OPPORTUNITIES AND BARRIERS OF BIOMASS GASIFIED POWER GENERATION SYSTEM IN XAYABURI PROVINCE, LAO PDR

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ABSTRACT

The aims of this study were to evaluate parameters of opportunities and barriers of biomass gasified power generation system and to compare cost of operation of the electric transmission line system with the economic evaluation of biomass gasified power generation system in Xayaburi province, Lao PDR for providing an overview to be the solution of electrical demand in the rural areas, far from grid connection transmission line. Parameters of opportunities and barriers included the following: a) Potential b) Policy c) Technology d) Social Acceptance and e) Economic. The results proved that enough biomass potential for feedstock such as corncob. The electricity demand in Phadam village is just about 30 kW. Therefore, biomass potential was the opportunity. Policy was the main barrier because the government does not provide adder or feed-in tariff for encouragement private investors. Technology: The downdraft gasification power system was selected for this study since it's very suitable for small scale power generation especially with corncob raw materials for feedstock. Social acceptance was the opportunity because the community cannot afford high tariffs and will support any project that gives them extra income from feedstock and reside sales. Economic was the opportunity and the low investment cost and NPV values showed that the biomass gasification system for electricity generation is cheaper than electric transmission line system and affordable for the communities in Phadam village, Phiang district, Xayaburi province, Lao PDR.

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CHAPTER I

INTRODUCTION

General information

The Lao People's Democratic Republic (Lao P.D.R.) is located in the Southeast Asia, bordered by Myanmar (Burma) and the People's Republic of China to the northwest, Vietnam to the east, Cambodia to the south, and Thailand to the west. The total area is 236,800 square kilometers (about half size of Thailand). The highest north is about latitude 22°30' north, the lowest south is about latitude 13°57' north, the farthest east is about longitude 107°30' east, the farthest west is about 100°21' east. The distance from north to south is about 1,060 kilometers. The largest parts include Luangnamtha, Luangprabang and Houaphan provinces, which are collectively about 510 kilometers. The narrowest part is Khoummouane province, which is about 90 kilometers. The border length, measured along the overall boundary is 4,500 kilometers. The borders connected with Myanmar has the length of 230 kilometers, with Vietnam has the length of 1,957 kilometers, with China has the length of 416 kilometers, with Thailand has the length of 1,810 kilometers (702 kilometers by land, and 1,108 kilometers by water), and with Cambodia has the length of 492 kilometers. Lao P.D.R. is therefore the country that has no sea shore [1]

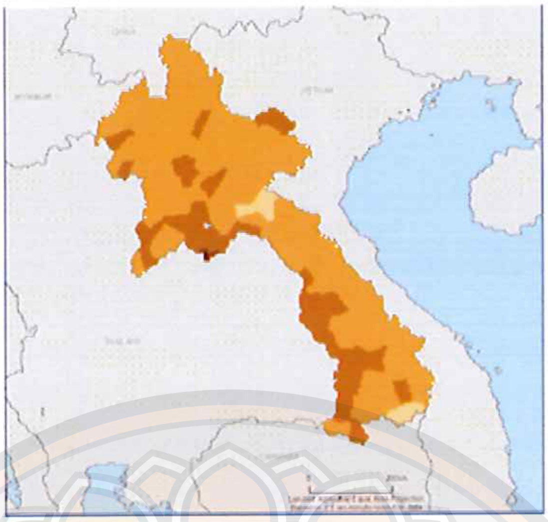

Figure 1 Map of the Lao People's Democratic Republic [1]

Geography and climates

Most areas of Laos are covered by mountains, which are full of rainforests and minerals. The high slopes are located in the northern and eastern parts of the country, and decline to the southwest. According to this geography, the flow of the rivers and other water resources are affected by the slopes. About ¾ of the country is occupied by forests and mountains. Most of the areas, about 96,760 square kilometers, are forest. There is a small area left for agriculture, which are low land around foothills and river bank and are estimated as 8%, or ¼ of the country, or 18,944 square kilometers. The 89% of the area is dry and not suitable for agriculture. [2]

The Lao People's Democratic Republic is in the tropical climate, which is influenced by southeast and northeast monsoons. Therefore, there are 3 seasons including summer, rainy season and winter, which last 4 months each. Since Lao PDR is in the path of the cyclones, forming at the southeastern part of the country, there are floods almost every year. Summer starts from March to July. The weather is very dry and hot, with the average temperature of 35ºC. The rainy season is from July to November, where the temperature drops down. There is a lot of rain in the mountains and forest areas. The average precipitation of the overall country is 1,270-2,290 mm. The winter is from November to March. The weather is cold, especially in the northern part and on top of the mountains. The lowest temperature occurs in January, with the average of 10 °C. However, the temperature is not as low in the middle and southern part.

The Lao People's Democratic Republic is a socialist republic communist state country, where the leader of country is the President and the only legal political party is the Lao People's Revolutionary Party [2].

The Loa People's Democratic Republic has the population of 6.8 million people in 2013. More than 90% of the population is Buddhism. The economic affairs in the country affect the standard of living. People in Laos face the problem of higher living expenses but lower incomes due to the value of money. This has an impact on people in the middle class. From the survey of the World Health Organization, Lao people who live in the rural area are poor; and occupation farmer [2]

Energy Generation and Consumption in the Lao PDR

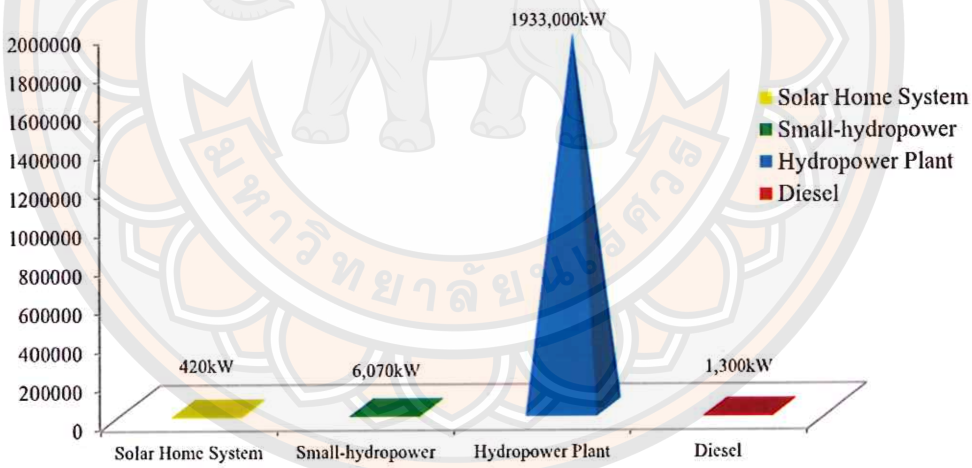

Figure 2 Graphical Energy Generation and Consumption in the Lao PDR

The Lao People's Democratic Republic is an agricultural country that grows many plants such as rice, corn, coffee, sugar cane and soybean. In each year, from the harvesting process and manufacturing process, there are a lot of agricultural residues that can be used as fuel. However, there has not been a specific study on the potential of biomass in Laos. Moreover, Lao PDR experiences lot of rain each year, therefore it is suitable to build large dams in order to produce hydropower. In order to study the potential of biomass for renewable energy, it is necessary to study the status of energy generation and usage in Laos. This study will yield guidelines for planning on the effective utilization of biomass, which has to be agreed with the energy utilization of the country; the especially, Xayaburi, Province of Lao PDR, that are closes to northern province of Thailand such as: Nan, Uttaradit and Chiangrai; have a rugged landscape with forested mountains. Most of the population live in rural areas and depend on agriculture as major source of income and it is known for the production of rice, cotton, peanuts, sesame, corn or maize and oranges [1]

The Lao People's Democratic Republic is a land-locked country located in South East Asia. In 2010, the population of Laos was 5.8 million people with a Gross Net Income per Capita of 580 USD; which the World Bank classifies as a low income country. As a result, the country has heavily relied over the years on foreign aid for its development. [1]

The current energy situation in Lao PDR is composed of: charcoal 12%, electricity 15%, petroleum17%, liquid petroleum gas 2%, Coal 2%, and fuelwood 52% per year as shown in Figure 4 below [3].

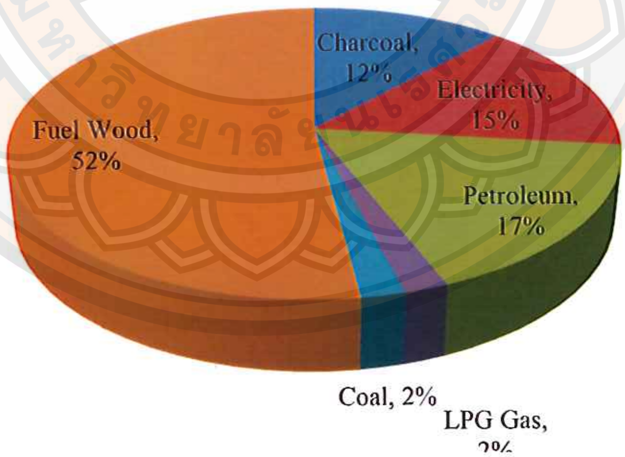

Figure 3 Graphical Energy Consumption in Laos 2010 [3]

Due to the energy shortage that is affecting the world economy; renewable energy study has become one way to help achieve continuous energy security improvement. Renewable energy technology in LAO PDR consists of Photovoltaic, a technology with high cost and mostly imported components, has been utilized mainly in the form of solar home systems, for stand-alone lighting applications in rural areas and the biogas plants using cattle dung and feedstock are popularized mainly for cooking household size, [2] Pico-hydro system, but not mostly used, and improved cooking stove for household to promote the use of renewable energy resources and technology in communities.

Lao People's Democratic Republic is an agricultural country where most of the land in the country is used for agriculture of plants and trees. Therefore residuals from the harvest and agricultural industries, which can be used as biomass fuel, are available in large quantities. However, there has not been a study on the potential utilization of this biomass. The study on the potential utilization of the biomass can lead to planning and research to improve the efficiency of bio-residuals into biomass fuel by applying the suitable technology to each type of biomass. Not only that biomass fuel has no environmental effects, but it also reduces costs on imported fuel, increases the income and improves the standard of livings of the people in the country.[1] This approach makes it possible to take advantage of existing resources in the area to generate electricity for themselves especially in the areas without power.

Rationale for the study and statement of the problem

Xayaburi province of LAO PDR is very close to the northern provinces of Thailand such as Nan, Uttaradit and Chiangrai and has a rugged landscape with forested mountains. Most of the populations live in rural areas which depend on agriculture as major source of income and this province is known for the production of rice, cotton, peanuts, sesame, corn or maize and oranges. [4]

Due to these area remoteness from the big cities, people live far away from each other, the income of local people are low, so they cannot afford the grid electricity of their area. Most projects on electricity distribution depend on foreign aid, due to Laos's small economy, therefore a need for a more sustainable energy alternative for these communities. [4]

The aim of this study was to provide an overview of the opportunities and barriers of Biomass Gasified Power Generation to be the solution for electrical demand in the rural areas, far from grid connection transmission line.

Objectives of the study

1. To analyze parameters of opportunities and barriers of biomass gasified power generation system in Xayaburi province, Lao PDR.

2. To compare cost of operation of the electric transmission line system with the economic evaluation of biomass gasified power generation system in Xayaburi province, Lao P.D.R.

Scope and Limitation of the study

Location:

Phadam village, Phiang District, Xayaburi province in Lao PDR was selected as the location for this study. This location was selected because it was not connected to the electricity grid due to its remoteness. Phadam is a community that depends on agriculture for their income which produce sufficient agricultural products and waste; especially corncob which does not require any pretreatment before being feed into the biomass power plant.

The opportunities and barriers of biomass gasified power generation system in Phadam village include the following parameters: 1) Potential 2) Policy 3) Technology 4) Social Acceptance 5) Economic

1. Potential of biomass for biomass gasified power generation system

1.1 Type of biomass that could be used as feed stock for the system.

1.2 Total amount of feedstock sufficient for production the electricity

2. Policy

Target plan must meet requirement of 25 years set by Laos's government to support biomass to be part of the Renewable Energy framework.

