CHAPTER I

INTRODUCTION

The national energy demand rapidly increases. Thailand is a net oil importing country and has been affected severely by oil price volatility. Moreover, there is increasing global concern over the depletion of fossil fuels in the near future and the environmental impacts from using conventional fossil fuel sources. Therefore, the use of renewable energy (RE) sources is becoming increasingly necessary. Biomass is the most common form of RE, widely use in the third world. Most of the biomass materials are found in the developing countries of Asia and Africa where the main source of revenue is agriculture [1]. Hence, biomass energy is only not essential in developing countries but has also aroused great interest in Europe [2]. In Thailand, biomass is an important source of RE. It provides basic requirement for cooking and process heating residential manufacturing sectors as well as for processing in traditional industries. Major sources of biomass in Thailand are sugar cane, rice, oil palm and wood waste which yield a total potential of nearly 80 million tons per year [3].

Rationale for the Study and Statement of the Problem

Agriculture sector is the base of Thailand's economy and accounts for about 60% of labor forces where the main agriculture residues consist of rice husk, straw, bagasse, palm oil waste, wood waste etc. Therefore, biomass is expected to be used for power generation [4]. As a result, biomass is considered to be the most potential RE source for communities in Thailand because of the huge plant materials which can be reached, harvested, and managed everywhere. Most communities, especially in rural area, do not have many activities to earn income. Therefore, people have enough time to manage their energy sources. Moreover, much unoccupied land in each community can be afforested or reforested. Nowadays, Thailand's entire unoccupied land is about 3.5 million Rai (5.60×10^9 m^2) which can be used to plant biomass for feeding stock of RE sources [5]. Latterly, much attention has been given to identifying suitable biomass species, which can provide high-energy output, to replace conventional fossil fuel sources. The conversion of energy encompasses a wide range of different types and sources of biomass, conversion options, end-use applications and infrastructure requirements. Biomass can be derived from the cultivation of dedicated energy crops and from biomass wastes. In each case the biomass feedstock has to be harvested/collected, transported and possibly stored, before being processed into a suitable form for the chosen energy conversion technology. Biomass gasification technology (BGT) is one of the most potential and suitable technologies for the developing country and also has abundant biomass. This technology has been researched and developed for a long time and has been receiving increasing attention in the energy market. Researches about the optimization and the development of this technology with the different kind of biomass and different conditions have to improve continuously in each country. The major of the power requirement in developing countries is for household consumption. Electrical energy is required because it is easily converted to other forms. The conversion of biomass by gasification into a suitable form of energy, usually electricity or as a gas fuel for use in a gas engine greatly increases the potential usefulness of biomass as a renewable resource.

The properties of the biomass feedstock and its preparation are key design parameters when selecting the gasifier system. Electricity generation using a gas engine operating on gas produced by gasification of biomass is applicable equally to both reducing greenhouse gas emissions by replacing fossil fuel and providing electricity in community derived from traditional biomass. Therefore, biomass gasification is the common technology for decentralized energy production. It has many advantages compared to the photovoltaic, wind and hydro power plants by the following.

1. The necessary investments are low, therefore, internal combustion engines can be economically operated even small load. The economic viability is yet to be proven for renewal in Thailand. Preliminary assessments show that biomass gasifiers were economically feasible [6, 7].

2. They are available in most countries without any problem base on good management.

3. The know-how for operation and maintenance are available in any regions.

4. Technology is mature with several designs and manufacturers who undertake planning and commissioning of small-scale biomass power system.

5. They are not characterized by daily fluctuation of energy supply unlike the regenerative sources of energy.

6. Biomass gasifiers are available in different capacities for decentralized applications from 5, 20, 100 to 500 kW.

7. Biomass gasifiers can be installed and operated in any community where biomass is available or can be grown. Such a flexibility does not exist for other renewable energies such as wind, solar and micro-hydro system.

8. BGT is indigenously developed and transferred to manufacturers.

9. Biomass gasifier-based power generation systems create jobs and skill in community in biomass feedstock production, transportation and processing, and in operation and maintenance of the gasifier-engine-genset systems as well as the end-use systems.

10. Thailand has wastelands which urgently require reforestation to prevent further degradation. Biomass production, as feedstock for power generation, provides economic incentive to reforest wastelands with energy forests.

11. Biodiversity conservation: Appropriate guidelines to discourage monoculture plantations and incentives to promote mixed species forestry, with appropriate density will promote biodiversity in degraded lands [8].

Nevertheless, the limitations of biomass utilizations in Thailand are limited at agro-industry because of the large scale production and expedient collection such as rice mills, sugar mills, and oil palm mills. Wood industry is also a major source which is mostly concentrated in the northern part of the country, whereas rubber wood and eucalyptus plantations are found mostly in southern and northeastern regions. Therefore, biomass sources for community power generation should be met, grown and harvested anywhere in the country. However, the drawback of biomass fuel is low energy intensity per unit. Therefore, sustainable biomass utilization for community power generation is a big concern for management. Moreover, the power plants should not be large scale. The secondary data showed that the suitable capacities of biomass gasified power generation system (BGPGS) range from 5 to 500 kW. In addition, the emission of CO_2 is one of the greatest environmental problems of our time but this technology is CO_2- neutral energy production [8].

For the sustainable RE technologies to produce community power in Thailand, the project of BGPGS was originated by the co-operation between School of Renewable Energy Technology (SERT), Naresuan University, Phitsanulok Thailand, Wind Company, Japan and Wire & Wireless Company.

