Indonesia

Renewable Energy Report

APCTT-UNESCAP

Asian and Pacific Centre for Transfer of Technology
Of the United Nations – Economic and Social
Commission for Asia and the Pacific (ESCAP)

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ACKNOWLEDGEMENT

We wish to extend our gratitude to our colleagues from LIPI, BPPT, DESDM who has supported and provided us with information and data during the preparation of this Report. We also thank to all secretariat staff who have support us to manage this report.

I also wish to express my sincere thanks to Dr. K. Ramanathan, Head of the Asian and Pacific Centre for Transfer of Technology (APCTT), Ms. Rosemarie Saldanha, Dr Krishnan for their support and excellent cooperation during the preparation oh this report.

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EXECUTIVE SUMMARY

Indonesia is the largest archipelago country with more than 17,500 island and the fourth populous country in the world located in the equator, between Asia and Australia continents. The population in 2008 was roughly 225 millions people. The country is blessed with abundant natural resources which can be used for energy resources. Geothermal, biomass, hydropower, solar energy, wind power and ocean wave are renewable energy resources that could be utilized to fulfill domestic energy needs. So far, petroleum oil, natural gas and coal are the major energy resources. Increasing number of population simultaneously with growing of the economic condition cause increasing demand of fossil energy. The shortage of petroleum oil production and concurrently with the emerge of global warming issues have caused Indonesia government and community to search alternative energy sources. Utilization alternative energy sources should not cause negative impact to environment. Under such circumstances, effective utilization of renewable energy resources is really prospective alternative.

The government of Republic of Indonesia has planned to reduce utilization of non renewable energy, and to replace it with renewable energy. In 2007, the role of renewable energy in domestic energy consumption is less than 5 % of total consumption. It is targeted in 2025, the role becomes three times higher, explicitly 15 % of total consumption. Geothermal energy, bio-fuels, and hydropower are expected to fulfill 5 %, 5 % and 2 % respectively.

Utilization of renewable energy resources have been known since many years, unfortunately the increasing of use of these energy resources were very limited. The main reason is that the people and industry have got used to receive huge energy subsidy from the government since many years ago. The energy subsidy has supported development of the country, but it has also caused inefficiently use of fossil energy resources.

In order to develop and promote utilization of renewable energy, the government has revealed several regulations and incentives to invite investment on renewable energy production, to drive current industry to utilize RE, and to promote the development of renewable energy technology. It is believed that the policies would result a significant impact on renewable energy utilization in several years to come.

The challenges for enhancement utilization of renewable energy in Indonesia are :

- the energy subsidy from the government has become ‘needs’ for most of the people. The influence of the subsidy to community life style is significant.
- Proven local renewable energy technologies, especially for the big scale commercial use, are very limited. Most of R&D budget in the country so far depend on the government budget, while the government R&D budget was small.

Involvement of private industries, professional associations, universities and NGO in development renewable energy technology and promotion of its utilization is expected would encourage people to utilize the energy sources and increase the community awareness.

CHAPTER 1

INTRODUCTION

This report presents an overview of renewable energy sector such as potency, market, policy, R&D institutions, indigenous technology and current renewable energy development, financial institutions, and renewable energy (RE) community in Indonesia. The report is prepared for the Asian and Pacific Center for Transfer of Technology (APCTT) to formulate a regional project for the development and promotion of Renewable Energy Technology (RET). Through the project, APCTT intends to develop institutional collaboration mechanism to create and enhance the cooperation among the countries in the region in promotion and utilization of renewable energy.

This report is prepared mostly by desk study through collecting reports and published information /data from related government and non governmental institutions included electronics publications. The format of this report mostly follows the guidance received from APCTT.

1.1. Country Overview

Indonesia is a vast archipelago located in the equator and fertilized islands. It is the largest archipelagic country in the world, cover 1,906,240 km^2 land area. It consists of 17,506 islands, and more than 80,000 kms beach line. It is located at 95^o to 141^o eastern longitude, and latitude between 6^o North and 11^o 8' South. The length of the country from east to west is more than 5400 km. About 2/3 of the country is covered by sea. Its population in year 2008 was around 225 Millions [1] and GDP per capita in 2008 was around USD 2,360. Indonesia is the third largest democratic country in the world.

1.2. National Energy Summary

Indonesia has abundant renewable energy resources such as geothermal, hydropower, solar energy, biomass, wind power, and tidal and ocean wave. Renewable energy sources in Indonesia offer huge amounts of sustainable energy to people in the country.

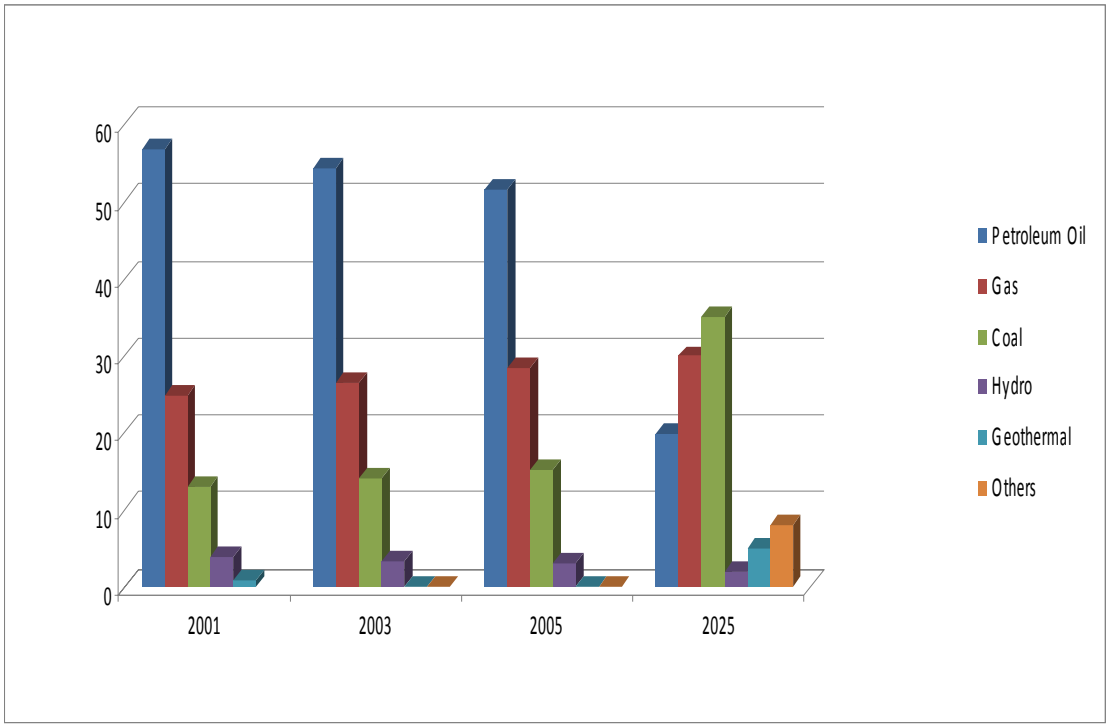
So far most renewable energy technology in Indonesia work at small scale, excluded hydro power and the production of bio-diesel. An advantage of utilization of renewable energy resources, especially for bio-fuels, is that the activities to produce bio-fuels would require lot of worker, especially for plantation areas. . So, it could open job opportunity for many people. In addition to that, most of equipment needed could be produced domestically, it could reduce the country dependency on imported technology. It is believed that renewable energy sources could contribute substantially to fulfill domestic energy demand, when a sustained commitment to enhance further research and development and to promote its utilization supported by suitable policy, could be implemented for this potential to be fully realized in near future.

Utilization of various kinds renewable energy are still in limited fraction. Their role in national energy are less than 5 % total energy consumption. Until now, primary energy sources are petroleum oil, natural gas, and coal. The oil role in national energy mix was

decreased, while gas and coal are increased as shown in figure 1.1 and figure 1.2 (adopted from various sources).

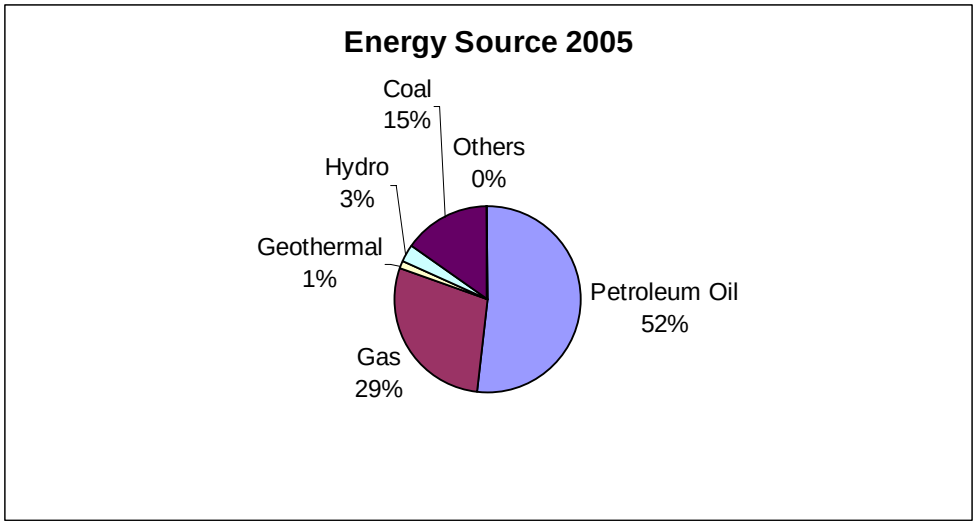
Figure 1.1. The progress of total energy consumption and the target.

(in % of total energy consumption in indicated year).



(Source : various sources and Presidential regulation no /2006.)

Figure 1.2. Typical distribution of energy source (Data for 2005)



1.3. A short background of the development and utilization of renewable energy in the country.

Increasing number of population, growing the economy, increasing GDP per capita and rising standard of living, has created an increasing demand of energy sources. So far, the country's primary energy sources is mainly from fossil oil and natural gas. Indonesia was an OPEC member country, and is one of major natural gas producer in the world. Unfortunately, finding of new petroleum oil sources are so limited, which cause oil production of Indonesia decreased. In 1993, Indonesia produced petroleum oil of 548.9 millions barrel per year (1.5 millions barrels per day), while in 2008 it was of 358.7 millions barrels per year (0.983 millions barrels per day) [2].

As the demand increased, while oil production decreased, hence Indonesia has to import the shortage, consequently since 2006 Indonesia has turned into an oil importing country. Fortunately, many studies mentioned that Indonesia has abundant potential renewable energy resources which could be used to replace the oil and domestic is a huge market for renewable energy technology implementation. This reason drives increasing attention, development program, promotion and utilization of various types of renewable energy resources.

Hydro power and geothermal energy have been used to generate electricity, while coal, gas, oil, solar energy and biomass have been used for electricity generation, industry, commercial, transportation and household activities. Other type of renewable energy sources are not utilized yet, or at most under pilot scale studies.

Hydropower, large, medium and small scales have been used to generate electricity since many years. Large hydro power has been utilized by the government to generate electricity in major islands such as in Java, Sumatera, Sulawesi, etc. In many villages, micro hydro electricity power generation has been used since early 1980. In rural areas, water power has also been utilized to run miller in rice milling units and also for water pumping

using a pump called as ‘hidram pump’. The pump utilizes power from water flow to lift water itself from a lower ground to a higher level area.

Indonesia has also a lot of geothermal resources. It has been utilized for electricity generation especially in Java island. Figure 1.3 shows location of geothermal source in the country.

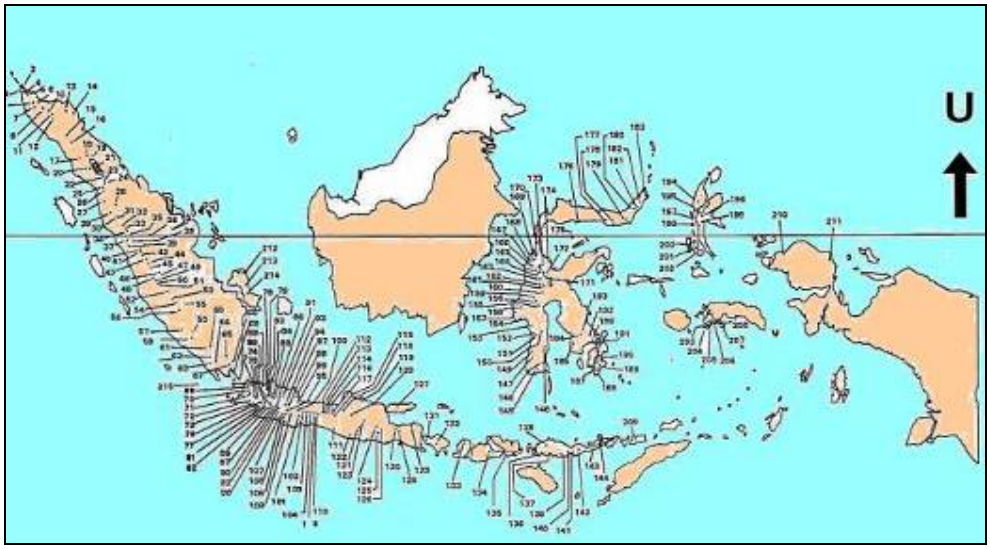


Figure 1.3. Distribution of potential geothermal location in Indonesia [3]

Solar energy have been used by households and small and medium scale firms. Utilization of solar cell panel for water heating become a trend of wealthy family who in many big houses or apartments. Solar system business is increased significantly since the increasing price of oil. This is one of positive impact of expensive oil in the country. Besides that, solar energy has also been used by many SMEs for agricultural products drying process.

