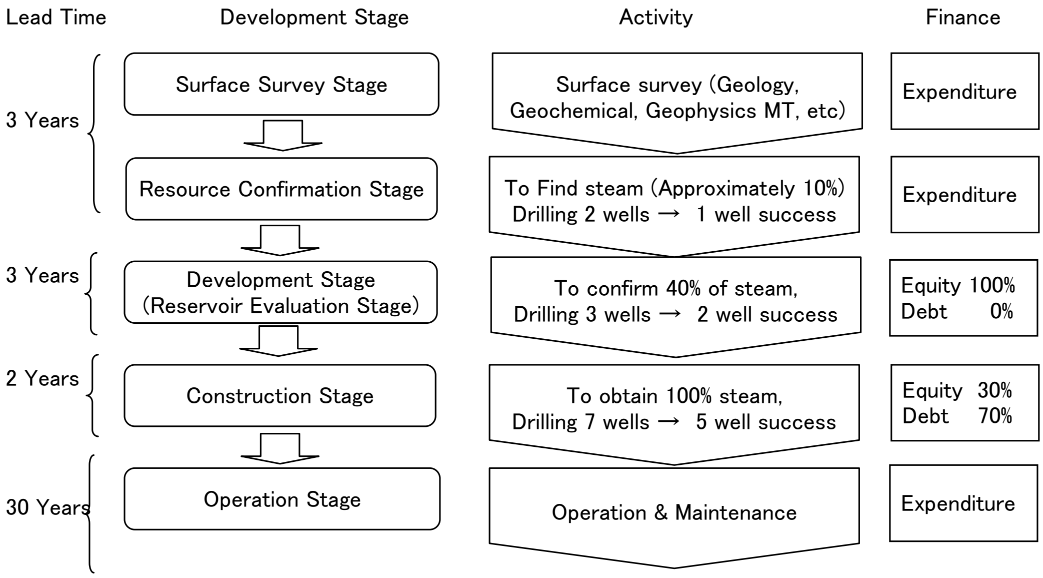


Fig. 8.2-1 Development Process of 55MW Model Geothermal Plant

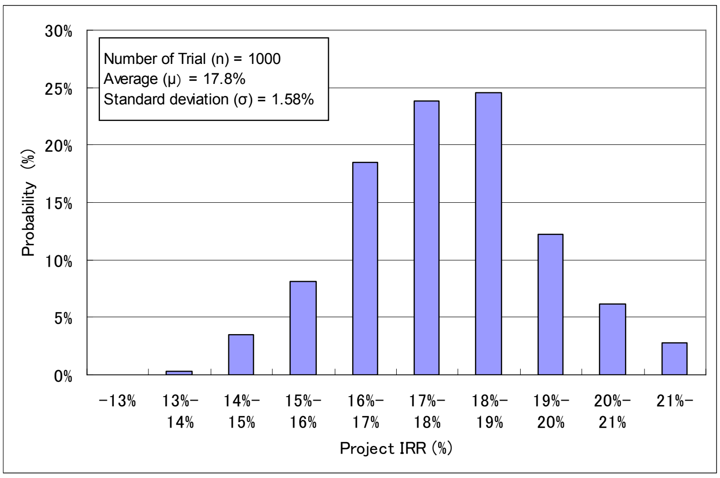


Fig. 8.2-2 IRR Distribution of Model Project (Selling price = 8.7 ¢/kWh)