3. Technology

This study selected the downdraft gasified technology for electricity production in Phadam village, Phiang district, Xayaburi province in Lao PDR due to the small size and demand of electricity (capacity not more than 500 kW), sufficient quantities of biomass feedstock such as corncob and cheap labour.

4. Social Acceptance

Questionnaire was used for collecting the data of Phadam village, Phiang district, Xayaburi province in Lao PDR. The data comprised society and basics of the people energy consumption, types and amount of biomass available.

5. Economic

Economic comparison methods of biomass gasified power generation and electric transmission line systems are listed below: NPV, IRR, BCR, PBP and LCOE

Benefit of the study

1. This research could be used by Laos government in Xayaburi province for making decisions concerning biomass gasified power generation system.

2. Community could get economic benefit from corncob sale to the biomass power plant.

3. The use of biomass power plant could contribute to green house gas emission reduction thus safe the environment.

4. This technology could be easily promoted and installed in similar communities.

CHAPTER II

REVIEW OF RELATED LITERATURE AND RESEARCH

Theory

The Laos government supports domestic and foreign entrepreneurs and investors to invest in energy projects at village level. The development of renewable energy result while responding to the needs of the local people contribute to the process of becoming self – sufficient in energy supply and for the development energy exports. Renewable energy development involves participation of public and private sector. Being a predominantly agriculture - base economy, Lao PDR generates substantial amount of waste from agriculture and forest production and processing such as sugarcane biogases, risk husk, corn cob, wood waste and etc. Also, with growing urbanization, main cities are also generating significant amount of solid waste. At present, there is no large-scale exploitation of this resource for energy generation. In addition community forest could also sustainably develop to supply fuel for energy generation. There resource could potentially generate power productive used and other modern energy service in both urban and rural area either for off- grid or grid connected systems. The government recognizes the used of these agriculture and municipal solids waste to form part of overall energy mix to ensure energy security of the country [2].

Gasification

Gasification is a process that converts organic or fossil based carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the material at high temperatures (>700°C), without combustion, with a controlled amount of oxygen and, or steam. The resulting gas mixture is called syngas (from synthesis gas or synthetic gas) or producer gas and is itself a fuel. The power derived from gasification of biomass and combustion of the resultant gas is considered to be a source of renewable energy the gasification of fossil fuel derived materials such as plastic is not considered to be renewable energy. For easier understanding :

Solid biomass fuel is converted into gas by heating in a limited time to accelerate the reaction, a gas producer or fuel gas [5]

Type of gasification

Gasifiers are divided into two main types, fixed bed and fluidized bed, with variations within each type. A third type, the entrained suspension gasifier, has been developed for coal gasification but the need for a finely divide feed material (<0.1-0.4 mm) presents problems for fibrous materials such as wood, which make the process largely unsuitable for most biomass materials and therefore the process is not considered further. [5]

Fixed bed gasification

The fixed bed gasifier has been the traditional process used for gasification, operated at temperatures around 1000 °C. Depending on the direction of airflow, the gasifiers are classified as updraft [Figure 3, (a)], downdraft [Figure 3, (b)], or cross-flow. [5]

Fluidized Bed Gasification

Fluidized bed (FB) gasification has been used extensively for coal gasification for many years, its advantage over fixed bed gasifiers being the uniform temperature distribution achieved in the gasification zone. The uniformity of temperature is achieved using a bed of fine-grained material into which air is introduced, fluidizing the bed material, the hot combustion gas and the biomass feed. [5]

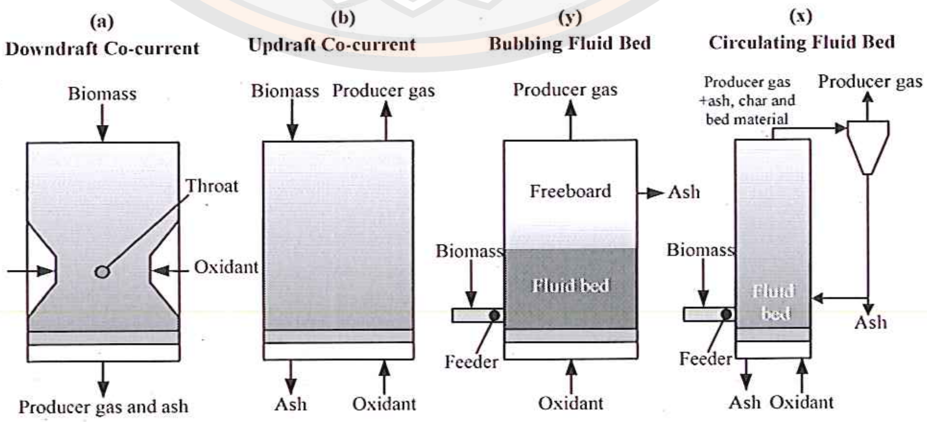

Figure 4 The main types of gasifier [5]

Calculate Gas efficiency

Efficiency of electricity generation from biomass, the fuel gas is defined by the ratio between Power system and the amount of electricity produced. The energy from biomass can be thought of separately, and can show you how to calculate the efficiency of the furnace gas and biomass fuel as follow: [5]

$$\eta_{th} = \frac{(H_g \times Q_g) + (Q_g \times \rho_g \times C_P \times \Delta T)}{H_s \times M_s} \times 100\% \qquad [Eq.1]$$

Where:

η_{th} : Efficiency of biomass fuel gas (0%) thermal

H_g : Heating value of fuel gas from biomass system (kJ/m3).

Q_g : Rate of flow of fuel gas from biomass system (m3/s).

ρ_g : Density of gas, biomass (kg/m3).

C_P : Specific heat of gas, biomass (kJ / kg. ° K).

ΔT : Heat difference between the biomass and fuel gases air entering the furnace (° K).

H_s : Heating value of biomass fuels as a fuel input of the system (kJ / kg).

M_s : Fuel consumption rate of biomass (kg / s).

If the production of biomass fuel gas system for the lure of cold in the system is the temperature of the gas. Biomass fuel from the system is close to the temperature of air entering burner gas bio fuels. Mass ($\Delta T = 0$), so the equation of fuel efficiency of gas production biomass is reduced to the related equation

Gasification is a process that converts carbonaceous materials, such as coal, petroleum, or biomass, into carbon monoxide and hydrogen by reacting with the raw material at high temperatures with a controlled amount of oxygen. The resulting gas mixture is called synthesis gas or syngas (sometime called producer gas, biomass gas, or corncob gas) and it is itself a fuel. Gasification is a very efficient method for extracting energy from many different types of organic materials, and also has applications as a clean waste disposal technique, This process occurs in the limited oxygen condition; therefore carbon monoxide (CO) is the major proportion in the producer gases. Other gases such as methane (CH_4) and hydrogen (H_2) also exist.

During the gasification process, there are series of reactions such as combustion, reduction, pyrolysis, and drying which are separated in different zone in the gasifier. [5]

Literature Review

S. Prasertsan, et al. [6] studied on biomass and biogas energy in Thailand: Potential, opportunity and barriers. This study possessed great biomass energy potential and opportunities are open. Thai government had laid a strong foundation and infrastructures for supporting and promoting the use of renewable energy and energy conservation especially in the form of necessary legislations and support funds. However, despite several financial incentives, the dissemination rate of the use of biomass energy technologies is still unsatisfactory due to institutional, policy, technical, financial and information barriers. Efforts have been made to try to remove some barriers such as government organization reform aiming to improve line of commands and coordination among organizations in the energy sector. More emphasis had been given to the promotion of renewable energy technologies particularly biomass energy. It is believed that some barriers have partially been understood and some are not known at all. It is recommended that more systematic and comprehensive study approaches involved extensive participation of stakeholders are needed to fully address barriers and set up effective measures to remove them Although energy policies adopted by the government are in the right direction, the pace of implementation is slow. A clear policy and a strong signal from the government are needed to disseminate information through

Barbara Sturm, et al. [7] studied on opportunities and barriers for efficient energy use in a medium-sized brewery. This paper gave an overview over the state of the art in the brewing industry commonly realized in large breweries and presented important barriers to efficiency in smaller companies. The production process of a typical medium-sized brewery in the UK was analyzed to identify principal measures to reduce energy and water demand. The case study also examined the particular problems preventing the brewery from realizing these measures. The analysis of the process showed that even basic and easily applicable efficiency measures have so far been neglected. Improving insulation and implementation of basic heat recovery measures could potentially reduce energy demand by 20 % and would result in a payback period of 1.3 years.

Qiang Wang, et al. [8] studied on barriers and opportunities of using the clean development mechanism to advance renewable energy development in China. Studying the barriers and opportunities of using clean development mechanism (CDM) to advance renewable energy deployment in China has a practical significance to achieve its ambitious renewable energy plan which affects the global efforts to curb carbon emission. This paper analyzed the role of CDM in promoting renewable energy development in China by reviewing the CDM activities, especially renewable energy CDM activities in China. There are three barriers to utilizing CDM for renewable energy deployment, namely the dilemma of additionality, lower proportional certified emission reduction credit revenues on the investment, and the lack of incentive for technology transfer. Whereas the opportunities of using CDM in promoting renewable energy development include the international carbon market redirection to renewable energy, Chinese renewable energy boom driven by a series of effective energy policies, and additional finance from CDM supporting Chinese renewable energy development. Based on the study on the barriers and opportunities, the article considered that CDM is an indispensable incentive and a viable choice to promote renewable energy deployment in China.

Mattijs Smits, et al. [9] studied on a feasibility study on biomass gasification at potential sites in Bokeo and Xiengkouang province. This study explored the feasibility of biomass gasification in Lao PDR in general and for three specific sites in the provinces Bokeo and Xiengkouang. The technology of biomass gasification involves the pyrolysis of various biomass sources, such as wood, rice husk and bamboo. The gas that is produced in this process can be used in various engines for electricity or heat generation. The first part of the study was dedicated to the key actors in the government and the relevant policies for biomass gasification. After that, three different types of sites for biomass gasification were discussed in general on biomass availability, (potential) demand and financial parameters at these sites. The chapters that follow explored a specific case for each of these sites in more detail and provide a detailed economic analysis for each of these cases. The main conclusion from this first study of biomass gasification was that there are several options that vary from commercially viable to options that need further research to make it work. Biomass gasification for village electrification offers opportunities for stable electricity supply even in areas deprived from water resources. However, the investment costs for these projects are high and the projected electricity demand low. Therefore, this option is currently not commercially viable and it is unlikely that it will be in the near future. This means that concerted effort from the public and private sector will be necessary to reap the benefits for socio-economic development at village sites. A gasifier near one of the many rivers in Lao PDR offers good options for bulk transport of biomass. However, combinations with other industrial practices or irrigation are needed to render the investment commercially viable. Commercial applications of biomass gasification using agricultural or industrial waste products (mainly rice husk) are commercially viable, provided that the energy demand is sufficient and enough biomass is available. All three parties involved in this study, PhiTrust, LIRE and Sunlabob were recommended to follow-up on one or more of the options mentioned in this feasibility study as well as exploring related projects and projects that fall outside the scope of this study.

Rade Karamarkovic, et al. [10] studied on biomass gasification opportunities in a district heating system. Biomass is usually gasified above the optimal temperature at the carbon-boundary point, due to the use of different types of gasifiers, gasifying media, clinkering/slugging of bed material, tar cracking, etc. This paper was focused on air gasification of biomass with different moisture at different gasification temperatures. A chemical equilibrium model was developed and analyses were carried out at pressures of 1 and 10 bar with the typical biomass feed represented by $CH1.4O0.59N0.0017$. At the temperature range 900–1373 K, the increase of moisture in biomass lead to the decrease of efficiencies for the examined processes. The moisture content of biomass may be designated as ''optimal'' only if the gasification temperature is equal to the carbon-boundary temperature for biomass with that specific moisture content. Compared with the efficiencies based on chemical energy and exergy, biomass feedstock drying with the product gas sensible heat is less beneficial for the efficiency based on total exergy. The gasification process at a given gasification temperature can be improved by the use of dry biomass and by the carbon-boundary temperature approaching the required temperature with the change of gasification pressure or with the addition of heat in the process.