Biomass, in the form of wood, has been used at household and industry activities. In remote rural areas, wood in addition to kerosene, is still as major source of energy for household cooking activities. Since 2006, the government launched a program to replace kerosene with LPG, in order to reduce the oil subsidy for low income family. The program is successful, and now millions of household uses the gas for cooking.

A few wind electricity power generations have been set up, and most of them to small scale power stations. Currently, many of wind power research projects are under pilot scale studies. Other type of renewable energy sources such as wave and sea tidal energy are not commercially utilized yet. These kinds of renewable energy resources are at most under research studies.

Total electricity power installed in 2007 was 24,856 MW. Most of the natural resources utilized to generate electricity power (83 %) come from non-renewable energy resources such as fuel oil, coal, natural gas, while other 17 % was renewable energy resources i.e. hydopower and geothermal energy of 15 and 2 % respectively [

1.4. Challenge

Hard challenges of Indonesia to shift its energy source to renewable resources are : 1) to change 'habit' of people who have got used to receive a huge subsidy from the government since many years, and 2) to create local RET which could compete economically with the current non renewable energy technologies. For the purposes, the government supports universities and R&D organizations to play their role to increase awareness and encourage community and industry to develop and utilize renewable energies efficiently.

CHAPTER II

Renewable Energy Resources, Market and Industries

2.1. Renewable Energy Resources Available.

Renewable energy resources in this report includes biomass, hydro power, geothermal, solar, and wind. As Indonesia is an archipelago country, energy resources such as ocean wave and tidal action are also available, but not be utilized yet.

As mentioned before that since many years, energy consumption in the country has been fulfilled mostly by petroleum oil, natural gas, coal and large size of hydropower. Statistics of the primary energy production shown in table 2.1. indicates that the production of petroleum oil decreases while both natural gas and coal increases.

Table 2.1. Primary Energy Production Per Year (MBOE)

Year	Petroleum Oil	Natural Gas	Coal	Hydro Power
1993	548.9	478.0	120.7	22.4
2000	517.4	520.0	362.6	25.2
2003	415.8	563.2	488.7	22.9
2005	385.4	535.9	648.1	24.7
2007	348.3	503.9	527.2	19.8
2008	358.7	-	-	-
2009	0.96 (*)	-	-	-

Source: [2, 4, and 5]

Note : (*) Millions barrels per day in March 2009.

On the other hand, utilization of renewable energy is still very small compared to availability of the resources. Table 2.2 to 2.7 show the potency and utilization of the renewable energy resources. Table 2.2 shows the potency renewable energy and utilization of the resources. It can be seen that the use of RE is around 5 % of the potency.

Table 2.2. Potency and Utilization of Renewable Energy Resources (GW).

Resources	Potency	Installed capacity	% Utilization (3 divided by:2)
1	2	3	4
Hydro Power (large)	75.6	4.2	5.5

Micro hydro	0.469	0.084	18
Geothermal	27.5	1.04	3.78
Biomass	0.734	0.0044	0.6
Total	**104.3**	**5.25**	**5.10**
Solar Energy in a range of 3- 5.5 kWh/m2/hari		0.008	
Wind in a range of : 3 – 5.7 m/ sec Sea Wave	9.29 10-35 MW per Km coast length	0.0011	0.012

Sources : Adopted from various sources [6-10, 45].

Utilization of micro hydro is quite intensive that is 18 % of its potential. Most of micro hydro electricity generating plant are located at remote rural area which can not be reached by electricity grid line.

Utilization of biomass is still very small. Biomass has been used to support daily activities at home, and industries. In industry for example, a saw mill with 1000 – 3000 m^3/y capacity can produce 40- 100kWe using CHP (combined heat and power) technology, while in a sugar industry a sugar mill with 1000- 4000 TCD (total cane/day) can produce 3-10 MWe. In the industry, the biomass is utilized to generate steam and electricity. Despite of the huge potential of biomass energy in Indonesia (see table 2.5 and 2.6) its utilization in Indonesia is limited to large sugar and palm oil industries. [11].

Geothermal is one of potential green energy resources which is also under utilized. There are 252 locations of prospective geothermal energy resources identified around the country [12]. As shown in table 2.3, it is only 1042.5 MW (3.8 %) of total source (27.58 GW) has been utilized to produce electricity.

Table 2.3 : Potential and installed capacity of geothermal energy (MWe)

No	Name Island, (Location)	Resources		Reserves			Total	Installed capacity
		Speculative	Hypothetic	Probable	Possible	Proven		
1	Sumatera	5,010	2,194	5,745	15	360	13,324	2.5
2	Java	1,950	1,771	3,225	885	1,815	9,646	1000
3	East Nusa Tenggara	410	359	973	-	15	1,757	-

4	Sulawesi	900	32	865	150	78	2,025	40
5	Maluku	370	37	327	-		734	-
6	Kalimantan	45	-	-	-		45	-
7	Papua	50	-	-	-		50	-
	Total	8,735	4,393	11,135	1,050	2,268	27,581	1042.5

Source : [8]

In addition to large scale of hydropower, there are 187 locations potential for small hydropower available to produce electricity especially for rural areas. Table 2.4 shows several potential locations of small hydro power measured by PLN and other organizations.

Table 2.4 ; Potential of Hydro Power for > 20 kV (15 kW)

(kW)

No	Locations	Potentials	Number of locations
1	Indonesia (a)	57,840	46
2	Sumatera and Java Island (b)	78,083	50
3	Kalimantan and Sulawesi Island (b)	39,215	50
4	Maluku, Papua, Nusa Tenggara (b)	26,545	41

Source : [7] pp 93-96.

(a) : measured by PLN (State Electricity Company).

(b) : measured by other organizations in different locations.

As an agricultural country, potency of biomass and biogas energy is big but it was under utilized. More than 49 MW (table 2.5) of potential energy from biomass waste and 684 MW (table 2.6) of biogas energy are available, while utilization are very small. Biogas has been used for cooking and also to generate electricity in rural area.

Table 2.5 : Potential of Biomass Energy

No	Type	Potential (million, kWh)	Potential (kW)
1	Energy from rice waste	138.8	
2	Energy from corn waste	49.7	
3	Energy from cassava waste	29.6	
4	Energy from wood waste	205.7	
5	Energy from bagasse waste	1.81	
6	Energy from coconut waste	6.78	
7	Energy from palm waste	3.84	
	Total	436.31	49,807

Source : [7], page 100.

Table 2.6. : Potential of Biogas Energy

No	Type	Potential (million, kWh)	Potential (kW)
1	Energy from cow dung	3,529.9	
2	Energy from buffalo dung	1,528.6	
3	Energy from pig waste	940.5	
	Total	5,999.1	684,831.

Source : [7], page 101.

As a country located in equator, the potency of solar energy and wind power is also abundant. The potency of wind at eastern Indonesia is higher than in the west Indonesia. Potential of wind energy, average velocity at elevation of 24 m above sea level is shown in table 2.7.

Table 2.7. Potential of Wind and Solar Energy.

No	Type	Potency
1	Wind power (wind speed) **(a)**	
	• 36 different locations at East region of Indonesia	2.45 – 5.51 m/sec
	• 30 different locations at West region of Indonesia.	2.29 – 5.57 m/sec
2	Solar Energy (average radiation (kWh/m2) **(b)** (Measured at 23 location of measurements around the country)	a range from : 4.10 (at Banda Aceh – Sumatera Island) to 5.75 (at Waingapu, East Nusa tenggara).

Source : (a) : [7] page 98-99, measured by BMG in a rage of 1990-1995.
(b) [7] page 97, measured by several institutions.

Other renewable energy resources available is ocean energy. As mentioned in chapter 1 that 2/3 of Indonesia is covered by sea with more than 17500 island. Length of beach is 80,791 km [13]. Under the condition, the potency of ocean thermal, wave action and tidal action are large. Unfortunately, research toward utilization of ocean energy is just started [14].

2.2. Renewable energy markets and major industries.

Eventhough market for renewable energy in the country is big, unfortunately utilization the energy so far is so small compared to potential resources. This is mainly due to, since many years, government provides a huge subsidy for the energy derived from crude oil. Gradually, the government has reduced the subsidy, and recently the subsidy is provided mainly for low income families and for gasoline.

Studies conducted by several institutions [7,8,9] showed that until 2007 utilization of renewable energy was around 5 % of its potential (table 2.2). It shows that so far the renewable energy plays a minor role in total energy consumption. The RE has been used in industry, commercial activities, houses and for electricity generation. In more detail figures of the renewable energy consumption are presented in Table 2.8. to 2.12.

Table 2.8 shows the growth and prediction of utilization of renewable energy in Indonesia [7]. It shows that from 1990 to 2005, the increasing of renewable energy use was in average of 2.2 % per year. The result of the studies of PE-UI indicates that the growth of utilization for the next twenty years is predicted in average 5 % per year.

The utilization and prediction of future consumption of renewable energy in different sector is shown in table 2.9 [7]. It shows that utilization of renewable energy is largely for household purposes. It could be understood that biomass is still as major renewable energy source especially for cooking and heating activities at households in many villages of Indonesia.

Table 2.8. Statistics of Renewable Energy Consumption (a)

(Million BOE)

Year	Renewable	Renewable (Excluding Biomass)	Biomass	Biomass Consumption (b)
1	2	3	4 =(2-3)	
1990	196.08	1.84	194.24	
1995	211.29	2.51	208.78	
2000	235.69	7.85	227.84	
2002	242.32	7.59	234.73	
2004	251.35	9.29	242.06	
2005	258.16	9.86	248.30	
2006	*276.19*	*9.55*	*266.64*	276.27
2007	*285.49*	*11.55*	*273.94*	274.37
2008	*298.48*	*14.07*	*284.41*	
2009	*309.72*	*16.64*	*293.08*	
2015	*372.83*	*26.55*	*346.28*	
2020	*433.37*	*36.30*	*397.07*	
2025	*504.99*	*49.55*	*455.44*	

(a) : Total renewable energy consumption including biomass, Source : [7]. pp19-20.
(b) Source : [8]

Table 2.9 : Renewable Energy Consumption for different purposes.

(Million BOE)

Year	Industry	Commercial	Residential (Included Biomass)	Transportation	Electricity
1990	11.35	0.51	181.54	0	2.69
1995	12.72	1.53	193.15	0	3.88
2000	13.43	1.57	208.61	0	12.08
2002	12.59	1.59	216.46	0.	11.68
2004	12.04	1.60	223.42	0.	14.29
2005	12.17	1.67	229.15	0.01	15.16
2006	12.36	1.73	247.43	0.02	14.68
2007	*12.55*	*1.78*	*253.40*	*0.03*	*17.76*
2008	*12.92*	*1.88*	*262.05*	*0.04*	*21.63*
2009	*13.15*	*1.95*	*269.03*	*0.07*	*25.59*
2015	*14.29*	*2.37*	*314.88*	*0.83*	*41.29*
2020	14.76	2.70	358.90	6.81	57.01
2025	14.48	2.94	408.95	53.56	78.62

Source :[7] pp 14-18.