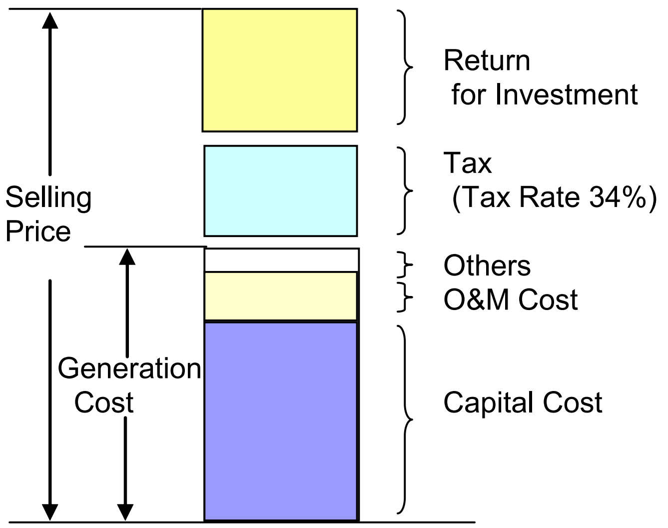


Fig. 8.2-3 Structure of Generation Cost and Selling Price

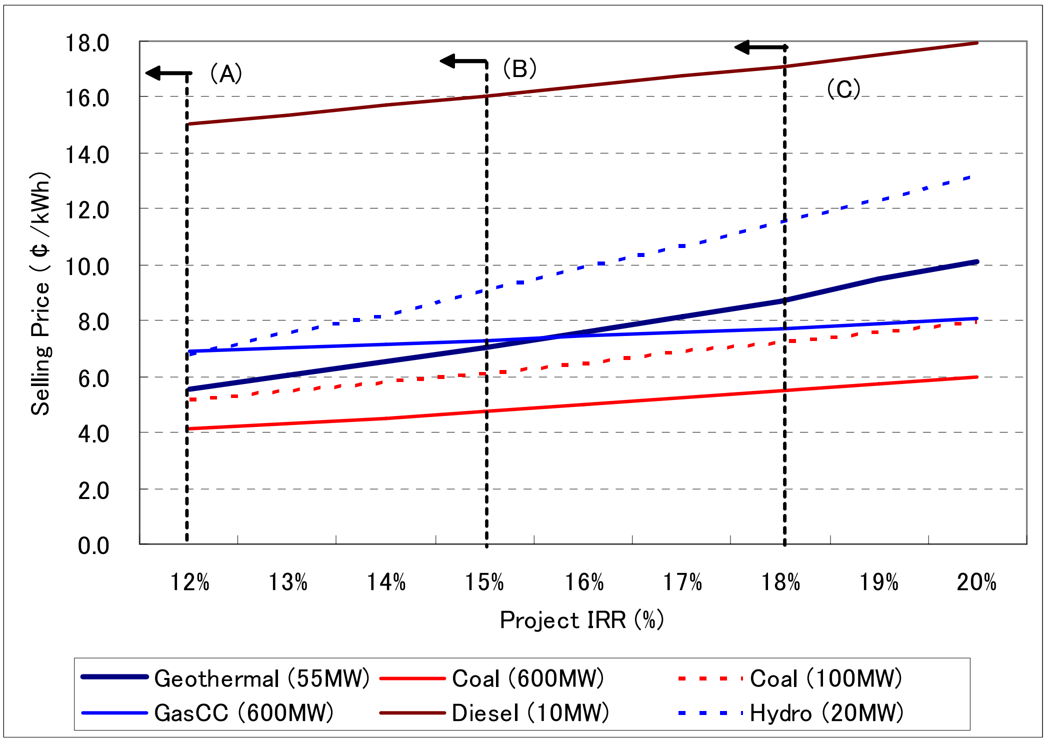


Fig. 8.2-4 Selling Price and Project IRR of each Energy Source

Table 8.3-1 Price Change before and after Economic Crisis

Power Plant	Selling Price (¢/kWh) Original (*1)	After Renegotiation
Bedugul, Bali	7.15	
Chibuni, west Java	6.90	
Darajat, West Java	6.95	4.20 (*2)
Dien, West Java	9.81	
Kamojang, West Java	7.03	
Patuha, West Java	8.46	
Karaha Bodas, Java	7.25	
Salak (unit 4-6), West Java	8.46	
Sibayak, North Sumatra	7.10	
Wayang Windu, West Java	8.39	4.90 (*3)
Wayang Windu (unit2)	-	4.94 (*4)
Sarulla	-	4.64 (*5)

(Source)

*1, *2: Indonesia's geothermal development (Embasy of USA in Indonesia)

