LOCALLY BASED ENERGY DEVELOPMENT
INCREASING ENERGY ACCESSIBILITY IN RURAL AREA THROUGH DECENTRALIZED ENERGY SYSTEM BASED ON RENEWABLE ENERGY
(Indonesian Case)

THESIS

A thesis submitted in partial fulfillment of the requirements for
the Master Degree from University of Groningen and
the Master Degree from Institute of Technology Bandung

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DOUBLE MASTER DEGREE PROGRAMME

DEVELOPMENT PLANNING AND INFRASTRUCTURE MANAGEMENT
SCHOOL OF ARCHITECTURE, PLANNING AND POLICY DEVELOPMENT
INSTITUT TEKNOLOGI BANDUNG

AND

ENVIRONMENTAL AND INFRASTRUCTURE PLANNING
FACULTY OF SPATIAL SCIENCE
UNIVERSITY OF GRONINGEN

2007

ACKNOWLEDGMENT

This thesis is the final part of my master study in Environmental and Infrastructure Planning, Faculty of Spatial Science, Rijks*universiteit* Groningen (R*u*G) and Development Planning and Infrastructure Management, School of Architecture, Planning and Policy Development, Institute of Technology Bandung (ITB).

First of all, I would like to express my greatest gratitude to Allah SWT, to been able to finish my study in the Netherlands and complete my thesis right on the time. Then I would like to address my sincere thanks to Mr. Ferry van Kann, MSc for providing me guidance, critics, support and supervision in writing my thesis and enhancing my horizon on how planner should be thought. I would also like to thanks to Bapak Dr. Ir. Uton Rustan Harun, MSc., who gives me some suggestions and critics to improve my thesis. Many thanks are devoted to Directorate New-Renewable Energy and Energy Conservation, DGEEU, that give me opportunity to continue my study, the Netherlands Government and Indonesian Government for giving me a scholarship through STUNED Program and Pusbindiklatren, Bappenas. My appreciation also goes to all my lecturers and faculty members of R*u*G, SAPPK ITB, and UPT Bahasa ITB, all my classmates, and all Indonesian students in Groningen. My thankfulness also address to my parents-in-law, who have done my responsibility to take care my children during my study, my sister, my brothers and all my family in Indonesia who always give me spirit to finish this study. Furthermore, this thesis is dedicated to my late beloved parents who always encouraged me to continue my study during their life. Finally, I would like to express my deepest gratitude to my beloved husband, Arif Rahmanto and my sweethearts Raisa and Haikal for your great support and patience during my study in Groningen.

Groningen, August 2007

Andriah Feby Misna

ABSTRACT

Energy plays an important role in achieving sustainable development. Almost all activities need energy. Unfortunately energy accessibility in rural areas, particularly in developing countries is still low, included in Indonesia. Rural electrification program -connecting rural areas to national grid- as an effort to increase energy accessibility in rural areas has been done since few decades. However, due to geographical and topographical condition most of rural and remote areas in Indonesia can not be reached by national grid. Around 47% of rural households in Indonesia have not been electrified yet. Locally based energy development through decentralized energy system based on renewable energy technologies, among others solar, biomass, wind, micro hydro, and geothermal energy, is promising to fulfill low energy demand in rural/remote areas. Unfortunately the result of this effort is still not significant. In the past rural electrification was conducted by top-down approach which emphasizes more on technical rationality. This approach showed many failures in promoting locally based energy development, because generalization approach can not encounter the complex issues in rural areas. Energy service is expected not only to increase energy accessibility in rural areas, but also should associate with sustainable development - social, economic and environmental dimensions. Therefore rural energy planning becomes more complex and planning approach might be shift from technical to communicative approach which is emphasized on process oriented by involving many actors in formulating plan. This approach is expected can grasp the real problem in grass root level by increasing the role of local government and community in planning process. This research explores the key success factors of developing local energy resources in rural/remote areas, actors involved in developing local energy resources and how rural communities are involved in developing local energy resources. The research shows that decentralized energy planning, integrated energy planning to other development sectors and community participation are the key success factors of decentralized energy system based on renewable energy.

Key words: *community participation, decentralized energy system, local energy resources, renewable energy, rural/remote area* and *sustainable development.*

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Abbreviations

ADB	Asian Development Bank
AIJ	Activity Implemented Jointly
APBN	Anggaran Pendapatan Belanja Negara (National Development Budget)
BAKOREN	Badan Koordinasi Energi Nasional – National Energy Coordination Agency
BAPPENAS	Badan Perencana Pembangunan Nasional (Bappenas)
BPPT	Badan Pengkajian dan Penerapan Teknologi – Agency for the Assessment and Application of Technology
CO2	Carbon Dioxide
DES	Decentralized Energy System
DGEEU	Directorate General of Electricity and Energy Utilization
DJLPE	Direktorat Jenderal Listrik dan Pemanfaat Energy, DGEEU
DSM	Demand Side Management
FAO	Food and Agricultural Organiation
GEF	Global Environment Facility
GEF/SGP	Global Environment Facility / Small Grant Programme
GHG	Greenhouse Gas
GOI	Government of Indonesia
GTZ	Deutsche Geselschaft fur Technische Zusammenarbeit (German Agency for Technical Cooperation)
IBEKA	Institut Bisnis dan Ekonomi Kerakyatan (People Centered Business and Economic Institute)
IDR	Indonesian Rupiah
IEA	International Energy Agency
IMIDAP	Integrated Microhydro Development and Application Program
ITB	Institut Teknologi Bandung (Bandung Institute of Technology)
JICA	Japan International Cooperation Agency
KEN	Kebijakan Energy Nasional (National Energy Policy)
KUBE	Kebijakan Umum Bidang Energi (General Guidelines on Energy Policy)
KW	Kilowatt
kWh	Kilowatt hour
LAPAN	Lembaga Antariksa dan Penerbangan Nasional (Indonesian National Institute of Aeronautic and Space)
LIPI	Lembaga Ilmu Pengetahuan Indonesia (Research Indonesia Institute of Sciences)
MEMR	Ministry of Energy and Mineral Resources
MHPP	Micro Hydro Power Plant
MH	Micro Hydro
NGO(s)	Non-Government Organization(s)
NTT	Nusa Tenggara Timur

O&M	Operation and Maintenance
PLD	Pengelola Listrik Desa (Village Electricity Management Unit)
PLN	Perusahaan Listrik Negara (State-Owned Electric Company)
PPLH	Pusat Pendidikan Lingkungan Hidup (Environmental Education Center)
PSK TERSEBAR	Pembangkit Skala Kecil Tersebar (Small Distributed Generation)
PUSKESMAS	Pusat Kesehatan Masyarakat (Community Health Center)
PV	Photo-voltaic
RE	Renewable Energy
REP	Rural Energy Planing
RES	Renewable Energy Sources
RET(s)	Renewable Energy Technology(ies)
RMU	Rice Milling Unit
RUKD	Rencana Umum Ketenagalistrikan Daerah (Local Electricity Master Plan)
RUKN	Rencana Umum Ketenagalistrikan Nasional (National Electricity Master Plan)
SGP	Small Grants Project
SMOC/SME	State Ministry of Cooperative, and Small and Medium Enterprises
SSM	Supply Side Management
UNDP	United Nation Development Program
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WB	World Bank
WEC	World Energy Council
YBUL	Yayasan Bina Usaha Lingkungan (Foundation for Environmental Development)

List of Energy Units

BOE	Barrel of Oil Equivalent
GW	Giga watt, 10^6 kilo watt
KW	Kilo watt
kWh	Kilo watt hour
MW	Mega watt, 1000 kilo watt
MJ	Mega joule, 1000 kilo joule
TSCF	Trillion Standard Cubic Feet

CHAPTER 1
INTRODUCTION

This chapter describes the beginning idea of the whole research. It consists of background, objective, methodology, structure and limitation of research. Firstly, the background depicts the idea behind doing the research in this particular topic. After that the objective describes the purpose of the research, elaborate the research question and the scope of the research. Later on research process and procedure are illustrated in research methodology. Then, the structure of research is expressed briefly and in the last part of this chapter, the limitation of research is revealed.

1.1 Background

Energy plays an important role in socio-economic development both in urban and rural areas. Increasing economic growth and people's living standard directly or indirectly associates with increasing energy utilization. Currently, fossil fuel particularly oil still plays an important role in energy supply and demand. However, increasing energy utilization, notably fossil fuel-based energy consumption has a big contribution on environmental degradation both locally and globally. Serious attention to decrease high dependency on oil has been done since the first oil crises of the late 1970s. Furthermore, increasing awareness on environmental issue in the late of 1990s also has encouraged the effort to switch from fossil fuel-based energy to cleaner energy (renewable energy). Nowadays, energy becomes a big issue in sustainable development due to this intertwine with social, economic and environmental aspects.

Even energy is essential for socio-economic development, many rural areas in developing countries including Indonesia have no accessibility to modern energy, particularly electricity. Lack of access to modern energy services results in rural areas is left behind with several problems such as undeveloped area and poverty (Barness, et al,1997).

Rural electrification program is an effort to increase energy accessibility in rural areas. This program has typically concentrated on connecting rural areas to a national grid (on-grid system) often owned and operated by the public utility. However, not all of areas technically and economically are reliable to reach by grid connection. Most of rural areas in developing countries are located in remote areas which are far away from the established electricity network, such as in small islands or in mountain areas which are difficult technically to reach by national grid. Furthermore, low demand and unevenly distributed population in rural/remote areas are also the main factors caused on-grid system is not feasible economically for electricity provision in rural areas. These conditions result in high investment cost for providing electricity through on-grid system. As stated by Barnes et. al (1997) "a*lthough grid electrification is a traditional means of providing reliable electricity supply, connection to distant grid with low demand will be too expensive to be cost effective for many rural area".*

Decentralized energy (off-grid) system is considered to be more reliable to meet low demand energy needs in rural areas and distance from national grid. Renewable energy as local energy

resources, among others solar photovoltaic, biomass, micro-hydro power plant, wind power, geothermal, etc. can be utilized to encounter lack of energy accessibility in rural areas through decentralized energy system. Some researches (Barness et al, 1997, Reddy et. al, 2006) showed that decentralized energy system based on renewable energy technologies can change life of rural people and offer new possibilities for economic and social development, education, political participation and also environment. It can create some productive activities which can improve quality of life of rural people. In addition, renewable energy technologies also can reduce environmental degradation due to low CO_2 emission produced by utilizing renewable energy resources compared to fossil fuel.

Some pilot and demonstration projects of decentralized energy system have been established in rural electrification program. Some successes and failures of the projects have been reported. Not all of project can sustain for a long time. Some reasons such as technically failure due to inappropriate technology to rural condition, lack of transfer knowledge, and lack of rural participation in planning process have been encountered. Nowadays, rural electrification program not only considers that the implemented technologies are feasible to apply in rural areas but also the technologies should be socially acceptable, economically feasible and environmentally sustainable.

Indonesia as one of developing countries faces the same problem as other developing countries in rural electrification program. Most of rural areas in Indonesia, technically (located in remote areas) and economically (limited budget for providing infrastructure), have not been electrified yet. In the past central government plays an important role in rural electrification program through public utility (State-Owned Electric Company-PLN). Due to economic crisis in 1997 and the shifting administration system from centralized to decentralized system in 1999, currently; rural electrification program is not only central government responsibility but also local government and community.

According to available data from Directorate General of Electricity and Energy Utilization (DGEEU, 2006) rural electrification ratio[1] at the end of 2005 was 80.9% in which 53,128 villages has been electrified from total 65,673 villages; however, electrification ratio[2] was still around 53%. It means that 47% of Indonesian households have not been electrified. To achieve electrification ratio of 90% by the year 2020 (MEMR, 2004), the Government has promoted the utilization of local energy resources which emphasizes on renewable energy technologies. A decentralized energy system based on renewable energy is expected can meet basic needs of energy particularly electricity in rural areas.

Planning is considered as an important part of development. Due to the changes in our society, planning theories and practices have evolved from technical (command and control) approach to a more communicative (participative and collaborative) approach (Healey, 1997). Top-down approach has no longer succeeded to solve the complex issues in rural electrification

[1] Rural electrification is the comparison of the electrified villages to the total villages. The village is categorized as an electrified village if at least 10% of households in this village have been electrified.
[2] Electrification ratio is the comparison of the electrified households to the total households.

particularly in achieving sustainable development. In addition, top-down approach also showed some failures in developing local energy resources based on renewable energy in rural areas because of the weaknesses of policymakers/planners to catch the real problem in rural areas (Neudoerffer, et. al, 2001). Involving community participation in planning process from the beginning until the end of the project is crucial, because they have the good insights into rural needs and priorities. Bottom-up approach shows a good promise of achieving the successful of decentralized energy system in rural areas (see Malhotra, et al, 2004).

1.2 Research Objective

The objective of this research is to understand locally based energy development through decentralized energy system (DES) based on renewable energy (RE) by exploring key success factors of DES based on RE in rural area particularly in Indonesia and the role of community participation as a planning approach for sustainability of decentralized energy system. Local energy resources particularly renewable energy can be as an alternative to increase energy accessibility in rural/remote area.

This research is developed based on three research questions:

1. *What are the key factors to encourage the success of developing local energy resources through decentralized energy system based on renewable energy and why do those factors become important.*
   Many factors can be as a driven even an obstacle of developing local energy resources. This research will assess what are the main factors that play an important role in encouraging local energy resources through DES based on renewable energy sources.

2. *Who are involved in developing local energy resources and what is the role of each actor.*
   Many actors might be involved in developing local energy resources. Each of them will have their own role. This research will explore the role of each actor and how they involve in rural energy planning.

3. *How rural communities are involved to develop local energy resources*
   Rural community is an important actor in developing local energy resources. They know more about their region. This research will elaborate how rural communities are involved in rural energy planning and how to empowered them to become self sufficient on developing their local sources for meet their own needs.

This research focuses on electricity provision in rural/remote areas through decentralized energy system based on renewable energy technologies. The term of "rural/remote" has many different definitions. In this research, the term of "rural/remote" has been considered as areas which electricity supply by national grid is not feasible either technically or economically. In addition, the term of local energy resources refers to renewable energy.

Furthermore, there are many factors associated with the successful of developing renewable energy in rural areas. This research emphasizes on planning approach particularly participatory

approach to encourage electricity provision based on renewable energy in rural areas is not only economic feasible, but also socially acceptable.

1.3 Research Methodology

This research is more emphasize on public policy analysis rather than engineering analysis. Therefore, the analysis is done by exploring the phenomena in planning practice and the gap to theoretical framework rather than statistical point of view. Data collection and analysis are described as follows.

Data collection

Data and information which is used in this research is based on secondary data. Data and information sources are found from the library, internet and official institution. The data and information needed for this research can be divided in 2 categories. The first is data and information that needs to build theoretical framework of locally based energy development and planning approach. The sources come from study of literature (books, theses, academic journals, articles, etc.). Previous researches related to locally based energy development and policy on developing local energy resources are explored as well.

The second is data and information related to empirical case of locally based energy development in Indonesia. Data and information is gathered from policy documents, project assessments related to renewable energy utilization and rural electrification program in Indonesia, academic journals, and articles. Furthermore, the data and information for case studies (Oeledo Village and Seloliman Village) are also collected from progress report of renewable energy project in Indonesia conducting by foreign agencies. For instances the project of Oeledo Hybrid system conducting by E7 and Kalimaron MHPP conducting by GTZ. Some information related to improving rural communities' living standards in the location of case studies are gathered from online news paper. In addition, those case studies are selected to show that different locations will have difference resources which need different approach.

Analysis Method

The research is organized by using qualitative method based on literature review. The research starts with identifying the problem in rural electrification. Some literatures are reviewed to build the theoretical framework to understand locally based energy development -decentralized energy system based on renewable energy- as an alternative to increase energy accessibility, particularly electricity, in rural areas. Based on theoretical framework for locally based energy development, planning approach is explored to find a good approach which associate with the rural electrification goals.

Furthermore, the research reviews some policies, regulation, project assessment, and progress report related to rural electrification in Indonesia as an empirical case. The trend of rural electrification program in the past is elaborated. This research presents two different case studies as a reflection of theoretical framework, micro hydro power plant in Seloliman Village, East Java Province and hybrid system (combination of solar photovoltaic, wind turbine and

diesel generator as back-up) in Oeledo Village, East Nusa Tenggara Province. Both of these case studies have been success in providing electricity through decentralized energy system based on RE and improving social-economic condition of communities in those rural areas. The case studies show that the different location will have different local energy resources and need different approach to develop local energy resources. These cases also show that the role of community participation is important for sustainability of DES based on RE.

Next, to answer the research questions, analysis of planning approach was conducted with the help of literature review, theoretical framework and empirical case. Personal experience as a staff of Directorate of New-Renewable Energy and Energy Conservation in Ministry of Energy and Mineral Resource of Indonesia also has been used in conducting this research. The planning approach for rural electrification in the past was elaborated. The failure of the old planning approach results in necessary to switch to communicative approach which more appropriate to deal with the complex issue in rural areas. The factors that support communicative approach are discussed to find a good approach for the future development of decentralized energy system based on renewable energy.

Finally, based on theoretical framework, empirical case, and analysis, the research is completed with the conclusion and some recommendations which can make decentralized energy system based on renewable energy more acceptable, feasible and sustainable for the future. Research Framework is presented in Figure 1.1.

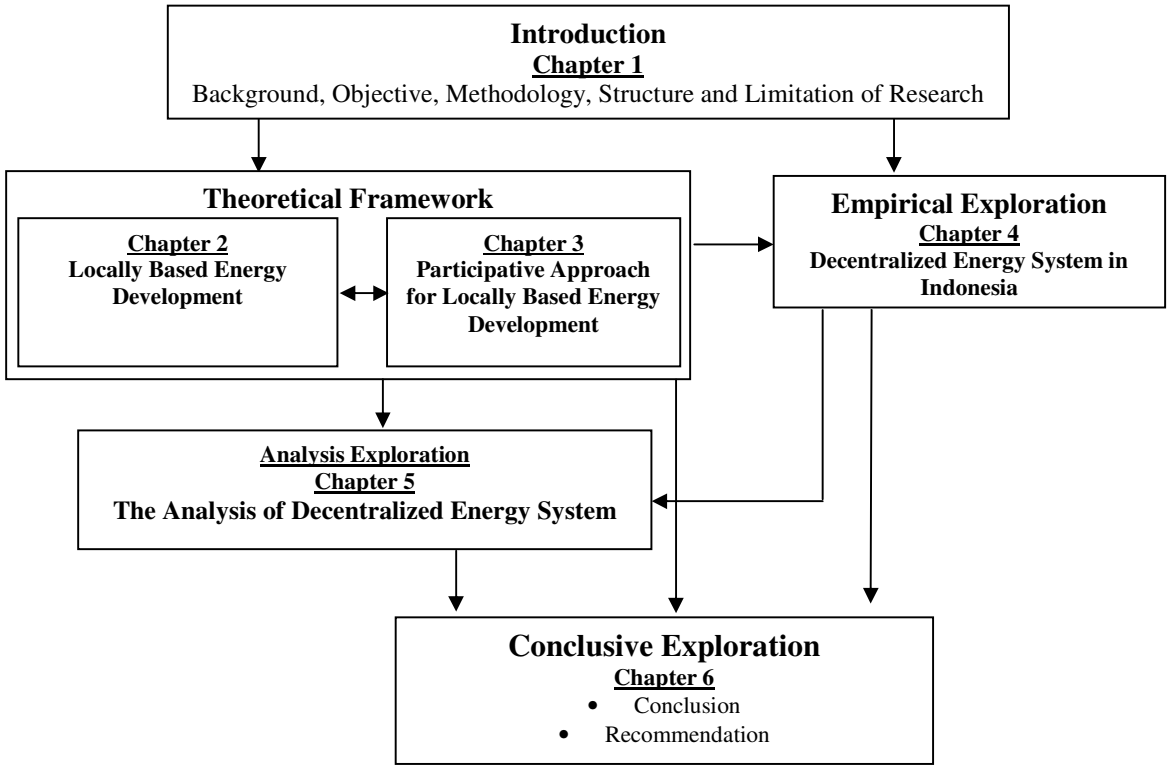


Figure 1.1. Research Framework

1.4. Structure of Research

The research consists of five parts arranged in 6 chapters. First part is introduction consisting one chapter. **Chapter 1** elaborates the background, objective, methodology, structure and limitation of research. The second part is theoretical framework consisting of two chapters; **Chapter 2** explores the basic principal of energy and sustainable development, renewable energy and sustainable, rural electrification, and decentralized energy system based on renewable energy for rural electrification program; and **Chapter 3** explores the participative approach as a planning approach to associates with the complex issues in rural electrification program. The third part is empirical exploration (Indonesian case) consist of one chapter (**Chapter 4**). This chapter elaborates renewable energy development in Indonesia, rural electrification, decentralized energy system and two success stories of decentralized energy system based on RET's. The fourth part is analysis of the DES implementation in Indonesia consist of one chapter (**Chapter 5**). Based on theoretical framework and empirical case the research discusses decentralized energy system based on renewable energy related to goal of rural electrification, planning approach, institution mechanism, participative approach and the constraints and strategies for increasing the implementation of DES based on RE in the future. Finally, Chapter **6** provides conclusion and some recommendations to encourage the re implementation of decentralized energy system based on renewable energy technologies.

1.5 Limitation of the Research

Although this research can reveal some conclusions and recommendation on increasing energy accessibility in rural areas through decentralized energy system based on renewable energy, it has many limitations. One of the limitations is that the research only uses secondary data and literature review. It means that, this research only explores general aspect of DES based on RE in rural area, particularly in Indonesia. The research faces the difficulties to find published information related to rural energy development in Indonesia. Based on this condition, it would be better to do further research by collecting primary data, such as survey or interview with the main actors to find the comprehensive information what are the key success factors to implement DES based on RE.