Objectives of the Study

1. To develop management model of Sustainable Biomass Gasified Power Generation System (SBGPGS) for community in Thailand.
2. To evaluate the technical performance, biomass supplied system, economic condition and environmental impacts of BGPGS that was designed and constructed at SERT, Naresuan University, Phitsanulok, Thailand.

Expected Benefits

1. A new management model of SBGPGS can be applied and used to other scale sizes.
2. A new prototype of BGPGS can be used as the RE power supplied system for community.
3. Basic knowledge for further development and research of BGPGS.
4. The management guideline for community.

Scopes of the Study

SBGPGS is based on 1) technical performance, 2) biomass supplied system, 3) economic condition, 4) environmental standards and 5) community. Nevertheless, this management model consisted of sub-models supported by experimental and secondary data, including social concept. The main sub-models in this study focus on biomass supplied system (biomass plantation area, logistics and biomass storage) and community.

This study started with technical performance evaluation.

1. The technical performance of BGPGS, case at SERT, would be to evaluate biomass gasifier, combined with cleaning/cooling system, and gas engine-

generator system. Eucalyptus wood chips, that are gathered from sawmill, were used for feeding in this technical performance evaluation because electricity from biomass eucalyptus wood can be quite competitive with conventional fossil fuel based power and heat plants in Thailand. Moreover, it was suggested that Eucalyptus plantations be a major potential source of biomass energy [9]. Wood chips were required ranging from $2\times2\times5$ cm^3 to $4\times4\times7$ cm^3. Capacity factor of biomass power plant was assumed as 80% [10].

2. Biomass supplied system

2.1 Biomass plantation area.

Area of sustainable biomass plantation is necessary to produce renewable fuel in order to ensure an uninterrupted supply of biomass fuel to the power plant. Long-term source of biomass must be estimated for confidence of investors. Biomass plantation area was assumed to be square biomass plantation areas and circular biomass plantation areas. Plants could be classified into two groups: tropical hardwood plants and fast growing plants. Distribution density of tropical hardwood plants could be assumed from the new theory farming, 30% of land use, that is suitable for sufficient economy of an agricultural country [11]. Thailand has a hot climate where the tropical hardwood plants can be assumed to be the C_4 plants whose growth rate is about 80 ton dry matter per hectare per year [12, 13]. The specific characteristics of suitable short-rotation forest (SRF) for Thailand are Eucalyptus camaldulensis, Leucaena leucocephala, and Acacia mangium. Suitable area for SRF plantation in the country is assumed by using computer program called THAI program. Biomass productivity and rotation of SRF used secondary data from Forest and Plant Conservation Research Office, National Park, Wildlife and Plant Conservation Department, Thailand that the details were shown in Table 26 of APPENDIX A. Biomass productivity is classified according to the amount of rain in any region in Thailand. The rotation of SRF is 2 years [14].

2.2 Logistics

The problem of biomass energy differs from fossil fuel. The relatively low heating value of biomass means that very larger volumes of material are needed to fuel the RE power plant and create fluctuations in transportation costs. Transportation and harvest per ton of biomass fuel have to be calculated.

The vehicle costs of tricycles, motor tricycles, pickup trucks and trucks had to be compared.

A mapping of logistics direction could be assumed from total biomass plantation area in the square biomass plantation areas and circular biomass plantation areas.

2.3 Biomass storage

Storage of biomass fuel is necessary for continuous supply of biomass feeding power plant, especially in rainy season because of the difficulty of drying process, harvest and logistics. The rainy season in Thailand was assumed to be around 5 months per year (between mid-May to mid-October) [15].

3. The parameters of economic study were cost of energy (COE), discounted payback period (PB), net present value (NPV) and internal rate of return (IRR). The COE was considered following the new subsidy adder for RE on November 20 of Thai Energy Policy Committee (EPC) under the National Energy Policy Council (NEPC) that approved a significant upgrade of Thailand's Very Small Power Producer (VSPP) regulations [16].

4. The environmental impact evaluation was classified to two parts:

4.1 Waste water from wet scrubber was classified namely: pH (pH unit), conductivity (microsiemens cm^{-1}), total dissolved solid, TDS (mg L^{-1}), suspended solid, SS (mg L^{-1}) and temperature, T (°C).

4.2 Air pollution, the parameters would be analyzed as namely:

4.2.1 CO (% v/v.) emission from exhaust gas.

4.2.2 HC (ppm) emission from exhaust gas.

4.3 Sound level of gas engine, dB. (A).

5. Community

The last important factor of SBGPGS was community. It was a local administrative organization, which would manage biomass supplied system, BGPGS and community power for SBGPGS.

6. Management model development of SBGPGS

Management model of SBGPGS based on technical performance, biomass supplied system, economic conditions, environmental impacts and community. Each factor was affected and related to each other. The management model was supported by experimental and secondary data including social concepts.

Management model of SBGPGS had to be based on the most appropriate alternative. Therefore, risk management is necessary for creation of the management model.

6.1 Risk assessment

A continual process of risk assessment should identify potential problems of each factor of SBGPGS and hopefully avoid them.

6.2 Risk solution

Because risk is distasteful, we attempt to solve these problems with avoidance, reduction, retention and transfer. In some cases, two of these approaches-transfer and retention were combined to create a fifth technique, risk sharing.

6.3 Consideration of the most appropriate alternative

The best condition would be considered for management model development of SBGPGS for community in Thailand.

6. Location

BGPGS had been constructed and operated at SERT, Naresuan University, Phitsanulok, Thailand.