*3: Energy Highlight Oct.2005 Embassy of USA in Indonesia

*4: Tempo Interaktif 15 Aug. 2006

*5: Antara NEWS, 19 June 2006

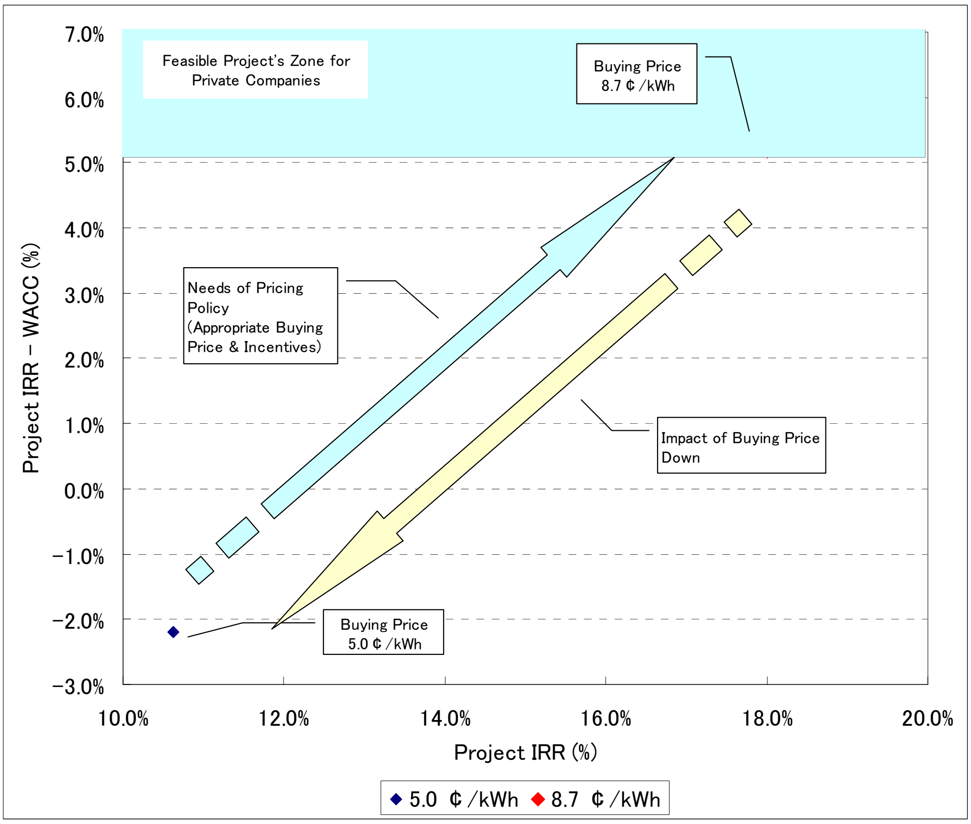


Fig. 8.3-1 Profitability Deterioration by Price Change

Table 8.3-2 Possible Development Capacity by Buying Price

Selling Price ¢/kWh	No Incentives <IRR15%> MW	No Incentives <IRR18%> MW	Total MW	Total (%)
5	0	0	0	0.0%
6	1,240	0	1,240	15.1%
7	2,370	790	3,160	38.5%
8	3,140	3,340	6,480	79.0%
9	3,140	4,090	7,230	88.2%
10	3,178	4,596	7,774	94.8%
11	3,178	4,651	7,829	95.5%
12	3,178	4,771	7,949	97.0%
15	3,178	4,991	8,169	99.6%
20	3,178	5,021	8,199	100.0%