Chapter 2 will discuss the challenge of local energy resources based on renewable energy as an alternative for rural electrification in point of view sustainable development.

CHAPTER 2
LOCALLY BASED ENERGY DEVELOPMENT FOR RURAL ELECTRIFICATION

This chapter build theoretical framework of developing local energy resources as an alternative for rural electrification in order to achieve sustainable development. It consists of five parts. The first part describes the relation of energy and sustainable development, element of sustainable development and energy resources. The second part elaborates renewable energy as local energy resources and sustainable development, renewable energy technology, and constraints in renewable energy development. The third part depicts rural electrification program. The fourth part describes decentralized energy system and the last part explores policies and institutional mechanism of rural electrification.

2.1. Energy and Sustainable Development

Energy has a significant role to achieve sustainable development and poverty reduction efforts. It affects all aspects of development -social, economic, and environmental- including for instances, livelihood, access to water, agricultural productivity, health, education, transportation and gender-related issues. Unfortunately, most current energy supply and use are unsustainable. During the past two decades the risk and reality of environmental degradation due to several combination factors such as increasing world population, energy production and distribution, and industrial activities have become more apparent. Problems with energy supply and use are not only associated with global warming but also related to air pollution, acid rain, forest devastation, and emission of radioactive substance (Dincer, 2000).

The concept of sustainability is pioneered by environmentalists who want to make balancing between development and ecological system. There are many definition of sustainable development, one is *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland Report, 1987). This research will use that definition related to sustainable development. The next part will discuss the elements of sustainable development which are related to this research.

Elements of Sustainable Development

There are three main pillars in sustainable development -economic, social and environmental sustainability. Concerning to energy development, Dincer and Rosen (2005) introduced energy and resources sustainability as addition pillar in sustainable development besides economic, social and environmental sustainability as presented in Figure 2.1.

This figure shows the interdependences among the elements of sustainable development. Discussion on sustainable development should consider energy and resource sustainability because energy and resource sustainability have a big implication on other elements. Energy in affordable price and stable supply is a main requirement for social and economics

development. Moreover, energy is also essential for human welfare and quality of life. Unfortunately, energy production and consumption can generate some environmental problems that can have serious implications for the lasting of our planet's ecosystem. Therefore, sustainable development should take into account energy and resources sustainability, besides social, economic and environmental sustainability (Dincer and Rosen, 2005).

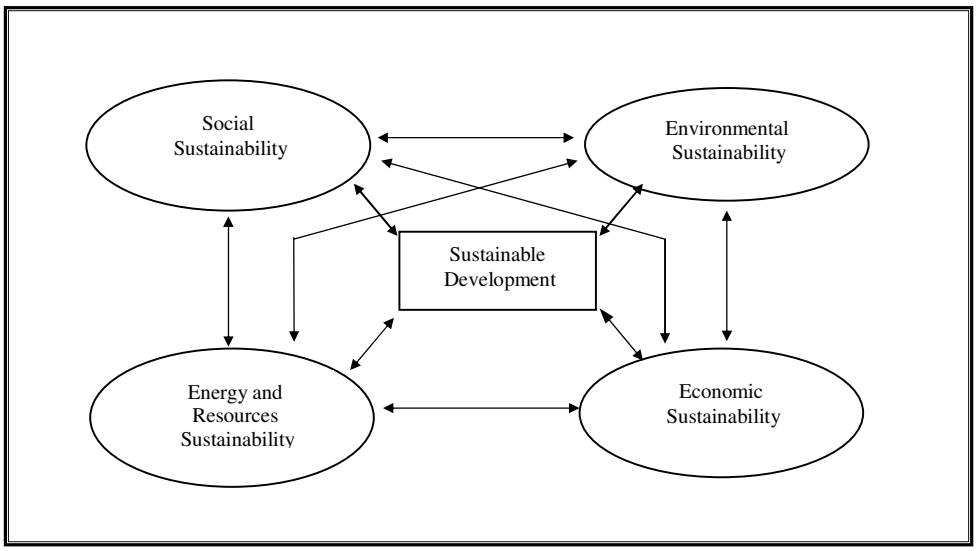


Fig. 2.1 Factor Affecting sustainable development and their interdependences (*Sources: Dincer and Rosen, 2005*)

The use of fossil fuel can accelerate social and economic development but has negative implications to environment, such as acid rain and global climate change. Moreover, fossil fuel is non-renewable energy which can be exhausted immediately if the exploitation is unwisely. It means that the future generation needs on energy are ignored if alternative energy for the future which is environmentally friendly and renewable are not considered. It is clear why energy and resources sustainability is also an important consideration for sustainable development, because all activities related to social and economic development need energy. Without energy the development is non sense. However, what kind of energy will be used that is appropriate for sustainable development is also questioned. Fossil fuel is not sustainable for environmental aspect and resources sustainability. At this point, it is clear why renewable energy can be as an alternative for achieving sustainable development because renewable energy is environmentally friendly and sustainabl. Before discussing renewable energy and sustainable development in the next section, the type of energy base on the resources will be elaborated first.

Energy Resources

In general, there are two main categories of energy based on the resources. The first is fossil-based energy such as oil, gas and coal, which is unsustainable and cannot be renewed. Fossil fuel can be exhausted and the reserves are limited. It takes million years for forming process of fossil fuel. In addition, the utilization of fossil fuel can eradicate environmental quality because

of green house gases (GHG) produced from the burning of that energy. High dependency on fossil fuel can be a big problem for future generation, due to the exhaustible of the resources and the negative impacts on the ecosystem.

Another category is non fossil-based energy (renewable energy), among others solar energy, wind energy, hydropower, tidal, wave energy, geothermal, and biomass which is sustainable and can be renewed. Renewable energy is environmentally friendly. Most of renewable energy resources is zero emission, even those resources emit pollution, such as biomass energy, the amount is much less than fossil fuel is (ADB, 2003). In this research the term of renewable energy refers to non fossil-based energy and non renewable energy refers to fossil-based energy. The diagram of energy categories based on the resources is presented in Figure 2.2.

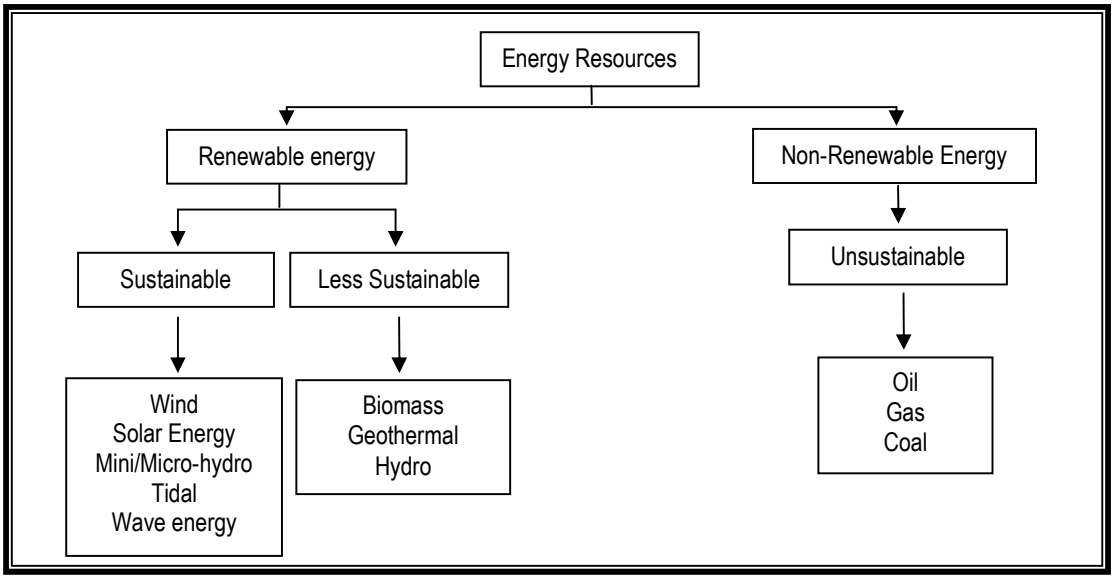


Figure 2.2 Energy categories based on the resources

Although renewable energy can be renewed and are sustainable, some researchers argue that biomass, geothermal and hydro power plants in large scale are less sustainable. Biomass utilization, notably intensive energy crops will directly compete with food production in land and water use particularly (Burkhardt, 2002). While Ling (2006) argued that without rational reforestation, intensive energy farm will cause soil erosion, decrease soil quality due to using of pesticide and herbicide. Ling (2006) also emphasized that biomass power plant in large scale without advance pollutant treatment will emit large quantity of air pollutant.

In addition, intensive energy farm particularly in large scale has implication for land use due to possibility of land conversion from forest to energy farming. Biomass based on energy crop is not feasible for the small countries which have limited land. However, for the big countries such as India, China and Indonesia which have more undeveloped marginal land, energy crops can be as an alternative for future energy resources. To avoid the conflict with food crops, land use planning should be formulated as well.

Similar to intensive energy crops, the exploitation of hydro and geothermal in large scale also appear less sustainable. They can fragment the nature and remove communities to the other place which can emerge some conflicts.

Increasing fossil-based energy consumption contributes significantly to environmental problems both locally and globally such as air pollution, acid rain and global warming. Under the current conditions, it can be concluded that energy is one of main the factors that must be taken into account in discussion of sustainable development. Next part will describe the role of renewable energy for sustainable development.

2.2. Renewable Energy and Sustainable Development

Renewable energy plays an important role in meeting future energy needs both in urban and rural areas. All countries in the world have some renewable energy sources. By implementing sustainable energy strategies, every country can maximize the benefits from renewable energy sources and technologies -environmental friendly energy sources-and minimize the use of fossil fuels (Madili et al, 2005) to reduce high dependency on other countries, particularly for countries which have no fossil-based energy resources and depend on imported fuel.

To achieve sustainable development, long-term planning and action is required to counter today's energy and environmental problems (Dincer and Rosen, 2004). It is not only to increase energy accessibility and ensure energy security supply for the future but also to minimize negative impacts emerging by energy production and consumption. Promoting renewable energy is one of alternatives to increase energy accessibility, decrease high dependency on fossil fuel and reduce environmental degradation.

In addition, most of renewable energy resources are locally bounded which have characteristic that they cannot be transported to other places instead of they only can be harvested in which place they are exist. For instances solar, micro hydro, geothermal, and wind energy can not be transported to other places, rather than the product generated by those resources can be transferred to other places such as electricity but it is not feasible if the resources are located in remote area and far away from the consumers. While, fossil fuel such as, oil, gas and coal can be transported to other places if infrastructure such as road, transportation or pipe network are exist. For rural/remote areas which are lack of those infrastructures, it is not feasible to use fossil fuel for rural electrification. Transportation cost is not effective to supply low demand in rural/remote areas. Therefore, decentralized energy system based on local energy resources, particularly renewable energy resources, is more suitable for rural electrification.

Dincer and Rosen (2005) stated that there are three main reasons why renewable energy resources and technologies can be seen as a key component of sustainable development:

- They generally cause less environment impact than fossil fuels;
- They can be renewed
- They favor system decentralization and local solution which are not dependence on national network. It can enhance the flexibility of the system and providing energy for remote area.

Furthermore, refer to Food and Agricultural Organization of the United Nation (FAO), some advantages of utilization renewable energy resources are as follows,

> *"Renewable energy systems offer benefits in terms of reducing the local and global environmental impact of energy production; they can provide both employment opportunities and economic benefits in rural areas due to their inherent localized nature. Renewable energy sources are an important means of providing increased diversity and security of supply, and they also offer another set of energy supply options that can help mitigate the impact of climate change by substituting for fossil fuels"* (FAO, 2000, p.10).

To understand more about local energy resources, next discussion will explore renewable energy technologies (RETs) which are used widely for rural and remote areas.

Renewable Energy Technologies (RETs) for Rural Areas

To increase energy accessibility in rural areas particularly the area that can not be reached by modern energy, developing renewable energy as local energy sources can be as an alternative solution. There is a huge potential of renewable energy which can provide clean, appropriate and efficient energy to the world's poorest. Millions of people can be lifted out of poverty without costing the earth, with the help of clean sustainable energy (Chakrabarti & Chakrabarti, 2002). Numerous renewable energy technologies have been developed for generation of energy in rural areas. Each technology has its own strengths and weaknesses, for instance, micro hydro and biomass power plant can be supplied energy for a whole year, however, wind and solar power plant can not produce energy continually. This research only describes some technologies which have been used widely to meet rural energy needs in rural areas, among others technology of solar, biomass, wind, micro hydropower, and geothermal energy.

a. Solar Energy

Solar energy is a technology of obtaining usable energy from the radiation of the sun. Solar energy has been used in many traditional technologies for centuries, and has come into widespread use where other power supplies are absent, such as in remote areas. Solar energy can be harvested in two different forms: solar thermal and solar photovoltaic. Both of these forms have been implemented in rural area. Different applications of solar thermal have been applied such as space heating for homes, offices and greenhouses; domestic and industrial hot water; pool heating; desalination; solar cooking and crop drying in rural areas, such as water heating system, space heating, solar cooker and solar dryer (El-Bassam and Maegaard, 2004).

Photovoltaic (PV) is a technology in which light is converted into electrical power. It is best known as a method for generating solar power by using solar cell or solar photovoltaic arrays to convert energy from the sun into electricity. Solar photovoltaic has been used for many applications both in rural and urban areas, such as lighting, water pumping, communication systems, telecom applications, traffic signaling, railway signaling systems etc. In rural area, mostly applications are used for lighting and water pumping. Solar home systems (PV systems designed for home use) can offer lighting and other services to large numbers of households

that are poorly served by existing energy sources or have no service at all. Here, solar energy can be utilized very decentralized system -individual unit (solar home system-SHS). Solar-PV also can be utilized as mini grid system while some panels are gathered to produce certain capacity to distribute to consumer.

b. Biomass

There are many definitions of biomass. According to El-Bassam and Maegaard (2004), biomass is organic matter existing on the earth's surface produced by photosynthesis. All energy in the biomass comes from the sun in which biomass acting as a kind of chemical energy storage. The sources of biomass come from organic waste, forest and energy crop (McKinney and Schock, 2002). Biomass can be utilized through direct burning and other conversion technologies such as gasification, an-aerobic digestion (biogas) and pyrolisis (bio oil), esterification (bio-diesel), and fermentation (bio ethanol) (El-Bassam and Maegaard, 2004).

Wood, mostly find from forestry operation and garden yard, is the most common form of biomass which has been used thousand years ago. In rural areas fuel-wood plays an important role for meeting energy needs in household. However, the use of fuel-wood tends to create environmental problem, particularly forestal degradation. In some areas, fuel-wood consumption exceeds the sustainable production from available and accessible supply sources (El-Bassam and Maegaard, 2004).

Biogas can be produced from animal husbandry waste or municipal waste. It can be used not only for cooking but also for generating heat and/or electricity. Some technologies such as anaerobic digestion, gasification and pyrolisis have been developed to produce gas from biomass.

Energy crops are developed predominantly to produce ethanol and bio-diesel. Ethanol is produced from sugar fermentation, starch hydrolysis or cellulose degradation followed by sugar fermentation. Mostly ethanol is used for transportation fuel (El Bassam and Maegaard, 2004, p. 105). While bio-diesel is produced from palm oil, peanut oil, etc. It is biodegradable and non-toxic substances. Moreover, it has significantly fewer emissions than petroleum-based and petro-diesel (Canakci, 2005) Due to similar characteristics as diesel fuel, it can be relied as an energy source in the future as substitute of diesel fuel which can be used for transportation and generating electricity.

Biomass energy has various resources with different energy products (solid, liquid and gas) depend on what kinds of techniques are used. For rural electrification, bio-diesel and biogas can be used for generating electricity. Differ from other renewable energy resources, biomass is not locally bounded, it can be transported to other places even it will need collecting activities to gather the sources. Furthermore, biomass has the advantage that they can be stored to compensate the fluctuation of the energy supply from other renewable resources- can be as back-up unit- (Groscurth, 1998) or the fluctuation of the harvest of energy crop (energy crop produced in summer can be stored to be used in winter). Therefore, due to unspecific location resources biomass power plant can be built every where.

c. Wind Energy

A wind energy system converts the energy in wind into electrical or mechanical energy. Wind energy for instance can be utilized to pump water, grind cereal and generate electricity. The utilization of wind energy has become increasingly attractive on economic grounds. Wind energy has been well-developed in US and Europe both at small and large scale. Today, wind turbines for electricity generation employ a proven technology, supply energy on a reliable and sustainable basis.

In developing countries small wind turbines are primarily used for rural energy applications. Using newly developed wind-electric pumping technology, wind turbine systems are also being used for village water supply and irrigation. China has been built about 200,000 stand-alone small-scale wind turbines (with installed capacity of 25 MW) that provide electricity to rural households located in remote areas (REDP, 2005).

d. Micro-hydropower

Micro hydropower is the small-scale harnessing of energy from water flow; for example, harnessing enough water from a local river to power a small factory or village. It will typically generate from 5kW up to 100 kW; usually providing power (for a small community or rural industry) in remote areas away from the grid. Hydropower is a well-proven technology, relying on a non-polluting, renewable and indigenous resource, which can be integrated easily with irrigation and water supply projects.

Micro hydropower plants play an important role in the economic development of rural and remote areas. Micro hydropower schemes can provide power for industrial, agricultural and domestic uses through direct mechanical power or by the coupling of the turbine to a generator to produce electricity. In China over 1500 counties have explored micro hydropower and around 48,000 micro hydropower plants have been built with the total capacity reach 30.8 GW in 2003 (Huizhou, 2003)

e. Geothermal Energy

Geothermal energy refers to energy contained in the heated rock and fluid that fills the fractures and pores within the earth's crust. It originates from radioactive decay deep within the earth and can exist as hot water, steam or hot dry rock (El-Bassam and Maegaard, 2005).

Geothermal resources are classified as low temperature (less than 90^oC), moderate temperature (90^oC– 150^oC) and high temperature (greater than 150^oC) (PEUI-2004). Geothermal can be used directly and indirectly. Geothermal hot water which has low and moderate temperature can be used directly for heating buildings and as a heat supply for a variety commercial and industrial use. Geothermal direct use is particularly favored for greenhouse and aquaculture. While, indirectly used, high temperature geothermal is utilized for generating electricity.

Most of those renewable energy technologies can be used for rural electrification through decentralized energy system. Simple technologies can be implemented to generate small

capacity to meet rural energy needs. Stand-alone PV can be used for remote area which the households are unevenly distributed and population density is very low. While, mini grid system can be implemented for the area in which the households is located rather closer. Theoretically, most of renewable energy systems run best at small to medium scales. Therefore, these systems are suitable for rural areas which have low demand and population density (Hiremath et. al, 2007). Unfortunately, there are many constraints hamper the development of renewable energy technologies. Next part of this chapter will describe the constraints of developing renewable energy resources.

Renewable Energy Development Constraints

Although some of renewable energy technologies have been mature, unfortunately not all of these technologies can be developed as well in rural areas. Many constraints have been hampered the development of renewable energy technologies particularly in developing countries. The constraints are different among countries; however the major constraints are almost similar. As pointed by Painuly (2001) renewable energy development constraints is listed in Table 2.1

Table 2.1 Major constraints of renewable energy development

Constraints Category	Constraints	Remarks
1. Market Failure	- Highly controlled energy sector	- This may lead to lack of investment in RETs
	- Lack of information and awareness	- It increase uncertainty, and hence cost
	- Restricted access to technology	- Technology is not available or available at high cost.
	- Lack of competition	- Product cost is increase
2. Market Distortions	- Favor (such as subsidies) to conventional energy	- This affect competitiveness of renewable energy adversely
	- Tax on RETs	- Cost of energy from RETs is increase
	- Non-consideration of externalities	- Cost of conventional energy is less than what it should be
3. Economic and Financial	- Economically is not viable	- Cost reduction in RETs is needed
	- High investment requirement result in high discount rates and payback period	- Incentive may be needed in the initial stages - Project becomes un-viable
	- Market size small	- Economy of scale cannot be achieved
	- Lack of access to capital	- Number of producers is less, and hence competition and market efficiency my suffer
	- Lack of financial institution to support RETs	- Supply of RETs product may suffer
4. Institutional	- Lack of institution/mechanism to disseminate information	- It leads to non availability of information with producers as well as consumers.
	- Lack of legal/regulatory framework	- Renewable energy producers may face market/economic/financial barriers
	- Unstable macro-economic environment	- This may increase risk and uncertainty for new investment.
	- Lack of involvement stakeholders in	- This can result in mis-placed priorities.

	decision making - Clash of interest - Lack of R &D culture - Lack of private sector participation - Lack of professional institution	 - This may lead to powerful lobbies against RETs - This may make adaptation to technology difficult - Lack of competition and inefficiency is possibly due to this. - Producers' problems and views on barriers cannot reach the policy makers effectively.
4. Technical	- Lack of standard, codes and certification - Lack of skilled personnel/training facilities - Lack of O & M facilities - Lack of entrepreneurs - System constraints - Product not reliable	- Affecting product quality and product acceptability. Purchase and commercial risk increase, as also negative perception about technology - Can be a constraint for producers. - This can affect product acceptance - It may lead to lack of competition and supply constraints - Market cannot be realized by producers - Market size get affected
5. Social and cultural behavior	- Lack of consumer/social acceptance of the product	- Market size become small
6. Other constraints	- Uncertain government policies - Environmental - High risk perception for RETs - Lack of infrastructure	- It creates uncertainty and result in lack of confidence. May also increase cost of project. - Environmental damages/pollution may be unacceptable - It increases cost of capital (high financial risk) as well as discount rate of producer. - RETs such as wind may need strong infrastructures development such as roads and transportation[3]and grid connectivity.