Under Ayeyawady – Chao Phraya, et al. [11] Mekong Economic Cooperation Strategy (ACMECS) studied on Demonstration of Biomass Gasification for Electricity Project in Lao PDR. This studied on the biomass gasification for electricity was one of the effective systems to produce electricity in non-electrification area. As Thailand has researched and developed the gasification of various biomasses for many years, hence, the study and demonstration of biomass gasification for electricity project was proposed to Lao PDR in the fiscal year of 2007. This was performed under the Ayeyawady - Chao Phraya-Mekong Economic Cooperation Strategy (ACMECS) and the aid to develop renewable energy and conservation of energy among Cambodia, Lao PDR, Myanmar, and Thailand. In this project, the biomass gasification for electricity sized of 30 kWe is designed, built, and installed at Thopsok village, Patoomphone district, Champasak province. The biomass for the system was either wood chips or char coal which come from the wood mill or fast growing tree (both from nature and self farming). The engine generator was the duel fuel system which utilizes diesel and producer gases from the gasifier. At present, the system distributes the electricity to 95 houses in the village for about 5-6 hours every day. This helped the people to have a better living standard. Beyond the lighting, the public health and information also benefitted. From the tests, the system could operate up to 48 kWe maximum. At the design condition, 30 kWe, the producer gases could substitute the diesel consumption of around 60-70%. The cost for production the electricity is 3.28 baht/kWh and the consumption of the wood chip was 25-30 kg/h depending on the moisture content in the wood chip. After the tests and demonstration, the system was transferred to the Department of Electricity, Electric Power Management Division, Ministry of Energy and Mines of Lao PDR on the 13th December 2007.

Institute for Renewable Energy (LIRE) [12] studied on prospects of biomass gasification in Lairthong and Nyotphaire villages in Phoukoud District, Xiengkouang Province. In Lao PDR the demand for electricity is primarily for lighting. However, in the economically growing society of today, access to electricity comes with the provision for other energy services that can bring about changes in lifestyle and enable development. Therefore, electricity generation and supply can be considered as a starting point towards providing access of energy to the rural and geographically dispersed communities, thus enabling them further to be involved in productive activities. A study by Smits and Rietzler (2008) entitled Biomass gasification in Lao PDR: A feasibility study on biomass gasification at potential sites in Bokeo and Xiengkouang province for the Phitrust Foundation was conducted earlier this year with the aim to identify possible sites for the implementation of biomass gasification unit in Lao PDR. The major criteria for selection of eligible villages in this study were that the settlements should be situated in off grid areas that would not be connected to the national grid in next 10 years and that a sustainable supply of desirable biomass was present in the immediate vicinity. In that process, Lairthong and Nyotphaire villages in Phoukoud district of Xiengkouang province were selected jointly as a potential village electrification site for a 22 kW biomass gasifier. The main conclusion of the feasibility study for eligible sites was that the demand for electricity is very low and investment costs are very high. As such, for a village site, commercial viability of a biomass gasifier is not valid. However, biomass gasification technology could contribute to a broader social objective of providing electrification in rural areas and promoting its productive usage. In the context of low energy demand as well as limited biomass resource for biomass gasification in the village site, there still remains an option for implementation of the technology in combination with other renewable energy technologies such as pico-hydro and solar as a part of a broader hybrid grid for village electrification. This report presents the findings of a follow up study focused on the detailed investigation of Lairthong and Nyotphaire villages, and the prospects for a village electricity grid.

A. van der Drifta, et al. [13] studied on ten residual biomass fuels for circulating uidized-bed gasification. In co-operation with a Dutch company (NV Afvalzorg) and the Dutch agency for energy and environment (Novem), ECN had successfully tested 10 different biomass residues in its 500kW/h circulating uidized-bed gasification facility. Among the fuels used are demolition wood (both pure and mixed with sewage sludge and paper sludge), verge grass, railroad ties, cacao shells and different woody fuels. Railroad ties turn out to contain very little (heavy) metals. Initially, fuel feeding problems often impeded smooth operation. Contrary to feeding systems, the circulating fluidized-bed gasification process itself seems very possible concerning the conversion of different kinds of biomass fuels. The fuel moisture content is one of the most important fuel characteristics. More moisture means that more air is needed to maintain the process temperature resulting in better carbon conversion and lower tar emission but also lower product gas heating value and lower cold gas efficiency. So, for a good comparison of the gasification behavior of deferent fuels, the moisture content should be similar. However, the moisture content should be dined on an ash-free basis rather than on total mass (the usual way). Some of the ashes produced and retained in the second cyclone were analyses both for elemental composition and leaching behavior. It turned out that the leaching rate of Mo and Br, elements only present in small concentrations, are preventing the ash to be considered as inert material according to the Dutch legislation for dumping on land sites. C 2001 Elsevier Science Ltd. All rights reserved.

M. A. Silva, et al. [14] studied on the use of biomass residues in the Brazilian soluble coffee industry. The objective of this paper was to discuss the use of coffee grounds in the Brazilian soluble coffee industry. This residue was used as a fuel in the boilers of the same industry; so, data about their utilize-action were presented and analysed, discussing the actual technology and the advantages of improving the drying of the biomass with the exhaust combustion gases. After that, an experimental study was reported.

Akio Katayamab, C., et al. [15] studied on potential for rural electrification based on biomass gasification in Cambodia. Around 76% of the 10,452 villages of Cambodia will still be without electricity in the year 2010. They examined the potential of biomass gasification fuelled by alternative resources of agricultural residues and woody biomass to increase rural power supply, using geographic and social economic databases provided by the Royal Government of Cambodia. About 77% of villages currently without electricity have sufficient land available for tree planting for electricity generation based on a requirement of 0.02 ha per household. Among 8008 villages with sufficient land, they assumed that those villages that had greater than 10% of households owning a television (powered by a battery or a generator) would have both a high electricity demand and a capacity to pay for electricity generation. Those 6418 villages were considered appropriate candidates for mini-grid installation by biomass gasification. This study demonstrated that while agricultural residues such as rice husks or cashew nut shells may have high energy potential, only tree farming or plantations would provide sufficient sustainable resources to supply a biomass gasification system. Cost per unit electricity generation by biomass gasification is less than diesel generation when the plant capacity factor exceeds 13%. In order to ensure long-term ecological sustainability as well as appropriate tree-farming technology for farmers, there is an urgent need for studies aimed at quantifying biomass production across multiple rotations and with different species across Cambodia.

Nguyen Le Truong, et al. [16] studied on potential of distributed power generation from biomass residues in Vietnam–status and prospect. Vietnam is a developing country with an ever increasing power demand. The development of power sources is limited mainly to large central power plants using hydropower and traditional fossil fuels. Agriculture still plays a vital role in production activities generating high quantity of residues (biogas, straw, rice husk, etc...). These biomass residues could be a potential source for energy supply as well as for power production. This paper summarized and quantified the potential of distributed power generation and cogeneration from biomass residues in Vietnam. Besides, present situation, obstacles and future trends of producing power from renewable energy in general and biomass energy in particular, were also discussed.

CHAPTER III

RESEARCH METHODOLOGY

This study was divided into 5 parts of methodology:

1. Potential of residues crop.
2. Policy
3. Technology
4. Social Acceptance
5. Economic evaluation.

Methodology

Potential

Total amount and types of biomass available for producing biomass fuel of BGP system in Phadam village, Phiang district,Xayaburi province in Lao PDR Resource biomass total potential per year: kJ/kg

Policy

Target plan must meet requirement of 25 years set by Laos's government to support biomass to be part of the Renewable Energy framework.

1. Adder Cost, the plan to supported development renewable energy work, on the policies of Laos government.
2. Feed in tariff; will to study trends of energy price, internal of Laos.

Technology

This study selected the downdraft gasified technology for electricity production in Phadam village, Phiang district, Xayaburi province in Lao PDR due to the small size and demand of electricity (capacity not more than 500 kW), sufficient quantities of biomass feedstock such as corncob and cheap labour.

Social Acceptance

Questionnaire was used for collecting the data of Phadam village, Phiang district, Xayaburi province in Lao PDR. The data comprised society and basics of the people energy consumption, types and amount of biomass available.

Economic evaluation

Economic comparison methods of biomass gasified power generation and electric transmission line systems are listed below:

NPV, IRR, BCR, PBP and LCOE [14].

$$\mathrm{NPV} = \sum_{n=0}^{N} \frac{B_n}{(1+i)^n} - \sum_{n=0}^{N} \frac{C_n}{(1+i)^n} = \mathrm{PVB} - \mathrm{PVC} \qquad \text{[Eq. 2]}$$

Where,

B_n = Expected benefit at the end of

year n C_n = Expected cost at the end

of year n i = Discount rate

n = Project duration in years

N = Project period

PVB = Present Value Benefit

PVC = Present Value Cost.

Internal rate of return (IRR)

$$\sum_{n=0}^{N} \frac{B_n}{(1+r)^n} - \sum_{n=0}^{N} \frac{C_n}{(1+r)^n} = 0 \qquad \text{[Eq. 3]}$$

Where r = IRR.

Benefit Cost Ratio(BCR)

$$\mathrm{BCR} = \frac{\mathrm{PVB}}{\mathrm{PVC}} \qquad \text{[Eq.4]}$$

Payback period (PBP)

$$\sum_{n=1}^{N} (B_n - C_n) = 0 \qquad \text{[Eq.5]}$$

Levelised Cost of Energy (LCOE) [14]:

$$LCOE = \frac{I_o + \sum_{t=1}^{n} \frac{A_t}{(1+i)^t}}{\sum_{t}^{n} 1 \frac{M_{el}}{(1+i)^t}} \qquad \text{[Eq.6]}$$

Where:

LCOE: Levelized costs of electricity in Dollars/kWh

I_o: investment cost

At: annual total costs

Me: electricity output in year t in

kWh i: interest rate (discount rate) n:

economic lifetime in years

t: year of operation (1, 2,…n)

CHAPTER IV

RESULTS AND DISCUSSION

Potential Analysis

The total amount and types of biomass available for producing biomass fuel of BGP system in Phadam village, Phiang district, Xayaburi province in Lao PDR Resource biomass total potential per year: kJ/kg

Figure 5 Agriculture data in Phadam village Phiang district, Xayaburi province in Lao PDR

Potential of Biomass in Phadam Village, Phiang district, Xayaburi province in Lao PDR

Table 1 Agriculture data in Phadam village Phiang district, Xayaburi province in Lao PDR

Survey data	Percentage
Rice	16 %
Corn or Maize	68%
Soybean	1%

Table 1 (cont.)

Survey data	Percentage
Cassava	1%
Sugarcane	2%
Palm oil	1%
Rubber trees	1%
Orange	4 %

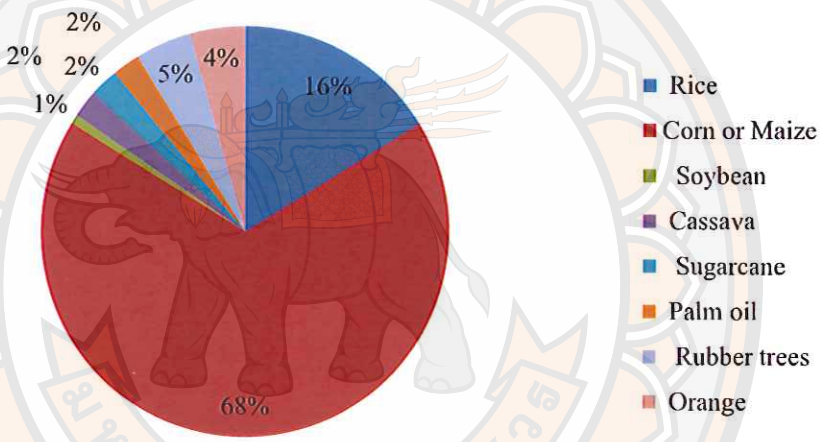

Figure 6 Graphical representation of agricultural produce in Phadam village Phiang district, Xayaburi province in Lao PDR

Table 1 and Figure 6 showed all of agriculture in phadam village. Mostly of agriculture produce there is corn or maize, rice, sugarcane, palm oil, cassava, orange and rubber with the following percentages 68%, 16%, 5%, 4%, 2% , 2% and 2% respectively.