Table 2.10: Biomass Energy Consumption, 1990-2004

(Million BOE)

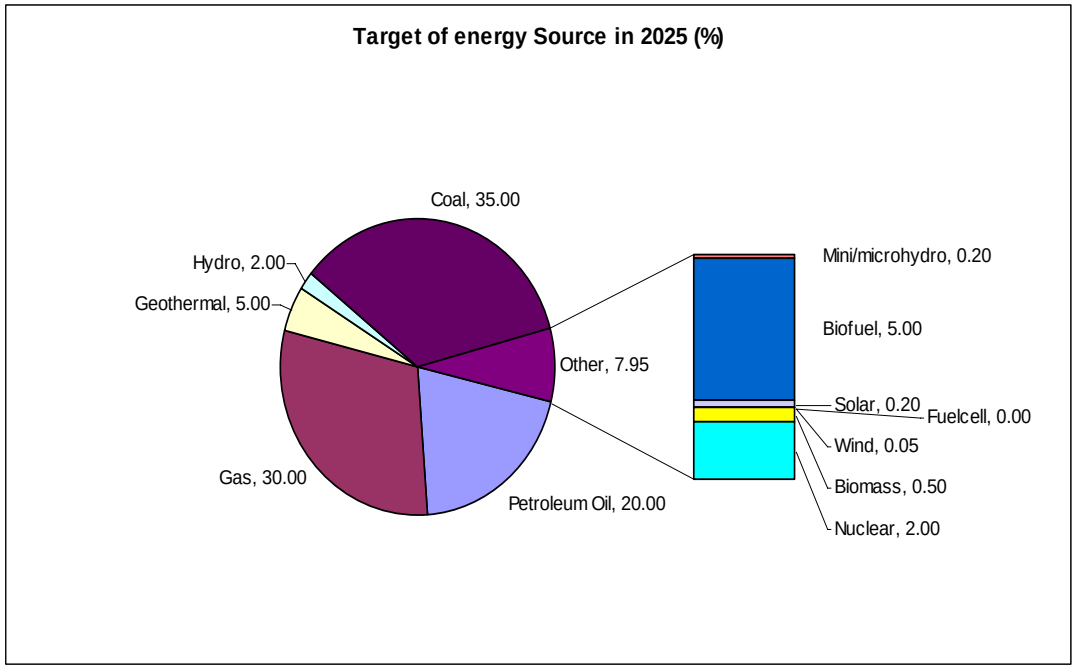
Year	Biomass
1990	193.2
1995	207.4
2000	223.6
2001	226.8
2002	230.6
2003	234.4
2004	237.0

Source : [7] page 107. (calculated by PE-UI based on Handbook of Indonesia's Energy Economy Statistics 2005, DEMR).

In 2005, the primary energy consumption by sources were coal (15.3 %), fossil oil (51.7 %), Geothermal (1.3 %), Hydropower (3.1 %), Natural Gas (28.6 %). Diversification of energy sources is main target of the country. Indonesia plans to reduce crude oil utilization from 51 % (2005) to around 20 % in 2025 [2]. The targeted national energy mix in 2025 is indicated in Presidential Regulation no 5, 2006. At that time energy sources should be crude oil (< 20 %), coal (> 35 %), gas (> 30 %), hydropower (> 2 %), Geothermal (> 5 %), and others such as micro and mini hydro, Bio-fuels, solar, wind, biomass, Nuclear (> 7.95 %).

The progress of energy sources since 2001 and target the energy mix of Indonesia by 2025 is shown in table 2.11. In order to meet the target, the government encourages research activities to optimally utilize renewable energy resources, revitalization of R&D institutions and networks and encourage research on national resources based energy such as bio-diesel, bio-ethanol, bio-gasoline, geothermal, solar energy, wind and hydrogen.. The framework policy covers utilization of environmentally friendly technology, efficient use, which based on local resources and sustainable development [15].

Figure 2.1. Target Energi Mix by 2025.



Source : The Presidential Regulation no 5/ 2006.

Table 2.11 : Utilization and Scenario for 2025 (% of total consumption).

Source	2001 (%)	2003 (%)	2005 (%)	2025 (%)	

Petroleum oil	57	54.4	51.66	20	
Gas	25	26.5	28.6	30	
Geothermal	1	1.4	1.32	5	
Hydro	4	3.4	3.11	2	
Coal	13	14.1	15.34	35	
Others : • Mini/Microhydro • Biofuel • Solar • Wind. • Fuelcell. • Biomass. • Nuclear		0.2		8	 0.2 5 0.2 0.05 0.004 0.5. 2
Source :	[43]	[10]	[44]	(*)	(*)

Source : (*) Presidential Regulation no 5 year 2006.

It might be noted that nuclear energy is one of potential energy for future. In 2025, it is planed that the role of nuclear would be 2 % of total national energy consumption. Until now, due to the objection of community, there is no nuclear energy power generation operating in Indonesia.

Biofuel Demand and Production Figure.

Biofuel, especially bio-alcohol and bio-diesel have been utilized in Indonesia since 2005. In 2009, total production capacity of APROBI (Indonesia Bio-fuel Producer Association) member for bio-ethanol is 212,500 kilolitre (kL), and they predicted domestic demand of 240,000 kL. Production capacity for bio-diesel is 2,521,000 MT/year, while local consumption was predicted 1,121.000 MT/year.

Major bio-ethanol and Bio-diesel producers, member of APROBI, is shown in Table 2.12.

Table 2.12. Name of Company of APROBI Member.

	Name of Company /Producer		
No	Bio-ethanol	no	Bio-diesel
1	PT Anugerah Kurnia Abadi.	1	Asian Agri Tbk.
2	Medco Group	2	PT. Energi Alternatif Indonesia,
3	Molindo Raya Industrial	3	Eterindo Wahanatama Tbk
4	Sugar Group	4	PT. Darmex Biofuel,
		5	Ganesha Energy Group,
		6	PT. Indo Biofuels Energy
		7	PT. Multikimia Pelangi,
		8	Musim Mas Group,
		9	Permata Hijau Group

Source : [16]

CHAPTER 3

Leading R&D institutions and national/international agencies working in the area of renewable energy, particularly those working on capacity building and information dissemination and R&D and demonstration program.

3.1. Leading Universities and R&D Institutions

Considering country's geographic condition, population and available of resources, the research programs on renewable energy are directed to find clean technology, and to utilize renewable energy locally. The need for enhancing in research, development and promotion (RD&P) to promote the R&D results in the fields of renewable energy combined with environmental conservation has been gaining increased attention in Indonesia, especially in Java island. Since many years, growing of population on Java island, as the most dense island of Indonesia, and increasing price of fossil fuel cause increasing demand on alternative energy sources.

Since 2000, RD&P for the energy sector especially on renewable energy has become one important area in the national development program reflecting increasing awareness of the government concerning national energy security and also climate change. This attention is becoming more intense as Indonesia turn into an oil importing country. This national energy policy is called as green energy policy [17].

R&D activities in renewable energy in Indonesia are conducted mostly by Public Universities, and R&D Centers (RDCs) under Departments (Departmental Research Institutions, DRIs) and RDCs under Non Departmental Research Institutions (NDRIs). The NDRIs are coordinated by the Minister of Research and Technology. R&D activities are also carried out by private industries and universities, but the portion is small.

Most of R&D activities on energy conducted by RDCs under Department of Energy and Mineral Resources (DEMR), RDCs under NDRIs and several major public universities such as Indonesia University (UI), Gajah Mada University (UGM), Airlangga University (UNAIR), Institute Technology of Bandung (ITB), and Institute Technology of Surabaya (ITS). Energy research in RDCs under NDRIs are conducted mostly by Indonesian Institute of Sciences (LIPI), National Nuclear Energy Agency (BATAN), Aeronautical and Space Agency (LAPAN), and Agency for Assessment and Application of Technology (BPPT).

The following describes function and activities of selected R&D institutions in RE field.

A. Department of Energy and Mineral Resources, DEMR (*Departemen Energi dan Sumber Daya Mineral*, DESDM)

DEMR has several RDCs in energy field namely : RDC for Coal and Mineral, RDC for Petroleum and Natural Gas, RDC for Electric and Renewable Energy. In line with their main tasks, their researches focus to petroleum oil, coal, geothermal, and biomass energy. Their

research capability related to energy are processing and benefiting coal, gas technology and processing, process technology of oil and gas. Their research on wind power electric generation has reached implementation stage. They built 8 units wind power electricity generations at 80 kW each in Bali.

The department has also conducted research on solar energy utilization. They built 1 (one) solar stove with 64 % efficiency, and a hybrid system of solar energy and wind energy . The system is located at Kepulauan Seribu near capital city of Jakarta.

Under research cooperation with NEDO, they also carry out research in the area of developing high speed circuit breaker.

As many other departments and RDC's, DEMR is also conducting research in biogas production, biomass gasification, bio-diesel derived from palm oil, micro-algae. Other information related to the institution could be accessed through their web (www.esdm.go.id).

B. Department of Industry (DoI)

In addition to the above institutions, in 2008, Department of Industry (Do) launched a program to increase technology capability of industry called 'Industry Technology Capability Enhancement Program'. The program is targeted to increase energy utilization efficiency by conducting energy audit and to drive utilization of alternative energy sources by :

1. development of bio-diesel industry. Bio-diesel is derived from jatropha curcas and crude palm oil.
2. Development of bio-ethanol industry by utilizing molasses and cellulosic waste from palm tree.
3. Coal gasification as an energy source for industry.
4. Utilization of organic waste.

A priority program in industrial development, which related to energy, was development of industry which use biofuel as energy sources. For 2008, the DoI allocated budget at the amount of Rp 70 billions (USD 7.8 millions) for the program [18]. Information on MoI could be accessed through www.depperin.go.id.

C. Other Department.

In addition R&D Agencies under the two department above, R&D Centers under Department of Agriculture and Department of Forestry also conduct researches on RE especially those related to utilization of waste such as agricultural industry wastes and forestry industry wastes .

D. Indonesian Institute of Sciences (*Lembaga Ilmu Pengetahuan Indonesia*, LIPI).

LIPI through several RDCs conducts several kinds of renewable energy research. Research Center (RC) for Chemistry, RC for Physics, RC for Electrical Power and Mechatronics, RC for Biotechnology, RC for Oceanography and Technical Implementation

Unit for Appropriate Technology Implementation Unit. The research activities are on energy equipment and instrument to increase efficiency of combustion engine, solar cell and solar module, clean coal combustion, bio-gasoline and fuel cell. Research result in micro hydro electric power generation has been implemented many rural areas in Indonesia, such as Kalimantan, West Java, NTB, and Sulawesi islands. Currently the institute conducts research on low head microhydro and picohydro electricity generation in order to utilize small volume of water flow. Research on wind power is related to low speed wind turbine. A demo plant of the low speed wind generators (1.3 kW) is being applied in Aceh for producing electricity in the area. Information of LIPI could be accessed through www.lipi.go.id.

Researches in green transportation are focused on electric car and hybrid car to be used at certain areas. A research product in form of a tool for reducing consumption of gasoline and solar in car engines has been commercialized. Starting in 2009, researches in area of concentrated solar power are commenced to search possibilities of direct use of solar energy for electricity generation at specific area of Indonesia.

A demonstration plant for a hybrid (wind, fuel cell and battery) system, at 5 kW electric power generation, has been set up and used by community in a village of Banten Province.

A unique membrane and gas diffusion electrode for fuel cell are also developed by LIPI. To support the hybrid energy system, development of lithium battery is also being conducted. In addition, hydrogen production by manipulating properties of consortium of alga is being investigated. The alga's strain is invented in RC for biotechnology – LIPI.

LIPI also offers training and technical assistance for running integrated system of biogas for electricity in villages of Indonesia. People from Bali, Yogyakarta and several other regions has experienced benefit by the training and assistance.

E. Assessment and Implementation Technology Agency (*Badan Pengkajian dan Penerapatan Teknologi*, BPPT)

BPPT has several RCs which conduct researches related to energy namely Center for Energy Resources (*Balai Besar Energi, BBE*), Center for Aerodynamics and Gas (*Balai Besar Aerodinamika dan Gas*, BBAG), Center for Propulsion Technology, and Center for Assessment and Implementation of Conversion Technology and Energy Conservation. Their main activities are related to wind power, clean coal, ocean wave, bio-fuel and combustion test. BPPT also conducts research related bio-ethanol production [(www.bppt.go.id) and [14].

Some achievements on RE and RET were bio-diesel and bio-ethanol production that has been utilized by industry.

Research activities on fuel cell includes the development of membrane and the stack construction. The CO2 capturing and hydrogen production using microorganism is also being investigated. Research on geothermal utilization is also carried out by the Agency. A research facilities for electricity generation based on ocean wave at 10 kW scale has been constructed at southern part of West Java.

F. National Nuclear Power Agency *(Badan Tenaga Nuklir Nasional,* BATAN).

In line with their main tasks, their researches relate to utilization of nuclear power and radioactive materials for social and economic development. Since many years ago, they have been producing radioactives materials for hospital and industries in Indonesia. They also conduct studies related to environmentally friendly nuclear power electricity generation, and the effect of irradiation on jatropha seed to produce bio-diesel. Due to the lack of acceptance of community to nuclear power electricity generation, utilization of nuclear energy for electricity in Indonesia is still not materialized.

Research on hydrogen storage is also being investigated by the agency. The agency also pays intention on the development of battery. They have a research cooperation with a developed country to develop solid battery. The intensive works on developing magnet material lead to energy-related purposes has been carried out for many years. Information on BATAN could be accessed through (www.batan.go.id).

G. National Institute of Aeronautics and Space (*Lembaga Penerbangan dan Antariksa Nasional,* LAPAN).

Their activities related to RE are on utilization of wind power especially for the low speed wind turbine and solar energy for electricity. They built a pilot system for a wind turbine at 10 kW. The Institute also develops an hybrid energy system combining solar and wind power. Information on LAPAN could be accessed through (www.lapan.go.id).

H. Institute Technology of Bandung (ITB).

As the oldest Institute Technology in Indonesia, ITB,conducts a lot of researches on renewable energy such as research on utilization of municipal solid waste for electricity generation, utilization of wind power, biomass for bio-fuels. ITB also conducts research on ocean wave power for electric generation. The Institute also developed membrane for fuel cell based on bio-cellulose. Information on ITB could be accessed through (www.itb.ac.id).