(Source : Adapted from Painuly, 2001)

Painuly more emphasizes the constraints on market oriented. Since this research more focuses on public policy, the categories of those constraints in the next chapter, Chapter 5 and 6, are grouped in 5 criteria which are more related to renewable energy development in rural areas. The criteria are as follows:

a) Political commitment constraints;
b) Institutional and Policy constraints;
c) Financial constraints;
d) Information constraints; and
e) Technical constraints

[3] Road and transportation infrastructures are necessary to make easy to catch the certain location, since the location is isolated it is difficult to bring some RETs equipments from the outside of this area.

Following discussion will explore the nature of rural electrification which depicts rural characteristic and rural energy needs.

2.3 Rural Electrification

Electricity is a form of energy which is used widely to support human activities. Moreover electricity is also a commodity that holds all three pillars of sustainable development-economic, social, and environmental dimension. Electricity drive economic development by enabling industry and commerce; stimulates social progress by catalyzing communications, healthcare, and education; and promotes environmental improvement by replacing less efficient means of energy conversion. Furthermore, accessible, reliable and affordable electricity is becoming a challenge for energy poverty (E7, 2003).

A rural electrification program, as an effort to increase energy accessibility in rural areas, has been implemented in many developing countries. Its strategy has typically concentrated on connecting rural areas to a national grid often owned and operated by the public utility (centralized energy system). Unfortunately many rural and remote areas are not feasible technically and economically to reach by grid connection. Nowadays, around 1.7 billion people in the world, notably in rural and remote areas have no access to electricity (Vera and Langlois, 2007).

This condition, combined with concerning on the environmental problems associated with fossil fuel-based forms of electricity generation, have fostered the development and implementation of rural electrification schemes through decentralized systems based on renewable energy sources (Etcheverry, 2003). Many experts recognize that renewable energy technologies such as solar, wind and small-scale hydropower are economically feasible and ideal for meeting energy needs in rural areas (Painuly, 2001). Decentralized energy system based on renewable energy can be conducted by government agencies, non-governmental agencies (NGO's), public-private partnership and community itself.

In the past rural electrification is conducted by top-down approach, however due to complex problems in rural areas, this approach is no longer appropriate to define and solve the real problem in rural and remote areas. Therefore, bottom-up approach is necessary to find a good solution for the complex problem in rural areas (Neudoerffer, et. al., 2000). The planning approach for rural electrification will elaborate more in Chapter 3.

Rural Characteristic

In general rural characteristic can be seen from three aspects, physical, social and economical characteristics. Physically, rural area is characterized as area which is still dominated by agricultural activities; distance from urban center which causes low accessibility to modernization development and low access of public service (Ruben and Pender, 2004, Hite, 1997). Socially, population density in rural areas is smaller than urban areas and life of quality of rural people is relatively low indicating by illiteracy, low skill level, high rate of mortality, etc (Hite, 1997; Bery et al, 2004). Economically, rural areas in developing countries are identic

with poor condition because most of rural people relatively have low income (Bery et al, 2004). Moreover, due to low accessibility to modernization development and public service, most of economic activities in rural areas are relatively small scale and unvaried (Hite, 1997).

Based on this condition, it is clear that providing infrastructure in general in rural areas is important to develop rural areas and reduce disparity between urban and rural areas. Nowadays, rural development is left behind from urban areas due to lack of pay attention on rural development. Energy is one of infrastructures that is essential to support other development in rural areas. Decentralized energy system based on renewable energy with small scale is appropriate to deal with unevenly distributed population and low density of population in rural areas which have not been connected to national grid.

Rural Energy Needs

In general, energy needs of rural people can be classified into basic needs, social needs and economic needs (Ramani, 2005, Ochieng in Chakravarthy, 2004):

1. Basic need, energy used for portable water (safe, and drinking water), health (refrigeration), water for livestock, non electrical renewable energy technologies for water pumping and irrigation.
2. Social needs, energy used for cooking, space heating/cooling, lighting (both for individual households or communal places, and public/street lighting), communication, other household appliances and community services.
3. Economic need, energy used for agriculture, off-farm enterprise, and rural small-medium industries.

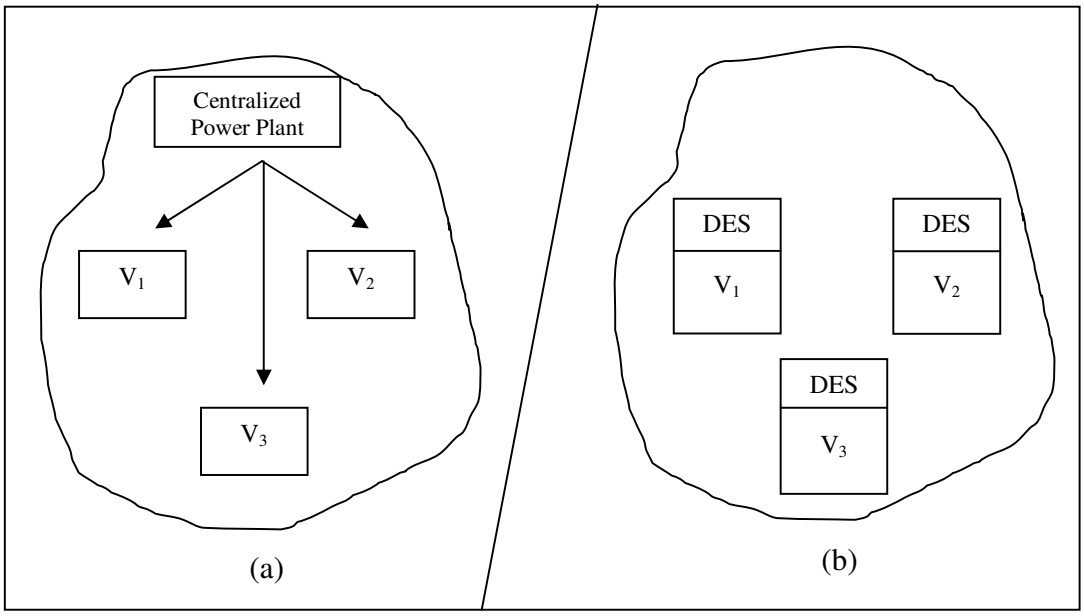
As mentioned previously, rural energy demand in rural areas is low, however energy service is expected can improve the quality of living standard of rural communities and drive productive activities in rural/remote areas. Consequently, energy accessibility in rural/remote areas should be increased. The next part will discuss decentralized energy system which is appropriate for meeting energy needs in rural/remote areas.

2.4 Decentralized Energy System (DES) for Rural Area

Decentralized energy system –also known as distributed/dispersed energy system-refers to generate energy power either connected to distribution network or completely independent of the grid (IEA, 2002). It can be build stand alone such as solar home system or use mini grid such as micro hydropower plant, biomass power plant, etc to distribute the power from the source to the consumers. Figure 2.3 shows the centralized and decentralized energy system. In centralized energy system village is connected to national grid, sometimes people are not interested in knowing where the electricity is generated, and they just know that they have access to electricity. However, in decentralized energy system, the power plant is located surrounded of their location. In this condition, social acceptable is important, because some conflicts can emerge related to the location of power plant. Therefore, planning becomes more complex in decentralized energy system. Technology acceptance by rural community is

different. It depends on their knowledge and how the technology is introduced and disseminated.

Decentralized energy system can be met by fossil based energy such as diesel generator, and renewable energy (IEA, 2002). Local energy resources, such as solar, wind, biomass, and micro-hydro can be harvested to generate electricity to meet rural electricity needs.



V = Village
DES = Decentralized energy system

Figure 2.3 Network energy system a) Centralized energy system and b) decentralized energy system

Decentralized energy system can be developed based on 1) one type of energy resources (stand-alone) such as micro hydropower plant, wind power, etc or 2) a combination of several resources (hybrid system), such as wind-PV power plant, micro hydro-PV power plant, and may be conventional generator for back up unit. All of it depends on the potential of resources in the local area. If there are many renewable energy potential resources, it is necessary to find which one is more appropriate economically, socially and environmentally. For instance, micro hydro (MH) power plant is more reliable to produce electricity compare to PV and wind power plant, because MH power plant can operate a whole day and a whole year, while PV and wind power plant can not operate continually. At this point, the systems will need storage system which will be costly.

Moreover, if single resource can not meet local need, it can be also combined with other resources as a back up unit. For instance, due to wind power or PV-power plant can not produce electricity continually for a whole day or capacity of the power system is not enough to meet local needs; a hybrid system such as wind-PV or wind-micro hydropower plant can be used as an alternative. In some cases diesel generator also used as back unit. For this reason, bio-diesel can be used to replace diesel oil for generator to make the system more sustainable.

Sustainable aspects of DES

Decentralized energy system based on renewable energy can be as a tool to achieve sustainable development. There are some advantages of decentralized energy system based on renewable energy. In economic aspect, it can be located closer to demand which can reduce the cost of transmission and distribution, the system has low operational cost because it does not need fuel for its operation; and in energetic aspect, increase the efficiency-reducing losses in transmission and distribution (Nguyen, 2007).

In social aspect, decentralized energy system can be built in isolated and remote area which can not be reached by national grid. It can improve living standard of the people in rural/remote area and create job opportunities locally through the availability of electricity.
In environmental aspect, it can reduce air pollution which can threat human health and world's ecosystem (Chakrabarti and Chakrabarti, 2002) and reducing forest degradation by decreasing dependency of rural areas on biomass come from the forest.

In addition, decentralized energy system based on renewable energy (as local energy) resources will encourage local independence from world markets, and create stability of social, economic and politic aspects (Burkhardt, 2002). It can reduce the dependency on fossil fuel. Currently, most of centralized energy system is still relied on fossil fuel. However, not every country has fossil fuel resources. By increasing DES based on local energy resources the dependency on other countries can be reduced and conflict related to oil resources can be decreased. Therefore, the future energy policies should put more emphasis on the development and deployment of renewable energy resources (Brundtland 1987).

Furthermore, access to energy should be considered as the fundamental right for everyone. Some efforts which must be applied to increase energy accessibility, availability and acceptability in rural areas (El Bassam and Maegaard, 2004; WEC, 1999) are as follows:

- Policy makers need to give high priority for rural development in general and rural energy development in particular.
- Rural energy development must be decentralized and rural people manage local resources.
- Rural energy development should be integrated with other aspects of rural development

Disparity between urban and rural area can be reduced by developing rural area as well. Local resources might be utilized optimally for the benefit of rural communities. One of the resources is local energy resource. Decentralized energy system can be as a tool to develop local energy resources. Therefore, local community should be empowered to make them reliant and capable to organize and develop their own local resources. Furthermore, to achieve sustainable development, rural energy might be integrated to other sectors such as health, education, transportation, economic, etc. Here, collaboration and coordination among institution is needed to get optimal advantages from local energy development. Following part discusses policies and institutional mechanism to support rural electrification program.

2.5. Policies and Institutional Mechanism of Rural Electrification

Renewable energy technologies are resources specific. To optimize the benefit of these technologies appropriate policies, strategies and institutional mechanism of rural electrification is required (Shukla, 2007, Neudoerffer, et. al., 2001). Decentralized energy system need more local participation than centralized energy system, therefore to achieve the goals, a different set of responsibilities in different level should be formulated (Sukla, 2007). Ring model approach (Shukla, 2007) –macro, meso and micro level- can be used to describe a different set of responsibilities at different stages as presented in Figure 2.4. The descriptions of each level are as follows:

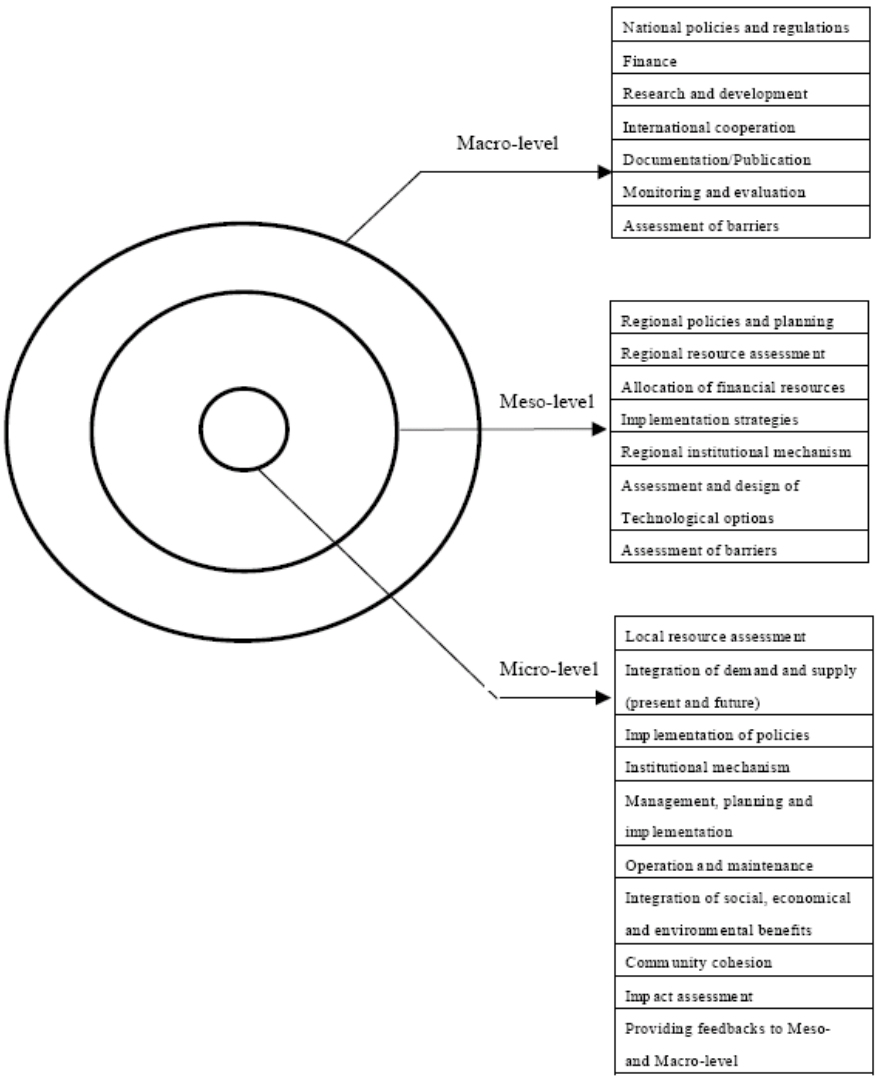


Figure 2.4 Ring Model Approach
(source: Shukla, 2007)

The Macro-level

The macro level represents the policies and strategies formulated at national level. Here, central government is responsible for all the arrangement of national policies and regulations, finance, research and development, international cooperation, documentation and publication, monitoring and evaluation and assessment barriers of rural electrification. In this level, countries with more diversified issues –geographical conditions, living status, local resources availability- deal with a complex situation to formulate favorable policies to achieve sustainable development (Shukla, 2007)

The Meso Level

The meso level has a responsibility for formulating policy and regulations in the regional/provincial level. The main task of this level is to build on a good understanding on national policies/regulations and implement them in regional/provincial level (Shukla, 2007). Furthermore, meso level might monitor and asses the impact of implementation process and record them as feedbacks to the macro level. This level plays an important role for the success of the implementation policies, therefore, stakeholder involvement in this level should be strengthened (Shukla, 2007).

The Micro level

The micro level represents the actual implementation of activities in local level. This stage determines the success and failure of rural electrification program policies and strategies. This level plays an important role in integrating social, economic and environmental issues. The diversity problems and constraints emerge in this level. In this level institutional mechanism is significantly required for sustainability of the decentralized energy system. Moreover, at this level it is important to study the priority of the people in the remote/rural areas and examine how electrification can useful for improving their life (Shukla, 2007)

Ring model approach will be used to explore the role of each level (national, regional and local) in decentralized energy system based on renewable energy in Chapter 5.

From the previous discussion, it is clear that the rural electrification is a complex issue. To tackle this issue we need a planning approach to deal with multiple goals of rural electrification. Bottom-up approach which emphasize on participative approach is needed to encounter the complex problems in rural areas. This approach focuses on communication among actors -central government, local government, non governmental organization, rural community and other stakeholders- to find a good solution to solve complex problems in rural areas. This approach associates with involving many actors in planning process. The next chapter of this research will explore the participative approach as a planning approach to cope with the complex issue in rural electrification.

CHAPTER 3
PARTICIPATIVE APPROACH
FOR LOCALLY BASED ENERGY DEVELOPMENT

Planning is a dynamic process related to preparing about the future by setting goals and designing the way to attain those goals (Clayton, et. al., 2003). According to Linden and Voogd (2004) *"planning is essential about shaping the future and managing urban and rural change in a way that benefits current and future generations*". In this context planning might be considered sustainable development. It is not only useful for present generations but also must recognize the future generations.

Locally based energy planning is close related to organize and manage the local resources. In the past, plan has usually been formulated by government without involving people who would be affected by that plan. In developing local resources, the planning process more emphasize on technical approach, rely on gathering basic information about the resources and socio-economic condition of the local area followed by analysis and interpretation (Clayton et. al ., 2003). Some evidence showed that many projects related to developing local resources have been abandoned due to lack of community participation in the project and lack of attention to building local organizations (Clayton, et. al., 3 Malhotra, et. al., 2004).

Actually, the outsiders can not identify what the local priorities are nor understand how to meet them as well (REDP, 2007; Clayton, et. al., 2003). Therefore, participative approach is necessary to capture the complex problems in developing local resource. Nowadays, sustainable development becomes a major issue in developing natural resources, including local energy resources. Consequently, planning might not only consider technical aspect, but also social, economic and environmental aspects.

This chapter explores theoretical framework of planning approach to encounter complex issue in rural electrification. It consists of three parts. First part describes participative approach in planning, what it is and why it becomes important. Second parts illustrates participative approach in rural energy planning which consist of community participation in rural energy planning, why community participation is important, and how community participation can be implemented. The last part of this chapter expresses top down planning approach vs bottom-up planning approach.

3.1. Participative Approach in Planning

Participation is an element of communicative approach. Participative approach emerges as a critic that planning appears to be top-down. The failures of top-down approach in rural energy planning show that technocratic approach can not capture all problems in rural area. Grass root level might be involved in every stage of development – planning (decision-making), implementation and operation and maintenance stages. (Purwatiningsih, et. al., 2004)- to get optimal benefit for the beneficiaries.

What participative approach is

There are many interpretations of participative approach. In general, participative approach is defined as a process through which the views of all interested parties (actors or stakeholders) are integrated into project decision making (Roncerel, 2003). According to World Bank (1994) quoted in Clayton, et. al., (2003), participative approach is:

> "*A process through which stakeholders influence and share control over development initiative, and the decisions and resources which affect them"*

According to those interpretations, it can be concluded that the main principal of participative approach to development is that the actors are involved in a project at every stage of project development to increase sense of belonging to the decisions and actions

Providing infrastructure that associates with sustainable development is a complex work. The planners not only consider what the goal of the providing of infrastructure is, but also how to build the infrastructure economically, socially and environmentally and who should be involved in this process. Many experts recognize that there is a huge diversity among people-different interest and perspective. Therefore policy activity should encounter diversity in equity way (Healey, 1997).

In the past, technical approach which associates with top-down approach is appropriate to solve the problem on providing energy infrastructure. However, due to a rapidly changing society and increasing complexity and dynamics of spatial developments, communicative approach seems more applicable instead of technical approach (Healey 1997, and de Roo, 2003). Many evidences reported some failures of top-down approach to solve the real problem in providing infrastructure (Geoff and Johanessen, 2003)

The concept of communicative approach emerged in the early 1990s (Woltjer, 2004). Building political will, involving societal actors, and building consensus in the community were the main ideas of communicative approach (de Roo, 2003). Healey (2006) argued that planning is understood as an interactive process, involving communicative work among participants, during which issues problem, strategies and policy ideas are given form and meaning. Today, no policy can be formulated and no planning project can be implemented without the collaborations of stakeholder (Woltjer, 2004). Moreover Woltjer argued that:

> "*Government agencies need other government agencies to make sure that their plan will be implemented, and they need societal groups and citizens to support and make use of their plans. In other words, policy actors (people, organizations) are interdependent. They can only function if they seek involvement and make sure they reach consensus on the topics that connect them"* (Woltjer, 2004)

It is clear that planning can be implemented as well through interaction and communication among actors. Here, actors with different interest must be allowed to participate in the process of planning formulation.

Why Participative Approach is needed

People have a huge diversity-interests and perspectives. It is a difficult task to meet all people desire in planning practice. Nowadays, planner is dealing with many goals which need many actors to involve in the planning. In addition, providing infrastructure has many consequences. One of these is spatial consequences. The conflicts among actors and sectors are inevitable. To reduce these conflicts and build consensus among actors a participative approach is needed (see Woltjer 2004; Wustenhagen, 2007).

As mentioned by de Roo (2006) "*Technical approach takes planning issue as predefined, and focuses on content and goals, formulating in blueprint planning. Certainty and control are present, due to the direct relationship between cause and effect, making it fairly easy for single actor-normally the national government or the local authority- to decide how to plan and act"*. Nowadays, the development faces uncertainty condition which cannot solve by technical approach. Therefore participative approach in planning is acceptance as a way to recognize the uncertainty (de Roo, 2006). This approach more emphasizes on the process rather than the content or goal. Interest parties might be drawn in the planning process to address the uncertainties and different interest to find the agreements used for further action (de Roo, 2006).

Rural electrification associates with multiple goals in achieving sustainable development. The goals not only to increase energy accessibility in rural/remote areas but also might associate with improving living standard of community, creating job opportunities, and reducing environmental degradation. To optimize the achieving of those goals, the focus of planning might be shift from goal oriented to process oriented which recognize many actors involved in planning process. It is needed an interaction, collaboration and participation among actors to attain the goals which can satisfy different parties (Healey 1997; Woltjer, 2004). The next part will discuss participative approach in rural energy planning.