Type of waste after harvested in Phadam Village, Phiang district, Xayaburi province in Lao PDR

Figure 7 Biomass waste after harvest Graphical representation of agricultural produce in Phadam village Phiang district, Xayaburi province in Lao P.D.R

Table 2 Waste after harvested data in Phadam village, Phieng district, Xayaburi Laos PDR

Survey data	Percentage
Type of waste after harvested	
Corn cob	64 %
Husk	15 %
Bagasse	2%
Wood waste	19 %
Waste usage	
Sale	10 %
Burnt	78 %
Fertilizer	12 %

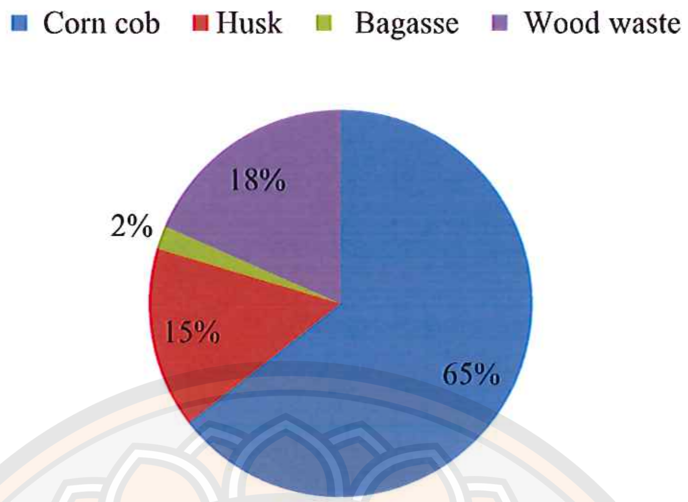

Figure 8 The harvest season in Phadam village, Phieng district, Xayaburi Laos PDR

Table 2 and Figure 8 shown above indicated agricultural residues from corn was the most abundant was 65%, and secondary is wood waste was 19%, and husk was 15%. All of the above waste is potentials to fuel the gasified power generator.

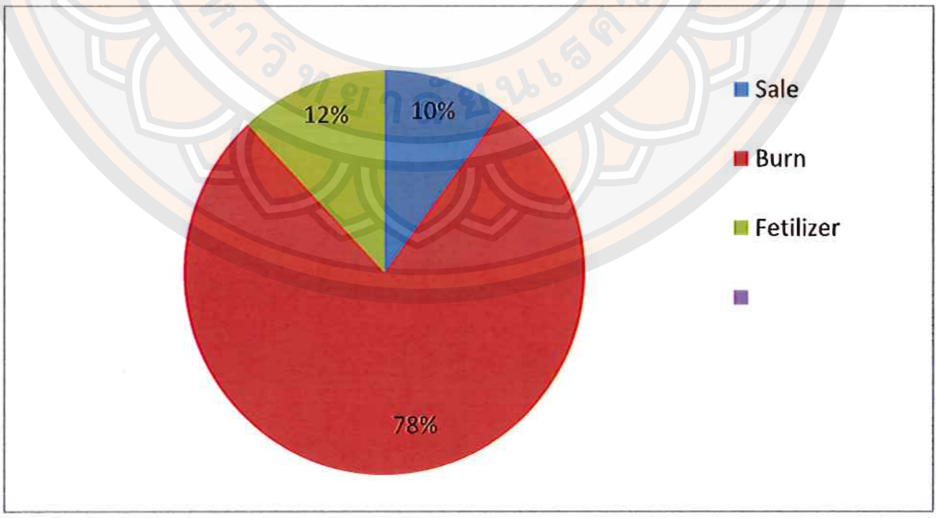

Figure 9 Graphical presentation of type of waste after harvest in Phadam village

Figure 10 Surveyed waste after harvested data in Phadam village

Table 2 and Figure 10 we can found that about waste usage of their village, almost to burn residue from agriculture after harvest is 78%, and In addition to sale is 10% of corn cob and husk, and In addition to made Fertilizer.

Biomass situation of the Phadam village, Phieng district Xayaburi Province, Lao PDR

This study, Analyzed the Opportunities and barriers to use biomass in Gasified Power Generation to be a solution for electricity demand in the rural areas; in Phadam village, Phiang district, Xayaburi province (Lao PDR). One option uses the biomass of agriculture as a source of energy from garbage residual such as corncob and wood chips to generate electricity. Analyzing quantitative and properties of the materials to be used in the production of gas in the province In Phadam village, Phiang district, Xayaburi province (Lao PDR); The analysis of data from a survey in the area. And analyze the economic, physical and chemical properties of the material to be gasified biomass, which is use as example here.

Table 3 Production (Ton), in Phadam village [2]

Year	Corn	Maize	Cotton	Peanut	Sesame	Orange
2006	180	92,420	70	4,985	1,170	6,000
2007	1,680	192,760	60	3,295	1,540	3,830
2008	1,400	220,905	70	4,120	1,550	6,535
2009	375	296,550	50	1,900	1,450	5,860
2010	370	284,400	125	5,430	1,640	11,835
Average	**801**	**217,407**	**75**	**3,946**	**1,470**	**6,812**

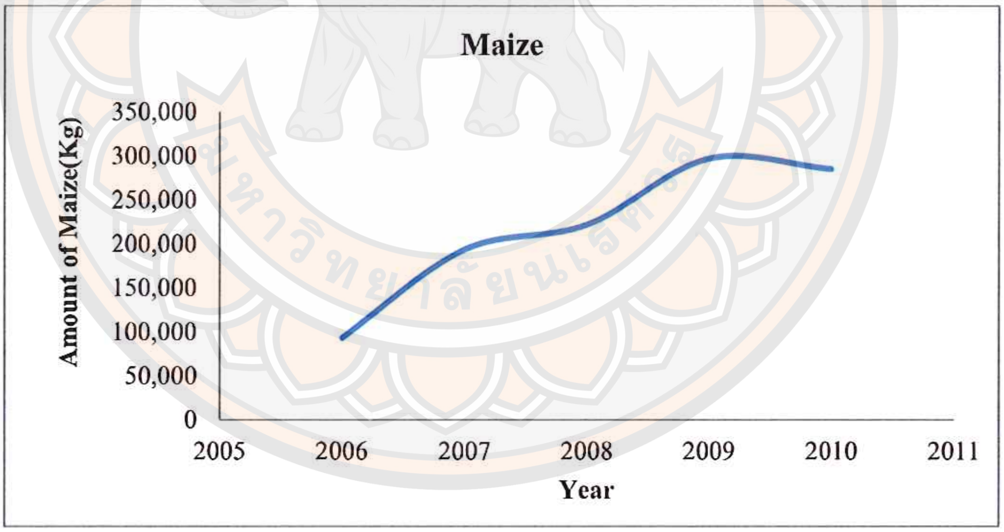

Figure 11 Graphical Potential of Maize in Phadam village [2].

After analyzing and evaluating on the potential of maize available in this area, as showed in the Figure 5. It was found the potential of biomass increase on each year from agricultural harvesting, especially during 2006-07 increase 93%, and 2007-08 increase 15%, and 2008-09 increase 30%. Therefore, the potential of biomass available agriculture in Xayaburi Laos has increased every years and had a lot of garbage from agricultural results support biomass gasified power generation system.

Table 4 Potential of waste to energy in Phadam village [2].

Potential of biomass	Energy	
	MJ	kWh
Maize	4532.083	1258.912
Corn	16.69771	4.638253
Total	4548.780	1263.550

From Table 3 above, the potential of biomass to produce a fuel gas had only Maize and corn, because their biomass residual had a high quantities with appropriate higher and lower heating value. Thereby the fuel gas to produce biomass gasified power generation system is using biomass residual from Maize and Corn and wood chip to responding the energy demand In Pardam village Piang district Xayaburi Province Lao PDR.

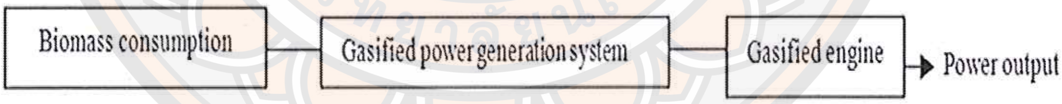

Figure 12 Flowchart of Biomass process converting [3]

The quantity of biomass fuel for the BGPS can be considered by the flow of energy conversion following from the system perspective, the technical performance of biomass energy production plants were characterized by the overall conversion efficiency, which dictated the required biomass amount for a given power output and, at the same time, was strongly dependent on the adopted technology and the plant size. As a consequence, for the purpose of this work, the plants were simply modeled as black boxes having a transfer function between the input biomass flow rate, M, (t $year^{-1}$) and the net power output, P_o, (kW_e). More specifically P_o results directly proportional to the biomass amount M, the biomass low heating value (LHV) (kJ kg^{-1}) at dry basis, and the plant energy conversion efficiency η_e, and inversely proportional to the plant annual operating hours, OH (h $year^{-1}$), as shown in Figure 4 [3].

$$P_o = \frac{M * \eta_e * LHV}{3{,}600 * OH} \quad [Eq. 7]$$

Where

M	=	218,208 T/year
M	=	218,208,000 Kg/year
η_e	=	20%
OH	=	7,008
LHV	=	17.19 kJ/kg
P_o	=	kWe

$$P_o = \frac{218{,}208{,}000 \; * 0.2 * 17.19}{3{,}600 * 7{,}008} = 29.7358 \text{ kWe}$$

Opportunities of Biomass Potential in Phadam Village

All the data collection tables and figures above show that Phadam village has sufficient and affordable feedstock to supply the proposed 30 kW biomass power plant. Most of the people living in Phadam village are farmers and their lively hood entirely depends on farming which makes this located ever more suitable since the biomass power plant will always have enough feedstock and cheap labour for operation. The laborers could be easily trained how to use reside to gain extra income.

Policy

The promotion and development renewable energy is one of priority policy of Government to stabilize energy supply and to assist in the social and economic improvement of the country. [4]

The Laos government supports domestic and foreign entrepreneurs and investors to invest in energy project at the village level. The development of renewable energy result while responding to demand of the local people contribute to the process of becoming self – sufficient in energy supply and for the development energy exports. Renewable energy development involves participation of public and private sector. Being a predominantly agriculture - base economy Lao PDR generate substantial amount of waste from agriculture and forest production and processing such as sugarcane biogases, risk husk, corn cob, wood waste and etc. Also, with growing urbanization, main cities are also generating significant amount of solid waste. At present, there is no large-scale exploitation of this resource for energy generation. In addition community forest could also sustainably develop to supply fuel for energy generation. There resource could potentially generate power productive used and other modern energy service in both urban and rural area either for off- grid or grid connected systems. The government recognizes the used of these agriculture and municipal solids waste to form part of overall energy mix to ensure energy security of the country. [4]

Promotion and development of other biomass energies: Being a predominantly agriculture-based economy, Lao PDR generates substantial amount of wastes from agriculture and forest production and processing such as sugarcane bagasse, rice husks, corn cobs, wood wastes, etc. Also, with growing urbanization, main cities are also generating significant amount of solid wastes. At present, there is no large-scale exploitation of these resources for energy generation. In addition, community forests could also be sustainably developed to supply fuel for energy generation. These resources could potentially generate power for productive uses and other modern energy services in both urban and rural areas, either for off grid or grid connected systems. The Government recognizes the use of these agricultural and municipal solid wastes to form part of the overall energy mix to ensure energy security of the country. [4]

In promoting biomass energy for electricity generation, the Government will undertake the following: [4]

1. Carry out biomass resource assessment and prepare a list of priority projects

2. Formulate a framework to stimulate private sector investments in power generation from various sources of biomass

3. Carry out pilot demonstration to test the framework developed and at the same time to demonstrate the technical viability of a specific biomass-based technology in the country

4. Undertake information dissemination and training programs

5. Develop biomass technology-based independent power producers (for both grid and off-grid power supply). [4]

Barriers of biomass due to the government policy in Laos PDR

The Laos PDR government has no adder and feed-in tariff to support renewable energy investments. Thailand unlike Laos PDR has very attractive adder and feed-in tariff which support renewable energy power plants such as biomass, solar PV, wind etc. The Laos PDR government has no immediate strategy or master plan that shows the financing of renewable especially such as biomass. Laos PDR population is a largely based on farming and hence sufficient feedstock such as corncob for the operation of biomass gasification power plants.