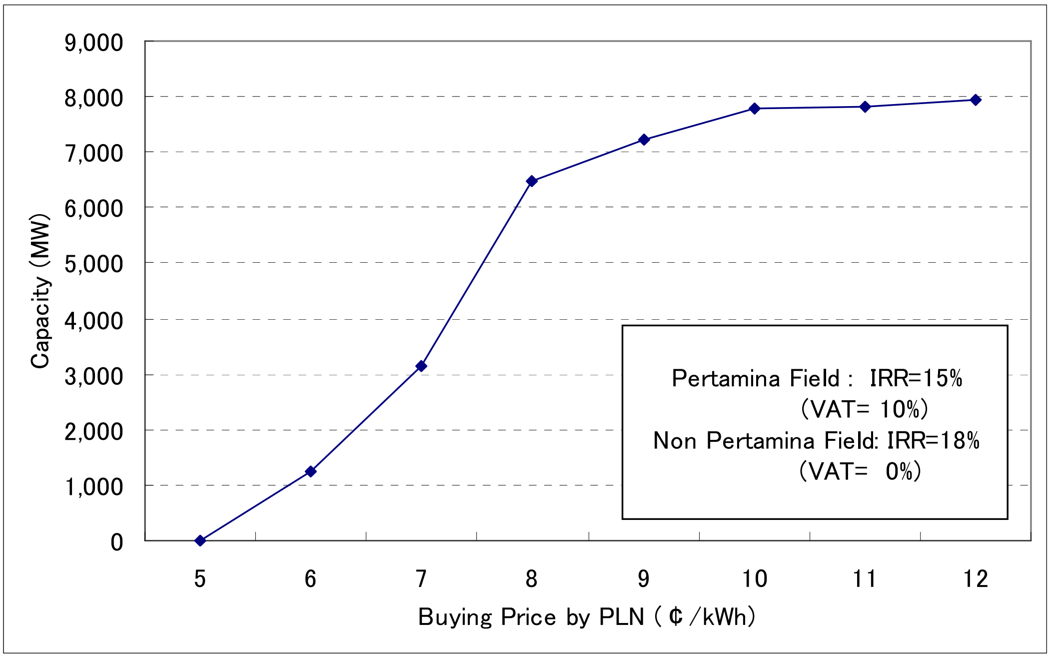


Fig. 8.3-2 Possible Development Capacity by Buying Price

Table 8.4-1 Possible Incentives for Geothermal Development

Incentive	Tax Credit (10 years)	Preliminary Survey by Government	Low Interest Finance for Development Stage	Low Interest Finance for Construction Stage	Subsidy to Construction Cost	Support by Yen Loan (Support for public entity's project)
Content of incentive	The corporate tax (34%) will be reduced to 10% for 10 years after operation for the geothermal power generation business by private companies.	In the promising geothermal potential area, the government executes preliminary survey to reduce initial resource development risks, and thus, to attract private developer's interest.	For the private company's geothermal development activity, which is not eligible for a commercial loan at present, governmental investment bank extends a loan of 50% of necessary fund with a special low interest rate. (The interest rate is 5.0%, while 8.5% is a usual rate. Loan repayment period is 12 years with 3 year grace period.)	For the private company's geothermal power plant construction activity (construction of wells, steam supply facilities), governmental investment bank extend a loan of 80% of necessary fund with a special low interest rate. (The interest rate is 5.0%, while 8.5% is a usual rate. Loan repayment period is 12 years with 3 year grace period.)	The government delivers the subsidy to geothermal construction cost (steam section). (subsidy cover ratio is 20%)	For projects executed by public entity such as PLN, Pertamina, GeoDipa, or regional government, government extend low interest loan using Yen Loan. (In a case of Emvironmental Yen Loan, interest rate is 0.65%、repayment period is 30 years with 10 year grace period.)

Table 8.4-2 Effect of Incentives

			No Incentives (VAT=0%)	Tax Credit (10yrs)	Gov's Svy.	Loan to Dev. (r=5%)	Loan to Const. (r=5%)	Sub. To Const (20%)	
Private Company's Case	Steam Price (¢/kWh)		4.3	3.9	3.6	3.4	3.3	2.9	
	Generation Price (¢/kWh)		4.4	4.1	4.1	3.9	3.7	3.7	
	Electricity Price (¢/kWh)		8.7	8.0	7.7	7.3	7.0	6.6	
(IRR=18%)	Price Down Effect (¢/kWh)		-	△ 0.7	△ 0.3	△ 0.4	△ 0.3	△ 0.4	
		No Incentives (VAT=10%)	VAT (0%)	Tax Credit (10yrs)	Gov's Svy.	Loan to Dev. (r=5%)	Loan to Const. (r=5%)	Sub. To Const (20%)	ODA Loan (VAT=10%)
State Company's Case	Steam Price (¢/kWh)	3.5	3.4	3.3	3.0	2.9	2.8	2.5	2.5
	Generation Price (¢/kWh)	3.9	3.6	3.4	3.4	3.3	3.1	3.1	2.9
	Electricity Price (¢/kWh)	7.4	7.0	6.7	6.4	6.2	5.9	5.6	5.4
(IRR=15%)	Price Down Effect (¢/kWh)	-	△ 0.4	△ 0.3	△ 0.3	△ 0.2	△ 0.3	△ 0.3	△ 2.0

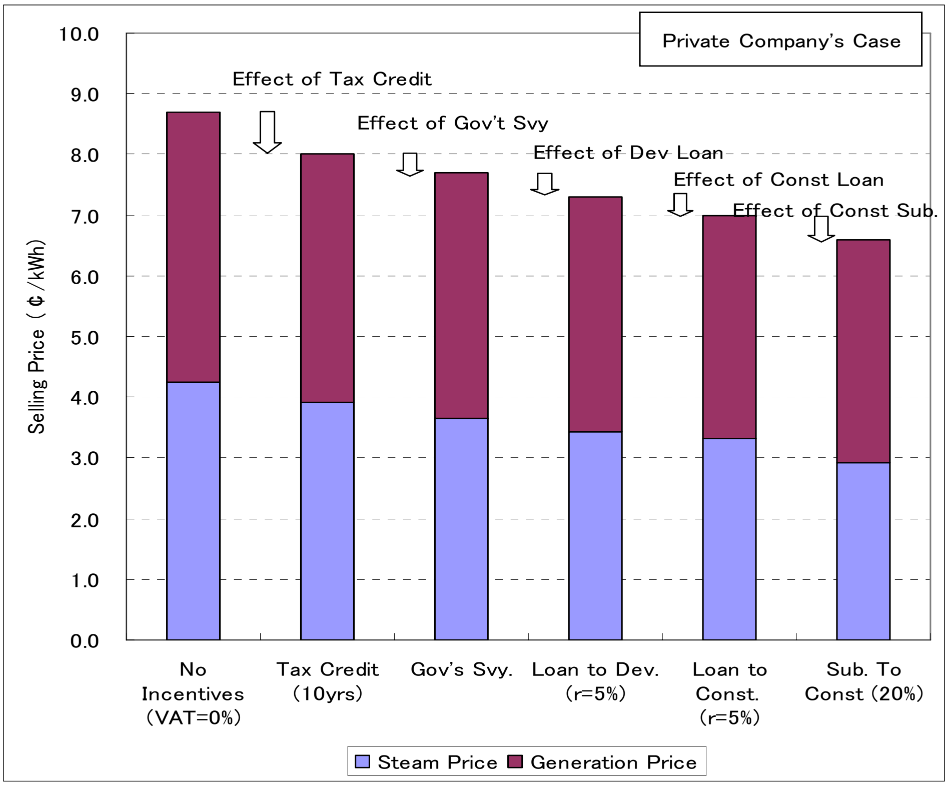


Fig. 8.4-1 Effect of Incentives

(Selling Price Reduction Effect in 55MW Model Plant in Private Company's Case)