I. Other Universities.

Other universities such as Gadjah Mada University (UGM), Surabaya Institute of Technology (ITS), Airlangga University (Unair), Indonesia university (UI), Sebelas Maret University (UNS), North Sumatra university (USU), Bogor Institute of Agriculture (IPB), and Diponegoro University, etc also conduct RDP on renewable energy.

These leading universities interest on microhydro, wind energy, solar energy, hydrogen (production) and fuel cell (components), and biomass (biogas and biofuel) researches. The researches include feasibility studies at some areas in Indonesia, engineering developments, system control and its applications.

Summary of RE research activities and its stages conducted by several universities and R&D organizations is shown in table 3.1.

Table 3.1 : List of Universities and R&D Institutions and their activities on RET.

(within last 5 years).

No	Name of Institution	Activities	Stage of activity
1	DRIs :		
	DEMR	Geothermal	Implemented
		Briquette (from coal)	
		Wind Power	Implemented
		Biodiesel, Bioethanol	
		Micro/mini hydro	implemented
		Biomass, Biogas	Pilot scale, demo plant
	MoI	Bioethanol, Biodiesel	
2	NDRIs :		
	BPPT	Bio-diesel from Jatropha oil (process technology)	Commercially transferred
		Electricity from Solar Energy (control equipment)	
		Hybrid Wind and Diesel Oil (control equipment)	
		Bio-ethanol from bagasse	
		Bio-ethanol from cassava	Commercial
		Ocean wave energy	Research, at 10 kW.
	BATAN	Nuclear materials and safety.	
		Hydrogen storage	
		Rechargeable battery	
	LIPI	Solar cell	Pilot scale fabrication
		Fuel cell (Membrane), and system.	
		Clean Coal for electricity, 250 kg/hour coal.	Pilot scale
		Solid battery	
		Micro hydro, up to 40 kW	Implemented in many villages
		Concentrated solar power (initiation stage).	
		Low speed wind turbine, and control system.	
		Magnet	
		Bio-fuels from sorghum Bio-gasoline from biomass.	
		Biogas for electricity generation	Implemented
	LAPAN	Wind turbine, 10 kW, prototype	
	UNIVERSITIES :		
1	IPB	Bio ethanol – sorghum	
		Bio diesel (jatropha), (seed).	

2	ITB	Turbine Francis, 300-5000 kW	
		Bio-fuel from corn waste, and bio-ethanol	
		Hydrogen storage	
		Fuel cell (membrane)	
		Fuel cell (electrode)	
		Wind turbine : low speed	
3	UGM	H2 production (for fuel cell)	
		Solar cell : (increase efficiency)	
4	UNDIP	Ocean Wave	
		Bio-diesel from micro algae	
5	UNHAS	Biogas	Implemented
6	UI	Hydrogen production.	
		Bio-ethanol (sugar cane waste)	(pilot plant)
		Fuel cell	
7	Muhamadiah University at Yogyakarta	Solar energy : chemical for energy storage.	
8	Jember University, East Java.	Bio-diesel from Jatropha oil.	
9	UPN Veteran at Yogyakarta	Biodiesel, Jatropha Oil.	Implemented at small scale in villages.
10	Mataram University at Lombok Island	Micro hydro.	Implemented
11	Education University (UPI) at Bandung.	Additive for bio-diesel.	
12	Institute Technology, Surabaya	PV panel and Solar cell	

Sources : Data collected from various publications and MRT Incentives Research Program, 2006, 2007, 2008.

Capacity Building.

As mentioned in the Law no 27 year 2003 regarding Geothermal that domestic capability on design and engineering and utilization of local technology, product and services are needed to be enhanced. The attempts to build and produce of local component such as small scale turbine has to be supported. Based on the spirit, universities and industry related to the area collaborate among others to develop their capability. Those leading universities and the selected R&D organizations conduct various program to enhance their own capacity and ability of community to use renewable energies.

Institute Technology Bandung (ITB) for an example, as the oldest institute of technology in the country, has developed softwares for technical and economic studies and evaluation activities in the area of geothermal energy [19]. In geothermal area, the leading

universities such ITB, UGM, UI collaborated with two state own companies i.e. PT PERTAMINA and PT. Rekayasa Industri, conduct non-academic training programs for those involved in the area.

Dissemination Information.

It could be noted that for dissemination of information in renewable energy, two public organizations i.e. Center for Documentation and Scientific Information LIPI, and Data and Information Center on Energy and Mineral Resources – DEMR play important role. Those centers manage and disseminate the information not only resulted from their own institution research results and activities, but also data and information resulted from universities and other R&D organizations research results.

In addition to these centers, selected publics and privates universities library are also actively perform the function. ITB, UI and UGM libraries for instances manage renewable energy research results and documentation for the purposes of education and promotion activities of RE. UI formed a team called as Energy Study of Indonesia University (PE-UI) who actively published related documents of energy.

Private Universities.

Many private universities are own renewable energy research programs, and they also conduct dissemination of their research results and promotion on renewable energy to encourage community to utilize RE. Muhammadiah University at Yogyakarta , UPN Veteran University at Yogyakarta as shown in table 3.1. are examples of them.

Darma Persada University at Jakarta, utilizing their Solar Energy Conversion Laboratory conducts R&D on utilization and conversion of solar energy to various means. This university also actively promote utilization of renewable energy [20].

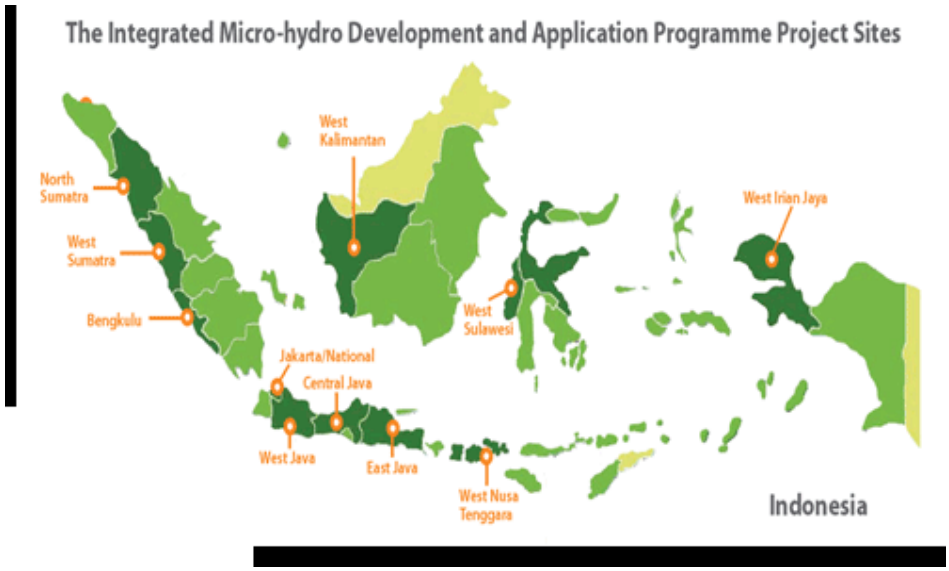
3.2. International Agencies in the RE Promotion.

A collaboration between Department of Energy and Mineral Resources and UNDP formed a program called IMIDAP, Integrated Micro-hydro Development and Application Program. The Objectives of IMIDAP are (Source : www.imidap.org) :

1. To enhance interest among the Indonesian private sector in the micro-hydro power business.
2. To increase the number of community-based micro-hydro projects as a result of effective institutional capacity building;
3. To improve the availability, and local knowledge, of micro-hydro technology applications in the potential locations of micro-hydro development;
4. To increase private sector and rural community joint implementation of micro-hydro projects.

It is believed that implementation of micro-hydro technology across Indonesia would help to reach more sustainable energy resources and use especially for rural areas. As in Indonesia has alot of potential water resources to be used for micro-hydro electricity generation and location distributed around the country, IMIDAP built many sites to utilize the resources locally and paralelly use the site to be a demo plant for community. Figure 3.1. indicates IMIDAP Project site.

Figure 3.1. IMIDAP Project Sites in the country.



(Source : www.imidap.org)

CHAPTER 4

Institutional infrastructure for the development, promotion and utilization of renewable energy

The major institutional infrastructures for renewable energy development, promotion and utilization in Indonesia are described as follows. The institution could be group into 4 categories i.e. policy development institutions, technology development institutions, production and product selling organizations, and non governmental institution which mostly active in promotion and capability enhancement.

4.1. Policy Development.

National Energy Council (*Dewan Energi Nasional*, DEN).

To enhance energy program development in the country, in year 2008 the President formed an energy council. The council is formed based on the Energy Law no 30/2007 and followed by Presidential Regulation no 26/2008 regarding to the formation of National Energy Council. The task of the council are :

- Prepare and formulate National Energy Program
- Determine National Energy Master Plan
- Determine emergency actions.
- Monitor cross sector energy policy implementation.

The board is directly chaired by the President of Republic of Indonesia, the vice chairman is the vice president and for daily activities is chaired by the Minister for Energy and Mineral Resources. Member of the board consist of 7 ministers or chairman of institutions and 8 people from energy stakeholder such as academicians, person from energy industry, expert on environment, and expert on energy technology and a representative of consumer.

Previously, before National energy Council is formed, for coordination on energy development program, there was a National Energy Coordinating Board (*Badan Koordinasi Energi Nasional*, BAKOREN) which has performed their duty from 1980 to 2008.

Department of Energy and Mineral Resources (DEMR)

Some of the functions of DEMR are to develop national policy, implementation policy and technical policy in the are aof energy and mineral resources, and to implement the national policy in those area. The department is responsible for development, promotion and utilization various kind of energy sources including renewable energy (Source : www.esdm.go.id) Under the department there are two directorate general which has tasks

related to renewable energy i.e. Directorate General for Mineral, Coal and Geothermal, and Directorate General for Electricity and Energy Utilization. Under the latter directorate general, there is Directorate for Renewable Energy and Energy Conservation which specifically deals with RE. RET development and assessment are conducted by the Research and Development Agency on Energy and Mineral Resources.

4.2. Technology Development.

The development and promotion renewable energy technology conducted by number of public and private institutions and universities and R&D organization, NGO and industries, state own industries and private industries. R&D organizations and universities involves in renewable energy technology development as mentioned in Chapter III, deals with various type development initiating with researches in laboratory up to developing the technology at pilot scale. Utilization and commercialization of some research results are conducted by private firms. Many of the researches in universities, both public and privates universities, were conducted to support small and medium scale enterprises. In this case, transfer of technology were conducted through workshop or training for the SMEs [21,22].

4.3. Production, Product Distribution and Selling.

PT. PERTAMINA

PT. PERTAMINA, a state own company on petroleum fuel and gas, is a major company who distribute and sell petroleum fuels and bio-diesel for community, industry and transportation sectors. In Mei 20th, 2006, PT PERTAMINA firstly launched bio-diesel as a mixture of 95 % of diesel oil and 5 % of FAME (Fatty acid Methyl Ester) to be used by transportation sector (source : www.pertamina.com).

MEDCO.

Medco is a private company which main business on petrelum oil. Since last few years, Medco actively involve in renewable energy development, productiona and promotion. Medco has an ethanol production with capacity of 180 kL per day in Kotabumi, Lampung Province [23]. The factory was designed to use various raw materials for ethanol production while cassava as major raw material.

PT. Rekayasa Industri.

This is a state own engineering company deals with engineering and construction big factories in the country and abroad such as urea fertilizer, geothermal facilities, etc. Since few years ago, the company actively expand their business and offer consultation and service in constructing bio-diesel processing plant. At early January 2009, the company signed a contract to build a factory for 100,000 MTon per year bio-diesel processing plant at South Sumatera. In 2007, the company collaborated with PT. Bakrie Sumatera Plantation also built a 60,000 MTon per year biodiesel processing plant in Sumatera. (source : www.rekayasa.com/news)

Other Bio-fuels Producers.

Several other major producers of biofuels and bioethanol is member of APROBI. Indonesia Biofuel Production Association (*Asosiasi Produsen Biofuel Indonesia*, APROBI) as shon in Table 2.12.

4.4. PLN

PLN, the only state own electricity company, is a company which produce and distribute electricity to users. Indonesia electrification ratio, number of household received electricity compared to total number of household in the country, is still low compared to other countries in the ASEAN region. In 2007, the ratio was 60.3 %. Based on an assumption that population growth of 1.2 %, PLN estimated that the ratio would be 74.4 % in year 2016 [46].