Technology

Study the technologies of biomass gasified power generation plant Installed and successful in southern of Laos. Type of down-draft gasified in the most suitable for the engine gases, because it give low tar gases and easy to operate [4]. In this project, the down-draft gasified is designed for the electricity of 30 KWe. Many parameters such as fuel properties, gas flow rate, gases properties should be known or assumed before the design can be carried out, the 30 KWe dual fuel diesel engine consume the biomass at around 40 kg/hr. this means the volume of the biomass fuel tank and hopper can be estimated when the running time is assumed. In this study, at least 100 hr of the test is performed. Therefore at least 4000 kg of biomass chip (wood). [4]

Design of down-draft gasifier [4]

In this section, the design of the down-draft gasifier is described. The step in the design has been adopted from the design of the small gasifier size smaller than 50 kW in the previous study. The size of the gasifier is re-calculated by entering the known information of the 30 kWe engine and generator and others. Parts which is designed are as following.

1. Hopper volume (or biomass stock tank)
2. Throat diameter
3. Size of the Nozzle
4. Distance between Nozzle and Throat
5. Length of Reduction Zone
6. Size of Combustion Zone
7. Cyclone
8. Burner

Assumption [4]

Operating period	= 5 hr
Gas flow rate	= 81.00 Nm3/hr [4] (see note)
1 kg of biomass produce gases	= 2.20 Nm3 [4]
If the gas flow rate is	= 81.00 Nm3/hr
Therefore the wood consumption	= 81/2.2
	= 36.82 kg/hr

Note: Gas flow rate of 81.00 Nm3/hr is estimated from the heating vale of the diesel Fuel required by the engine which is 11.3 L/hr at the electricity load of 30 kWe. The diesel heating value is 43 MJ/kg and its density is 830 kg/ m3, where the low heating value of the producer gas is 5.0 MJ/Nm3 approximately. In this assumption, the gas heating value is equal to 100% diesel in order to ensure the producer gas is enough to run at the maximum diesel replacement.

Hopper volume [4]

If the gasifier is operated 5 hr/day, hence

Wood quantity	= 36.82 x 5
	= 184.1 kg
Bulk Density of wood	= 288 kg/m^3
i.e. volume	= 184.1/288
	= 0.640 m^3

Volume of the wood hopper = 0.640 m^3

Throat diameter [4]

When the gas flow rate = 81.00 Nm^3/hr

The gasifer works as double throat

Heart Load for Downdraft Gasifier = 0.3 - 0.9 $Nm^3/hr\text{-}cm^2$

Give Heart Load = 0.5 $Nm^3/hr\text{-}cm^2$

Cross section area of throat, At = 81.00/0.5

= 162 cm2

Throat diameter = 14.36 cm

Over sized for 20% extra = 17.23 cm

Size of the Nozzle [4]

When wood consumption = 184.1 kg/day (5 hrs)

Biomass 1 g need air 1.6 g (Equivalent Ratio = 0.255) [4]

Air requirement = 1.60 g.Air/g.Wood

Hence, total air requirement = 294.4 kg

Air flow rate becomes = 58.88 kg/hr

Mass flow rate = 0.015 kg/s

At 30 °C , 1atm, air density = 1.16 kg/m^3

Volume flow rate = 0.016/1.16

= 0.013 m^3/s

Air inlet velocity to combustion zone = 15-30 m/s

Assume air velocity = 20 m/s

Air inlet area = 0.013/20

= 6.5×10^{-4} m^2

If 8 nozzle is used, inlet area = 8.1×10^{-5} m^2

i.e Nozzle diameter = 10.17 mm

Over estimated for 10% = 11.12 mm

Distance between Nozzle and Throat [4]

From the Design guideline of Imbert Gasifier

Distance between Nozzle – Throat = 0.5 – 1.4 Throat diameter

For small Gasifier (<50 kW) [1]

Distance between Nozzle – Throat ≅ throat diameter

Hence, in this case, distance between Nozzle – Throat = 17.00 cm

Length of Reduction Zone [4]

For small Gasifier (<50 kW) [1]

Length of the Reduction Zone ≅ 3xThroat diameter

Hence, the length of the Reduction Zone = 51.00 cm

Size of Combustion Zone [4]

Size of the Combustion Zone affects the temperature and the quality of the Producer Gas

For Swedish design rule [4]

Size of the Combustion Zone ≅ 2 – 4 x Throat diameter

Select the size of Combustion Zone = 3 x Throat diameter

= 51.00 cm

Cyclone [4]

Information

Inlet gas temperature to Cyclone

Gas flow rate to Cyclone

Gas velocity to Cyclone

Flow rate of Producer Gas = 20.75 Nm^3/hr

= 0.00576 Nm^3/s

Assume the inlet gas to cyclone temperature = 200 °C (473 K)

From Ideal Gas Law

$$\frac{PV}{T} = \text{Const.} \qquad \text{[Eq.8]}$$

When P = Const.

Gas flow rate to cyclone, Q = 0.00576x (473/303)

= 0.00899 m^3/s

Gas velocity to cyclone, V = 15 m/s

Q = VA

Cross section area of the cyclone inlet, A = 0.00899/15

= 0.000599 m^2

= 5.99 cm^2

Select the inlet pipe = 2x4 cm

Actual gas velocity to Cyclone = 0.0089/ (2x4x10-4)

= 11.24 m/s

Relationship in the High Efficiency Cyclone is shown in Figure 17

Pressure lose in Cyclone

Pf

$$P_f = \frac{6.5\rho_g v_g^2 A_d}{D_e^2} \quad \text{[Eq. 9]}$$

When vg = Gas inlet velocity, m/s

Ad = Inlet duct area, m^2

De = Diameter of cyclone exit duct, m

ρ_g = Gas density, kg/m^3

Gas density, ρ_g

$$PV = nRT \quad \text{[Eq. 10]}$$

When m = mass of gases, kg

n = mole of gases, kmol

R = 8.3143 kJ/kmol K.

P = 1 atm. (1.013x105 N/m2)

V = gas volume, m^3

T = temperature of producer gas

(Average 124.7 at gas flow rate of 5.0x10-3 m^3/s)

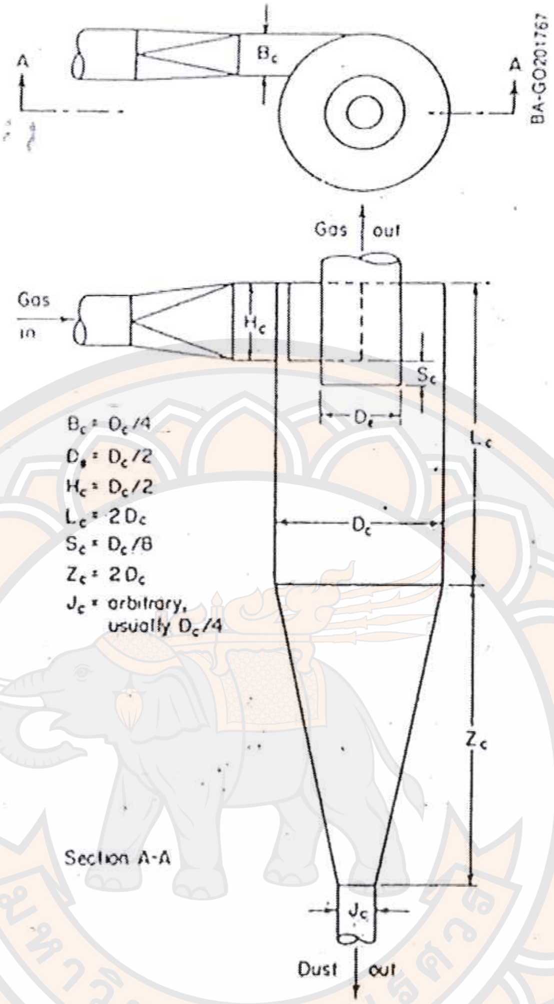

Figure 13 Relationship of each dimension in an efficient cyclone [4]

Opportunity of Biomass Technology

Biomass gasification technology for power generation has been proven to be very successful especially in large farming countries which have huge raw material for feedstock such as corncob, bagasse, rice husk etc.

Laos PDR is a major agriculture country in asian and hence have the potential for biomass gasification.

Social Acceptance

After surveying and analyzing data by the questionnaire forms in Pardam village, Phiang district, Xayaburi Province, Laos; we can see about purpose there, in Phadam village, Phiang district, Xayaburi province (Lao PDR). One option uses the biomass as a source of energy from garbage residual of agriculture such as: corncob and wood chips to generate electricity. Analyzing quantitative and properties of the materials to be used in the production of gas in the province In Phadam village, Phiang district, Xayaburi province (Lao PDR); The analysis of data from a survey in the area. And analyze the economic, physical and chemical properties of the material to be gasified biomass.

Figure 14 View of Pardam village, Phiang district, Xayaburi province in Lao PDR

Phadam village is a small village in Phieng district and has a rugged landscape with forested mountains with 120 households. Most of the populations live in rural areas which depend on agriculture as major source of income and this province is known for the production of rice, cotton, peanuts, sesame, corn or maize and oranges.

Figure 15 Appearance of house in Pardam village, Phiang district, Xayaburi province in Lao PDR

Due to this area's remotes from the big city, people live far away from each other, the incomes of local people are low, and so they cannot afford the grid electricity of their area. Most projects on transmission line of electric and distribution depend on foreign aid due to Laos's small economy.

Figure 16 Survey and data collection team

After the data collection team arrived at the that area, they started to walk around to inform and interview the people about their lives, in Phadam village, Phiang district, Xayaburi province (Lao PDR)

Figure 17 Data collection Meeting in Phadam village, Phiang district, Xayaburi province (Lao PDR)

The village headman informed and invited the representative of families to join the interview for collecting data of demand and interest in installation of biomass gasified power generation to the community.

Tables 5 Data of surveyed population in Phadam village, Phiang district, Xayaburi province (Lao PDR)

Survey data	Sample Population	Percentage from overall
Gender		
Male	80	67%
Female	40	33 %
Age		
20 – 25 years	17	5%
30 – 40 years	50	42 %
40 – 51 years	51	43 %
Marital status		
Single	23	20 %
Married	94	80 %
Level of education		

Tables 5 (cont.)

Survey data	Sample Population	Percentage from overall
High school certificated	11	10 %
Certificated of Technical vocation	11	10 %
Certificated of Vocational education	10	9 %
Diploma or High vocational certificated	12	11 %
Farmer	76	70 %

The population in this area included male 67%, female 33 %, and ages between 20 – 25, 30 – 40 and 40 – 51 years were 15%, 42%, and 43% respectively. Singles 20%, married is 80%, and the accepted level of education with high school certificated in this village was 10 %, certificated technical vocation 10 %, certificated of vocational education 9%, diploma or high vocational certificated 11 % and farmer 70 % as shown in table 5.

Table 6 Surveyed electricity requirements data in Phadam village electricity demand

Survey data	Percentage
Family members per house	
3 persons	21 %
5 persons	31 %
More than 5 persons	48 %
Electricity demand	
Needless	1 %
Demand	18 %
High demand	42 %
Very high demand	39 %

Table 6 (cont.)