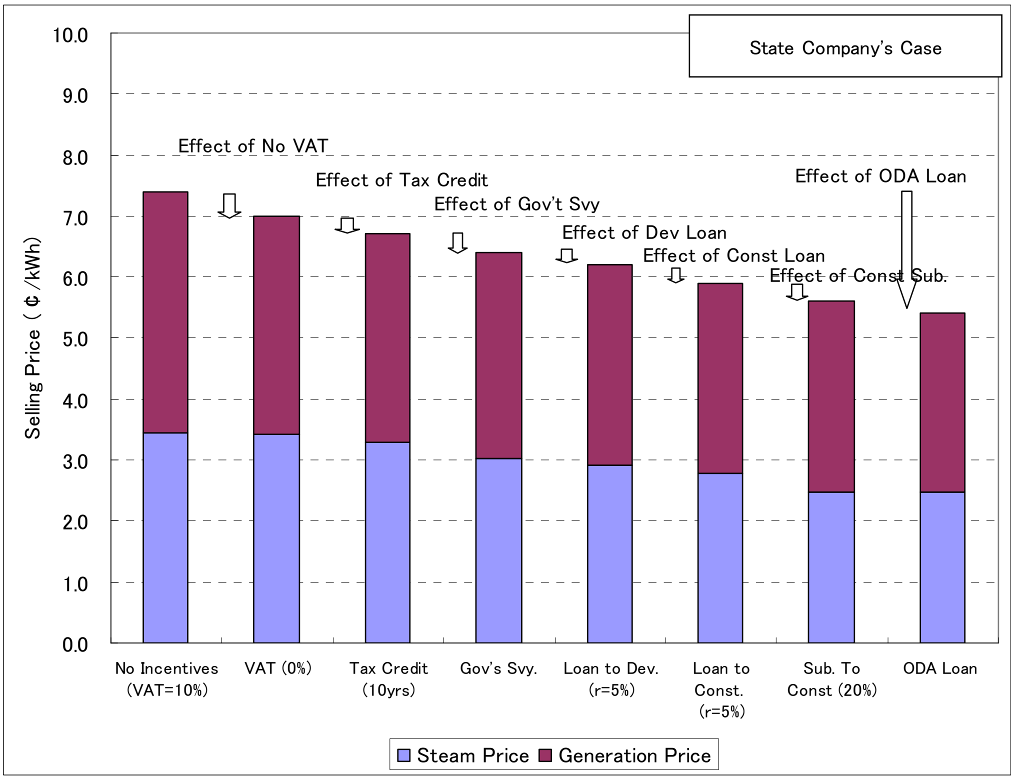


Fig. 8.4-2 Effect of Incentives

(Selling Price Reduction Effect in 55MW Model Plant in State Company's Case)

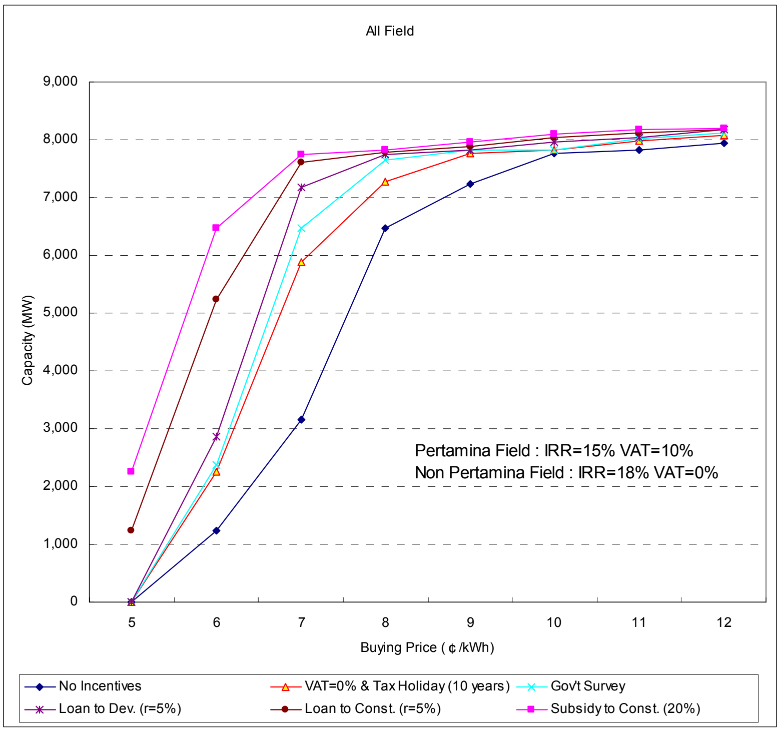


Fig. 8.4-3 Effect of Incentives (Development Amount in 49 Field Estimation) (Private Company & State Company Total)