The government programs on electricity in relation with utilization of renewable energy to generate electricity are [45] :

a) Program on rural electrification is to provide access of electricity for rural communities. Since 2005, the government has decided to use only locally available renewable energy resources (if the extension of grid to the rural is not possible), not to use fossil fuel to generate electricity.
b) Program on interconnection of Renewable Energy Power. The program is as an initiative for investor to develop small / medium scale power generation from renewable energy to sell electricity produced to PLN.
c) Integrated Micro hydro Development Program (IMIDAP) is a program to accelerate micro hydro implementation electricity. The program is supported by GEF through UNDP from 2007 to 2012.
d) Micro Hydro Power Program (MHPP), in cooperation with Germany, is a program to develop capacities on technology and sustainability of micro hydro implementation. T
e) Program on Boigas is launched in January 2009 in cooperation with Dutch government on technical assistance and financing mechanism development system.
f) Program on Energy Self-Sufficient Village (Desa Mandiri Energi) was launched in 2007. The program is to improve energy security on village level by diversifying rural energy mix. The program is to utilize and develop locally available renewable energy resources in the form of bio-fuel and electricity produced is for household and also for productive users.

4.5. NGO

There are numbers of NGO which actively conduct promotion of renewable, energy diversification, energy saving, efficiently utilization of energy resources and perform training program. Several of them are highlighted here.

<u>Indonesia Renewable Energy Community (METI)</u>

Indonesia Renewable Energy Community (*Masyarakat Energy Terbarukan Indonesia*, METI) is a NGO which become an organization where expert, industry and community who has interest to develop and promote utilization of renewable energy in Indonesia, gather together. The community was established for two function : to be a media for

communication, consultation and develop collaboration among renewable energy doer, and to accelerate growing of utilization of renewable energy in fulfillment national energy demand. METI focus their activities in renewable energy on geothermal, biomass, microhydro, solar power and wind power [23].

Yayasan Pijar Cendikiawan (Pijar Cendikiawan Foundation)

The foundation concerns on renewable energy development and utilization. Their activities includes surveys to search potential renewable energy resources, collaborated with universities to conduct training for people in villages to utilize RE, and to socialize energy conservation through education, workshop and training for high school student, under graduate student, and industry. Furthermore, the foundation is also attempting to form a research center to carry out R&D in the area renewable energy resources development and utilization and energy conservation. (Source : www.pijar.org).

Yayasan Pelangi (Pelangi Foundation)

The foundation is an independent research institute concerns on climate change and renewable energy promotion and utilization. Their activities on renewable energy were participating in the Global Village Energy Partnership, and currently active to promote and encourage efficiently use energy sources at non-star hotels (source : www.pelangi.or.id)

Yayasan Dian Desa (Dian Desa Foundation)

Dian Desa is a NGO which has a lot of activities related to promotion of RE and training for people in villages in utilizing RET. The goal of the NGO is to enhance the viability of biomass fuel as a manageable and environmentally sound energy source. An example of their activities is to improve cook stove to utilize briquette. Their program also includes a Kitchen Improvement Program. (See: www.tungku.or.id).

CHAPTER V

Policies and Policy Instruments, and Incentives for the Promotion, Utilization and Development of Renewable Energy Technologies.

5.1. Policies and Policy Instruments.

Increasing demand of fossil oil while decreasing of domestic production has driven government and community to exploit available renewable energy resources in the country. This section describes the policy and policy instrument of the government with the intention of development, promotion and utilization of renewable energy in Indonesia.

In Indonesia, to drive development and utilization renewable energy and to increase energy utilization efficiency, energy policies were constructed to be used as references in energy development and energy conservation. Renewable energy policy, as part of national energy policy particularly on energy diversification policy, is aimed to drive utilization of renewable energy resources efficiently and effectively. Furthermore, providing energy for electricity, industry, business and transportation without escalating the effects on city environment and climate change is a priority of the Government of Republic of Indonesia (GOI). The government has established policies of providing energy for community and country development, and in those policies utilization green energy is one of the key issues in energy supply.

To support and drive effort and program in developing renewable energy, the government revealed several policies and regulations as follows.

In December 2003, DEMR launched an Renewable Energy Development and Energy Conservation Policy known as Green Energy Policy [24]. The policy is stated in Ministerial Regulation no 002/2004, regarding Policy for Green Energy Development. The policy mentioned that, based on domestic condition and capability, the utilization of renewable energy sources in Indonesia could be differentiated into three categories :

1. renewable energy which has been utilized commercially such as geothermal, large hydropower and biomass such as wood waste, agricultural waste, animal manure, etc.

2. renewable energy which been limited developed such as wind and solar energy.

3. renewable energy which is still under research and development activities such as ocean / tidal action.

The Ministerial regulation is also mentioned that support and incentives for those categories were different. The incentives for category 1 are to drive development of businesses, while for category 3 are mostly for enhancement of researches.

In 2006, through Presidential Regulation no 5/2006, the national energy policy and target energy mix in 2025 was announced. It was stated that the main objective of the country energy policies is to diversify energy sources. At 2025, it is targeted the role of renewable energy 15 % of total energy demand, and the energy sources for domestic consumption should be as shown in figure 2.1 in Chapter II.

National Energy Policy of Indonesia, in addressing energy and environmental challenges, was also stated in the President's remarks in front of the DPR (the Parliament) on August 16th, 2006 [5]. The President's remark mentioned that energy policy is aimed at utilizing coal, hydropower, gas and other renewable materials especially bio-fuel for replacement of fossil oil.

In Law no. 30, August 10th, 2007, concerning Energy, Indonesia aims to reduce significantly the national economy dependence on imported refined oil, and increasing utilization of other energy sources such as geothermal, hydro power and other renewable energy resources such as bio-fuels, solar energy, etc. Based on the law, the government formed a strategic council i.e. the National Energy Council with one of their tasks is to determine National Energy Master Plan. Their tasks in more detail are presented in Chapter IV.

In 2007, through the degree of Minister Coordinator for Economic (KepMenko Perekonomian 11/m.ekon/03/2007), the government set up a team to coordinate various policies and action programs for production and utilization of alternative energy. Some of the team's function are :

1. to arrange and to formulate the appropriate policies to encourage the sources of alternative energy growth
2. to provide a direction and input in the formulation of national policies in the field of alternative energy
3. to take steps to accelerate the concrete provision and utilization of alternative energy through the coordination and synchronization of the compilation and sharpening/ exacerbation the implementation of alternative energy supply policy
4. to improve a coordination among all of central government agencies, regional government, state-owned enterprises, local government-owned enterprises, businesses, professional institutions, and communities in the provision and utilization of alternative energy .

Utilization of RE for Small and Medium Scale Electricity Power Generation.

The government through the government regulation no 26/2006 concerning electricity supply and utilization put priority to utilize locally available renewable energy resources for electricity generation.

In 2006, Minister of Energy Mineral Resources, through Minister Regulation no 002/2006 concerning Development Medium Scale (1 to 10 MW) Power Plant facilitated business entity to produce electricity utilizing renewable energy. Through this regulation

together with Ministerial Decree no 1122/2002 (KepMen ESDM no 1122K/30/MEM/2002) concerning Development of Small Scale Electricity Power Generation (capacity less than 1 MW) by Small Enterprises the government of Indonesia attempts to facilitate and urge utilization of renewable energy resources for electricity generation by community and private companies in regions around the country. These regulation drives and facilitates small firms, private companies and community to produce electricity utilizing renewable energy sources such as biomass, geothermal, wind and other type of renewable energy sources.

Production, Utilization and Obligation to Utilize Bio-fuels

It is realized that one of challenges of sustainable development and utilization of bio-fuels in Indonesia is the capacity of people and institutions. As very long time depend on cheap and subsidized fossil oil have caused community difficult to adopt new condition, new energy sources. Indonesia also realized that commercially available local technology is also limited, as many of technologies developed in the past stopped at laboratory or pilot scale activities. In order to expedite supply and utilization of energy alternative, the government has to arrange regulations, provide technology, etc. In 2006, through the Presidential Instruction no 1/2006 regarding to Supply and Utilization of Bio-fuels, the President assigned several Minister to prepare things related to the purposes. For example DEMR has to prepare incentives and tariff for bio-fuels development and utilization, standard quality and procedure for quality assurance, etc. Department of Agriculture has to facilitate development of cultivated area for targeted plants, to prepare seed and technical assistance to farmer who willing to grow the plants. Department of Industry has to prepare matters need to increase bio-fuels production, while MRT has to develop suitable technologies, and need to suggested the way for application of technology for processing, utilization of bio-fuels.

In 2008 the government, through the Energy and Mineral Resources Ministerial Degree (*KepMen* ESDM 32/2008) obligated industry and transportation sectors to begin utilization of use bio-fuels especially bio-diesel and bio-ethanol as fuels for their activities. The obligation should be implemented gradually from 2009 to 2025 by transportation, electricity generation and industrial sectors. For an example, mandatory minimum bio-fuels content (in % of total fuel demand) for industry and commercial sector are : 2.5 % bio-diesel for their fuel consumption (2009), and the percentage is increased gradually to 20 % in year 2025. Utilization of bio-ethanol for the sector should be at 5 % in year 2009, and gradually increased to 15 % in year 2025. Minimum content of bio-diesel for public service transportation is 1 % in 2009, and increases to 20 % in 2025. Minimum content of bio-ethanol is 1 % and 15 % in year 2009 and 2025 respectively.

Indonesia Biofuel Production Association (*Asosiasi Produsen Biofuel Indonesia*, APROBI) predicted that in 2009 demand for bio-ethanol and bio-diesel is 240,000 and 260,000 kilolitres respectively [25].

By these Degrees, the government expect to drive utilization of various available plant oil to produce bio-fuels. It also open possibilities for community through *Desa Mandiri Energi* to utilize various kinds of plant oil such as jatropha, and other plant oil and agricultural wastes as raw materials for bio-fuels production. As mentioned before that *Desa Mandiri Energi*, is a concept of Self Sufficiency Energy Village in which community in the village should attempt to fulfill their energy needs through utilization of various kinds of energy sources in the village.

In order to enhance community capability, in 2007 the government formed *Program Nasional Pemberdayaan Masyarakat Mandiri* (PNPM Mandiri), National Program on Community Empowerment. This program, designed to be carried out until 2015, is aimed to support and enhance community, especially low income family, by creating job opportunities. Utilization and promotion of renewable energy in rural and remote areas includes in this program.

Biomass Utilization.

Policies with aims of biomass utilization show that many attempts through various action programs of the government have been set up to push community and industry to develop, create RE technology in order to utilize biomass, especially utilization of agricultural and forestry industry wastes as sources to produce renewable energy. For the industries, the government urges the industries to integrate utilization of the wastes in their process activities. The government also urges community for utilization of renewable energy from biomass, include municipal solid waste in their economic activities. It is also urged development of technology for conversion of biomass energy to other energy form. and development supporting industries and firms [11].

S&T Policy.

The increasing market price of fossil fuel lately drove many research institutions and universities in Indonesia to enhance their research activity on energy especially on topics to find alternatives sources of energy, efficient use, and clean and renewable energy sources. The research related on energy become more significant. The activities were also attract attention of Indonesian politician. In June 2008 the President invited energy related research scientists to the presidential palace to discuss progress and current condition on energy research in Indonesia.

The essential of S & T development to the achievement of national development objectives has been emphasized in the Law no 25 of 2000 on National Development Program, and the Law no 18 of 2002 on 'National System of the Research, Development and Application of Science and Technology', and Law no 17/2007 on Long Term Development Planning (RPJP, a development plan up to 2025). Following to the implementation of the Law no 18, the Government of Indonesia introduced two new government regulations, which regulate technology transfer mechanism and to require industry to participate and invest in R & D activity, while the government provides appropriate incentives. The technology transfer regulation is also to regulate the earning from R & D commercialization by research institutions. In addition, to drive utilization of product resulted by local industry, the President enacted the Presidential Decree no 18 of 2000 on Utilization of National Product.

Indonesia's S&T Strategic Policy that follow enactment of the National Systems on S&T Law, in general has made direction and put in priority on 6 research areas. In 2008, considering limited R&D resources, the government determined to focus R&D activities in two main areas i.e. Energy and Food. Meanwhile R&D capabilities in other areas have to be maintained and developed as well. All R&D activities in energy were encouraged to provide

outcomes not only in medium/long term (3-5 years or more) but also in short term (1-2 years).

S&T policy development published by the MRT called as National Strategic Policy of S&T (*Kebijakan Strategis Nasional IPTEK 2005-2025*) stated the vision and mission to be fulfilled for a term of 2005-2025. The R&D priority for 2005-2009 states in the National Research Agenda (*Agenda Riset Nasional* 2005-2009). For 2005-2009, S&T Programs are focused on 6 areas namely Food Resilience and Agriculture, Energy, Defense, Transportation, ICT, and Health and Pharmaceutical [26]. In the energy program, research activities are focused on new and renewable energy resources. The research target is to increase utilization of geothermal energy, renewable energy resources, clean coal, and gas considering environmentally issues [15].