Survey data	Percentage
Benefits expected to be received from electricity	
Less benefit	2 %
Moderate benefit	19 %
High benefit	42 %
Necessary	31 %
Unnecessary	4 %
Opinions on installation of 30 kW biomass power plant	
Disinterested	1 %
Interested	28 %
Very interested	49 %
Most interested	16 %
Participation of the community towards the biomass power plant	
Would like to participate	63 %
Not wish to participate	3%
Participate with incentive conditions	33 %

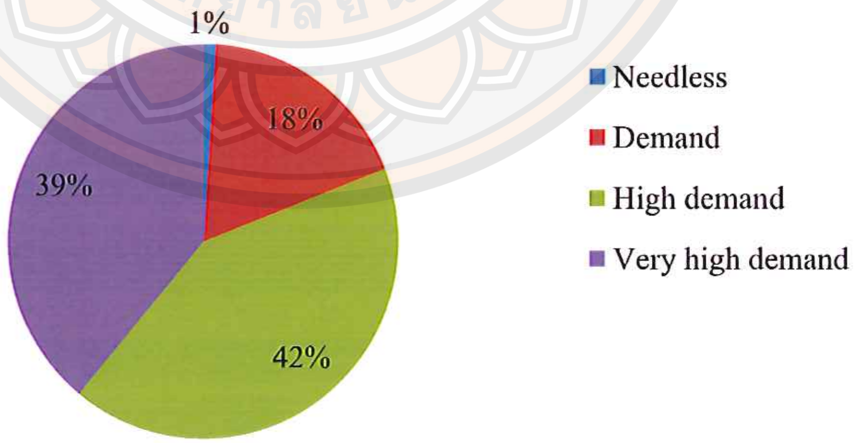

Figure 18 Graphical presentation of electricity demand in Phadam village, Phiang district, Xayaburi province (Lao PDR)

The collected data analyzes in figure 31 above showed people's Electricity demand. And any information also; such as : lamp for activities on night, and also safety, children can reading and doing a home work from school as well; in addition to people in that village still had the entertainment from watching tv, radio. And except that electricity energy still too could help increasing income to community there to sustainable.

Benefits expected to receive from electricity

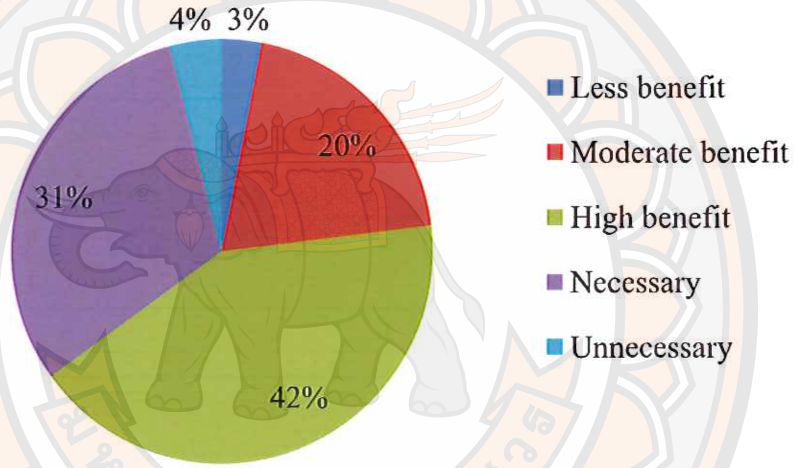

Figure 19 Benefits expected to receive from electricity in Phadam village, Phiang district, Xayaburi province (Lao PDR)

After show Graphical presentation of benefits expected to be received from electricity we can see the percentage of people to interested about benefits expected to be received from biomass gasified power generation system, the high benefit is 42%, less benefit just to 3%, and moderate benefit is 20%, and necessary is 31%, and unnecessary is 4%. So, after analyze can conclusion of that benefit to be necessary, and too important for the demands of that community area.

Opinions on installation of 30 kW biomass power plant plants in Phadam village, Phiang district, Xayaburi province (Lao PDR)

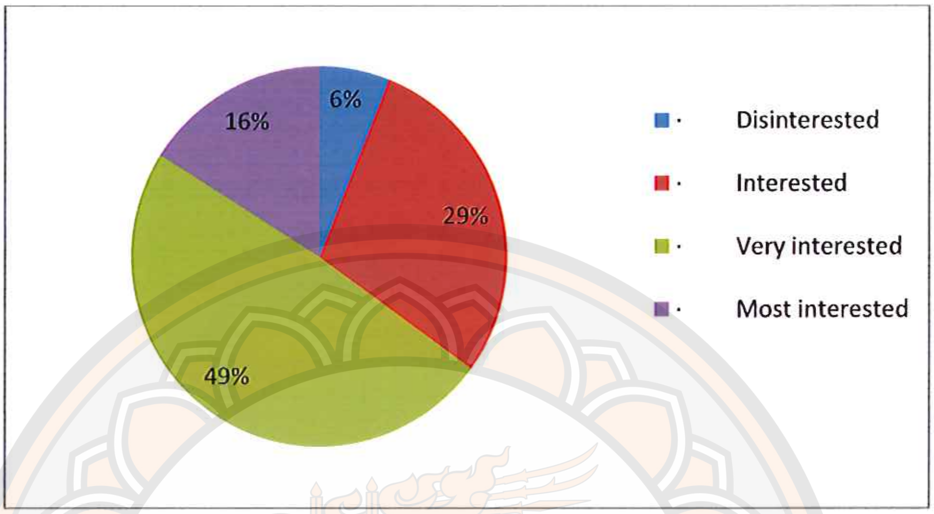

Figure 20 Installation of 30 kW biomass power plants in Phadam village, Phiang district, Xayaburi province (Lao PDR)

Due to have a demands using energy of electricity of people in that community. We have to survey and interview to collected data, to analyzing; follow the graph we can see that very interested is 49%, and interested 29%, and most interested is 16%, and accept that disinterested just to 6%. So we can conclusion the people of Phadam village look at the important for demands of energy electricity to community.

Participation of the community towards the biomass power plant

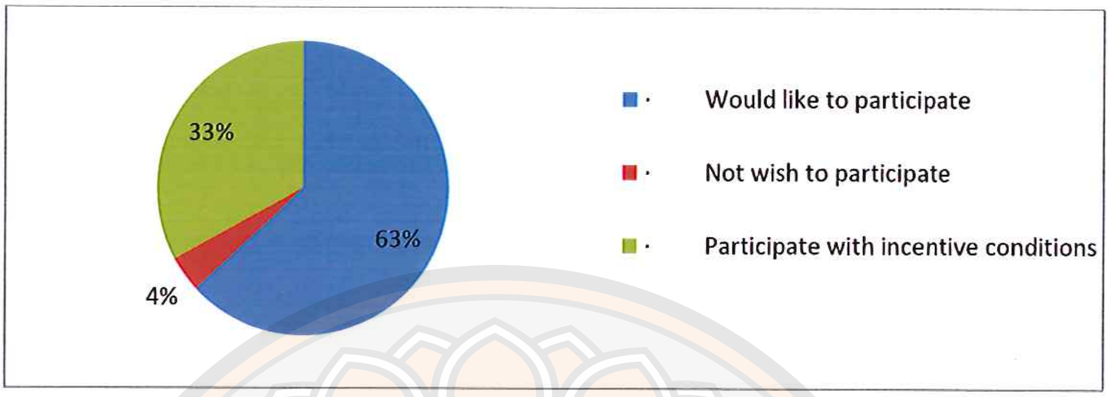

Figure 21 Graphical presentation of participation of the community towards the biomass power plant

After graph to show from collected data in that area, we can see demand of energy using of people in community and to demonstrate to cooperating of the people; would like to participate is 63%, not wish to participate is just 4%, and participate incentive condition is 33%. That to as a resulting for should've been a opportunities to installation the system that. To respond of demanding

Opportunity of Social Acceptance

After analyzing data from of social acceptance collected in Phadam village Phieng district, Lao PDR. We can see the demand to using electrical energy of people in that area, and resource of residual crop agriculture as shown from every table, and graphical; could be of the opportunity to installation the biomass gasified power generation. All the community is interested in cheap source of electricity (Biomass) and could also of benefit the community in areas of education of children, information from television, radio, that is basic necessary of the human to live. The community also want electricity help increase product from produce such as Corn mill, irrigation and processing which supported agriculture in the community.

Economic

This study using corncob to produce electricity, by the gasification power generation system has capacities is 30 KWe of project, during 25 years and rate at 9%. The data was analyzed by using parameters of economy; the production consists of cost of energy, payback period, net value (NPV), and internal rate of return (IRR). In southern of Laos, by using wood chip available, that project is completes at for convert fuel gasification system. So this study can conclusion of gasified power generation system. To applying maize material available for utilization in Phadam village, Xayaburi Province Lao PDR.

Table 7 Economic of 0.4 Distribution and 22 kV Transmission lines of electricity system in Xayaburi Province Laos

List	0.4 Distribution and 22 kV Transmission lines of electricity system, 1 km fixed cost
22kv transmission line	16000$ / km
0.4kv transmission line	8000$/ km
100 kVa Transformer	6000$ /Unit
Total	**30,000 $**

The table 12 above show the parameters of 0.4 and 22 kV distribution and transmission line system from Xayaburi Province in Laos. The cost of the 22 kV transmission line is 16000 USD/ km. While the 0.4 kV distribution line for Phadam Village is estimated to cost 8,000 USD/ km. The overall system is to be connected to a single 100 kVA transformer which cost about 6,000 USD. The overall cost for the transmission and distribution of electricity needed for Phadam village could cost about 30,000 USD.

Table 8 Economic of 0.4 Distribution and 22 kV Transmission lines of electricity system in Xayaburi province Laos

List	**0.4 Distribution and 22 kV Transmission lines of electricity system, 10 km and 77 km respectively: fixed cost (USD)**
22 kV transmission line	1,232,000
0.4 kV transmission line 10 kM	80,000
100 kVa Transformer	6000$ /Unit
Total	**1,318,000**

Table 8 show the overall lost for the full transmission and distribution system of 0.4 and 22 kV coming from Xayaburi Province to Phadam village in Laos PDR. The total distance between Xayaburi Province and Phadam village is about 77 km. The overall calculations on Table 8 above show the total cost for connecting Xayaburi Province to Phadam village is about 1,318,000 USD.

The inital cost for operating a 30 kW biomass gasifier power plant in Phadam village, Laos PDR was estimated to be about 45,966.70 USD as shown in Table 9 below. The calculations were over a period of 25 years in which the power plant O & M was about 20 % of total initial cost while the discount factor is kept at 7 %. The return of invest or payback period of the 25 years project life time was 15.03 years with a levelized cost of energy of 0.04 USD.

Table 9 30 kW Biomass project in Phadam village using corncob 25 years

List	30 kW Biomass project using corncob 25 years (USD)
Investment cost	45,966.70
O & M cost	20%
Discount factor	7%
Total Cost	206,219.93

Table 9 (cont.)

List	30 kW Biomass project using corncob 25 years (USD)
Total Benefit	269,183.30
NPV	62,963.37
IRR	9%
BCR	1.31
PBP	15.03 years
LCOE	1.18

Table 10 Comparison of 30 kW Biomass project and 0.4 Distribution and 22 kV Transmission lines in Phadam Village, Phieng District, Lao PDR.

List	30 kW Biomass project using corncob 25 years (USD)	0.4 Distribution and 22 kV Transmission lines, 10 km and 77 km respectively: fixed cost
Investment cost	45,966.70	1,318,000
O & M cost	20%	-
NPV	62,963.37	-
IRR	7 %	-
BC ratio	1,31	-
Payback period	15.03 Years	-
Total Cost	**206,219.93**	**1,318,000**

After analyzing and comparing the economic calculations of 30 kW biomass gasification project and 0.4 and 22 kV transmission and distribution line for Phadam village in Xayaburi province Laos, it was found that installing the 30 kW biomass gasification power plant was cheaper and more beneficial than installing transmission lines from Xayaburi province which is 77 km away from Phadam village. The feasibility to applying of biomass gasified power generation system, for utilization produced electricity efficiently. The net present value (NPV) =62,963.37 USD, Internal rate of return (IRR) = 7 %, BC ratio = 1.31 with payback period of 15 years.

Opportunity of economic feasibility of biomass in Phadam Village, Phieng District, Lao PDR

The Tables 13, 14 and 15 above showed that the 30 kW biomass gasification power plant is cheaper than the transmission and distribution line. The overall cost for transmission and distribution line from Xayaburi province is very expensive and most of the people living in Phadam village cannot afford the electricity tariff set by Laos PDR government.