3.2 Participative Approach in Rural Energy Planning

Due to the complex issue of rural electrification and failure of top down approach to meet the real rural needs, therefore, rural energy planning should be decentralized and give opportunity for public to involve in planning process. According to REDP (2007)

> "*the traditional approach of energy development is characterized by external agencies determining the suitability of selected technologies to the beneficiary population in rural areas. Therefore the typical rural energy planning begins with the assessment of available energy technologies and then proceeds to implement these technologies. This gives little or no flexibility to adjust the program according to the local situation, the user's needs and preferences*"

The communities as beneficiaries did not participate and involve in planning even in implementation of rural electrification. These condition results in communities have no capability to manage the system and have no sense of the ownership towards the scheme. Consequently, technological successes are limited, because most of technologies are being rejected by the communities (REDP, 2007).

Therefore, to augment sustainability of rural electrification project and increase benefit of energy services for improve living condition of rural communities, community might be involved in formulating rural energy planning. Community participation in rural energy planning will be elaborated in the next discussion.

Community Participation in Rural Energy Planning

What community is

Community has several meanings. Based on Oxford Dictionary, community is defined as "*all the people living in one place"* or "*group of people who share the same interest*". Healey (1997) describes the meaning of community is not only all people living in one area. It brings dual image. Firstly, an integrated place-based social world (*gemeinschaft)* in which people bounded in social networks[4]. Secondly, the meaning of community associates with opposition to dominating force or government[5] (Williams, 1976; Mayo 1994, quoted in Healey, 1997).

Related to those images, Healey (1997) argued that awareness of diversity while building trust and understanding is necessary for building political community.

Why community participation is important

As mentioned previously, there is an immense diversity among people. Centralized energy planning is not suitable to deal with the complex problem in local area. Different resources, interests, preferences, ethnics, social-economic conditions must be tackle in different ways. Therefore, generalization approach cannot be implemented to develop local energy resources. In the context of rural energy planning, every rural area will need specific approach to cope with the real problem in that area because each rural/remote area has specific condition related to economic, social, culture, ethnic, etc.

Community might be drawn to participate in rural energy planning because they know well about their region and they know what they needs are. As mentioned before, the outsiders do not understand what rural priorities are. By involving rural community in decision making, it is expected that a good solution to solve the problems in rural area can be found.

There are three main advantages of involving community participation in rural energy planning. First, the decisions made can be more represented of local need and desire. Second, the technologies can be more accepted by community, therefore conflict due to utilization of renewable energy can be reduced. Last, it can increase awareness and sense of belonging of rural people to the project (Loring, 2007; Wustenhagen et al , 2007; Neudoerffer et. al 2000).

How community participation can be implemented

[4] *"The idea of the place-based community has a long tradition in planning thought. It encapsulated an idea of village life, where the relation of living, working, raising children, relaxation and managing common affairs took place in a-place bounded world."* (Healey, 1997 p.123).

[5] "*It expresses our shared interest as human being trying to live our lives, versus the spheres of business organization and political institution."* (Healey, 1997 p.124)

To encourage community to participate in planning process, building capacity of rural community is important. As mentioned by Neudoerffer et. al (2001) that participative approach in rural energy planning is not easy to be implemented. It will take time and effort. They suggested that government needs "*investing in participation, organizing participation and institutionalizing participation" to* make sure that participative approach in decentralized planning can be conducted as well.

Investing in participation means investing in building capacities. Government/planners cannot be faulted for doing as they have been taught. They need to be responsive to local needs and issues. Moreover, in planning process government planners should change their vision about rural people from targeted beneficiaries to be partners (Neudoerffer et. al, 2001).

Organizing participation in decentralized planning means assisting the local people to organize themselves, to think through the planning process and to take action related to their needs and desires. As a result, capacity building is needed at the local levels for people to be able to participate meaningfully (Neudoerffer et. al, 2001). Training, education and information are significantly necessary for increasing capacity building of rural people.

Institutionalizing participation means creating/strengthening the local institution to facilitate planning. If local planning facilities exist, it only needs to redefine the functional hierarchy to ensure that local decision-makers have been included. However, if no such institution exists, it is needed to create local level institution (Neudoerffer et. al, 2001).

From this discussion, it is clear that capacity building is needed to encourage rural community involvement in planning process. The last part of this chapter will elaborate the planning-oriented action, the shifting from top-down approach to bottom-up approach.

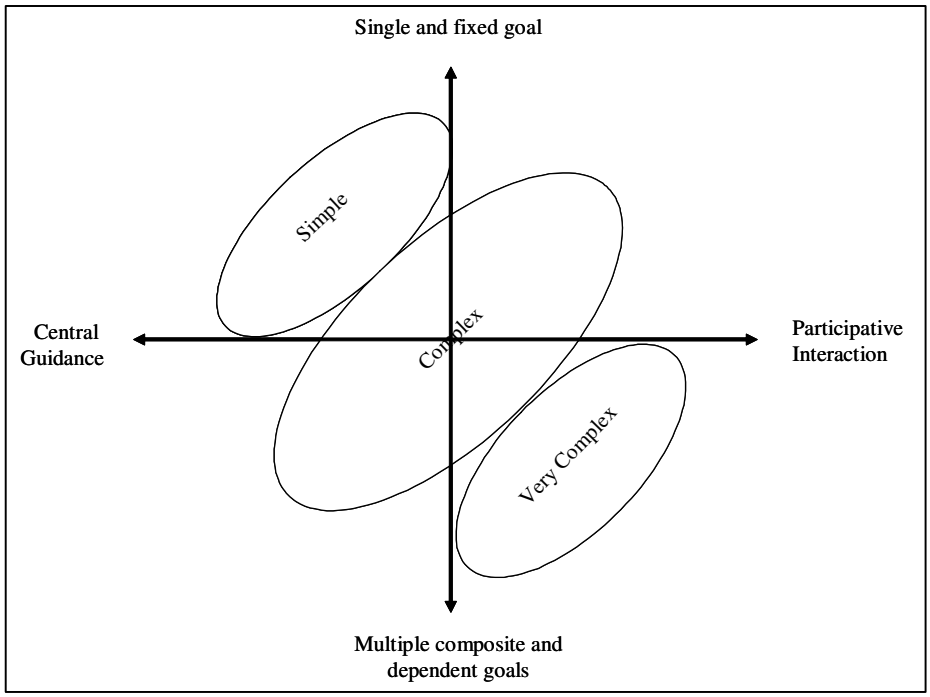
3.3 Top-Down Approach Vs Bottom-Up Approach

Rapid changing in society and increasing awareness on environmental degradation result in top down approach is not appropriate to solve multiple goals in development. De Roo (2003) briefed clearly the shift of planning oriented action from command and control planning (*top down approach*) to shared governance (*bottom-up approach*). He used three degrees of complexity (simple, complex and very complex) to categories planning issues.

Planning has shifted from simple issue which has only single goal and single actor to very complex issue which has multiple goals and multi actors involve in that. The framework for planning-oriented action, in which the relationship between planning goals and interaction based on complexity, is presented in Figure 3.1. From this figure, decision making become more complex since the goal of planning associate with multiple goals and many actors involve in the planning process.

In the context of decentralized energy system based on renewable energy, participative approach is an element of the successfulness of locally based energy development. Therefore, rural energy planning might be decentralized and many actors are recognized to involve in

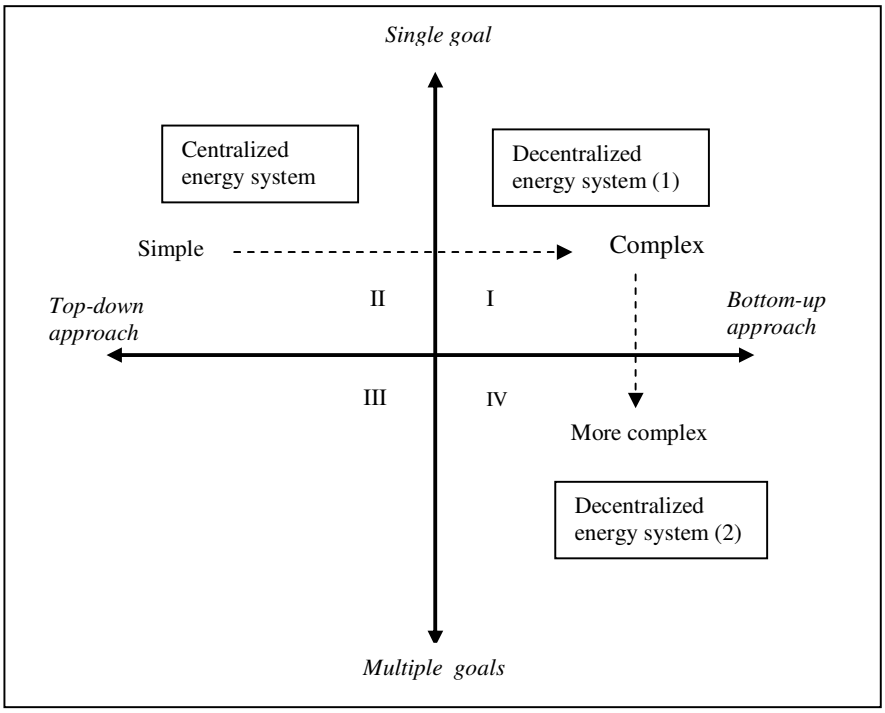
decision making. Furthermore, some evidences show that involving rural community in planning and implementation can make diffusion of decentralized energy system based on renewable energy more sustainable (Neudoerffer et al 2001).



Source: de Roo (2003)

Figure 3.1 Framework for Planning-Oriented Action based on complexity

The reflection of figure 3.1 to planning issue in rural electrification is shown in Figure 3.2. Centralized energy system can be implemented by top-down approach, because planning issue is simple (in quadrant II). The goal only associates with providing energy infrastructure for economic growth. The actor involve in this system is limited (it can be handled by government itself). While decentralized energy system is implemented, many actors are needed to involve in planning process. If the goal without considering sustainable development (only single goal such as economic point of view) the planning issue become complex (quadrant I). At this context, the successful of project is determined by increasing participation of many actors in decision making. Furthermore, if decentralized energy system considering sustainable development (social, economic, and environmental aspects the planning issue becomes more complex because it is not only associated with many actors involvement and but also multiple goals might be achieved (quadrant IV).



(1) = DES without considering sustainable development
(2) = DES considering sustainable development

Figure 3.2 Planning issue in rural electrification program related to the complexity

The next chapter will describe empirical case of locally based energy development for rural electrification in Indonesia to support the analysis of this research.

CHAPTER 4
DECENTRALIZED ENERGY SYSTEM IN INDONESIA

This chapter explores the decentralized energy system based on renewable energy in Indonesia. The illustration is beginning by the description of country background followed by overview of energy development and renewable energy development in Indonesia, the application of renewable energy technologies and some constraints. After that energy policy framework that supports RE development is described. Indonesian rural electrification, policies institutional framework and Indonesian program on DES are explored in the next part. The last part of this chapter shows the two case studies of DES system based on RE in East Java and East Nusa Tenggara.

4.1 Country Background

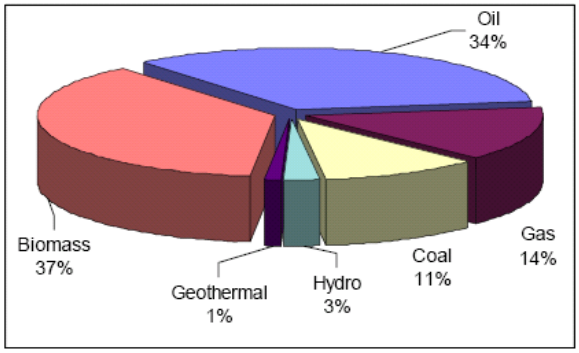
Geographically, Indonesia consists of 5 main islands and around 17,000 islands. The major islands are Sumatra, Java, Kalimantan, Sulawesi, and Irian Jaya. In 2002 Indonesian population is approximately 212 Million. About 60% of the population lives in Java and Madura, where the land area of this region is just 7% of the total land area of Indonesia.

Socially, Indonesia's people consist of many ethnic groups distinguished by language, religion, ecological adaptation and social organization. The number of ethnics scattered throughout the islands. There are around 300 tribal and ethnics group exist (ADB, 2003).

Economically, Indonesia has long been now known as exporter raw materials particularly tropical foodstuffs and petroleum because of high potential of natural resources, (ADB, 2003). In the past, oil plays an important role for Indonesian national income. According to economic crisis that hit Indonesia since the mid of 1997 results in various impact on development projects including energy sector.

4.2 Overview of Energy Development in Indonesia

As developing countries and due to rapid growth of population, energy consumption in Indonesia has been growing at high rate. The national primary energy demand has been fulfilled by oil. gas, coal, hydro and geothermal. Total energy consumption by sources is presented in Figure 4.1. Commercial energy (oil, gas, coal, hydro and geothermal) sources contribute around 63% of national energy supply; the rest 37% is met by biomass, firewood and agricultural waste (ADB, 2003). Biomass is majority used for cooking in rural households.



Source : ADB, 2003

Figure 4.1 Total Energy Consumption by Sources

Energy consumption for electricity generation is also dominated by fossil fuels as shown in Figure 4.2. In 2004, the share of fossil fuel in electricity generation is about 86.9% with the composition of coal 31.1%, oil 29,2% and gas 22.6%. The rest is fulfilled by renewable energy consist of hydropower 11.4%, geothermal 3.9%, biomass 1,6% and other renewable energy sources (RES) such as solar energy, wind and micro-hydro 0.3% (DGEEU[6], 2005).

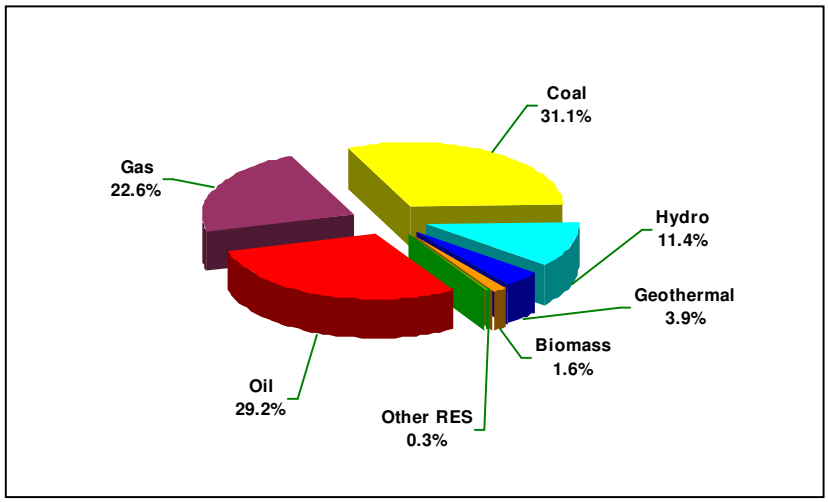


Figure 4.2 Electricity Energy Consumption by Type
(Source : Directorate General of Electricity and Energy Utilization, 2005)

Fossil fuel as non renewable energy resources can be exhausted. Table 4.1 shows national fossil fuel reserve in Indonesia. In 2004, total reserve of oil in Indonesia is 86.9 billion barrel, with proven reserve about 9 billion barrel. Considering the crude oil production around 500

[6] DGEEU (Directorate General of Electricity and Energy Utilization) a division of Ministry of Energy and Mineral Resources which is responsible for providing policy and regulation on electricity and energy utilization

million barrel/year, thus, without finding new oil reserves, Indonesian's oil reserve will be used up in the next 17 years. Due to limited reserve of oil and continuously rise of world's oil price the dependency on oil must be reduced gradually. Therefore, energy diversification and conservation is essential to anticipate the demand on energy and ensure energy security supply in the future.

Table 4.1 National Fuel Reserve

ENERGY TYPE	TOTAL RESERVE	PROVEN RESERVE	PRODUCTION/ YEAR	COMPARISON (RESERVE/ PRODUCTION)
Oil	86.9 billion bbl	9 billion bbl	500 million bbl	17 years
Natural Gas	384.7 TSCF	188 TSCF	3 TSCF	62 years
Coal	57 billion Ton	19.3 billion ton	130 million ton	147 years

Source : DGEEU, 2005

Final energy consumption in Indonesia is growing at the average rate of 7% per annum and the growth of primary energy consumption is around 8.5% (DGEEU, 2005). To accommodate energy need with relatively annual high growth in the future, the use of alternative energy sources should be increased. Realizing this conditions, the government commits to reduce the dependency on oil by issuing Presidential Regulation No.5 year 2006 concerning on National Energy Policy which set the target in year 2025, among others, that energy elasticity should be less than 1 (one) and, oil share in primary energy supply less than 20% and renewable energy share more than 5 % (excluded hydro and geothermal in large scale).

Furthermore, based on Presidential Regulation No 5/2006, Directorate General of Electricity and Energy Utilization (DGEEU) has estimated the projection of energy provision in 2005-2025 as presented in Table 4.2.

Table 4.2. The Projection of Primary Energy Provision 2005-2025

Type of Energy	2005		2010		2015		2020		2025	
	Million BOE	%	Million BOE	%	Million BOE	%	Million BOE	%	Million BOE	%
Oil	415	49	447	40	482	32	520	26	560	20
Gas	156	18	237	21	362	24	551	27	840	30
Coal	206	24	300	27	436	29	635	31	924	33
Hydro	23	3	30	3	40	3	53	3	70	3
Geothermal	44	5	59	5	78	5	105	5	140	5
Liquefied Coal	0	0	0	0	0	0	0	0	56	2
Biofuel	0	0	26	2	69	5	91	4	140	5
Other RE	0	0	6	1	25	2	75	4	70	3
Total	844		1096		1492		2030		2800	

Source DGEEU, 2006

From Table 4.2, we can see that in 2020 and 2025 the amount of energy consumption will increase almost three and four times of the amount in 2005 respectively. The role of oil is expected will decrease gradually, while the role of coal and gas is expected to increase. Even the role of fossil fuel is still high, in 2020 and 2025 the role of bio-fuel and other renewable energy such as wind, solar energy, and micro-hydro is expected will progressively increase. Following part discusses renewable energy development in Indonesia.

4.3 Renewable Energy Development in Indonesia

Indonesia is blessed a huge potential of renewable energy scattered in a whole part of Indonesia. Unfortunately, renewable energy development in Indonesia goes slowly due to some constraints that will be elaborated in next part of this chapter.

Nowadays, most of renewable energy in Indonesia is utilized for generating electricity. The potential of renewable energy and installed capacity are presented in Table 4.3.

Table 4.3 Potential and Installed Capacity of Renewable Energy in Indonesia

Energy Type	Potential	Installed Capacity
Hydro	75 GW	4200 MW
Geothermal	19,658 GW	807 MW
Mini/micro hydro	500 MW	84 MW
Biomass	49.81 GW	445 MW
Solar	900 MW*	8 MW
Wind	448 MW**	0.6 MW

Source: Directorate General of Electricity and Energy Utilization, 2005
* (quoted in Retnanestri, 2004)
** (quoted in Sumiarso, 2001)

As a whole, utilization of renewable energy in Indonesia can be classified into three stages (MEMR, 2003):

- already developed commercially (biomass, geothermal and hydro energy);
- already developed but still limited (solar and wind energy); and
- still at the research stage (tidal, wave energy)

In general, the utilization of renewable energy in Indonesia in short term is emphasized to fulfill rural basic energy needs (in small scale), while in long term the use of renewable energy in large capacity will be developed to substitute fossil energy (National Energy Policy, 2004). This research focuses on utilization renewable energy technology for providing electricity in rural/remote area, therefore, next part will discuss the application of renewable energy technologies in Indonesia.

Application of Renewable Energy Technologies (RETs) in Indonesia

a. Solar Energy

Located on the equator, Indonesia has a good potential of yearly solar energy with high level of average daily radiation. There are two kinds of technology that have been applied; the photovoltaic solar energy and the thermal solar energy. Photovoltaic solar energy is used in rural areas to generate electricity for daily life. Currently, the total generated capacities of this technology is around 8 MW (DGEEU, 2005) due to lack of socialization, high operational (repair and maintenance) cost, high investment cost cause it cannot compete with the subsidized conventional fossil fuel energy.

Most of the electricity generated by PV is generally used only for application like solar home systems in remote areas, rural Community Health Centers, Rural Community Centers, drinking water pumping stations, satellite TV receiver, and telecommunication facilities (ADB, 2003). Due to the limitation of energy generated by solar photovoltaic, hybrid system such as PV-Diesel hybrid system, PV-Micro-hydro, etc. also has been introduced to provide electricity continuously. Therefore, diesel and micro-hydro can be as a back up of PV system particularly at peak load. Some pilot project of hybrid systems have been implemented in Indonesia. For instance, PV– Micro-hydro Hybrid System in Taratak, West Nusa Tenggara with a 48 kW PV and micro-hydro with a 6.3 kW and Photovoltaic-Diesel Hybrid System in West Java with a PV Module 72 kW and diesel 2 x 10 kW (DGEEU, 2005).

b. Biomass

Indonesia has a huge source of biomass such as waste of agriculture, plantation, pulp industry, forest, and animal dung. Biomass, particularly fuel-wood has been used widely in Indonesia. It is one of the oldest energy sources that has a big contribution in energy provision particularly in rural areas. Almost 37% of total national energy consumption in Indonesia comes from biomass (ADB, 2003) and 80% of total energy consumption in rural areas is met by biomass (ADB, 2003). Energy produced from biomass has been used for several purposes among other for cooking, drying and milling agricultural products and timber industry, home industry, and power plant in the timber and sugar industry.

c. Wind Energy

The potential of wind energy in Indonesia is relatively small. The wind speed is ranging from 2 to 4m/s (DGEEU, 1997). However, most of commercial wind turbines in the world operating at sites with the average wind speed higher than 5 m/s (El Bassam and Maegaard, 2004). In some parts of Indonesia, such as eastern part of Indonesia (East Nusa Tenggara (NTT), South Sulawesi, South-East Sulawesi) and South Coast of Java, and Karimun Jawa (MEMR, 2003 and ADB, 2003) wind speed is more than 5 m/s.. Currently, the utilization of wind energy is still limited; it is only around 6 MW. Generally, wind turbine is used for electricity generation, water pump, and battery charging particularly in rural areas (Green Energy Policy, 2003).

d. Hydropower

As an archipelago country with many mountains and rivers, Indonesia has a large potential of hydropower. Theoretically, the potential of hydropower throughout Indonesia about 75 GW scattered in 1,315 locations (MEMR, 2003), while the potential of mini/micro hydro is around 500 MW (DGEEU, 2005).