5.2. Incentives for the promotion and utilization of renewable energy.

As mentioned above that, the country's primary energy sources is mainly from fossil oil and natural gas. As the increasing of international oil market price, the price of fuels in Indonesia gradually increased. To support low income family, for many years the government has provided lot of subsidies for fuel oils derived from petroleum oil. The subsidize is for transportation and for low income household fuel, not for industry. The high increase of the fuel price has caused the subsidy become a huge burden to the government budget. To reduce the burden, government encourages utilization of non fossil fuels especially renewable energy sources.

To reach targets and aims of national renewable energy development and energy conservation, some of national strategies are ;

a. To drive development of renewable energy and energy conservation infrastructure based on community capability.
b. To prioritize utilization of renewable energy sources.
c. To increase stakeholder role in utilization of renewable energy
d. Enhance national, regional and international collaboration especially in order to access information, technology transfer and budget.
e. To drive utilization of local product and service related to renewable energy utilization and energy conservation.

In order to push utilization of RE the government launched several incentives as follows.

In 2003, through Law no 27 year 2003 concerning Geothermal, the central government encourage local government to build and utilize geothermal energy available in their region. The law endorses utilization, management and profit sharing (between central and provincial government) of geothermal for electricity generation. The law has driven local government to utilize geothermal resources available in their province.

In 2003, the strategic steps in energy policy through the Green Policy Energy [24] was the government would give incentives to, such as :

a) lower rate for companies who make investment in renewable energy production.
b) Arrange conducive investment mechanism.

Those incentives latter on were stated in more detail in Government Regulation no 1/2007, and renewed by Government Regulation no 62/2008.

Considering that activities in renewable energy fields are not yet as interesting as those in natural gas and petroleum oil, incentives are considered necessary to drive activities. The government realizes that to conduct renewable energy development activities and energy conservation need a big investment. To encourage industry and community to develop and utilize RE, government provide rolling fund, loan guarantee, soft loan and micro credit for renewable energy companies. To attract the business attention, government launched several type of incentives as follows :

1. tax incentive reduction, adjournment, reduction or free VAT, and free import tax for companies which has activities in renewable energy development and energy conservation.
2. grant award for companies which show successful result in implementation energy conservation principles .
3. free import tax for exclusive product, equipment needed at renewable energy and energy conservation activities.
4. fiscal and non fiscal incentives such as :

- procurement of electrical equipment or system such as electric power generation utilizing renewable energy could be conducted without following national bidding process regulation [27]. The government through Government Regulation No 26/2006 (PP No. 3/2005 and PP No. 26/2006)) also provides non fiscal incentive for electric power selling without bidding process.
- The government provide subsidy for cost difference arise in utilizing renewable energy, compared to the cost of petroleum oil utilization, in order to generate electricity. This incentive is granted for industry who utilize renewable energy, includes bio-fuels [28].
- In a government regulation (PP no 1/2007 and renewed by PP 62/2008) and Finance Ministerial Regulation , the government also plan to provide incentives such as [29] :

    - Soft loan for capital investment.
    - Reducing VAT,
    - Free import tax for product and equipment related to renewable energy.

- Since September 2008 (Government Regulation, PP no 62 / 2008) the government gives income tax incentive for geothermal and bio-fuels development industries.
- Other kind of incentive provided by the government is simple and uncomplicated process to make an investment in area of renewable energy activities such as to acquire :

    - Information and data on available renewable energy resources.
    - Technology and its information,
    - Human resources
    - Regional development Plan
    - Permit document for business activities.

In addition to that, in order to drive utilization of renewable energy sources, especially bio-fuels, in 2007 the government allocated budget at the amount of Rp 1 trillion (roughly USD 110 millions) for subsidizing the interest rate for enterprises who develop and produce bio-fuels [5].

Chapter VI

Details of financial institutions supporting RE projects and brief illustrative examples and status of the projects funded

The financing for renewable energy programs in Indonesia could be differentiated into three kinds i.e. the first and main source is from the central government, the second source is from regional government and third source is from local agencies or companies and from international agencies. This chapter describes the first and second sources, as the financing information from the third sources could not be tracked in the period of this report preparation.

6.2. Government Funding for Energy Research.

This section shows government Science &Technology budget for energy development activities only.

Most of research budget in Indonesia come from the government. The amount of budget of the government S&T budget tends to increase. For many years, Indonesia's research activities still rely heavily on government financial support. In 2005, 70 % of the total R&D budget in Indonesia came from the government annual budget, and this situation seems to remain until recently [30].

Allocation of S&T budget was around 0.085 % of GDP in 2005-2008 (Table 6.1) [30, 31]. It could be noted in 2006 population was 224.1 millions, and GDP per capita was USD 1,651 and GDP per capita 2007 was USD 1,946 [32].

Table 6.1 : Progress of the Government S&T Budget. (% of GDP)

Year	GDP (Rp trillion)	S&T Budget (Rp billions) And (% GDP)	Note
2005	2729.0	2496.5 (b) (0.09)	
2006	3338.0	2756.7 (b) (0.083)	224.186 millions people GPD per capita USD 1651
2007	3957.0 (a)	3346.6 (b) (0.085)	GDP percapita USD 1946 (a)
2008	(-)	3758.8 (b)	-

Note ;

- GDP based on current price.
- S&T budget includes R&D budget, diffusion and training.
- Conversion rate on July 14, 2008 : Rp 9200 / USD.

Data Sources [30]; (a) GDP 2007 is taken [32], (b) from [31].

A typical of RE research budget is shown in table 6.2. In 2005, total budget for energy research in selected public R&D institutions of Rp 191.2 billions (USD 21.2 millions), includes the budget for nuclear energy research. The distribution of the budget in each institutions is shown in table 6.3.

Table 6.2: The amount of R&D Budget on New and Renewable Energy Resources for each category in 2005.

No	Category	Amount (Rp billions)
1	Non Conventional energy resources	3.7 (1.94 %)
2	Nuclear energy	13.8 (7.22 %)
3	Renewable energy	11.1 (5.80 %)
4	Energy conservation and efficiency	8.4 (4.39 %)
5	Other energy resources not elsewhere classified	154.2 (80.65 %)
	Total	191.2 (100 %)

Source : [33]

Specific Public Funding for RE Program.

The proportion of government R&D budget for energy research activities conducted by selected Public R&D Institutions were relatively small. For 2005, the research budget for energy researches in selected public R&D institutions was also small in a range of 0.56 to 7.11 % of the institutions total budget (table 6.3). [calculated from 33,34,35]. As the increasing important of RETs, it is believed that the budget for energy research in future is going to be increased.

Research Support Scheme.

In early 1990s, MRT launched A Competitive and Collaborative Research Scheme called as RUT. This RUT scheme was followed by other schemes such as Selected Partnership Research Grant (called as RUK), National Strategic Research Scheme (called as RUSNAS) and Technology Incubator Program. In the RUK scheme for example, the government provided up to 80 % of budget (or up to Rp 1 billion, roughly US $ 115,000) to conduct a collaborative research between public R&D institution and a firm. The other 20 % of budget should be provided by the firm involved. Target of the collaborative scheme was to set up a pilot plant for scaling up a process for a product manufacturing, includes activity on renewable energy development [36].

Table 6.3. Research budget for energy in selected public R&D Institutions.

No	Institution	Research Budget for Energy (Rp billions) and (%	% of the institution total budget

		of total)	
1	R&D Agency of Dept of Energy and Mineral Resources (DESDM)	158.5 (82.90 %)	5.08 %
2	Indonesian Institute of Sciences (LIPI)	2.2 (1.15 %)	0.56 %
3	National Nuclear Power Agency (BATAN)	14.3 (7.48 %)	7.11 %
4	Agency for Assessment and Application of Technology (BPPT)	14.5 (7.58 %)	5.37 %
5	Aerospace (LAPAN)	1.7 (0.89 %)	1.13 %
	Total	191.2 (100 %)	19.25 %

In 2001, MRT launched several research schemes such as Technology Catalyst, Start Up Company, and in 2003 introduced Entrepreneurship Development and New Technology Insurance Programs to stimulate innovation, and to promote creating new industries based on R & D results conducted by public research institutions and universities, and to give a protection for an inventor who implement his/her research result in an industry [37]. In 2006, MRT launched an Incentive Research Scheme to drive research on the 6 priority areas, one of them is RE researches, and for replacing RUT and RUK programs [38].

Even though the government is facing budget constraints, through these policies and programs the Government showed its commitment to push research activities include research on energy in Indonesia. The government also facilitates relationship and interconnection between enterprises and universities or public research institutions in order to increase innovation in Indonesia.

Examples of the result of government funding on RE that could be gathered in the period for preparing this report are :

a). Various plants derived oils currently used to be mixed with diesel oil to produce bio-diesel available in local market.
b). Production of bio-ethanol from cassava at commercial scale conducted by BPPT at Lampung Province.
c). 6 unit, 80 kW each, electricity power generation utilizing wind power and solar energy conducted by several institutions coordinated by DEMR in Bali Province. The project is at pilot scale, and the electricity utilized by local community.

6.2. Local Institutions/Companies.

It seems that development and promotion of renewable energy could not yet attract intention of local financial institutions. It is clearly seen that, in the period of study, there is no data which indicates special program of local bank with aims to support these activities.

A discussion facilitated by Department of Energy and Mineral Resources through an activity of Integrated Microhydro Development and Application Program (IMIDAP) entitled

Enhancement Financial Institutions in Facilitating Microhydro Financing Scheme, Jakarta, 27 May 2009 clearly indicated that very few bank and non-bank financial institutions which has programs to support renewable energy development, especially at small and medium scale project (source : www.imidap.go.id).

Medco Oil Company.

Medco is a local oil company which actively promote development and utilization of renewable energy in Indonesia. Eventhough the company is not a financial institution, the company provides fund to support other organization or institution in area of renewable energy development and promotion. (Source www.medco.com). Community jatropha plantation development, plant seeds development, and other kinds of research and development in RE have been supported by the company.

6.3. International Institutions.

International institutions recently supported renewable energy projects in Indonesia that could be accessed during the preparation of this report are as follows.

ADB

In 2005, Asian Development Bank supported Indonesia through Department of Energy and Mineral Resources to make a study on gas generation from waste. A grant from ADB was utilized to produce gas from waste produced by palm oil processing industries. Besides that ADB also supported development of 4 units mini-hydro electricity generation at Gorontalo, North Sulawesi, West Kalimantan, Nusa Tenggara Timur, and Wonosobo. ADB also supported a PREGA (Promotion on Renewable Energy, Energy Efficiency and Greenhouse Gas Abatement) project [39].

UNDP , World Bank

United Nation Development Program (UNDP) Indonesia collaborated with Department of Energy and Mineral Resources to form IMIDAP. The activities of IMIDAP is funded by Global Environment Facility (GEF) mechanism of World Bank. Through IMIDAP, UNDP supports the development and promotion of renewable energy utilization especially micro hydro and mini hydro power for electricity generation.(source www.undp.or.id, accessed Nov 19, 2009).

To enhance the development of geothermal energy utilization to overcome electricity supply shortage in Indonesia, in 2008 the World Bank via GEF scheme also supported the Geothermal Power Generation Development Project. (web.worldbank.org/wbsite/external/countries/eastasiapasific/).

WAITRO

World Association Industrial Technology Research Organization (WAITRO) is not a financial institution, fortunately it also supports grants for activities in the area of renewable energy development. In 2008, WAITRO supported LIPI through a grant to build a system for micro-hydro electricity power generation in a village called Cibunar at Tasikmalaya district

of West Java. The system could generate 30 kW electricity, and it has been utilized by community for their daily activities. In 2009, WAITRO is also supporting LIPI by another grant to build a small tea processing unit in the village utilizing electricity generated by the micro hydro [40].

Chapter VII

Scope for Utilizing Renewable Energy Technology

It is realized that renewable energy sources are very potential for fulfillment of Indonesia's future energy demand. As mentioned in previous chapter that Indonesia really depend on fossil fuels to fulfill domestic energy demand. In order to find replacement for fossil fuels, research programs on energy is focused to utilize available renewable resource such as hydro power, geothermal energy, and biomass in addition to find the way for efficiently used petroleum oil and coal.

Utilization of biomass to produce bio-ethanol, and use of various plants oil such as jatropha oil, crude palm oil and other various plants oil to produce bio-diesel and bio-gasoline, utilization of ocean wave, wind power, and solar energy are area of research activities which are strongly supported by the government. Utilization of solar energy through solar cell is so far directed for small scale solar energy system for housing. As most of wind speed in Indonesia is relatively low i.e. up to 5.7 m/sec in most islands of Indonesia [7], so that research in this field is focused on low speed win turbine.

As also mentioned in previous chapter that Indonesia has planned the targets of energy mix up to 2025. It includes utilization of RE in addition to fossil fuel and gas. For reaching the target, the government has setup RE roadmaps and milestones of development up to 2025 for bio-diesel, bio-ethanol, geothermal energy, wind power, solar energy, microhydro, tidal action, wave ocean, and fuel cell.

7.1 Solar Energy

Indonesia located in equatorial receives solar energy for whole year with average power around 4.8 kWh/m^2/hari. Realizing this potency, the central and local governments encourage participation of community, industry, and private enterprises in developing related industries, and drive participation of financial sector such as bank, etc to utilize the potency to replace energy from fossil.