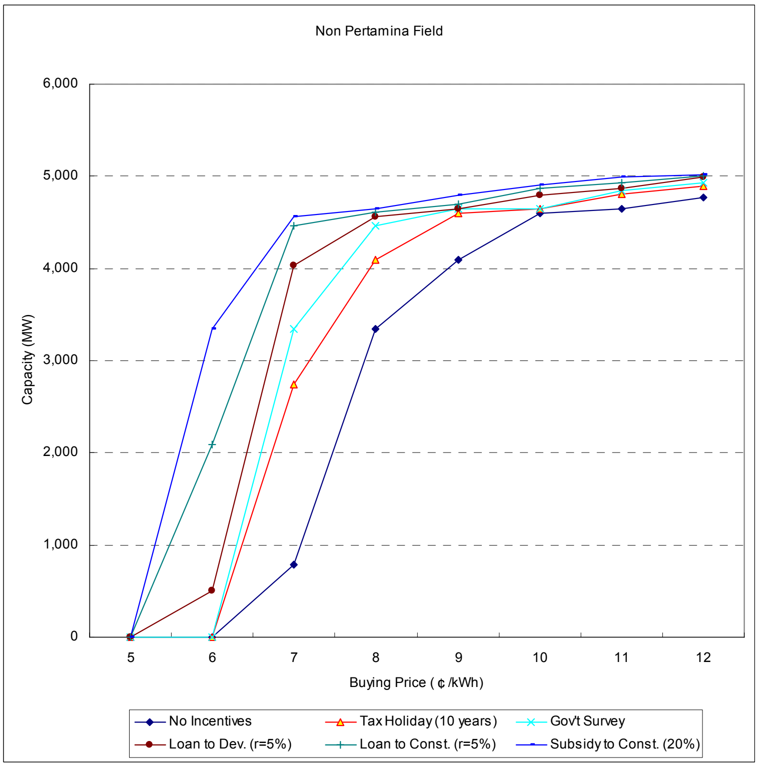


Fig. 8.4-4 Effect of Incentives (Development Amount in 38 Field Estimation) (Private Company's Case)

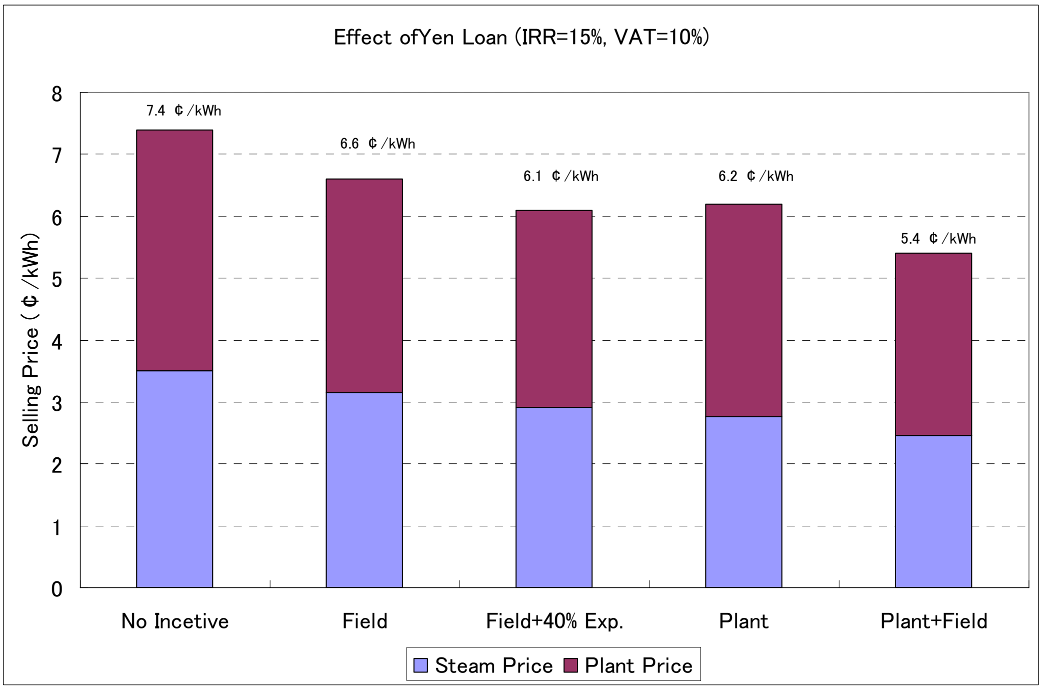


Fig. 8.4-5 Effect of ODA Loan
(Selling Price Reduction Effect in 55MW Model Plant in State Company's Case)