Basically, hydropower is divided in three categories, namely large scale, mini scale and micro-scale. Even there are no clear criteria for the classification[7], in Indonesia hydropower with capacity of more than 10 MW is classified as large scale hydropower, the capacity of 200 kW up to 10 MW is mini-scale hydropower, and the capacity of up to 200 kW is micro-scale hydropower (MEMR, 2003). Since large scale hydropower has many constraints- social and environmental, mini and micro-hydro seem more suitable than large one.

Micro hydropower has been operating hundreds years ago in Indonesia. This technology has been implemented for many purposes e.g. rice milling, coffee & tea processing, tapioka production, timber saw mills, water pumping, and electricity generation (ADB, 2003). Nowadays, a 50 kW pelton turbine built in 1892 still operates in the Patuah Wattee Tea Estate, West Java (ADB, 2003). With a total potential of 500 MW only 84 MW (about 17%) of micro-hydro resources has been developed particularly to meet energy need in rural areas

e. Geothermal

Geothermal energy can be used directly or indirectly. Directly use, particularly the geothermal resources with low heat, among others are for drying agricultural, spa and hot water pool for tourism, and sterilization of the media for mushroom plantation. Indirectly use, particularly the resource with high temperature can be utilized for generating electricity.

The potential of geothermal in Indonesia is located along Sumatra Island, Java-Bali Island, East Nusa Tenggara, West Nusa Tenggara, Halmahera and Sulalwesi Island. The total potential of geothermal in Indonesia is about 19,658 GW which of 5,331 MW situated in Java Islands, 9,562 MW in Sumatra Island, and the rest 4,765 MW spread in Sulawesi and other islands (MEMR, 2003). The utilization of geothermal for electricity generation is about 807 MW (4% of the potential).

Similar to other developing countries, the diffusion of renewable energy technologies in Indonesia is not smooth, some constraints of renewable energy development in Indonesia describe in the next part of this chapter.

[7] According to El-Bassam and Maegaard (2004), classification of hydropower by size are as follows:
- large scale : more than 100 MW (feeding into a large electricity grid)
- Medium scale : 15-100 MW (feeding into a grid)
- Small- Hydro : 1-15 MW (feeding into a grid)
- Mini hydro : 100 kW up to 1 MW (can be off grid or feeding into a grid)
- Micro hydro : from few hundred watts to 100 kW (off grid)

The Constraint of Renewable Energy Development

Some constraints hamper renewable energy development in Indonesia. Even this technology has been introduced more than three decades ago; the application of this technology is still limited. Some barriers can be described as follows (ADB, 2003; Cogen 2003, Hutapea 2005; UNDP, 2006).

a. Political commitment constraints

Although, some policies and regulations have been issued to promote renewable energy technologies, policymakers and planner are still reluctance to implement renewable energy technologies due to lack of knowledge on those technologies. Moreover, the awareness on energy sustainability is also still low. Nowadays, grid connection and off grid connection using diesel generator are still a favorite choice to policymakers/planner due to easier to establish and control.

b. Institutional and Policy Constraint

Some strategic policies have been formulated to promote renewable energy. However those policies, such as National Energy Policy, Green Energy Policy, are not translated to specific localized guidelines, rules, and regulations (UNDP, 2006). Therefore, local level is difficult to deal with the implementation of those policies. On the other hand, reluctance of planners and policymakers to change their old and existing ways and practices to new ones, as they are more comfortable with proven, well-accepted systems, notwithstanding the existing problems and costs of conventional energy systems.

Additionally, there is no integrated policy and program on promoting renewable energy that will direct coordination among institutions that are involved in renewable energy development (UNDP, 2006). Many institutions in national level have promoted renewable energy technologies in different ways that related to their own sector policies.

c. Financial Constraint

Most of renewable energy technologies have high investment cost but relatively low operating cost. Due to the high initial cost of renewable energy technologies result in high price of energy generated by renewable energy technologies. This price can not compete to fossil fuel (diesel, kerosene, and gasoline) since the fossil fuel gets subsidy from the government. Moreover the payback period of renewable energy power plant is longer than fossil fuel power plant. This condition causes renewable energy power plant are less attractive for investor. In addition, lack of financial incentives for market development and the apprehension of bank to renewable energy power plant also hamper renewable energy promotion in Indonesia.

d. Information Constraint

Dissemination of policies, regulation and technologies of renewable energy technologies is still limited. Lack of publication and documentation of success stories of renewable energy projects

result in renewable energy is not popular in society. Furthermore, inadequate information about data of renewable energy potential and renewable energy implementation result in the progress of renewable energy development is not clear. Even Ministry of Energy and Mineral Resource through Directorate General of Electricity and Energy Utilization has been established Clearing House[8] (as a pioneer is Mini/Micro-hydro Clearing House which will expand to become Renewable Energy Clearing House in the future) but the performance of this agency is still not optimal (UNDP, 2006).

e. Technology constraints

Technology of renewable energy has not been mastered fully by own local expert. Local manufacturing of renewable energy is still limited. Most of renewable energy equipment such as, solar panel and generator for micro-hydro power plant are still imported from abroad which result in high investment cost. Some parts of micro-hydro equipment such as turbine have been produced locally, but it is still limited.

The success of renewable energy development also depends on the ability of planner particularly local planner to develop local energy resources. Due to local autonomy, local government plays an important role in developing local energy resources. The lack of capacity of local government to promote renewable energy can be as a barrier in developing renewable energy. Moreover, rural communities also play an important role in renewable energy development, increasing their role in energy provision since at beginning (planning), implementation and evaluation can increase their awareness on the projects. Therefore, empowering rural community by training, transfer knowledge can significantly improve the ability of rural community, so they can manage and develop local resources in a sustainable way by themselves for their needs as presented in study cases. The next part will discuss rural electrification program in Indonesia.

4.4 Indonesian Rural Electrification

Geographically, Indonesia consists of 5 main islands and thousand small islands which are scattered in whole part of Indonesia. Based on national census conducted by Biro Pusat Statistik (Center Board of Statistic) Indonesia in 2000, around 58% of the Indonesian population still dwells in rural and remote areas.

Many rural and remote areas have not been interconnected by national grid due to physical and financial reasons. In 2004, rural electrification[9] in Indonesia is about 80.9%, indicates that 53,128 villages have been electrified of the total number 65,673 villages. However electrification ratio[10] until 2004 is only 53% (DGEEU, 2005) indicated that 47% of Indonesian

[8] Clearing house is established for providing information relating to renewable energy development and energy conservation as well as network among stakeholders.

[9] Rural electrification is the comparison of the electrified villages to the total villages, even there are not all household in the villages have been electrified.

[10] Electrification ratio is the comparison of the electrified households to the total household.

households have not been electrified yet. More than 75 million people have no access to electricity and 80% of them live in rural areas (World Bank, 2005). Nearly 1.3 million new connections annually will need to achieve the target of 90% electrification ratio in 2020 (World Bank, 2005).

Rural electrification program has been run for more than three decades in Indonesia. This program has been conducted by extending national grid for areas which are possible to reach by national grid and implementing decentralized energy system both based on fossil fuel (diesel generator) or renewable energy (solar photovoltaic, micro-hydro power plant and wind energy) for areas which can not be reached by national grid. However, due to the increasing of awareness on environment, limitation of fossil fuel reserve and increasing world's oil price, decentralized energy system by utilizing local energy resources can be as a good solution for the future rural electrification.

Energy accessibility plays a significant role to improve rural community welfare. Since funding from Government is limited, thus, strong collaborations among stakeholders (government, donors, NGOs, private sector, financing institutions, communities, etc.) is required to participate in providing rural energy services.

Moreover, due to local autonomy, nowadays, providing electricity in rural and remote areas is not only a responsibility of the central government but also the local government (province and local level). Related to the Government Regulation no. 3/2005 concerning on Electricity Supply and Utilization, the government is responsible for formulating the National Electricity Master Plan(Rencana Umum Ketenagalistrikan Nasional-RUKN) by considering the input from local government and society. Local government both provincial and district governments prepare and submit yearly proposal concerning on Local Electricity Master Plan (Rencana Umum Ketenagalistrikan Daerah-RUKD) to central government. Even the government has forced to use renewable energy for rural energy service, in fact, many provincial and district governments still rely on diesel generator for electricity provision due to their lack capacity in renewable energy technology and availability, flexibility and ease to acquire and operate of diesel generator (UNDP, 2006).

In general energy needs in rural/remote areas are still low, before discussing energy used in rural/remote areas, this research will illustrate Indonesian rural characteristic.

Indonesian Rural Characteristic

Characteristic of rural areas in Indonesia is diverse one to the others; however, some features are almost similar. This research focuses on Indonesian rural condition in general rather than focus on specific location of rural area. Physically, land use in Indonesian rural areas is dominated by agricultural and plantation purposes. Public infrastructures such as road, clean water, telecommunication, and electricity are relatively limited. Due to geographical condition, spatial location of village in Indonesia is distributed unevenly and villages are distance among others.

Socially, basic needs of rural people among others health service and education, have not been met properly. Low access to public service results in rural people trap in poor condition (GOI, 2004[a]) and left behind of urban areas. Furthermore, low access to education and job opportunities cause rural young people migrate to urban areas for continuing their study and seeking job. This condition results in rural areas lack of productive man power to develop their areas.

Economically, farming is the main economic activity in rural areas. Due to decreasing competitiveness of agriculture, young people have migrated to urban areas for looking other job opportunities; particularly in informal sectors because of relying income on agricultural sector can not meet their basic need (Indarto, 2006). Some of them who have better education are more attractive to be as informal manpower in abroad. In addition, off-farming activities in Indonesia rural areas are still limited low linkages between urban and rural areas result in lack of market of off-farming activities.

Based on this condition, providing infrastructure in rural areas is important to develop rural areas, poverty alleviation, and reduce the gap between urban and rural areas. Energy is one of infrastructures that is essential to support other development in rural areas. In addition, as mentioned in chapter 2, every area has local energy resources which can be developed to fulfill basic energy needs in this area. Decentralized energy system with small scale is appropriate to deal with unevenly distributed population and low density of population in Indonesian rural areas which have not been reached by national grid

Rural Energy Use

Data of energy used in rural areas is very limited because most of energy used in rural areas is met by non commercial energy such as biomass-fuel-wood and animal dung-, human and animal power. The use of biomass, particularly fuel-wood has negative implications on health and environment due to pollution produced by burning fuel-wood and deforestation. To decrease negative impact of the utilization of burning fuel-wood some efforts have been done such as promoting Improved Cook Stove (Efficient Stove) which can reduce the number use of fuel-wood and the amount smoke produced during cooking process.

Generally, energy in rural areas is used for household, public service and economic activities. Detail information is as follows:

a. Rural Households Demands

Energy demand in rural area is low. According to ADB (2003), the average daily per capita energy consumption in Indonesian rural households is about 25 MJ. Most of energy consumption in rural households is used for cooking (93%) and lighting (5%). Fuel-wood and biomass residue are a dominant energy in all rural households particularly for cooking. For lighting most of rural community use kerosene as energy source, however the utilization of kerosene has created problems in rural households. Most rural communities use typical kerosene lamps that emit black smoke. Moreover, the conversion efficiency (from oil to light) is very low (about 7%) and its light intensity is also poor (about 300 lumens) (ADB, 2003).

Some of rural families with better income can operate small diesel generator for providing electricity, however it is not a sustainable way. Moreover, limited access of transportation result in the price of kerosene and diesel-oil in rural and remote areas is not reliable. It can be as high as three folds compared to the official prices. Hence, rural communities do not get benefit from subsidy given for fossil fuel which actually purposed to help poor people. Regarding to this condition developing renewable energy technologies as local energy source can be more feasible economically in rural and remote areas.

b. Public Services

The most important public service facilities in rural villages among others are community health center, drinking water supply and street lighting. Some communities lack health infrastructure such as medicinal, vaccine, and drinking water supplies. In other villages, the required vaccines have to be transported every day from the closest hospital to the rural community health center (CHC, Indonesia: PUSKESMAS) or sub-health center by means of an icebox to keep vaccine alive (ADB, 2003). During monsoon or heavy rains, the supply is sometimes disturbed and damaged upon arrival at PUSKESMAS because of exceeding the hold-over-time of the icebox. Therefore, by developing local energy resources such as biomass or solar energy, community health center can be provided by refrigerator to keep some medicine and vaccine for community health.

c. Rural Enterprise and Economic Activities

As mentioned before, agriculture is the major economic activity in rural areas, besides fishery and small cottage industries in rural area. The typical energy needs of agricultural activities generally include land preparation/plowing, sowing, harvesting, post-harvest activities, and transportation. The use of mechanical devices has increased over the years, even the use of traditional energy sources, such as human and animal labor, traditional sun drying and burning agricultural residue, still continue to be the major energy inputs in agriculture. Human and animal labor is extensively used in land preparation, sowing, harvesting and transportation (ADB, 2003). Solar energy is the principal energy source for traditional crop drying.

Energy service is essential for agricultural businesses. Most of rural people need energy for treating their harvest such as rice, rubber, copra, coconut oil, tea, coffee, and cacao. Typical technologies applicable for agricultural businesses, may include among others integrated rice factories or rice milling units (RMU) using rice husk wastes, fermentation and drying facilities for cacao processing using solar in combination with biomass, and biomass furnace for tea drying (ADB 2003).

Cottage industries in rural areas, can be classified as agro-processing industries, such as manufacture of sugar, palm oil, plywood mill, sawmill, copra, tea and cacao, non-agro-processing industries, such as small- and medium-scale facilities for handicraft, brick-making, lime production, charcoal manufacture, etc. and shops and small-scale establishment. Due to the limited access for modern energy, fuel-wood is also the major energy source for rural Industries.

Based on discussion of rural electrification, rural characteristic and rural energy use, next part will elaborate the policies and institutional framework of rural electrification in Indonesia.

4.5 Policies and Institutional Framework of Rural Electrification

This section elaborates some policies to encourage renewable energy development and institution that involve in promoting renewable energy in Indonesia.

Energy Policy Framework

As mentioned previously, national oil reserve is limited; hence, the dependency on fossil fuel must be gradually decreased. Moreover, increasing environmental degradation-acid rain, and global warming-due to burned fossil fuel- also encourage the government to promote energy alternatives both renewable and non renewable energy which are cleaner than oil. The government has formulated some policies and regulations for diversification and conservation of energy to guarantee energy security supply in order to achieve sustainable development. In this research, this research only emphasizes on policies/regulations related to renewable energy development.

a. *The National Energy Policy*

The first Energy Policy was issued in 1976 (Yusgiantoro quoted in Sugiyono, 2004) intended to maximize the utilization of energy resources. In 1984, National Energy Coordination Board (BAKOREN)[11] published General Energy Policy (KUBE). This policy aimed at reducing high dependency on oil by developing non oil energy resources.

The General Energy Policy has been revised several times to accommodate some changes related to Indonesian development strategies. The first revised of General Energy Policy (1990) aim at energy intensification, diversification and conservation. In 1998, the second revised of General Energy Policy determined the five main policies, namely: energy diversification, intensification and exploration of energy sources, energy conservation, energy price, and environmental dimension.

Furthermore, in 2004 the General Energy Policy has been revised again and now known as The National Energy Policy 2003-2020. This policy is formulated by the government in conjunction with stakeholders in energy sector. The main policies in the National Energy Policy are almost similar to the previous one: intensification, diversification and conservation of energy with additional legislation and institutional instruments. The basic improvement in this policy is that policy has been shift from *supply side management* (SSM) to *demand side management* (DSM) which considering energy need from the demand side.

In general the National Energy Policy purposes to guarantee national energy supply, to increase the added values of energy sources, to manage energy sources in ethical and

[11] BAKOREN (Badan Koordinasi Energi Nasional) an inter-ministerial national energy co-ordination board. This board responsible for coordinating national energy program

sustainable manner, to provide an affordable energy for low income people and develop domestic capacities in the field of energy management. In specific, this policy promotes renewable energy for electricity with target of more than 5% of the total power capacity should be based on renewable energy in year 2025 (excluded geothermal and large scale hydropower[12]).

b. Green Energy Policy

Increasing awareness on environmental degradation and oil depletion encourage Government of Indonesia (GOI) to initiate renewable energy development and energy conservation program. In 2003 Policy on Renewable Energy Development and Energy Conservation known as Green Energy Policy has been launched. The purpose and objective of Green Energy policy is to realize sustainable energy supply and utilization in order to support sustainable development. This policy concerns with programs to maximize utilization of renewable energy, to increase energy utilization (both renewable and non-renewable) efficiently, and to increase public awareness and behavior in energy efficiency.

c. Distributed Small Power Generation

Economic crisis attacking Indonesia since 1997 results in the government should reduce budget for infrastructure establishment including energy infrastructure. However energy demand increase every year. State Owned Electric Company can not meet this demand. On the other hand electricity has a big contribution in improving quality life of community. To increase electrification ratio, particularly in rural areas, Ministry of Energy and Mineral Resources issued Ministerial Decree no. 1122.K/30/Mem/2002) concerning the Small-Scale Distributed Power generation utilizing renewable energy sources, which is called "*PSK Tersebar*" (GOI, 2002). The main objective of this policy is to promote renewable energy development by involving private sector, particularly small scale enterprise, and community in energy provision. The capacity of power generation is limited under 1 MW. Electricity produced by this scheme can be interconnected to existing grid. This policy obliges PLN to purchase the electricity generated by renewable energy sources.

d. Geothermal Law

Law No. 27/ 2003 on Geothermal (GOI, 2003) regulates the management and development of geothermal energy sources both as commodity and energy sources for direct and indirect utilization (electricity generation). It also regulates licensing based on activities phases and/or total project by the central government and regional administration, acting according to their respective authorities.

f. Regulation on Electricity Supply and Utilization

Government Regulation No. 03/2005 (GOI, 2005[a]) concerning on Electricity and Utilization Supply determines that electricity provision will be met by using local energy resources with

[12] In this policy, the target of renewable energy development is emphasized on utilization small scale power plant generate from solar, wind, micro-hydro, and biomass.

the obligation to prioritize the utilization of renewable energy for power generation. Furthermore, this regulation also determines that Central Government and Local Government (Province and District level) will endow budget for establishment electricity infrastructure for poor people, undeveloped area, remote area, border area and rural electrification

Institutional Framework

Government of Indonesia is responsible for electricity provision through State Owned Electric Company (PT. PLN). To improve the electrification ratio, PLN has extended existing transmission and distribution networks to rural areas which are not possible technically and economically to reach by national grid, particularly in outer islands of Java-Bali (JICA, 2003). Electricity Law No 15/1985 (GOI, 1985) stipulates the requirement for ensuring the supply of electricity through state-owned electric company (PLN) as the holder of electricity enterprise authorization. Furthermore, Government Regulation No. 3/2005 sets the basis for supply and utilization of electricity.

For a long time, PLN was the driving force behind urban and rural electrification. Nowadays, approximately 53% of the villages in the country have not been electrified, representing 80% of the villages on Java and 20% on the other islands (DGEEU, 2005). However, the situation has radically changed since the start of the financial crisis in 1997. PLN is no longer in a financial position to undertake further investment in rural electrification and the Government is not able to support these activities through state budgets. In fact, PLN has abolished its division for rural electrification because of lack of resources to continue with the rural electrification program. PLN is required by the Government to cut investments and reduce costs. Consequently, over the last few years the growth of rural electrification has been minimal.

Besides PLN, there are many institutions - government institutions, non government organizations (NGOs), donor agency- play an important role in promoting renewable energy and rural electrification program in Indonesia.

Government Institution

Many Government institutions have been involved in renewable energy development in Indonesia with different role. The key players from the government are as follows (Cogen, 2003; JICA 2003):

a. BAPPENAS (National Development Planning Board - Bureau for Electricity, Energy Development and Mining): it prioritizes renewable energy projects, special rural electrification projects, determines (level of) government support, and appoints government project partners.

b. BAKOREN (National Energy Coordination Board): an inter-ministerial national energy co-ordination board, this is the energy policy and decision making agency in Indonesia; it co-ordinates the national energy program.

c. MEMR (Ministry of Energy and Mineral Resources): the main actor of the ministries in BAKOREN, this is the supervisor of the state-owned utilities and energy service companies.

d. DGEEU (Directorate General for Electricity and Energy Utilization): the main actor in the field of fossil and renewable energies, DGEEU also chairs the rural electrification Steering Committee which is responsible for the insurance of inter-agency co-ordination and co-operation in matters related to the government's rural electrification program

e. Ministry of Public Works : responsible for hydropower power resource surveys and, in a few cases, the operation of hydropower plants.

f. SMOC/SME (State Ministry of Cooperatives and Small Medium Enterprises): responsible for enhancing the role of co-operatives in rural electrification, and in some cases initiator of electrification projects.

g. Directorate General of Local Development, Ministry of Home Affairs: which is also concerned with rural electricity development. The institution is responsible for co-ordination for rural electrification projects with provincial, district and village authorities and for providing regional development funds.

h. State Ministry of Research and Technology, among others BPPT (Agency for Assessment and Application of Technology), LIPI (Research Indonesian Institute of Sciences), LAPAN (Indonesian National Institute of Aeronautics and Space): responsible for carrying out research and assess the viability of new and improved technologies for all types of energy including renewable energy.