Therefore the biomass project is more viable and beneficial for the farmers since will provide cheaper electricity, money back from sales of feedstock, labour and CO_2 emission reduction.

CHAPTER V

CONCLUSION

Opportunities and barriers of analyze parameters of biomass gasified power generation system in Phadam village, Xayaburi province, Lao PDR.

1. Potential

Phadam village, Xayaburi province in Lao PDR produces enough agricultural resources necessary to support biomass power plants because this community entirely depends on agriculture for their income. The agricultural produce include corn, maize, cotton, peanuts, sesame and oranges, but maize is the largest produce crop in Phadam village.

Opportunities of biomass potential: All the figures in the data collected from Phadam village showed it has sufficient and affordable feedstock to supply the proposed 30 kW biomass power plant. Corn and maize produced in Phadam constitutes about 68% or 218,208 ton per year of the entire village's total farm produce which is huge. Labour is also cheap and readily available in this community, which can also gain extra income from crop residue sales.

2. Policy

The Lao PDR government promotes the development of new renewable energy resources which are not yet widely explored in Lao PDR to replace resources that will be exhausted in the future, also known as "nonrenewable energy" (fossil fuels, coal, natural gas etc.). These renewable energy resources comprise biomass energy (bio fuels, biogas, etc.); solar energy; wind; small hydropower. The government hopes to increase the share of renewable energies to 30% of the total energy consumption in 2025 and reduce the importation of fossil fuels, the Government outlines a tentative vision to reach 10% of the total transport energy consumption from bio fuels.

Barriers of biomass due to the government policy: Lack of awareness Barriers among policy makers, consumers, suppliers, Lack of knowledge concerning opportunities, reliability and lifetime of technologies, Lack of knowledge concerning impacts on environment from renewable energy production, Lack of information on resources available and sustainability, in particular with regard to biomass. The lack of a clear and proper financing mechanism for low capacity power plants (30 kW biomass power plants). Laos government does not support adder and feed in tariff support for renewable investments and lacks local standards for renewable energy instruments

3. Technology

The downdraft gasification power system was selected for this study since it's very suitable for small scale power generation especially with corncob raw materials for feedstock. These raw materials are easily available in farming rural areas such as Phadam village and could be easily promote and installed in similar villages.

Opportunity of Biomass Technology: Biomass gasification technology for power generation has been proven to be very successful especially in large farming countries which have huge raw material for feedstock such as corncob, bagasse, rice husk etc. The corncob as feedstock saves a lot of time and money since it does not require and pretreatment before its used for power generation. This reduces complexity of operating this system in such community with less skills.

4. Social Acceptance

A survey was conducted in Phadam to ask questions about their energy and also promote the 30 kW biomass power plant as suitable source of energy. A community meeting was used to inform and promote the benefits of biomass technology. The data collection results showed that majority of the villagers support and will welcome the installation of the biomass gasification technology.

Opportunity of Social Acceptance: The Phadam community is interested in cheap source of electricity (Biomass) and the benefits it generate such as information from TV, radio, corn mill, irrigation and food processing which are all factors that will improve life in the village.

5. Economic

Phadam village is about 77 km from Xayaburi Province and the total cost for connecting Xayaburi Province to Phadam village is about 1,318,000 USD. This transmission line when installed will have a feed-in- tariff that is too expensive for the poor rural farming community of Phadam village.

The investment cost for installing a 30 kW biomass power plant in Phadam village, Laos PDR was calculated to be about 45,966.70 USD as shown in table 14 below. The calculations were over a period of 25 years in which the power plant O & M was about 20 % of the total initial cost while the discount factor was kept at 7 %. The return of invest or payback period of the 25 years project life time was 15.03 years with a levelized cost of energy of 0.04 USD.

Opportunity of economic feasibility of biomass in Phadam village: The overall cost for transmission and distribution line from Xayaburi province is very expensive and most of the people living in Phadam village cannot afford the electricity tariff set by Laos PDR government.

Therefore the biomass project is more viable and beneficial for the farmers since will provide cheaper electricity, money back from sales of feedstock, labour and CO_2 emission reduction.

Table 11 Opportunities and barriers of analyze parameters of biomass gasified power generation system in Phadam village, Xayaburi province, Lao PDR.

List	Opportunities	Barriers
Potential	1. Phadam village has sufficient and affordable feedstock to supply the proposed 30 kW biomass power plant. 2. Corn and maize produced in Phadam constitutes about 68% or 218,208 T/year 3. Labour is also cheap and readily available in this community, which can also gain extra income from crop residue sales 4. Gain extra income to community	

Table 11 (cont.)

List	Opportunities	Barriers
Policy		1. The Lao PDR government plan and development of renewable energy resources are not yet widely. 2. Lack of awareness in the policy makers, consumers, suppliers and reliability 3. Laos PR government does not have the plan for support adder and feed in tariff for renewable investment.
Technology	1. The downdraft gasification power system was selected for this study since it is a very suitable technology for small scale biomass power generation especially with corncob raw materials for feedstock. 2. The corncob as feedstock saves a lot of time and money since it does not require and pretreatment before its used for power generation	

Table 11 (cont.)

List	Opportunities	Barriers
Social acceptance	1. A survey was conducted in Phadam to ask questions about their energy cmsumtion and also promote the 30 kW biomass power plant. 2. Villagers will support and they are welcome the installation of the biomass gasification technology 3. The Phadam community is interested in cheap source of electricity from biomass and the benefits from it for TV, radio, corn mill, irrigation and food processing which are all factors that will improve life in the village.	
Economic	The investment cost for installing a 30 kW biomass power plant in Phadam village, Laos PDR was calculated to be about 45,966.70 USD and cost of energy was 0.04 USD per kWh. Therefore, COE of biomass power generation can compete with other source of energy.	

Economic Comparison between Transmission line and 30 kw Biomass plant

The analysis calculated the potential biomass efficiency derived from agricultural residues for materials conversion into gasified power generation system, and especially using corncob available in the area. The transmission and distribution line was found to be very expensive and even if when it's installed the poor farming community of Phadam village cannot afford the electricity tariff.

The total distance between Xayaburi Province and Phadam village is about 77 km. The overall calculations on table 13 above show the total cost for connecting Xayaburi Province to Phadam village is about 1,318,000 USD. This transmission line when installed will have a feed-in- tariff that is too expensive for the poor rural farming community of Phadam village.

The initial cost for operating a 30 kW biomass gasifier power plant in Phadam village, Laos PDR was estimated to be about 45,966.70 USD as shown in table 14 below. The calculations were over a period of 25 years in which the power plant O & M was about 20 % of the total initial cost while the discount factor was kept at 7 %. The return of invest or payback period of the 25 years project life time was 15.03 years with a levelized cost of energy of 0.04 USD.

This economic comparison showed that the 30 kW biomass power plant is far cheaper and more economically viable to install in Phadam Village instead of connecting the village to the transmission line.

The installation of 30 kW biomass power plant has many benefits for the small community since it could provide cheaper electricity but also farmers could also get income from the sales of feed stock and residue.

The biomass power plant could be more environmentally friendly than the transmission line which will pollute and add green house gases which cause severe damage to the climate.

Recommendation

1. The Lao PDR government should consider providing incentive such as adder, subsidies and low feed-in tariffs to help attract and promote investments in renewable energy especially in biomass gasification

2. The biomass gasification technology is very suitable and easy to install in farming rural communities

3. The social acceptance of biomass project is rural farming communities is always welcomed since they benefit more than they spend on energy consumption

4. The economical assessment for biomass gasification and installation in most countries such as Thailand is a success story and could be promoted and installed in all Lao PDR rural farming communities away from the electricity grid.

REFERENCE

REFERENCE

[1] Mattijs Smits and Jakob Rietzler. (2008). **A feasibility study on biomass gasification at potential Sites in Bokeo and Xiengkouang Province.** Lao PDR.: Lao Institute for Renewable Energy.

[2] Gurung, S.P. (2008). **Prospects of biomass gasification in Lairthong and Nyotphaire Villages in Phoukoud District, Xiengkouang.** Lao PDR.: Lao Institute for Renewable Energy (LIRE).

[3] Ministry of Energy. (2009). **Current situation of energy in Lao PDR: Data energy consumption report.** Lao PDR.: Department of Electricity.

[4] Prachason Sajin, Suree Jaroonsak, R.Uma.T.C. Kandpal and G. Foley, G. Barnard. (2008). Study and demonstration of biomass gasificationfor electricity project in Lao PDR. In **Ayeyawady - Chao Phraya - Mekong Economic Cooperation Strategy (ACMECS)** (pp. 1-14). Lao PDR.: Ubon Ratchathani University.

[5] Sahataya Ladpala. (2008). **Management model of sustainable biomass gasifier power generation system for community in Thailand.** Doctoral dissertation, Ph.D., Naresuan University, Phitsanulok.

[6] Kristina Difs, Elisabeth Wetterlund, Louise Trygg and Mats Söderström. (2010). Biomass gasification opportunities in a district heating system **Biomass and Bioenergy**, 34(5), 2914–2922.

[7] Andri Faaij, Reni, Van Ree, Lars, Waldheim, Eva Olsson, Andri oudhuis f, Ad Van Wijk, Cees Daey –Ouwensll and Wim Turkenburg. (1997). Gasification of biomass waste and residues for electricity production, **Biomass and Bioenergy,** 12(6), 387-407.

[8] Jia Li, XiLiang, TimCockerill , Jon Gibbins , DavidReiner. (2012). Opportunities and barriers for implementing CO_2 capture ready design. **Energy Policy,** 45, 243–251.

[9] Sturm, B., Hugenschmidt, S., Joyce, S., Hofacker, W. and Roskilly, A. P. (2013). Opportunities and barriers for efficient energy use in a medium-sized brewer. **Applied Thermal Engineering,** 53(2), 397–404.

[10] Van der Drift, A., J. Van Doorn, and J. W. Vermeulen. (1995). Ten residual biomass fuels for circulating uidized-bed gasification. **Netherlands Energy Research Foundation (ECN),** 20(1), 45-56.

[11] Silva, M. A., Nebra, S. A., Silva, M. M. and Sanchez, C. G. (1998). The use of biomass residues in the Brazilian soluble coffee industry. **Campinas, Brazil,** 14(5-6), 457- 467

[12] Abe, H., Katayama, A., Sah, B. P., Toriu, T., Samy, S., Pheach, P. and Grierson, P. F. (2007). Potential for rural electrification based on biomass gasification in Cambodia. In **Proceedings of a Joint Workshop of IEA Bioenergy Task 30 and Task** (pp. 656–664). Perth, Western Australia: Nippon Koei Co. Ltd., Tokyo, Japan.

[13] Le Truong, Nguyen and Tran Quang, Cu. (2005). Potential of Distributed Power Generation from Biomass Residues in Vietnam–Status and Prospect. **International Energy Journal,** 6(1), 1-12.

[14] Prasertsan, S, and B, Sajjakulnukit. (2006). Biomass and biogas energy in Thailand: Potential, opportunity and barriers. **Renewable Energy,** 31(5), 599–610.

[15] A.V. Bridgwater. (1995). The technical and economic feasibility of biomass gasification for power generation. **Fuel,** 74(5), 631–653.

[16] Wang, Qiang and Yong Chen. (2010). Barriers and opportunities of using the clean development mechanism to advance renewable energy development in China. **Renewable and Sustainable Energy Reviews,** 14(7), 15-50.