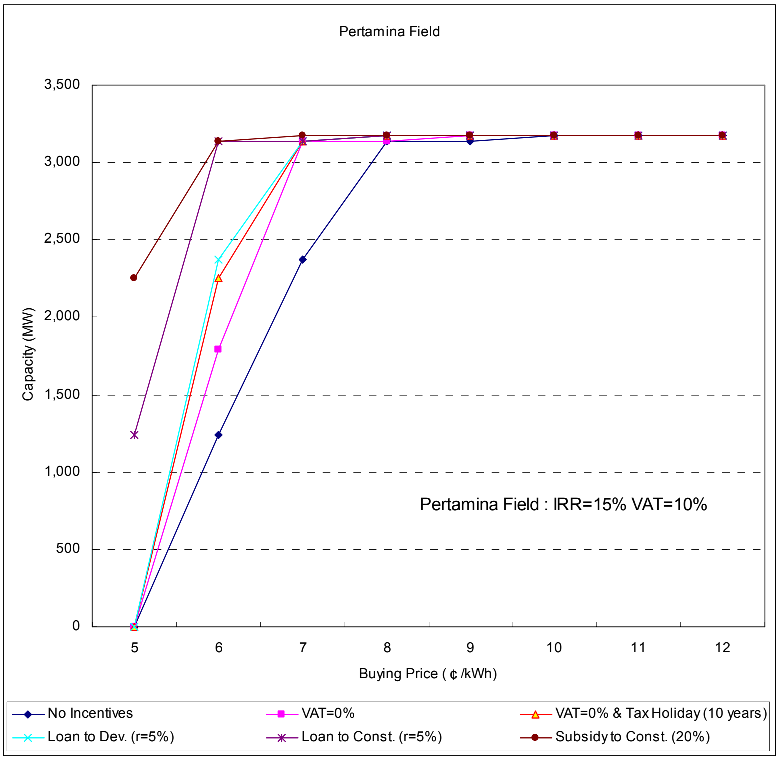


Fig. 8.4-6 Effect of ODA Loan (Development Amount in 11 Field Estimation)
(State Company's Case)

Table 8.4-3 Options of Incentive Combination

Options	State Company's Case		Private Company's Case	
	Buying Price of PLN	Incentives of Government	Buying Price of PLN	Incentives of Government
No Incentive Case	8 Cents/kWh	-	10 Cents/kWh	-
Option 1	7 Cents/kWh	- VAT Exemption	9 Cents/kWh	- Tax Holiday (10 years)
Option 2	6 Cents/kWh	- VAT Exemption - Tax Holiday (10 years) - Loan to Development (r=5%) - Loan to Construction (r=5%)	8 Cents/kWh	- Tax Holiday (10 years) - Government Survey
Option 3			7 Cents/kWh	- Tax Holiday (10 years) - Government Survey - Loan to Development (r=5%) - Loan to Construction (r=5%)

Chapter 9 Proposal for Geothermal Development Promotion

9.1 Basic Strategy for Geothermal Development

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. . (Table 9.1-1, Table 9.1-2)

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 well 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 Yen Loans for the projects of Pertamina, GeoDipa, and/or PT. PLN, be used, as the effect of ODA funding is considerable. (Table 9.1-3)

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. (Table 9.1-4)

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. (Table 9.1-5)

9.2 Proposals for Geothermal Development

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.
(Fig.9.2-1)

Table 9.1-1 Classification Criteria for 73 Fields

Rank	Progress of Development	Possibility of Promising Resources	Number of Fields	Expected Amount of Development by 2025
A	WKP has been set. Developer is designated.	Estimated as very high.	22	6,556 MW
B	WKP has not yet set. Developer is not yet designated.	Estimated as very high. No existence of well data. Existence of geochemical data.	9	1,250 MW
C	- ditto -	Estimated as very high. No existence of well data. No Existence of geochemical data.	16	1,150 MW
L	- ditto -	Less expectation of high temperature resources.	3	120 MW
N	- ditto -	No estimation due to insufficient information.	23	424 MW
Total			73	9,500 MW

Table 9.1-2 Development Amount by Ranks

(MW)