Non Government Organization

Non Government Organizations (NGOs) such as Yayasan Bina Usaha Lingkungan (YBUL), IBEKA, Pelangi, PPLH has a big contribution in renewable energy promotion in Indonesia. They role particularly are for empowering and assisting rural people to develop local resources. Moreover, they also can be as a mediator for finding supporting fund and technical assistance from donor agency.

Donor Agency

Donor agencies dominated by foreign company among others World Bank (WB), Asian Development Bank (ADB), Global Environment Facility (GEF), GTZ, etc, play an important role in providing fund and technical assistance for developing renewable energy in rural areas in Indonesia.

After discussing policies and institutional framework of rural electrification in Indonesia, next part of this chapter will describe the implementation of Indonesian's program on decentralized energy system.

4.5 Indonesian's Program on Decentralized Energy System

As stated before, decentralized energy system based on local energy source (renewable energy) seems promising to meet energy need in rural and remote areas. Remote communities which have low demand on energy and scattered in large areas are often ideal sites for many renewable energy exploitations due to higher costs of providing conventional energy in those areas (ADB, 2003). Moreover, renewable energy technologies provide long-term benefits in terms of lower operating costs and reduced environmental pollution.

Currently, renewable energy technologies that have implemented widely for electricity generating in Indonesia is small-scale hydropower (micro-hydro) and solar photovoltaic The programs related to decentralized energy system based on renewable energy which have been implemented are rural pre-electrification and distributed small scale generation

Rural Pre-electrification

Ministry of Energy and Mineral Resources on January 23, 1998 published Ministerial Decree no. 064.K/40/M.PE/1998 concerning the rural pre-electrification program utilizing photovoltaic and micro. The objectives of the rural pre-electrification program are to:

(i) provide electricity for remote areas which have no access to national grid and demand for electricity is considerably low and the people are scattered ;
(ii) utilize the locally available energy sources i.e. solar photovoltaic and micro hydro;
(iii) improve the living conditions of the people and provide and equitable access to electricity without having to purchase the power generating plants and the network;
(iv) optimize the limited financial resources provided by the GOI for rural electrification program; and
(v) accelerate rural electrification program

The generating power capacity considered in this program is up to 200 kW (ADB, 2003). The costs for the engineering, procurement and construction are financed by the government in utilizing the development budget allocated for PLN.

Distributed Small Scale Generation

To encourage public participation in energy provision, GOI has issued Ministerial Decree No. 1122 K/30/MEM/2002 concerning on the small distributed power generation. This policy creates opportunity for small scale enterprise to involve in energy provision which is generated by renewable energy resources. PLN is obliged to purchase up-to 1 MW electricity generated using renewable energy sources by small scale enterprise. This initiative represents a major step in the removal of one of the largest barrier to small renewable power development by small scale enterprise and increases the share of renewable energy sources in electricity supply.

The implementation of Distributed Small Scale generation as follows (DGEEU, 2007):

i) Micro Hydropower Power Plant (MHPP) which has been interconnected to national grid :
   - MHPP Kalimaron East Java (30 kW)
   - MHPP Curug Agung, West Java (11 kW)
   - MHPP Waikelosawah, Sumba Timur, (14 kW)
   - MHPP Cinta Mekar, West Java (100 kW)

ii) Micro Hydropower under processing to be interconnected to national grid :
   - MHPP Dompyong Jatim (20 kW)
   - MHPP Santong Lombok Barat (15 kW)
   - MHPP Kalumpang (700 kW)
   - MHPP Lab. PLN JTK Cipayung (250 kW)
   - MHPP Anggrek Mekarsari Sumbar (1000 kW)

The last part of this chapter will illustrate two case studies of decentralized energy system in Indonesia which have been successful to increase energy accessibility in rural/remote area and improve social economic condition of the villagers

4.7 Case Studies of DES based on RE in Indonesia

Some DES projects which have a good management and well rural communities empowerment have been successful for improving rural communities' life. This research chooses Kalimaron Micro hydropower Plant in Seloliman Village, East Java Province and Oeledo (Wind-PV Hybrid-Diesel System), in Rote Island, East Nusa Tenggara Province as case studies to support the research.

The selection is based on the successfulness of both projects to meet energy need in rural/remote area and improve living standard of village communities by creating some job opportunities. Furthermore, community empowerment also has been conducted as well in both of the projects. Rural communities have been opportunities to manage and organize the projects by themselves. This effort results in the sustainability of the projects.

Seloliman and Oeledo have different energy potential resources. Seloliman village is located in hilly area and surrounded by forest area. Due to the nature of this location, local energy resource which exists and be potential to develop for generating electricity is river flow. Kalimaron, a river that passes through the village has a good potential to be harvested for generating electricity in certain capacity. Therefore, micro hydro power plant is established in this area to fulfill local energy needs. While, Oeledo Village, located in small island, has a good potential of wind and solar energy. Oeledo was selected by E7[13] as a pilot project for hybrid system of Wind–Photovoltaic hybrid system. To support the continuously power of this system diesel generator is installed as a back unit.

[13] E-7 is a group of eight leading electricity companies from six G7 countries established in 1992. The mission of this group is to examine and cooperate on major global electricity-related issue, with emphasis on the global environment and sustainable energy development. The countries of E7 are France, Italy, Canada, Japan, Germany, and United States

In the first case, the energy source is single; however in the second case the sources used are combination of some resources which are integrated to fulfill local demands. In the second case planning to determine which technologies will be implemented that meets the desired needs become more complex.

Kalimaron Micro Hydropower Plant (MHPP), East Java Province

Overview of the Project

In general, almost all rural areas in East Java Province have been electrified. Rural electrification of this province until 2004 was 98.59% (DGEEU, 2005). Some Rural areas which can not be reached by PLN have been electrified by decentralized energy system both generated by diesel generator and renewable energy technologies among others solar photovoltaic and micro hydropower plant.

Kalimaron Micro hydropower plant is one decentralized energy system implemented in East Java. Kalimaron MHPP is located in Seloliman Village, Trawas Sub District, Mojokerto District, East Java Province. Figure 4.3 show the location of Mojokerto District. This village is occupied by 6,000 inhabitants who are generally farmers, small-scale traders, craftsmen, and unskilled labors. The village is passed by Maron River (Kalimaron) which has flow about 300 liter/second and Janjing River.

In 1994, the village which consists of 4 hamlets (Binting, Sempur, Janjing and Balekambang hamlet) has been reached by national grid. Unfortunately Janjing hamlet occupied by 35 households can not be electrified by national grid due to low demand and physical constraints-remote area and lack of other infrastructure particularly road (Suroso, 2006).

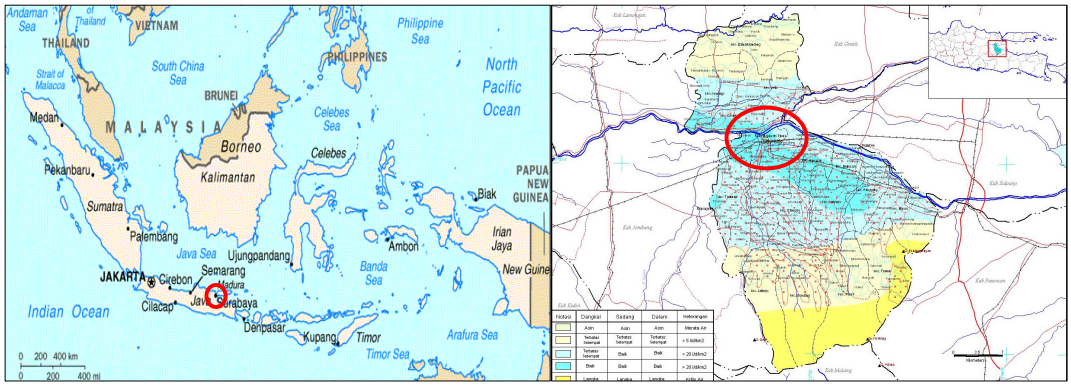


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Figure 4.3 Location of Mojokerto, one of districts in East Java

Pusat Pendidikan dan Lingkungan Hidup-Environmental and Education Center- (PPLH) that has base activity in that area initiated to build Micro hydropower plant to meet energy need for Janjing hamlet. The construction of Kalimaron Micro hydropower plant (MHPP), the capacity of 10 kW, finished in 1994. This project was supported by Germany Embassy through Small

Project Fund and technical assistance providing by Miny-Hydro Power Project (GTZ). At that moment the management of MHPP Kalimaron was handled by PPLH but the monthly payment for maintenance was determined by the villagers.

According to the increasing demand of electricity- particularly for small industry-, the capacity of MHPP Kalimaron is no longer enough to meet villagers need. Due to the high potential of Maron River, MHPP Kalimaron has been upgraded to the capacity of 25 kW in 2000. Global Environment Facility (GEF) through Yayasan Bina Usaha Lingkungan- Foudation for Environmental Development (YBUL) supported funds for this project while technical assistance is supported by Mini-hydro Power Project, GTZ.

Due to the power produced by MHPP Kalimaron exceeds the demand of the villagers, Paguyuban Kalimaron, an organization built for managing the facility of MHPP Kalimaron, proposed to interconnect this project to national grid in 2002. The proposal was supported by Directorate General of Electricity and Energy Utilization. In 2003 MHPP Kalimaron has been interconnected to national grid under the regulation of Distributed Small Scale Power Generation (PSK Tersebar). This project is a pioneer for the implementation of Distributed Small Scale Power Generation. In this scheme, villager use electricity generated by MHPP Kalimaron and the exceed power is sold to PLN.

Key Actors in Kalimaron Micro hydropower Plant (MHPP)

Several actors with different role have been involved in this project. The role of each actor is as follow:

a. PPLH (Pusat Pendidikan Lingkungan Hidup-Evironmental Education Center) Seloliman is an initiator and facilitator of this project.
b. Germany Embassy and Global Environment Facility – Small Grants Program (GEF-SGP) are donor agencies who provided funding for the project and Mini Hydro Power Project (MHPP)-GTZ , Germany conducted technical assistance for the project.
c. Central Government and Local Government. Ministry of Energy and Mineral Resources through Directorate General of Electricity and Energy Utilization as a facilitator and mediator for interconnecting MHPP Kalimaron to national grid. Local Government of Mojokerto who has support and facilitate the process of interconnecting MHPP Kalimaron to national grid (grid of PLN).
d. PLN who has cooperated and was involved directly in the technical process of the interconnecting to grid system.
e. Yayasan Mandiri and PT. Heksa Prakarsa as contractor for Micro hydropower Plant Manufacture. They provide equipment which can be produced locally.
f. *Janjing Hamlet community*. Acting as local resources, Janjing community contributes mainly on human resources in Micro hydropower plant. Their commitment is one of the key parts in the success of this initiative (Suroso, 2006).

Implication of the Kalimaron MHPP

In general, this project has improved the quality life of people in Janjing hamlet. MHPP Kalimaron not only provides lighting for Janjing hamlet but also create job opportunities. According to sustainable development next to the energy aspect, following are the benefit of this project socially, economically, and environmentally.

- ***Social aspect***

Direct impact of this project is 40 households in this hamlet nowadays have more access to information and education which positively enhance the capacity knowledge of villagers, particularly young generation. Some cottage industries are developed to increase villager's income. In addition, electricity produced by micro hydropower plant is clean which can escape women and children, who spend a lot of time at home, from the problem of respiratory infection due to the use of kerosene and fuel-wood.

- ***Economic aspect***

The economic benefit of Kalimaron MHPP is as follows (Suroso, 2006):

- The Micro hydropower Plant Kalimaron has created job opportunities for the youth in Janjing village. Five young men has been employed as well trained team to ensure constant electricity supply. Each of the them has been paid Rp. 350,000,- /month (equivalent to US$ 40/month[14]). In addition, these teams and other communities who are involved in educational and environmental program providing by PPLH also will get additional income Rp. 25,000 (US$3)/person per day of activity.

- The Micro hydropower plant has created productive industries such as the recycled paper production managed by the women organization called *Sempedu Care*. Market of this paper covers local domestic vendors and Switzerland Company. This activity has generated additional income for the women. MHPP Kalimaron is also utilized for kapok blower industry to produce local mattress.

- Interconnecting the exceed power -12 kW- of Kalimaron MHPP to national grid give added value for Janjing community. Regular collective income can reach up to Rp. 4 million/month (or equivalent toUS$ 450).

- ***Environmental Aspect***

In general, the positive impacts of this project to environment is increasing people awareness to preserve the forest surrounded their hamlet. Now they realize, by protecting forest the sustainability of water can be maintained so Kalimaron MHPP can operate as well. Furthermore, since 2004 MHPP Kalimaron can generate electricity about 230.000 kWh/year. It means that Kalimaron MHPP can safe diesel oil around 69,000 liter diesel oil per year if power produced by diesel generator. Emission of carbon dioxide can be reduced more than 200 ton/year (MHPP Entec, 2004)

[14] US$ 1 ≈ IDR 9000,-

How Rural Community Involved in the Kalimaron MHPP

Key success of Kalimaron MHPP initiative is direct involvement of community in this project. The first initiative to harness water flow of Maron River for producing electricity comes from PPLH. At the beginning, villagers were not interesting on this initiative, because the villagers are doubt of the successfulness of this project. Intensive communication and interaction are conducted by PPLH to convince villagers about the project. The information about renewable energy technologies and environmental protection is disseminated to the villagers through traditional events and local meeting until they believe and agree to utilize water flow of Maron river to produce electricity.

During the construction, rural community also actively include in the civil construction of the project. They do it together (*gotong royong* -one of Indonesian culture). After construction rural community is involved in the management of the project. They were asked to arrange how monthly payment is determined and who will responsible for that. Paguyuban Kali Maron (Local Based Organization) was built to manage and organize the daily activity of Kalimaron MHPP.

The role of women is also considering for the success of the project. During the village meeting, women were involved as stakeholder in the Kalimaron community cooperative and in the implementation of the project. Education on waste management and water conservation through re-greening and medical plants activities uses the relevant knowledge of women, especially the elders, to link between the traditional wisdom of biodiversity resources conservation.

Kalimaron micro hydropower plant has been changed rural community life in Seloliman Village. This project has been successful in providing electricity to fulfill communities' needs and improving rural communities' life. This project also provides side benefit for Seloliman Village, since the exceed power generated by Kalimaron MHPP has been connected to national grid, village gets additional income from power selling. This project also shows that rural communities have been involved in the project since at beginning (planning), implementation and operation. Capacity building of rural people was conducted as well. Villagers have been empowered by providing training for technician and the member of Local Based Organization (Paguyuban Kalimaron) who will organize and manage daily operation of Kalimaron MHPP. Regularly meeting also conducted to increase rural communities awareness on environmental protection, particularly forest, to ensure the sustainability of Kalimaron MHPP.

Oeledo (Wind-PV Hybrid-Diesel System), Rote Island, East Nusa Tenggara Province

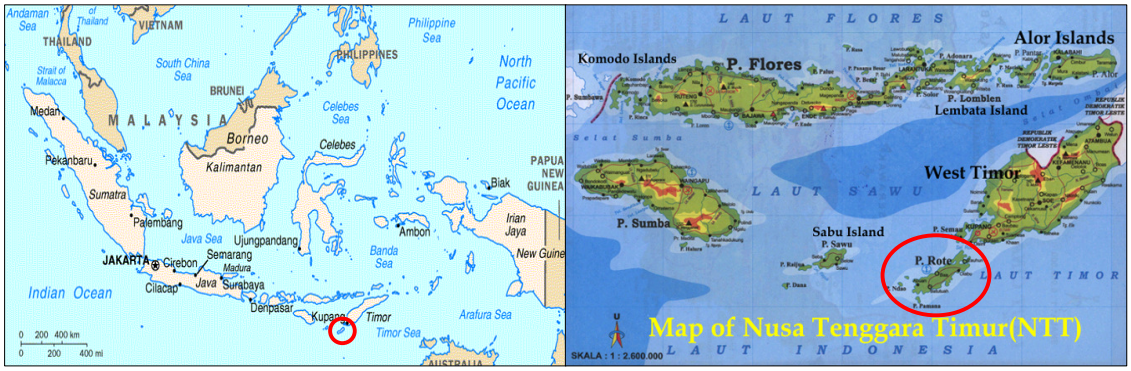
Overview of the Project

Oeledo village is situated in Rote island one of 566 islands[15] in East Nusa Tenggara Timur Province (Bappenas, 2006). The village is one of undeveloped villages and very remote area. Undeveloped and poverty become the major issue since the Rote Island lies in border area. The

[15] Based on data from http://kawasan.bappenas.go.id/k_perbatasan/data_batas/bukurinci_ntt.pdf (accessed on 19 June 2007)

location of Rote Island is presented in Figure 4.4. Until 2004, rural electrification in Nusa Tenggara Timur (NTT) Province was 41.26% (DGEEU, 2005). The number of village in NTT Province is 1,060 villages, it means that more than 500 villages have not been electrified.

Nusa Tenggra Timur has a large potential of renewable energy, notably solar and wind energy. Average wind speed in NTT is the highest in Indonesia. It can be reach more than 5 m/s. In 1998, E7 within the framework of the UNFCCC (United Nations Framework Climate Change Conventions) as an Activity Implemented Jointly (AIJ) was recognized by GOI to build some renewable energy projects in rural and remote areas. Oeledo one of remote areas in Rote Islands, NTT Province was selected by E7 for implementing hybrid system, with the combination of 22 kW PV, 10 kW wind and 20 kW back-up diesel generator. One wind turbine 10 kW, 256 modules and one diesel generators have been installed to deliver electricity in average of 48 kWh/day to 120 households.



Source : : http://www.columbia.edu/cu/csis/Indonesia_map.gif (accessed on 10 June, 2007)
http://www.goseentt.com/Photos/NTT%20map%202.jpg (accessed on 10 June, 2007)

Figure 4.4 Location of Rote Island

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Key Actors in the Oeledo Hybrid System

The main actors in implementing renewable energy hybrid system in Oeledo villages can be described as follow:

a. Yayasan Womintra is non government organization who acted as facilitator and mediator among donor agency, the government and rural community. This NGO also conducting some activity to empower rural community.

b. E7, who provided budget and direction to develop a new sustainable and decentralized management concept for rural electrification
c. Government and local government play an important as a facilitator of the project.
d. Local community as beneficiaries who were involved during the construction and daily operation of the project.

The Implication of the Oeledo Hybrid System Project

The project has changed the village performance from isolated and poor village become more modern village. The economic activities are starting to grow and the quality life of people is improving. Following are the benefit of this project socially, economically and environmentally.

- ***Social Aspect***

The utilization of renewable energy makes sense for improving community welfare in Oeledo. Previously, villagers use candle and kerosene for lighting. Nowadays they can use electricity from renewable energy which is cleaner than kerosene and candle for lighting. They also can listen to the radio and enjoy TV program. Teenagers can study longer at night. Electricity also utilized for public service such as worship facilities and street light.

- ***Economic Aspect***

This project has a significant effect on improving economic condition of the villagers. Some new job opportunities have been created by the existing of electricity. It makes the Oeledo more interesting and also decreases the desire of rural people to do migration for looking the job in the cities. Before the new job, their main occupation in agriculture, livestock, and handicraft activities can be continued as before even better. Economic activities like wood carving and threading for weaving now can be extended into the night. In 1998, income per capita of Oeledo community is about US$ 9/month, however, in 2003 their income per capita are increase to $ 35/month in average (Kompas, 2003).

- ***Environmental aspect***

The utilization of hybrid system can be meet electricity needs of 120 households in Oeledo. Currently, the system can supply electricity around 22 MWh/year with the reducing CO_2 around 24 ton/year however the maximum produced power can be extended until 44 MWh/year for the future (DGEEU, 2007).

How Rural Community Involved in the Oeledo Hybrid System.

Rural communities have been involved before the project was started. They were informed about the objective of the project through village workshop and neighboring discussion. During the construction the local manpower is involved in civil construction of the project. The villagers were also following training session conducted by representative of E7 in Kupang,

NTT to enhance their knowledge about renewable energy technologies and increase community acceptance.

The gender issues were of particular interest in the way decisions are taken and respected. Special attention was paid during the entire implementation to address this issue the appropriate context in order to avoid gender-related discrimination. In addition, house installation was mostly made based on the recommendation provided by women.

To manage the Oeledo hybrid system, PLD (Pengelola Listrik Desa) a village based management unit has been established. This unit is organized by local community, they are responsible for managing administration and providing technical assistance after construction. The members of PLD were elected by local community with the assistance by the NGOs. Technicians from PLD were trained to increase their capacity in the operation and maintenance of hybrid system. Theoretical material and Operation and Maintenance manual were supplied to the technicians (PLD members) in Indonesia language.

Oeledo hybrid system also shows positive impact of local energy development. Differ from Kalimaron MHPP power plant, planning for established Oeledo hybrids system comes from the outsider. But rural communities have been informed as well about the planning, and they were involved in the implementation and operation of the project. Empowering rural communities also conducted as well by Yayasan Womintra.

Both cases show that a NGO plays an important role in developing local energy resources. They not only can be as a mediator for getting fund but also play an important role in empowering rural communities.

Next chapter will provide analysis related to goals, planning approach, institutional mechanism and participative approach in rural electrification. Some strategies also discuss to encounter the constraints in developing decentralized energy system based on renewable energy.