The most current application is by using photovoltaic to generate electricity, and direct use of solar thermal for drying purposes. Electricity for telecommunication apparatus, solar cooker, solar water heater, small scale electricity generation are examples of current utilization. In National Energy Blue Print [10] is mentioned that the targets for the period 2010-2015 are utilization for residential area, microgrids. The targets of electricity production from solar energy are 25.6 MWp, 17.1 MWp and 11.1 MWp in year 2013, 2018, and 2020 respectively.

The government projected to reduce the PV cell cost from $5/W in 2005 to $ 0,5 -$ 1/W in 2025. Some of the related solar technologies already developed in Indonesia such as solar cell, PV cell, panels fabrications. Besides that final product such as solar cooker, solar dryer, and etc have also been produced locally. The government also shoves researches on the area of solar dryer, solar collector, solar thermal pump, and concentrated solar power to generate electricity or for other purposes. Ministry of Research and Technology's solar thermal roadmap also expects products on solar concentrator, thermal storage system by 2025. Figure 7.1 to 7.3 several examples of solar energy utilization in the country.

Figure 7.1. An example of Stove Solar Collector for Household Use.
(Stove Diameter of 2 m) (Source : DEMR)

Figure 7.2. 2 kWp Solar Panel for Household Use. (Source : DEMR)

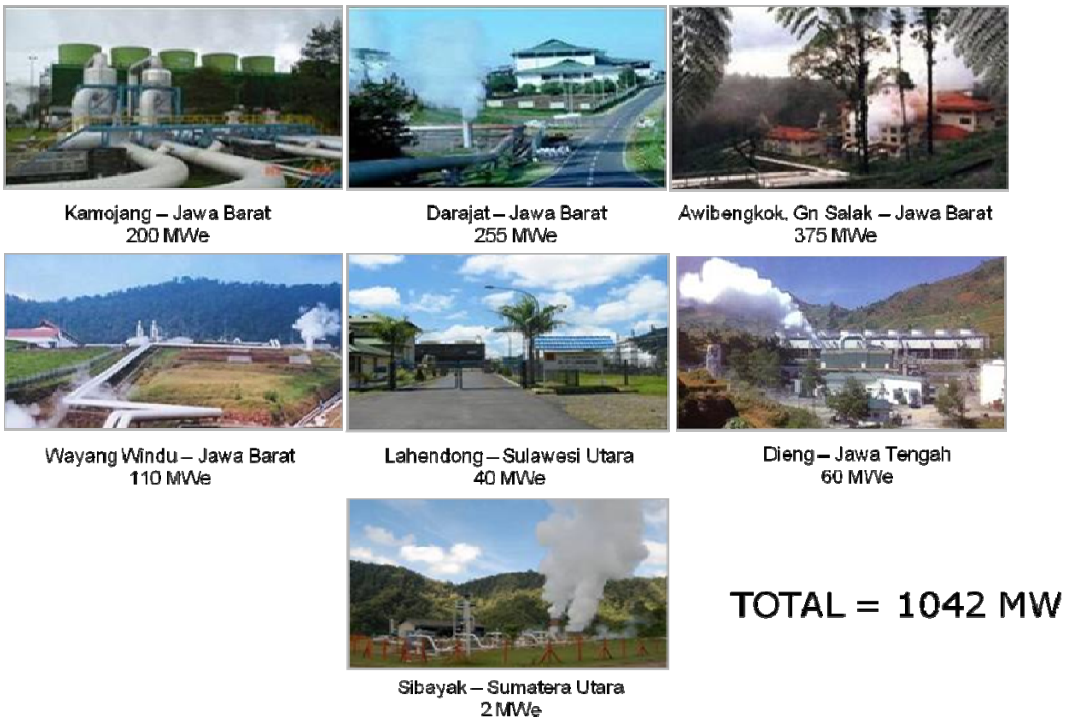
Figure 7.3. 80 kW p Solar Panel in Bandung (Source : DEMR)

7.2. Geothermal Energy.

As mentioned previously, the total potential of geothermal energy in Indonesia is 27.5 GW. It spreads in Java, Sumatra, Sulawesi, Maluku and other island as shown in figure 1.3 in Chapter 1. The 1042 MW has been installed in 7 locations in Indonesia as pictures shown in Figure 7.4. It is projected to be 4600 MW (2016), 6000 MW (2020) and 9500 MWe to be installed in 2025 of contributing 5% of energy demand in year 2025.

To achieve the target, the government invites involvement of many parties for (i) improving the existing site, (ii) improving technology and methodologies for utilization, (iii) performing research on high temperature geothermal (> 300oC), and for (iv) technical and economical feasibility study of available site in Java and Sumatra.

Figure 7.4. Presentation of existing geothermal site in Indonesia [3].



7.3. Wind Power Utilization.

The potential of wind energy in Indonesia is roughly 9.29 GW. Utilization of wind power is mostly for electricity generation, and a small amount for non-electricity purposes such as for water pumping to agricultural fields. The latter activity has been conducted since more than two decades ago. Some villages in Lombok and NTT Islands for an example have utilized the system to take underground water for their agricultural fields. The program is supported by district government and also supported by an international agencies.

Considering slow speed of wind flow in most area of Indonesia, development of small scale to medium scale wind turbine (50-100 kW) are encouraged and supported by the government. To search suitable low speed wind turbine to be applied under Indonesia circumstances, research centers in LIPI and ITB undertake researches in the area. Figure 7.5. shows a research facility of LIPI for low speed wind turbine installed at roof of building in Bandung, West Java Province.

It is planning, in national wind energy roadmap, to expect by 2015 as much as 25 MW will be put on grid and other 600 kW on off-grid, and in 2025 as much as 250 MW on grid, and 5 MW off-grid.

Figure 7.5. Low speed Wind Turbine Combined With PV panel at LIPI's Research facilities.

Figure 7.6. Installation of a 2.5 kW Wind Power Electricity Generation unit, an example of DEMR activity on RE at Sukabumi, West Java Province.

Figure 7.7. Wind Power electricity Generation, 80 kW system, at Nusa Penida, Bali built by DEMR (Source : http://daus.tral.la/2007/12/nusa-penida).

7.4. Hydro Power.

The potential of hydro power in Indonesia is 76.5 GW. The potency of large rivers have been utilized to generate electricity by PLN, the only state own company for electricity generation and distribution. Besides to large rivers, there are so many small streams available to be used to generate electricity using small or mini scale hydro-power electricity generation.

Micro-hydro electricity power is one of most popular RE in Indonesia. Researches and its implementation in this area have been carried out by many universities and research centers since many years. The availability of technology ease utilization of micro hydro power to support economic activities in rural areas.

The technology development including preparation of low head turbine, system control, improving system efficiency are R&D and Engineering programs supported by the government. It is expected around 500 MW will be put on grid and 330 MW off grid by 2025 [10].

7.5. Biodiesel and Bioethanol

Currently biodiesel and bioethanol has been produced by several producers as mentioned in previous chapter. Bio-diesel is already available in the market since 2006. It is available in petrol pumping stations. The development is also still continued by PERTAMINA, a state own oil company. Universities and research centers also conduct

research and development of bio-diesel using different raw materials. It is planned to produce 1.5 million kilo Liter (kL) at 2015, which is to 3 % of domestic diesel consumption, and 6.4 million kL in 2025 equal to 5% of the consumption [10].

In the national energy blue print 2025 [10] stated that the production of bio-ethanol is planned to supply 3 % and 5 % of domestic gasoline consumption in 2015 and 2025 respectively.

7.6. Biomass

Various form of biomass such as manure, agricultural waste, wood processing waste, algae, etc is predicted could contribute energy of 733 MW (See table 2.5) for national energy need. Currently, biomass energy is utilized at household for cooking and lighting, industry for heating, and to generate electricity. Biomass briquette and biogas are typical product derived from biomass in Indonesia. Universities, research centers, private companies and community contribute in developing the appropriate technology for utilizing biomass energy.

Utilization of various processes such as fermentation, gasification and combustion of various form of biomass are also increasing in attempting to replace function of fossil oil. Companies such as PT Siak Raya Timber in Pekan Baru, Riau Province, and PT Kurnia Musi Plywood in Palembang, South Sumatera Province utilized biomass in form of wood waste to generate roughly 5.5 MW electricity power utilizing cogeneration system [47].

Biogas become more and more popular to generate electricity in rural areas. Various types of digester and gasholder are used. Figure 7.8 and 7.9 shows example of biogas digester and gas collector utilized by community in rural area.

Figure 7.8. A fixed dome small scale biogas digester for a household uses introduced by Muhamadiah University, Malang, East Java Province, (Source : DEMR)

7.9. Effluent of cassava processing industry goes to biogas process.

7.10. An example of system of biogas to electricity utilized by community (Source : P2 Telimek LIPI, 2009).

Figure A : A biogas system at Minahasa district, North Sulawesi utilizing a mixture of weed and horse manure to generate electricity.

Figure B ; Digester and Weed

Figure C : A typical digester, for a company, PT. Asian Agri , in Jambi Province, to be utilize for electricity generation for local households.

Figure D : Modified Generator utilized for electricity generation utilizing biogas.

Figure E : Simple biogas collector to collect gas for electricity generation in rural area.

7.6 BIO-OIL

Bio-oil is liquid fuel produced from thermal degradation of ligno-cellulose materials. It contains hydrocarbon substances with characteristics similar to those in heavy fuel oil, so bio-oil could be utilized to replace function of heavy fuel oil. Indonesia produces abundant ligno-cellulose materials as waste from agricultural activities and municipal solid waste, and from wood processing industries. Hence currently number of research centers and universities conduct researches on production and utilization of Bio-Oil. Unfortunately, there is no bio-oil product available commercially yet.

7.7. Ocean

Utilization of tidal action and ocean wave is not yet realized. The total potential of this RE is not clearly predicted yet. Eventhough Indonesia has very long beach line, due to low speed of wind flow, so the waves at most of beaches are not as high as those in subtropic countries where wind flow is faster. The energy extracted from wave is difficult to be calculated. Its utilization for electricity generation is projected begin in 2025. It is projected Indonesia could gain 1.5 MW off grid and 5 MW on grid in 2025 [10].

CHAPTER VIII

Indigenously Developed RETs and Selected Case Studies on Dissemination/Utilization/Transfer of RETs.

8.1. Indigenously Developed RET

In this chapter the indigenous is defined as a product or technology bird from idea of domestic person of the nation. It includes the product of technology arise recently or at the ancient time. The ancient product or RET does not necessarily to produce energy resources, but the function of the product is needed renewable energy for operation.

In addition to various processes and technology to produce bio-diesel and bio-ethanol, and technology to utilize wind power, geothermal and solar energy as mentioned above, the following is few pictures of some product and technology considered as indigenously developed in Indonesia related to renewable energy.

A. Ancient Technology Rice Storages

In Indonesia, there are several types of traditional rice house/storage still be utilized by people in villages (see figures below). Principle of the rice storage is the storage should be located where wind flow freely, the floor should be at certain level above ground, and wall should be penetrated by wind flow. It usually constructed from bamboo, wood, and rice straw, coconut leave or other type of long plant leaf.

	It calls Rangkiang, the traditional storage technology to store rice for a long time and keep rice dry. (West Sumatra, traditional storage house)

 B	The other traditional technology for storage and to dry and keep rice after harvesting rice in Nusa Tenggara Barat (NTB). Many similar storage house are also available in Java and other island of Indonesia.

B. Traditional Wood / Agriculture Waste Stove.

Various types of wood stove are still utilize by community at their household, for cooking and for auxiliary heating purposes especially for people who live at mountain villages

	A type of sawdust stove technology utilizing wood waste or other biomass waste which is available in societies. [41]

C. Traditional Rice Milling.

In many villages located near river, the people utilize hydro power to run water wheel (***Kincir Air***) for rice milling. This technology are still available in many area of Sumatera. At certain villages, the system is also utilized for other purposes such as to bring water from lower level to a higher level of rice field. It is believed that this kind of water wheel could also be found in other Asian countries.

	A typical of a Rice Milling house utilizing a Water Wheel in Sumatera Island

D. Solar dryer

Various types of solar dryer, especially for drying of agricultural products utilize by community.