	Existing	2012		2016		2020		2025		Total	
A	857	1,097	(98.2%)	645	(67.2%)	1,713	(58.7%)	2,245	(61.5%)	6,556	(69.0%)
B		20	(1.8%)	315	(32.8%)	535	(18.3%)	380	(10.4%)	1,250	(13.2%)
C		0	(0.0%)	0	(0.0%)	670	(23.0%)	480	(13.2%)	1,150	(12.1%)
L		0	(0.0%)	0	(0.0%)	0	(0.0%)	120	(3.3%)	120	(1.3%)
N		0	(0.0%)	0	(0.0%)	0	(0.0%)	424	(11.6%)	424	(4.5%)
Total	857	1,117	(100.0%)	960	(100.0%)	2,918	(100.0%)	3,649	(100.0%)	9,500	(100.0%)
(cum.)	857	1,974		2,934		5,851		9,500			

Table 9.1-3 Fields to be Promoted Urgently by Providing Economic Incentives (Rank A fields)

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

Table 9.1-4 Fields to be Promoted Urgently by Government Survey (Rank B and Rank C fields)

No.	Region	Field 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 9.1-5 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

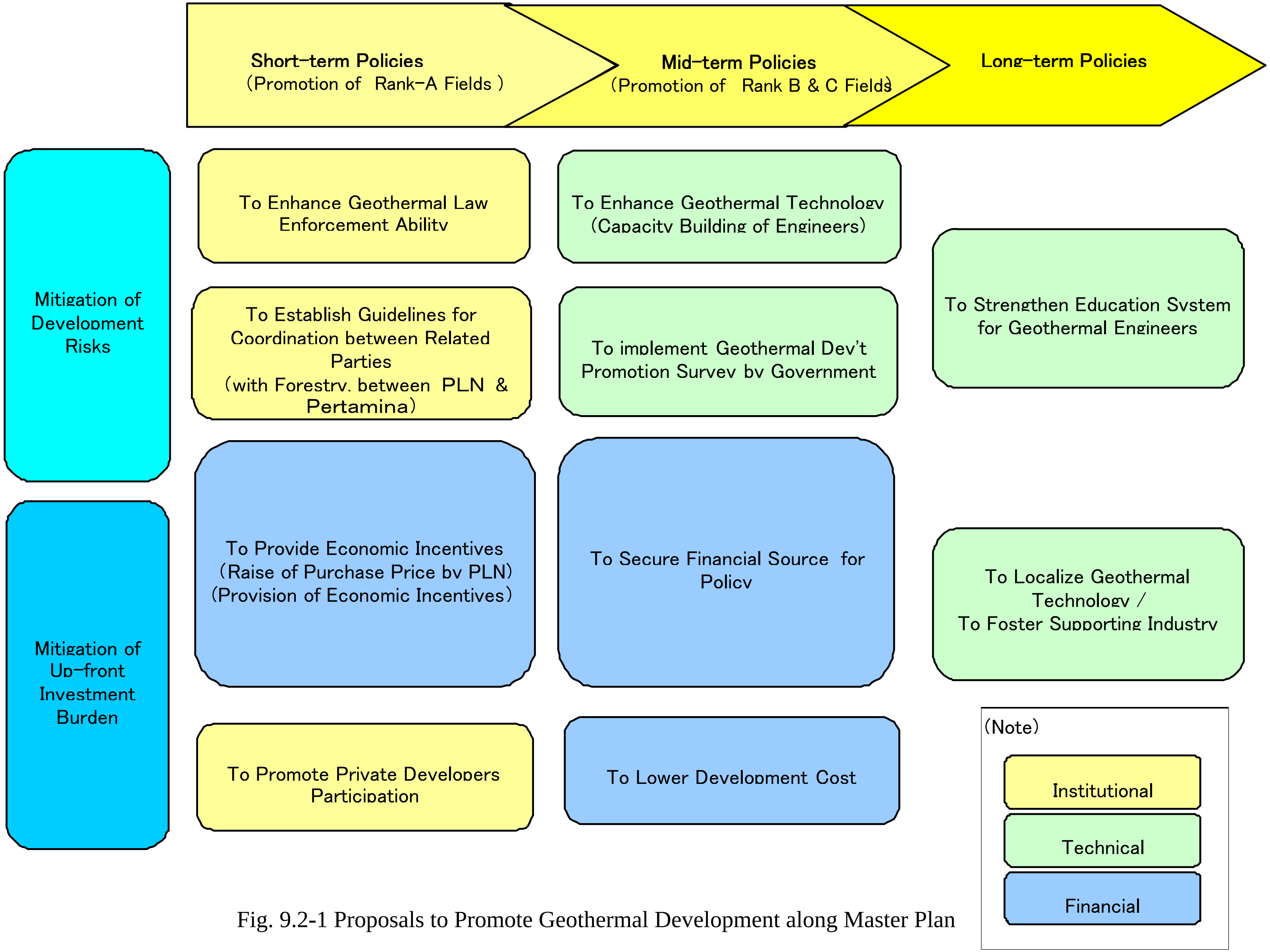


Fig. 9.2-1 Proposals to Promote Geothermal Development along Master Plan