CHAPTER 5
THE ANALYSIS OF DECENTRALIZED ENERGY SYSTEM

As mentioned in chapter 2, decentralized energy system can be a solution to increase energy accessibility in rural and remote areas which can not be reached by national grid. Local energy resources based on renewable energy are reliable to meet rural energy needs. In social-economic aspect, increasing energy accessibility in rural areas is expected can stimulate productive activities which can create job opportunities and improve community welfare. While in environmental aspect (global, national and local), the use of renewable energy can protect our ecosystem from air pollution, which also can reduce health risk, and deforestation.

Energy is believed as a key element to attain poverty eradication, better education, improved health, and environmental sustainability (UNMD, 2000). Therefore, rural electrification program is not only deal with how to bring electricity to rural/remote areas but also how to deal with poverty eradication, environmental degradation, and other social-economic problem such as increasing accessibility for health and education service, and creating job opportunities. These problems are different locality to locality which make that planning becomes more complex and needs a different approach to solve those problems. Therefore, technical approach (traditional planning), associating with single problem, might not be suitable to cope with multiple problems (de Roo, 2003) in rural areas.

Although providing energy infrastructure based on local energy resources has been recognized as a solution for poverty alleviation and environmental degradation, in practice developing local energy resources particularly in Indonesia face some obstacles as mentioned in chapter 4. The next of this chapter will discuss and analyze rural electrification goal, planning approach for rural electrification, institutional mechanism for rural electrification, participative approach in rural electrification, and constraints and strategies to increase the implementation of DES based on RE.

5.1 Rural Electrification Goal

In the past, rural electrification program in Indonesia adopted a top-down approach, because rural electrification is fully responsibility of the central government. Unfortunately, some evidences showed that this program was not successfully implemented. Although rural electrification ratio has been increased from 37.6 % in 1990 to 80.9 % in 2004 (DGEEU, 2005), it has had not a significant impact on poverty alleviation. Because rural electrification program was done without taking into account the benefit for improving living standard of people and environmental consideration. Most of rural electrification programs more emphasize on providing infrastructure to increase rural electrification ratio without considering electricity utilization for productive use and environmental implication due to the energy use. Although renewable energy technologies have been promoted to electrify rural and remote areas, technology transfer was more focused on dissemination and introduction a new technology (ADB, 2003)

Decentralized energy system based on diesel generation still dominated in rural electrification program in Indonesia, because this system is easier to build and control. Compare to micro hydropower plant which has a high location bound, this technology cannot be developed in every where. It needs a good planning and well preparation, such as potential survey of resources, demand survey, appropriate design off equipments, community preparation for operational and maintenance, etc. Furthermore, micro hydropower plant also has high dependency on natural condition, such as water debit will decrease in dry season or due to forest degradation. Therefore, planning for decentralized energy system based on RE is more complex compare to DES based on diesel generator, because planning might integrated with other sector not only on improving living standard of community but also environmental quality.

Nowadays, rural electrification goal should be associated with sustainable development – considering on economic, social and environmental aspects. Economically, rural electrification should encourage economic growth in rural/remote areas. Energy services are expected can support the economic activities in both farming and off-farming. Transformation process from traditional to modernization can be accelerated by increasing energy services in rural/areas. In case of Seloliman Village, currently, villagers can utilize electricity for kapok blower. It makes their work easier than before and can increase the number of mattress production with better quality compare to traditional way. Consequently, the villagers can increase their income by energy services and decrease migration of younger people from rural to urban areas due to looking for the job opportunities.

Socially, energy services might increase living standard of rural community and alleviate poverty. Increasing electricity access in rural/remote areas can remove rural/remote areas from the remoteness and isolated condition. Teenagers can study at night longer than before which expected can improve their education level. Electricity makes access to media (radio and television) much easier and cheaper than the use of car batteries. Health risk due to pollution emerging by utilizing kerosene for lighting can be reduced by utilizing electricity generate by RETs and Community Health Center can be equipped by refrigerator to keep medicinal material that support rural/remote healthy.

Environmentally, rural electrification should not have negative implications for environment. Energy services based on fossil fuel can eradicate the quality of our ecosystem. Air pollution increases due to the increasing of green house gas emission. Therefore, electricity supply should be provided in sustainable manner. Decentralized energy system based on renewable energy is a good alternative to meet requirement of sustainable development. Because renewable energy is a sustainable resource and has less environmental impact compare to fossil fuel.

To get optimal benefit of this program, rural electrification should be integrated with other development in order to reduce poverty, increase job opportunities, decrease environmental degradation (pollution and deforestation) and to improve quality of life of rural people. As argued by Rosario (2002):

> *"We have focused on energy supply as a poverty alleviation tool but it has to be noted that energy alone will not be enough. Recent information indicates that rural electrification by itself will not reduce poverty. Energy supply works best in conjunction with other basic infrastructure, and particularly when their confluence enables and supports local business and employment opportunities. Without these parallel infrastructures, energy supply becomes a luxury that the poor cannot afford.*(Rosario, 2002)

It is clear that to achieve multiple goals of rural electrification program, energy development might be integrated to other rural development in rural/remote areas such as, economic development, transportation, health, education, etc. Consequently, a specific approach is needed to cope with this. The next discussion focuses on planning approach for rural electrification in rural/remote areas.

5.2 Planning Approach for Rural Electrification

As mentioned before, top-down approach in decision making which more emphasize on technical approach is no longer suitable to cover the complex issues in rural areas. Diversity of conditions and problems in rural/remote areas can not be solved by generalization method. Every local area might be handled by a specific approach. Hence, bottom-up approach which more emphasize on participative approach in decision making can be a solution to encounter these problems.

Related to planning-oriented action, the changes of planning approach in rural electrification has been summarized in Table 5.1 and Figure 5.1.

Tabel 5.1 Planning-oriented action in Rural Electrification

Planning oriented	**Centralized Energy System**	**Decentralized energy system based on RE**
Goal	• Increasing rural electrification	• Increasing rural electrification • Creating job opportunities • Poverty alleviation • Improving living standard of community • Environmental Protection
Decision Making	Technical approach-top down approach (on-grid system)	Participative approach- bottom up approach (off-grid system)
Institution	Government (single actor)	Share governance - Government/NGOs/Donor Agency/Financial Institution/RE Manufacture/Community (many actors involved)

According to Table 5.1, in centralized energy system, planning issue associates with single goal. Here, the planning issue is rather simple. Technical approach can be used to solve the problem and actor involvement is limited. Meanwhile, in decentralized energy system, planning issue associates with multiple goals and wide diversity of problems in rural/remote areas. Hence, planning issues become complex even very complex, as shown in Figure 5.1, depend on the complexity and diversity problems in rural areas. For instance in the case of Oeledo hybrid system, planning becomes more complex than Kalimaron MHPP because hybrid system should consider the integration of some resources which need specific approach on technology. Although both systems are complex in point of view the goals in achieving sustainable development but Oeledo hybrid system become very complex because planner should take into account not only multiple goals but also multiple resources.

To solve those complex/very complex issues, participative approach (bottom-up approach) is needed. Involving many actors in rural energy planning, included rural community, are expected can bring a good solution to solve the real problems in rural/remote areas.

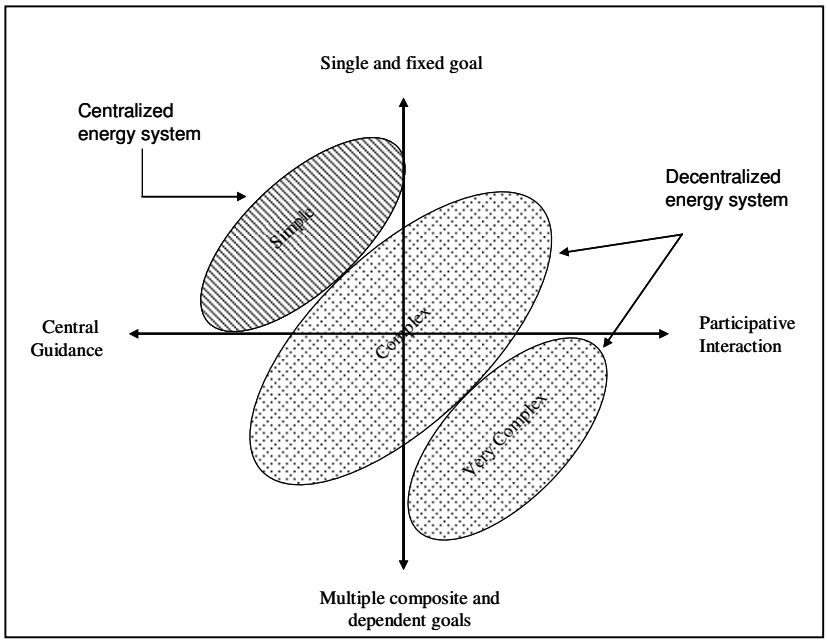

Figure 5.1. Framework for planning-oriented action based on complexity of rural electrification problem

Furthermore, planning not only relates to what kind of technologies are suitable to be implemented in those areas, but also might consider how to link energy services with economic, social and environmental development. Therefore, energy planning should integrate to other development, because as mentioned before, energy itself can not solve the complex problem in rural areas without integrating to other sector. Consequently, the rural energy planning might be shifted from centralized to decentralized system. Thus, local governments have more authorities to manage their local resources.

Shifting Paradigm in Rural Energy Planning

The implication of the shifting rural energy planning approach from centralized to decentralized rural energy planning, among others, are shifting decision making process from *top-down* approach to *bottom-up* approach, planning more emphasize on process rather than product such as a plan document and institutional change because many actors will involve in rural energy planning, (Clayton et al, 2003). The shifting of rural energy planning is presented in Figure 5.2.

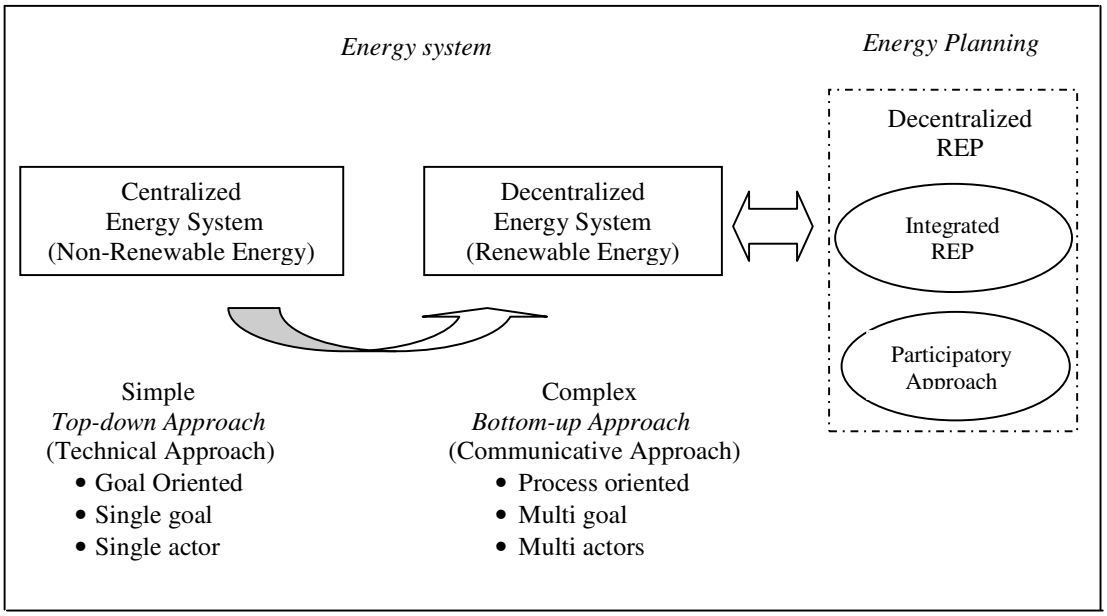

Figure 5.2 Shifting of Rural Energy Planning (REP)

As mentioned in Chapter 2, to support decentralized energy system based on renewable energy, rural energy planning might be decentralized, integrated to other sectors and need participative approach (WEC, 1999; Neudoerffer et. al., 2001, El- Bassam and Maegaard, 2004). Following part of this section will discuss decentralized energy planning and integrated energy planning. While participative approach will discuss in separate section.

Decentralized Rural Energy Planning

Before discussing decentralized rural energy planning, it is better to know what the basic idea of decentralization is. There are many definitions of decentralization. Rondinelli, et. al (1981) defined decentralization as *"the transfer of responsibility for planning, management, and resource-raising and allocation from the central government to (a) field units of central government ministries or agencies; (b) subordinate units or levels of government; (c) semi-autonomous public authorities or corporations; (d) area-wide regional or functional authorities"* .

Furthermore, related to decentralized rural planning, Goldman (1998) mentioned that "*decentralizatio*n *appeared to offer a locus for integrated rural development, an institution to deal with it (local government), and the potential for downsizing central government and promoting good governance".* In policy point of view, decentralization refers to transfer of authority from central government to local government to manage and organize administrative system autonomously. Here, local governments have more opportunities to develop and manage their resources to meet their needs.

As mentioned in Chapter 2, to increase energy accessibility, availability and acceptability in rural area, rural energy development must be decentralized and rural people manage local resources (El-Bassam and Maegaard, 2004; WEC, 1999). For that reason, planning is formulated by local level and rural communities are involved in planning process. A key factor of involving local level and community is to ensure that the priorities and needs of the future users are well reflected in the development plans. Rural communities are the beneficiaries of rural electrification program, so this program should be appropriate with their needs and their priorities. To ensure that the program is suitable to rural communities, they must participate in planning process. At this point, the role of institution in micro level should be strengthened to give more opportunities for rural communities to contribute in formulation plan. Furthermore to get optimal benefit of rural electrification, rural energy planning should be integrated to other sectors, because energy development is interdependence to other sectors.

Integrated Rural Energy planning

Energy planning is important not only to formulate energy supply and demand for the future but also to choose energy technologies which will be suitable for meeting energy needs. Basically, energy planning is associated to the establishment of goals, policies, and procedures regarding to the supply and demand of energy in the future (Beeck, 2003). Energy planning at local and global level should be conducted carefully to get the long term benefit because energy choices have severe and long term impact on a society Burkhardt (2002).

A good energy planning is needed to provide reliable and affordable energy in a sustainable way in rural areas. Integrated energy planning can be seen as an approach to tackle energy problems in rural areas. The term of integrated can be defined in twofold (Qui, 1990). The first, integrated is defined as combination used of several energy sources (hybrid system) which are available in rural areas or other possibilities of commercial energy supply from out of the rural area to meet energy needs in that area. For instance, micro-hydro power plant combined with diesel generator, solar photovoltaic combined with wind power, etc. In this context planning is more complex than single source. Planners should have more knowledge and capabilities to formulate what kind of technologies are more feasible technically, economically, socially and environmentally to implement based on the existing resources.

The second is rural energy planning should be comprehensive with other rural development such as education, health, infrastructure and financing (World Energy Council, 1999), because energy has many implications and multiple goals. In this context integrated need coordination and collaboration among sectors. As argued by Woltjer (2004), see Chapter 2 that interaction

among government agencies and stakeholders are important to ensure that plan can be implemented as well.

Energy services without creating productive activities will be less useful for rural/remote communities. As we now that high capital investment is the main barrier in developing RETs. Most of rural communities have no ability to contribute in investment cost of DES due to their low income. Most of decentralized energy systems based on RE projects are fully financed by government, NGOs, or donor agencies. Rural community responsible for monthly payment for operation and maintenance cost of the electricity infrastructure. However, if rural electrification can not improve their income by the existing of energy services, consequently they can not pay monthly payment. The implication is that the sustainability of DES is questioned. Therefore, energy services are expected can create some job opportunities to increase rural/remote communities' income.

As showed in case of Seloliman and Oeledo, energy services are utilized for productive activities such as kapok blowers to produce local mattress in Seloliman and wood carving in Oeledo. By creating job opportunities, rural community's income can be improve, and they can be self reliant To realize this condition, community should be empowered and the market should be created. In other word rural energy development should be integrated to other development sector such as economic, social, and other infrastructures (such as road and transportation to increase urban-rural linkages in creating market).

5.3 Institutional Mechanism

Institutional mechanism might be changed in implementing DES based on RE. If in the past the central government (macro level) plays an important role in rural energy planning. Nowadays, meso level (regional/provincial level) and micro level (local level) must be encouraged to play an important role in rural energy planning.

Macro Level

Macro levels (the central government), formulate some strategies in national scale to encouraged renewable energy technologies for electrification. Political commitment is a requirement to accelerate electrification based on renewable energy technologies in the country (Shukla, 2007). The strong commitment of policymakers/planners is a key success factor of promoting renewable energy technologies. Some of developing countries, among others China, India and Brazil have put the target of achieving electrification for the society in their national energy policy (Shukla, 2007).

Indonesian National Energy Policy also briefly sets the target of achieving electrification ratio 90% in 2020 (MEMR, 2004). The share of RE in power plant in 2025 is expected more than 5% -excluded hydropower and geothermal in large scale (GOI, 2006). It's mean that the Government has had been an initiative to bring electricity to rural and remote areas which have been not connected yet to national grid. The problem is how to provide electricity in rural area that meets the requirements of sustainable development. Does government has a strong commitment to switch from non-renewable energy base to renewable energy base?

Initiative is not enough without the strong commitment of policy makers/planners to implement it. Since the government is still concern on the large scale power plant project and fossil fuel based energy, decentralized energy system based on renewable energy can not be recognized as an alternative to provide energy in Indonesia. At this point, strong commitment is necessary in all level -macro, meso and micro level.

Meso Level

Meso level (regional/provincial government) has responsibility to translate the strategies in macro level to implementation process in regional/provincial scale which appropriate with the condition of the region. The tasks of this level are designing, regulating, implementing, monitoring and evaluating the process of rural electrification in regional/provincial state (Shukla, 2007). This level is also functioning as a mediate level between micro and macro level (Clayton et. al., 2003). Moreover, meso level should have capability to grasp the information from grass root level to formulate planning that suitable with the real problems in that region.

Micro Level

Micro level (district level) is responsible for direct implementation of rural electrification. In a big country, it is important to establish a committee below district level to get deeper outreach of rural/remote community needs (Shukla, 2007). Micro level is responsible for facilitating the maintenance of services through training and capacity building; coordinating with regional/provincial level for procurement of hardware equipments, spare parts, and training material and manual; monitoring the service quality and operation and maintenance of the equipment; determining the real demand and resource assessment utilizing its local resources; conducting finance for civil work and facilitating access of credit for expansion of the rural electrification process (Shukla, 2007).

In Indonesian context, due to the Regional Administration Act No. 22/1999 (GOI, 1999) renewed by the Act No. 32/2004 (GOI, 2004[b]), province and district have the same responsibilities but on different spatial scale. Therefore, meso and micro level might play an important role in developing local resource. Furthermore, the central government has delegated local energy planning to local government. Currently, every province and district is responsible for providing RUKD (Local Electricity General Plan). RUKD will be an input for the central Government to formulate National Electricity Master Plan (RUKN). Local government is also responsible for providing fund for rural/remote electrification.

To conduct these tasks as well, meso and micro levels also must be more sensitive on the problems in their region. Unfortunately, the lack of local government capabilities in translating the national energy policy to local policy and regulation has been an obstacle of promoting decentralized energy system based on renewable energy. The capacity of human resources on these levels are important to ensure the success of DES based on RE. The ability of local government to get information about the real condition in rural/remote areas, such as local

energy resources, social-culture of communities, economic condition, energy demand and the priority, etc, are important to formulate a good rural energy planning.

Ideally, to guarantee that decentralized energy planning process can be run as well, the central government has responsibility for empowering local government capacity. Capacity building of local government can be enhanced by conducting comprehensive training and technical assistances on DES based on RE. Basically, local governments are more receptive and have more potential than is recognized by the central government (Geoff and Johannessen, 2003). Furthermore related to enhance local capacity building in providing infrastructure in rural areas, Geoff and Johanessen (2003) argued that "*Through the provision of technical assistance to programs of this nature, it is possible to (i) develop effective local planning procedures with a high degree of direct user involvement, (ii) establish an effective contracts management system within local government and (iii) develop the local construction industry to respond to the specific requirements of a rural infrastructure works programs*.

As motioned before, decentralized energy planning will need many actors involved in planning process, the next section will discuss participative approach in rural electrification.

5.4 Participative Approach in Rural Electrification

It is clear that to encourage DES based on RE planning should be shift from centralized to decentralized administration system and planning also might be integrated to other sector. Participative approach is needed to make sure that decentralized and integrated approach are well implemented.

Rural electrification programs face multiple goals and diverse problems in rural areas. Technical approach by connecting rural/remote areas to national grid is not always suitable to solve those problems, because many rural and remote areas are located far away from the existing national grid. Therefore, participative approach which emphasize on intersubjective (interactions many actors) seem appropriate to deal with the complex issue in rural electrification program.

The Government of Indonesia has been recognized the important role of public participation in energy sector. Indonesian National Energy Policy (GOI, 2006) has been put public participation as a strategy in energy development by increasing partnership between government and private sectors in developing energy facilities and energy industries, and increasing role of community, small and medium enterprise and cooperative in the energy industry. Public participation is not only useful to ensure the sustainability of project but also can assist the government in financial provision.

Key Actors in Decentralized *Energy System (DES)*

Many actors have been involved in renewable energy development in rural areas in Indonesia. There is not only Government but also many interest parties such as Non Government Organization (NGOs), Donor Agency, Financial Institution, Renewable Energy Manufactures

and rural community. The key role of Government is to formulate the policy and regulation that will guarantee an appropriate institutional and regulatory environment (ADB, 2003).