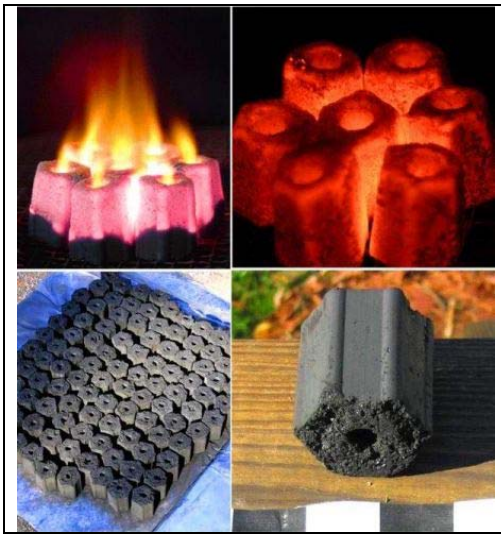
	A type solar dryer installed in Cimahi, West Java to dry cacao. • Dryer capacity: 175 pack of product/day (around 3500 kg / year), 5-6 hrs/day operation. Source : [20]

	A typical of adjustable dryer direction to track the sun position during the day. [20]

E. Briquette Technlogy.

Briquette is become more popular as fuel for household and industry due to increasing price of petroleum fuel. Currently, various type agriculture wastes such as coconut shell, wood waste and low rank coal are utilized as materials for briquette production.

Many small and medium scale private industries have successfully commercialized briquette. Some of the product is costumer-friendly used, and low emission. Several private companies also produce stoves for the briquette.

	A typical of coconut shell briquette.

	A type of Briquette Stove produced by a private company.

F. Electric Generator

	This is a cyclone incinerator to produce steam to generate electricity of 0.9 MW. The system can use wood, agricultural waste or low rank coal as raw fuel. The system is still under pilot studies and developed by RC for Physics – LIPI. (Source : P2 F – LIPI)

G. Micro hydro electric generating unit


8.2. Selected case studies on dissemination/utilization/transfer of RETs.

Non Commercially Technology Transfer.

Many designs of very simple and cheap biogas digester resulted from several universities and research institutes have been used by community to produce biogas from animal manure or organic waste for cooking activity and electricity generation. Recently, due to high price of fuels, there is an increasing trend of utilization of this appropriate technology by people in villages.

Several designs of micro hydro electric power generation have also been introduced by several public research institutes and universities in many villages of Indonesia. The plant scale are up to 50 kW per unit. The generation system has given benefit for the people in villages which are not reached by the PLN electricity distribution line.

Demonstration plant for hybrid (wind, fuel-cell, battery) electric power generation for 10 kW has been operated in Banten province. The demoplant is used for research and its product is distributed to near by houses. Several wind turbines at 80 kW each unit developed by DEMR have also been operated in several provinces of Indonesia.

Renewable Energy Related Product Successfully Commercialized.

Bio-diesel

Biodiesel derived from crude jatropha curcas oil has been produced commercially since 2006. Eventhough the portion of biodiesel is still small, compared to total fossil fuel oil used for vehicles, but it is planned to increase significantly as the increasing price of petroleum oil recently. Currently, PT PERTAMINA (the Oil and Gas State Owned Company) pumping stations are selling bio-diesel fuel which contain mixture of 5 % renewable oil (FAME) and 95 % diesel oil.

In addition to PT. PERTAMINA, Bio-diesel has also been produced by MEDCO, and other Members of APROBI as listed in chapter II.

Solar Cell and Module.

Solar cell module for housing water heating system produced by several private companies have also been commercialized. Besides the heating system, solar cell lighting for households at rural areas have also been produced supported by government budget.

Solar Cell Related Products such as Solar cell Module, LED Solar Street Lighting, Water Heater System are produced by PT.WIKA, PT Azet Surya Lestari, PT Sundaya.

Wind Turbine.

Wind Turbine up to 100 kW has been produced by PT. PINDAD under licensing foreign technology. (Source : a Discussion at P2 Telimek LIPI, 2009).

8.3. Indigenous Technology Patented and Patent Filling.

In the period of preparation of this report, the authors could only collect indigenous technologies in patent documents proposed by LIPI. Some of patent were granted and the other are filling and under substance examinations.

Bio-fuels.

There are two patents related to bio-fuels, those are a simple patent for an equipment for jatropha seed peeling and a patent concerning a continues process for plant oil processing to produce bio-diesel.

Fuel cell.

There is a patent related to fuel cell technology i.e. a patent for preparing a polystyrene membrane material for fuel cell.

Wind Power

A patent regarding to small scale runner turbine has been filed, and now under examination.

Micro Hydro Power and Biomass.

A simple patent on 'Hidram Pump' to increase water from low to a higher area, and a patent regarding to a rice dryer utilizing renewable energy have also been filed.

CHAPTER IX

Barriers faced in transferring RETs.

Beside the advantages of abundant availability of resources such as biomass, solar power, hydro, geothermal, and many public and private institutions, universities and industries involved in RD&P of renewable energy, and the government support for utilization RET and renewable resources , Indonesia is still facing barriers in transferring and developing RET. The barriers are describes as follows.

9.1. Dependency on the fossil oil.

Indonesian community are aware about the important of reducing of consumption of petroleum oil as the government has reduced the amount of subsidy several time in last four years. The dependency on the subsidized oil is large.

Since early 1990, research activities to find alternative on energy resources especially to replace the fuel oil has been conducted by universities and R&D institution. Unfortunately as the price of the fuel oil in Indonesia was low due to government subsidy, it was difficult to find alternative sources which could compete with the subsidized fuel oil. . In 2007 the government provided the subsidy for fuels derived from crude oil as much as Rp 68.6 trillion (equivalent to US $ 7.6 billions, with exchange rate Rp 9000 = US $ [5]. To reduce the amount of the subsidy, in June 2008, government increased the price of fuel oil from Rp 4500/L to Rp 6000 / L for gasoline, and from Rp 4000 to Rp 5500/L for diesel oil. In late 2008, the price of gasoline was reduce again to Rp 4500/L following to reduction of global fuel oil price.

It is realize that it is not an easy task to change the community's habit because they have had very long experience with the energy subsidy. Introducing RET could mean that they have to change the way of their live. The government launched programs focused to reduce the dependency. Several pilot projects have been set up to encourage people to use RE, but it is believed that Indonesia still need few years time to successfully change the people habit.

9.2. Policy Barrier.

The subsidize policy has caused movement of development and diversification program on energy alternative in Indonesia developed at a very limited pace. The high price of the fuel oil in last few years, combined with decreasing petroleum oil sources, have created a big energy challenge for Indonesia. All of these are triggering energy policy, development program and researches related on renewable energy become primary interest of policy makers, investor and research scientists.

It is realized that the government of Indonesia could not eliminate the energy subsidy in a short time because it would give big impact to the unfortunate people in the country, especially to the economic of most rural areas. In order to drive diversification of energy sources and promotion of renewable energy, government encourages public-private

partnership in order to promote RET utilization, however government incentives to support private company to adopt locally produced technology are limited.

9.3. Technological Barriers

As mentioned above that most of the researches on renewable energy are conducted by government research institutions or in public universities. So that most of the results are publicly funded technologies. Most of the publicly funded technologies on energy are still on lab scale or pilot scale stages. Some of them that has been utilized commercially or utilized by community. There are results on energy which have been utilized commercially or by community since few years ago such as solar water heater, or solar cell electricity generation and bio-diesel fuel. Unfortunately the technology especially for production of solar cell itself is imported, it is not indigenous technology, despite Indonesia has abundance of raw materials for solar cell.

In order to implement technology resulted from the R&D institutions and universities, barriers have been encountered one of them is a weak link between RD Institutions and Industry.

Lack of local technologies which have been proved commercial viability cause a low attention of industry to make use of RET resulted by local R&D institutions or universities. Demonstration of commercially successful implementation of R&D results is needed to promote RET.

Need lot of investment to conduct pilot and market test of a research result, while government research budget is limited. Currently the government encourages private firm to make investment in R&D or to make research collaboration between R&D institutions and a firm.

CHAPTER X

Strategies and future development of renewable energy.

Thinking about the country circumstances and observing the regulation and other policies instruments established by the government, it could be understood strategies taken by the government to face the barriers.

Poverty is the most difficult problem to be solved in Indonesia. Various information concerning number of poverty were published by different parties. The government published that around 35 millions people (15 %) in the country are still life as 'poor people', while other mentioned that the number is much greater that is 30 %. For those who said as poor people, the government arranges supportive programs, give subsidy such as gas subsidy, fuel oil subsidy. The fuel oil subsidy is actually targeted to this community. Unfortunately, the government can not control distribution of the fuel. Many of untargeted also use the oil subsidy. This situation has occurred since many years.

To facilitate community development and to provide better education standard, commencing year 2009 the government allocates 20 % of the national development budget for education budget. By increasing the national education budget, it could be expected a better education facilities and standard in the country. Better education hopefully would give a better job opportunities, and finally would increase living standard of community, especially for the unfortunate.

To speed up enhancement of certain community capability, especially for unfortunate people, for people who live in remote area, who live at isolated location such as small island, etc the government introduced special programs. Poverty alleviation become main priority of the government programs. One of the program is PNPM, *Program Nasional Pemberdayaan Masyarakat Mandiri*, National Program on Community Empowerment. This program is aimed to support and enhance the community by various means such as training, workshop, provide certain amount of budget for capital, etc. One of activities is to promote of available renewable energy utilization in rural and remote areas. *Desa Energi Mandiri* is part of the program.

When the program is successful, at least two positive impacts could be gained by the country specifically reducing the dependency of people to the subsidy and increasing awareness of advantages of renewable energy utilization.

Various of government incentives as mentioned in previous chapter are government approaches believed would give positive impact toward increasing utilization of renewable energy and reducing dependency to the fuel oil.

In order to increase utilization of locally produced renewable energy technology, some approaches are taken by parties.

The objective of the S&T energy program is the creation and utilization of RE to support the policy of energy conservation and diversification, to optimally utilize RE resources, revitalization of institutions and networks, and to encourage innovative energy technology creation based on national resources. The government through MRT stated that the priority research and development programs is to increase contribution of geothermal energy and other RE, coal and gas by 2025 [15]. The RE research programs directed to find green and renewable energy based on local resources are strongly supported by the government.

In the next 5 years National Development Program of 2010-2014 [42] is stated that the energy development program is one of the government priority. In the energy program, in addition to fossil fuel resources, development renewable energy become part of the program. To carry on the national priority on energy development program, several related Ministries included Ministry of Research and Technology, Department of energy and Mineral resources have to specify their work programs in the area of renewable energy development.

Information dissemination, included renewable energy related information, has become interest of local governments since few years ago. Warung Informasi Teknologi (Warintek) and Warung Internet (Warnet), a kind of information and internet kiosk, could be found at many towns in the country. Some of them are supported by local government, and some are private businesses. People could access information and internet through these kiosks. R&D organizations, especially LIPI and many universities utilize this kiosk to distribute R&D results to people, industry and student.

In 2008, Ministry of Research and Technology set up BIC, Business Information Center. The center is focused to market technologies resulted by universities and R&D organization. Through these activities, and enhanced by government incentives as mentioned in chapter V, it is expected to flow information to industries and to bridge relationship among universities, R&D organizations and industries in order to increase utilization of local technology including RET.

CHAPTER XI

CONCLUSIONS

The government of Republic of Indonesia set energy diversification and energy development program as one of priorities in the long term and in the next five years national development programs. This policy reveals that the government intended to reduce the dependency of national energy on non-renewable resources especially fossil oil, and correspondingly push utilization of available renewable energy resources.

Indonesia now has a supportive frame work of energy policies and also an institutional mechanism coordinated by the National Energy Council supported by related organizations to augment the development and promotion of renewable energy. Combining participation of public and private organizations, NGO and industry with the proper energy policies, it is expected could overcome the barriers facing in development and utilization of renewable energy.

In future S&T program, the development of energy has become one of the six priority research areas. In next five years national development program, energy is one of the eleven national priorities. The researches on energy are supported by government especially to find alternative and clean energy resources, and also to reduce the effect of industry and community activities which finally cause global warming. R&D related to RE in Indonesia conducts by several R&D institutions and universities, and most of the RET produced are still in infant technology, whether in pilot scale or in demonstration-plant type. A wide area of RE related research activities indicated that the programs need to be focused on selected and most favorable RE sources.

Solar energy, especially direct utilization of solar energy to produces steam and hence electricity (known as concentrated solar power, CSP), is not much touched yet by R&D institutions and universities in Indonesia nor in most countries in the region. Considering most Asian countries, especially ASEAN countries are located at or near equator, they receives abundant solar energy, despite a lot of cloud. Collaborative program on this topic is important, as it would help countries in this region with the purpose to reduce dependency on fossil fuel for electricity generation, and also to reduce air pollution and reduce impact of community activities to the global warming. In addition, collaboration and exchange of information and experience on wind power for electric power generation is believed would give benefit for the people in the region especially for the community who live in small islands.

The policy of the government of Republic of Indonesia is to participate and support in development and enhancement of regional cooperation for example the south-south cooperation. In December 2007, Indonesia and UNIDO signed an MoU for a study to set up a UNIDO Regional Center for South-South Industrial Cooperation (RCSSIC) in Indonesia. The RCSSIC is aimed to enhance south-south industry collaboration especially for agro based

industry. The action indicated a strong support of the government to participate in cooperation among the nations in the region. Participation of Indonesia in ASEAN Energy Office Jakarta also indicates that Indonesia supports collaboration among the nations in the region on energy development.

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