Non Government Organizations, particularly Environmental and Social Foundation which concern on environmental degradation and rural poverty, play a significant role in developing renewable energy in rural areas in Indonesia NGOs in Indonesia such as Yayasan Womintra, PELANGI, IBEKA, PPLH, etc. They are interested in developing local energy resources to improve quality life of rural community. Their role is important particularly in empowering rural community for poverty alleviation. Most of Government project can not be associated with empowering rural community due to limitation budget and restricted time for implementation. Therefore, Government might collaborate with NGOs in implementing the project. Some evidences show that DES based on RE project which are supported well by NGOs particularly in empowering rural community for managing the project and creating job opportunities more sustain than the project without supporting by NGOs.

Furthermore, non governmental organizations (NGOs) can be a mediator to obtain financial and technical support from donor agency, since rural communities have no capability to find it. In addition, NGOs can be government partners to disseminate the government policy. On the other hand NGOs also can be as controller of the government activities.

Donor Agencies, such as World Bank, Asian Development Bank, GEF, JICA, etc, have important role in technical and financial support of renewable energy program in developing countries. In addition, the World Bank (and other multilateral banks) should actively promote a multimodal approach to rural electrification (ADB, 2003).

Local renewable energy manufactures also has important role in developing local energy sources. High dependency on imported equipment such as solar panel and wind turbine has hampered renewable energy development in developing countries. The high investment cost of renewable energy is a reason why developing renewable energy in rural area goes slowly.

The other key actors in developing local energy source are local communities. Because at the moment they are directly get impacts of the projects. Unfortunately their role in developing local energy source is not significant. To ensure that local energy development can give more benefit for rural people and be sustainable, involving rural community in rural energy planning process since the beginning is essential. The next part of this section will elaborate the role of community participation in decentralized energy system based on renewable energy

Community Participation

Rural community as the lowest level might be involved in planning process. The good information and insights on rural energy issues come from the rural people themselves who will get benefit from energy provision (World Energy Council, 1999). The outsiders cannot fully understand what local priority needs are and how to meet them (Clayton et. al, 2003)

In the past, rural community is only seen as an object of the project. Nowadays rural community as beneficiaries of rural electrification program must be a subject of this program.

Increasing stakeholders participation in many project related to sustainable development has been as a requirement of many international agency, NGOs even government (Clayton, et al., 2003). To increase community participation in planning process, institution in micro level should be strengthened to give more space for community to involve in decision making.

Community participation in rural electrification program is useful not only to define the problem but also to find a good solution to solve the complex problem in rural areas and to increase social acceptability of project. Empirical cases in Kalimaron and Oeledo show that the projects are sustained because rural communities have been involved in the project since the beginning of the implementation stage. Rural communities are also given opportunities to manage the project by themselves. Community involvement during the construction and eventually during the operation and maintenance stages may result in improved transparency in management of funds (Geoff and Johanessen, 2003). Consequently, sense of belonging to the project is emerged and they will operate and maintain of the project voluntarily.

The government of Indonesia realized that community participation is an important element of rural infrastructure, including DES based on RE. Currently, many projects of DES based on RE conducting by involving rural communities, even only at the implementation stage. In the future community must be involved earlier in the decision making process.

According to Geoff and Johanessen (2003), in general, community participation in providing rural infrastructure can be as follows:

- Local communities providing some of resources required for the works in the form of providing their own labor, tools, materials and some times cash
- Local communities take charge of the works implementation, either directly by organizing themselves into work groups or by engaging a local contractor
- Local communities or specific groups are contracted to carry out works under the supervision of local government authorities
- Local communities monitor the works carried out by local government and private contractors.

Ideally, community participation must be involved in all stages of development, since the planning throughout to operation and maintenance stage. Unfortunately, this condition has not been completely implemented in Indonesia, although the policy and regulation has directed to involving community participation not only in the implementation stage but also in all stages of development. Most of development projects in rural areas involved rural community only in implementation stage, however mobilization of people's political participation in rural development is decreasing (see Purwatiningsih, et.al, 2004).

The Government Regulation No. 72/2005 concerning on Village Administrative has regulated administration system in rural areas (GOI, 2005[b]). Rural development planning should be formulated in participative way. Villagers can establish village community institution *(lembaga kemasyarakatan)* to assist rural administration in formulating rural development planning, conducting, controlling and developing development in participative way, increasing participation of rural community in development and empowering rural community. Village

community institution also can be a channel forum for rural aspiration. Unfortunately, this institution has not been utilized as well.

According to Purwatiningsih et. al. (2004), there are four main factors influencing people's political participation in rural development. The first is social-economic factor. Most of community in rural areas has low education level and income. This condition results in decreasing people's desire to involve in political participation. Second is political factor. In general political awareness and political education in rural areas are still low. The image that policy is made by government- rural communities just follow and implement it - has been grounded inherently. The third is physical condition, such as lack of facility in rural area result in decreasing social interaction in rural areas. The last is cultural factor. According to Purwatinginsih et. al., (2004) culture value is important factor which influence peoples political participation. For instance, in Java culture, obedient behaviors to leader results in communities do anything for leader interest.

To encounter these problems, rural capacity should be increased and community should be empowered to increase communities' knowledge and ability to organize and manage local resources.

Capacity Building

Although community participation has been recognized as a key success factor of decentralized energy system based on renewable energy, rural community involvement in decision making is still limited. Most of planning for rural electrification comes from the outsider and community just informed about the project. Some projects show that rural communities have been involved in the project but the involvement of communities is only in construction and the operation of project, not in planning process.

The main reasons why rural communities are ignored to involve in decision making is the lack of capability of rural communities and lack of institutional mechanism to support rural communities to involve in planning process. To remove these barriers the capacity building or rural communities must be increased.

According to IEA (2003), capacity building is defined as "*the development of an organization's or individual's knowledge, skill capabilities in order to build and enhance the organization's effectiveness and sustainability"*. Similar to IEA, Morgan (1999) defines *"capacity building can be seen as an intervention or activity by an organization or group …to help … another to improve their ability to carry out certain function or archive certain objectives*.

Furthermore, Healey (2003) sees capacity as an ability to learn new ideas and ways of doing things. Capacity relates to the processes to build "institutional capital" among stakeholders which then will generate knowledge resources (intellectual capital), social network resources (social capital), and power bases (political capital) (Healey, 1997 p. 23)

The concept of capacity building associates to the concept of collaborative and participative approach that emerged in 1990's. The changing of planning approach from top-down to bottom-up approach result in planning transformation from government to governance. Healey (2003) states that *"the experience of attempts to break out of traditional hierarchical and 'bureaucratic' processes to involve new groupings and networks, new 'partnerships', including sometimes business or NGOs or community representatives or all of these at once, focused increasing attention on both the nature of the processes that developed in these interactions and the biases that built up within them"*

It is clear that capacity building is needed to make participative approach can be well implemented. Capacity building is facilitated through the provision of technical assistance, training, and resources networking (IEA, 2003). Local energy resources have a huge potential to be developed to meet rural/remote energy needs. However, the technologies are still new for rural/remote communities, even for local governments. Providing them knowledge about renewable energy technologies and sustainable development can increase their awareness and ability to develop their own resources based on sustainable development.

Local government and rural communities cannot be involved as well in formulating planning related to local energy resources if they have no basic knowledge about renewable energy technologies. The type of capacity building activities associated with DES based on RE among others are awareness rising, evaluation and selection technologies option, preparation of business plan, resources assessment, investment promotion, financial analysis, project finance, technical advisory service, product development, operational and maintenance, etc. (IEA, 2003). The training and technical assistance to empower local government and rural community can be done by central government, international agency or NGOs who has capacity to conduct these activities.

After discussing and analyzing the goal of rural electrification and its relation to planning approach and institutional mechanism, it is clear that participative approach is necessary to be implemented in rural electrification program. Decentralization gives more opportunities for local governments to organize and manage their own resource. Therefore, strengthening meso and micro level institutions is an important thing. Local governments might be empowered to increase their role in local energy planning and to be more responsive to local needs and issues.

In addition, rural communities as a center of development also might be empowered to bring them in decision making process. They have more knowledge about their local condition, however, due to lack of capacity and ability result in their participation in decision making is limited. Consequently, capacity building is necessary in local level, not only for local government but also for rural communities to encourage them to participate meaningfully (Neudoerffer et. al 2001). Finally, the last part of this chapter will discuss the constraints of decentralized energy system in Indonesia and some strategies which can be built to diminish those constraints.

5.5 The Constraints and Strategies to increase DES implementation

Renewable energy technologies are resource specific which have high local bouned. Each rural/remote area has typical condition of local energy resources which needs specific strategy to develop. Hence, ready-made strategies are not suitable to develop decentralized energy system based on renewable energy technologies.

Furthermore, every rural/remote area also has different economic condition, social-culture, level of energy demand and level of knowledge. Meanwhile, the complexities of technology of renewable energy are also diverse (Gururaja and Mubayi, 1999). For instance, technology of solar PV is more complex than micro-hydro, because the fabrication of solar PV cell need a specific scientific and technological base (Gururaja and Mubayi, 1999). Consequently, the strategies to implement decentralized energy system based on renewable energy have to be tailor-made which are appropriate to local energy resources, local technologies, local demand, and social-economic capabilities of each rural/remote area.

Some constraints hamper the implementing of decentralized energy system based on renewable energy (RE) in Indonesia. The constraints of implementing DES based on RE are almost similar to the constraints that hinder the renewable energy development presented in chapter 4. Some strategies can be developed to remove the constraints of DES based on RE as described below.

Political commitment constraints

Political commitment of policymakers and planners is still low due lack of knowledge and awareness on sustainable development. In the past Indonesia has a huge potential of fossil fuel reserves which make policymakers/planners reluctance to switch to other energy technologies which are still new and need a long learning process to implement those ones. As mentioned previously, centralized energy system is easier to build and control rather than decentralized energy system, however centralized energy system is not feasible technically and economically even environmentally to fulfill low energy demand in rural/remote area. Therefore, increasing awareness of policymakers/and planners on DES based on RE and sustainable development is important to encourage renewable energy development particularly decentralized energy system in rural/remote areas.

Policy and institutional constraints

In the past decision making for energy planning is determined by top-down approach. However due to the complex issue in rural electrification which should associate with sustainable development, top-down approach is no longer fit to encounter the complex problem in rural areas. Therefore, bottom-up approach which emphasize on the interaction among actors seems more suitable to encounter complex issues in rural areas. Empowering local government and community is needed to increase their capacity on providing energy in rural and remote areas. Self reliant on energy provision can be established in rural/remote areas by increasing capacity of local people to utilize their own local energy resources. For instance, China's county level and India's block level planning both represent decentralized area-based approaches have been

successful in identifying of local resources and determining the priority energy needs in rural areas (WEC, 1999). Both institutions show a significant achievement of decentralized energy planning. Currently China's rural electrification is around 98 and India's rural electrification is around 54% (Suhkla, 2007). Both countries commit to electrify all their rural areas by 2011 (Suhkla, 2007).

In addition, lack of integrated policy between energy sector and other sector makes the achievement of rural electrification program is not optimal. Energy sector has interdependency to other sectors. Without integrated planning the advantage of rural electrification program is not optimal. Therefore, increasing collaboration and coordination -vertical, horizontal and across sectors- are needed to get an optimal benefit of rural electrification in specific and rural development in general.

Furthermore, many institutions have been involved in renewable energy development in Indonesia, particularly in rural areas. UNDP (2000) had been reported that in developing countries, there is often lack of clarity on the specific role and responsibilities of various institution/ministries that involved in promoting energy services in rural areas. Related to this condition, it is necessary to increase coordination, collaboration and integration among institutions in formulating energy policy. Reformulate institutional responsibilities in promoting energy services in rural areas is necessary to avoid functional overlaps

Financial constraints

Financial constraints is the main barriers in developing DES based on RE, because RETs has a high investment cost; however, rural/remote communities have low willingness to pay. Lack of incentive for RE development result in DES based on RE is not attractive for the investors. To remove this barrier, the government should provide suitable financial scheme such as loan and interest subsidy in capital investment. Revolving fund can be as an alternative.

Lack of support from financial institutions such as from commercial bank, result in community difficult to develop DES based on RE by themselves. In the future, credit for energy must be considered in rural area. It can encourage rural community to develop their local energy resources by themselves.

Subsidy for fossil fuel is a big dilemma for promoting RETs. Since the price of fossil fuel is still subsidized by government, it is difficult for RETs to compete to fossil fuel. This condition hampers the process of commercialization of renewable energy. Removing subsidy gradually has been done by GOI. In the future the price of energy from RETs is expected can be competitive to fossil fuel. Furthermore, the cooperation with international organization should be increased for getting supporting fund for renewable energy technologies.

Technical constraints

Currently, local manufacture of RETs is still limited in Indonesia. Most of RETs equipment must be imported from abroad. The implication of this condition also results in financial constraint due to high cost of initiative investment. Therefore, capacity and capability of local

manufacture on RETs should be increased not only to increase self reliant on renewable energy development but also to reduce investment cost and create new job opportunities.
Standard for RE equipment is also still limited. Here, Government should formulate the national standard for the RET's equipment. This standard is important to ensure the quality and safety of the equipment. Some evidences show that the failure of renewable energy project technically due to lack of equipment standard. Therefore, the central Government has responsibility to formulate national standard of RE equipment. Moreover, cooperation with international organization might be increased to accelerate transfer of knowledge of RE and get technical assistance for developing local manufacture.

Information constraints

Dissemination and publication of RETs is still limited. The success stories of DES based on RE must be socialized to public. It can increase awareness of public for promoting RETs. Furthermore, inadequate data of RE potential can be a barrier for investor. The central government and local government are responsible for providing accurate data to attract more investor from local or abroad. Data of RETs implementation is also inaccurate. Therefore, renewable energy clearing house should be empowered to provide and upgrade data regularly.

The summary of the constraints and strategies of promoting DES based on RE is provided in Table 5.2.

Table 5.2 The constraints of DES based on RE and Some Strategies

Constraints	Description	Strategies
Political commitment constraints	• Policymakers and planners are still not favorable to DES based on RE	• Increasing awareness of policymakers and planners on DES based on RE and sustainable development
Policy and institutional constraints	• Decision making is determined by top down approach • No integrated policy of rural electrification and rural development • Lack of clarity on specific role and responsibility of institutions that involved in rural energy services	• Increasing local participation in decision making (bottom-up approach) • Increasing coordination and collaboration in formulating policy • Reformulate responsibility of those institutions and increasing coordination, collaboration and integration among institutions in formulating energy policy
Financial constraints	• Lack of financial incentives for RE development • Lack of support from financial institution	• Providing a suitable financial scheme such as soft loan, and interest subsidy in capital investments. • Providing micro finance by involving rural bank in DES • Increasing cooperation with international organization for getting finance support
Technical constraints	• Lack of RE industry capability • Lack of standard of RE equipment	• Increasing capacity and capability of local manufacture in RE industry • Formulating national standard for the RE's equipments • Increasing cooperation with international organization for increasing transfer of knowledge on RETs
Information constraints	• Lack of publication and documentation of sustainable RE application • Inadequate data of RE potential and implementation	• Providing and disseminating information and success stories of RE technologies • Providing adequate data on RE potential and implementation • Empowering clearing house and updating RE data regularly

The next chapter will draw some conclusions related to the implementation of decentralized energy system based on renewable energy in rural areas. Some recommendations are proposed to encourage the implementation of renewable energy technologies in rural electrification program.

CHAPTER 6
CONCLUSION AND RECOMMENDATION

Based on the discussion in the previous chapters, this chapter will complete this research with conclusion and some recommendation for the future development of decentralized energy system based on renewable energy development, particularly in Indonesia.

6.1 Conclusion

Energy is essential for sustainable development. Energy services play an important role in economic, social and environmental development both in urban and rural areas. Unfortunately many people in rural/remote areas have not been reached by modern energy service, particularly electricity. Although rural electrification in Indonesia has been reached 80.9%, the electrification ratio is still low, 53% (DGEEU, 2005). It indicates that almost a half of total households in Indonesia have not access to electricity and about 80% of them live in rural and remote areas (World Bank, 2005).

Rural electrification program has been conducted since three decades ago to increase energy accessibility in rural area. Centralized energy system based on extensification and intensification of national grid had been a choice in the past. However, this effort is not feasible technically and economically, because most of rural areas are located in isolated areas with unevenly distributed population and rural energy demand is still low. Moreover, centralized energy system has negative implication on environment because most of energy used still relies on fossil fuels which are unsustainable in resources. Fossil fuels also have a big contribution on environmental damage due to high pollution emitted by using these resources.

Decentralized energy system based on renewable energy is a good alternative to increase energy accessibility in rural and remote areas which can not be reached by national grid. (Barness et al, 1997 and Reddy et. al, 2006). Decentralized energy system can utilize local energy resources such as solar, wind, biomass, micro hydro and geothermal energy. These resources are sustainable because the resources can be renewed. Furthermore, renewable energy resources are also environmentally friendly due to low polluted emission produced by utilization these resources.

Similar to other developing countries, Indonesia has been started to achieve transition to modern energy system in rural areas by introduce renewable energy technologies. Access to sustainable and affordable energy is important not only for economic development but also for poverty alleviation and social equity (E7, 2003). In the past rural electrification program in Indonesia was formulated by top down approach which emphasis on economic growth and less considering on improving of living standard of rural community. In that time, macro level plays an important role in rural electrification.
Nowadays, to achieve sustainability of rural electrification program which associates with multiple goals and multiple planning issues in rural areas, technical approach is no longer

suitable to deal with the diversity problem in rural/remote area. Bottom-up approach involving many stakeholders (government, NGOs, local manufacture, local community, etc) should be implemented to achieve sustainable development. Therefore, planning should be switch from centralized system (government) to decentralized system (share governance). For this reason, meso and micro level are encouraged to play a significant role in process of formulating policies in the future. This approach actually is in line with decentralized administration system which has been implemented in Indonesia since 1999.

Furthermore, to get the optimal benefit of the implementation of decentralized energy system based on renewable energy, rural energy planning should be integrated to other rural development. Energy service is nothing without the integration to other sectors of development, such as health, economic, education, road and transportation. Creating income generating activities is the main point for sustainability of the project. Energy services in rural areas is expected can improve living standard of rural communities, poverty alleviation, creating job opportunities, and decreasing environmental damage. Here, coordination and collaboration among sector is needed to achieve the multiple goals of rural electrification program.

Participative approach which emphasizes on communication and interaction among actors should be implemented in formulating planning. To ensure that every level is capable to involve in planning process, capacity building is needed. Capacity building is a tool to increase capacity and capability of rural community even local government to deal with the complex issue in energy planning. Training and technical assistance can be used as efforts to increase capability of rural community and local government.

Moreover, to ensure long term sustainability of rural electrification, demand driven approach should be applied as a mechanism for stimulating the process of project initiative (JICA, 2003). At this reason, rural community must be recognized to involve in the planning process. In the past the central government identifies, develops and implements the project of rural electrification. While in the future, rural electrification program might be more emphasizes on village initiative. What kind of energy is their priority? Do energy services can improve their life? What kinds of technologies are appropriate with the resources and rural community condition, etc. To answer those questions, rural community must be a subject in the planning process, because they know more about their region and their needs.

Nowadays, rural community is not involved optimally in developing decentralized energy system based on renewable energy. Most of rural communities are just involved in implementation stage. The planning concept for DES based on RE still come from the outsiders. In the future, rural community is expected can more participate in rural energy planning. Here, capacity building is needed to increase rural capacity and ability to manage and organize their resources to fulfill their needs in sustainable way.

The shifting administration system from centralized to decentralized administrative in Indonesia give more authorities for local governments to manage their own resources. The act No. 22/1999 renewed with the act No. 32/2004 concerning on Regional Autonomy allows every province and district to develop their local resources that will provide maximum benefit

for the local economy. Rural electrification based on renewable energy is expected can be more developed in the future. National energy policy has been directed to use renewable energy to increase energy accessibility in rural areas and decrease high dependency on fossil fuel, particularly oil. For this reason, local government should be proactive to develop their renewable energy sources. Capacity building also needed to enhance local staff knowledge on renewable energy technologies and formulating energy planning based on RETs,

As mentioned previously. The central government is dominated in the planning and implementation of rural electrification program in the past. However, in the future the central government will act as a facilitator and mediator, while local government will take more responsibility for rural electrification. By implementing regional autonomy, central government has transferred the authority to local government to organize and mange their own local resource. Share governance must be implemented as well to get more benefit of developing local energy resources in the future.

6.2 Recommendation

Based on current condition of decentralized energy system, there are some recommendations are proposed to increase the future development of decentralized energy system:

- Understanding on locally based energy system based on decentralized energy system might be increased in all level of administrative systems and society to enhance their awareness on decentralized energy system and sustainable development.

- To achieve the successfulness of decentralized energy system, rural energy planning might be decentralized. Therefore, the role of local government might be increase in formulation rural energy planning. At this point, capacity building of local governments is important to improve their capacity and ability in formulation rural energy planning based on renewable energy technologies.

- Good governance practices should be implemented as well and good coordination and collaboration among the institutions - local, provincial and national- might be built to get more benefit of DES base on RE to improve living standard of rural community.

- Empowering rural communities are important to increase their knowledge and capacity to manage their local resource. Rural communities might be drawn to participate in decision making by strengthening the institution in micro level such as village community institution.

- The result of research also shows that NGOs has a big contribution in empowering rural community. Therefore in the future, the role of NGOs must be encouraged notably in assisting and empowering rural community to achieve self-reliant community in energy provision.

- It is necessary to provide adequate and accurate information of renewable energy resources and project implementations to encourage public/private participation in developing local energy resource and to monitor the implementation progress of renewable energy technologies. Nowadays many documents which provide data/information of renewable energy resources or implementations show different figure.

- Finally, it is important to increase international network in order to increase capacity building through transfer of knowledge on RETs, get technical assistance in empowering local government and local manufacture. International cooperation is also necessary to get financial support for promoting DES based on RE.

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