APPENDIX

APPENDIX A ECONOMIC

30 kW Biomass Gasification power plant using Corncob in Phadam Village, Xayaburi Province, Laos PDR

					5278041	Gasfer	350,000
Investment cost of Thermal Plant		45,967 Baht/kWp		Discount Rate	9%	Diesel engine	420000
				Plant capacity	30 kWp	Instrument	105000
Corn crop	1.15 kgs	1 kWh			7,008 Hr	travel cost	204000
Total Wood	241,776 kgs	210,240 kWh				commision	200000
	242 tonne					Training	100000
1 tonne wood	50 Bath	12,089 Bath/year	2%			Cost Area	
							1,379,000

Electricity Cost			2.26 Baht/kWh	(Increase	3% for each year)
O & M	20%	275,800	9,193 Baht/kWp	(Increase	2% for each year)
Envir. Benefits		10.42 US$/ton CO2	438 Baht/ton CO2	(Increase	3% for each year)
CO2 Reduction Emissi		0.43 kg CO2/kWh	0.44 Baht/kg CO2		

477193.3333

1.16388885 0.00021

Year	DF 7%	Direct Benefit Annual Gen (kWh)	Electricity Cost	CO2 Emission	Agriculture Waste Income	Total Benefit (Baht)	Total Cost Investment of System	O & M Cost	Present Value @ 9% DR Total Cost (Baht)	Benefit	Cost	NPV
0	1	-	-	-	-	-	1,379,000	-	1,379,000	-	1,379,000	-1,379,000
1	0.935	210,240	475,142	39,564	12,089	526,795		1,032,593	1,032,593	492,343	965,062	-472,719
2	0.873	210,240	489,397	40,751	12,331	542,478		281,316	281,316	473,800	245,701	228,099
3	0.816	210,240	504,079	41,974	12,577	558,629		286,942	286,942	456,009	234,231	221,778
4	0.769	210,240	519,201	43,233	12,829	575,262		292,681	292,681	442,377	225,072	217,305
5	0.713	210,240	534,777	44,530	13,085	592,392		298,535	298,535	422,375	212,855	209,520
6	0.666	210,240	550,820	45,866	13,347	610,033		304,505	304,505	406,465	202,892	203,573
7	0.623	210,240	567,345	47,242	13,614	628,200		310,596	310,596	391,180	193,408	197,772
8	0.582	210,240	584,365	48,659	13,886	646,910		588,378	588,378	376,502	342,436	34,066
9	0.544	210,240	601,896	50,119	14,164	666,179		323,144	323,144	362,335	175,758	186,577
10	0.508	210,240	619,953	51,622	14,447	686,022		329,607	329,607	348,705	167,539	181,166
11	0.475	210,240	638,552	53,171	14,736	706,459		336,199	336,199	335,638	159,728	175,911
12	0.444	210,240	657,708	54,766	15,031	727,505		342,923	342,923	323,012	152,258	170,755
13	0.415	210,240	677,439	56,409	15,332	749,180		349,781	349,781	310,910	145,159	165,750
14	0.388	210,240	697,763	58,101	15,638	771,502		356,777	356,777	299,188	138,358	160,830
15	0.362	210,240	718,696	59,844	15,951	794,491		363,912	363,912	287,923	131,882	156,042
16	0.339	210,240	740,256	61,640	16,270	818,166		642,760	642,760	277,113	217,703	59,410
17	0.317	210,240	762,464	63,489	16,595	842,548		378,614	378,614	266,751	119,869	146,881
18	0.296	210,240	785,338	65,393	16,927	867,659		386,187	386,187	256,740	114,273	142,468
19	0.277	210,240	808,898	67,355	17,266	893,519		393,910	393,910	247,058	108,916	138,142
20	0.258	210,240	833,165	69,376	17,611	920,152		401,789	401,789	237,767	103,822	133,945
21	0.242	210,240	858,160	71,457	17,963	947,580		409,824	409,824	228,841	98,973	129,868
22	0.226	210,240	883,905	73,601	18,323	975,828		418,021	418,021	220,244	94,347	125,897
23	0.211	210,240	910,422	75,809	18,689	1,004,920		426,381	426,381	211,938	89,924	122,014
24	0.197	210,240	937,735	78,083	19,063	1,034,881		434,909	434,909	203,975	85,721	118,254
25	0.184	210,240	965,867	80,426	19,444	1,065,736		443,607	443,607	196,309	81,712	114,596
Total						19,153,027		10,133,890	11,512,890	8,075,499	6,186,598	7%
		5,256,000	17,323,342	1,442,476	387,208							
labor	300000					766,121		405,356			NPV=	1,888,901
transport	36000										IRR	7%
wood	201400										BC ratio	1.31
mantanar	18000										Payback	15.03
	555400										LCOE	1.18
	40.28											

Table Electricity Tariff [3]

Electricity Tariff

1$ = 8010 kip

Category	Tariff kip/kWh
1. Residential	
Low Voltage(22 to 35 kV	
0-25 kWh	230
26-150 kWh	301
> 150 kWh	773
2. Non Residential	
Irrigation	362
Government off	674
Industry	607
General business	835
International	1077
Entertainment	1106
3. Medium Voltage(22 to 35 kV)	
Irrigation	308
Industry	516
Government off	573
General business	709
Average Tariff	540

6

6

APPENDIX B POLICY

Policy: The promotion and development renewable energy

The Laos government supports domestic and foreign entrepreneurs and investors to invest in energy project at the village level. The development of renewable energy result while responding to demand of the local people contribute to the process of becoming self – sufficient in energy supply and for the development energy exports. Renewable energy development involves participation of public and private sector. Being a predominantly agriculture - base economy Lao PDR generate substantial amount of waste from agriculture and forest production and processing such as sugarcane biogases, risk husk, corn cob, wood waste and etc. Also, with growing urbanization, main cities are also generating significant amount of solid waste. At present, there is no large-scale exploitation of this resource for energy generation. In addition community forest could also sustainably develop to supply fuel for energy generation. There resource could potentially generate power productive used and other modern energy service in both urban and rural area either for off- grid or grid connected systems. The government recognizes the used of these agriculture and municipal solids waste to form part of overall energy mix to ensure energy security of the country.

Promotion and development of other biomass energies: Being a predominantly agriculture-based economy, Lao PDR generates substantial amount of wastes from agriculture and forest production and processing such as sugarcane bagasse, rice husks, corn cobs, wood wastes, etc. Also, with growing urbanization, main cities are also generating significant amount of solid wastes. At present, there is no large-scale exploitation of these resources for energy generation. In addition, community forests could also be sustainably developed to supply fuel for energy generation. These resources could potentially generate power for productive uses and other modern energy services in both urban and rural areas, either for off grid or grid connected systems. The Government recognizes the use of these agricultural and municipal solid wastes to form part of the overall energy mix to ensure energy security of the country.

1. Carry out biomass resource assessment and prepare a list of priority projects

2. Formulate a framework to stimulate private sector investments in power generation from various sources of biomass

3. Carry out pilot demonstration to test the framework developed and at the same time to demonstrate the technical viability of a specific biomass-based technology in the country

4. Undertake information dissemination and training programs

5. Develop biomass technology-based independent power producers (for both grid and off-grid power supply)

POLICY

Table Potential and capacity to meet 30% target of renewable energy development until 2025

Item	Renewable energy types	Potential	Existing	2015		2020		2025	
		MW	MW	MW	Ktoe	MW	Ktoe	MW	Ktoe
A	**Electricity**			140		243		728	416
1	Small Hydropower	2000	12	80	51	134	85	400	256
2	Solar	511	1	22	14	36	23	33	21
3	Wind	>40		6	4	12	8	73	47
4	Biomass	938		13	8	24	16	58	37
5	Biogas	313		10	6	19	12	51	33
6	Solid waste	216		9	6	17	11	36	23
7	Geothermal	59							
B	**Bio-fuel**	**ML**	**ML**	**ML**		**ML**		**ML**	
1	Ethanol	600		10	7	106	178	150	279
2	Biodiesel	1200	0.01	15	13	205	239	300	383
C	**Thermal energy**	**Ktoe**	**Ktoe**						
1	Biomass	227			23		29		113
2	Biogas	444			22		44		178
3	Solar	218			17		22		109
Total									
Energy demand (Ktoe)		2145			2504		4064		4930
Renewable energy contribution					172		668		1479
Proportion		30%			7 %		20%		30%

Table Investment in renewable energy sector

Item	Phase / Description	2015		2020		2025	
		MW	MUSD	MW	MUSD	MW	MUSD
1	**Electricity**	137	491	299	1105	481	1799
1.1	Small Hydropower	96	288	209	629	337	1010
1.2	Solar	14	41	30	90	48	144
1.3	Biomass	7	24	15	52	24	72
1.4	Biogas	7	21	15	45	24	192
1.5	Municipal solid waste	7	48	15	105	24	168
1.6	Wind	7	55	15	120	24	168
2	**Biofuel production**	**ML**	**MUSD**	**ML**	**MUSD**	**ML**	**MUSD**
2.1	Ethanol	2	5	41	33	79	63
2.2	Biodiesel	2	9	50	33	79	63
C	**Research & Development**		56		10		17
Total			491		1105		1799
Public investment			5		10		17
Public Enterprise Investment			10		22		36
Private Investment			476		1073		1746

APPENDIX C PAPER

Biomass gasified power generation system in Xayaburi province Lao PDR

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Abstract: A study in the evaluation of gasified power generation. With corn cobs as feedstock in Xayaburi province Laos. By studying the potential of biomass in the area. And studying the policy to supports on renewable energy, especially in part of biomass gasified power generation system. The assessment revealed that in Economics. With biomass gasified power generation. Using corncob in Xayaburi province Laos. Is opportunity and possible. By after studied the potential of biomass, and can calculated to evaluate power output from biomass material gasified available is Po = 144,426.16 KWe. And the evaluation of economic from the analysis can found that result from investment cost the project of gasification power generation system by the assumption during of time 25 years; such as investment cost 1,529,000 BTH, O & M cost 442,632 BTH, NPV 3,121,866 BTH, IRR 8%, BC ratio 4,88%. This is a result of success after analysis, to tend possible.

Keywords: Biomass, gasified power generation, Corncob, Potential, Economic.

Introduction: The Lao People's Democratic Republic is a land-locked country located in South East Asia. In 2010, the population of Laos was 6.3 million people with a Gross Net Income per Capita of 580 USD; which the World Bank classifies as a low income country. As a result, the country has heavily relied over the years on foreign aid for its development.

Lao People's Democratic Republic is an agricultural country where most of the land in the country is used for agriculture of plants and trees. Therefore residuals from the harvest and agricultural industries, which can be used as biomass fuel, are in large quantity. However, there has not been a study on the potential utilization of this biomass. The study on the potential utilization of the biomass can lead to planning and searching for the means to efficiently transform bio-residuals into biomass fuel by applying the suitable technology to each type of biomass. Not only that biomass fuel has no environmental effects, but it also reduces costs on imported fuel, increases the income and improves the standard of livings of the people in the country.

Energy Consumption

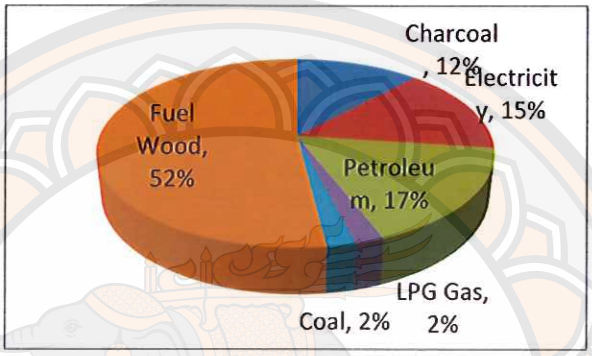

Figure 1 Energy Consumption in Laos 2010

Due to the energy shortage crisis is affected to the world's economy; therefore the study of renewable energy is one way to help achieve continuous improvement. And the most important of a development is self-reliant. Renewable energy technology in LAO PDR consists of Photovoltaic, a technology with high cost and mostly imported components, has been utilized mainly in the form of solar home systems, for stand-alone lighting applications in rural areas and the biogas plants using cattle dung and feedstock are popularized mainly for cooking household size, [2] Pico-hydro system, but not mostly used, and improved saving stove for household to promote the use of renewable energy resources and technology in communities.

Xayaburi province of LAO PDR is very close to the northern provinces of Thailand such as Nan, Uttaradit and Chiangrai and has a rugged landscape with forested mountains. Most of the populations live in rural areas which depend on agriculture as major source of income and this province is known for the production of rice, cotton, peanuts, sesame, corn or maize and oranges; Due to these area remotes from the big city, people live far away from each other, the incomes of local people are low, so they cannot afford for grid electricity to their area. Most projects on transmission line of electric and distribution depend on foreign aid due to Laos's small economy.

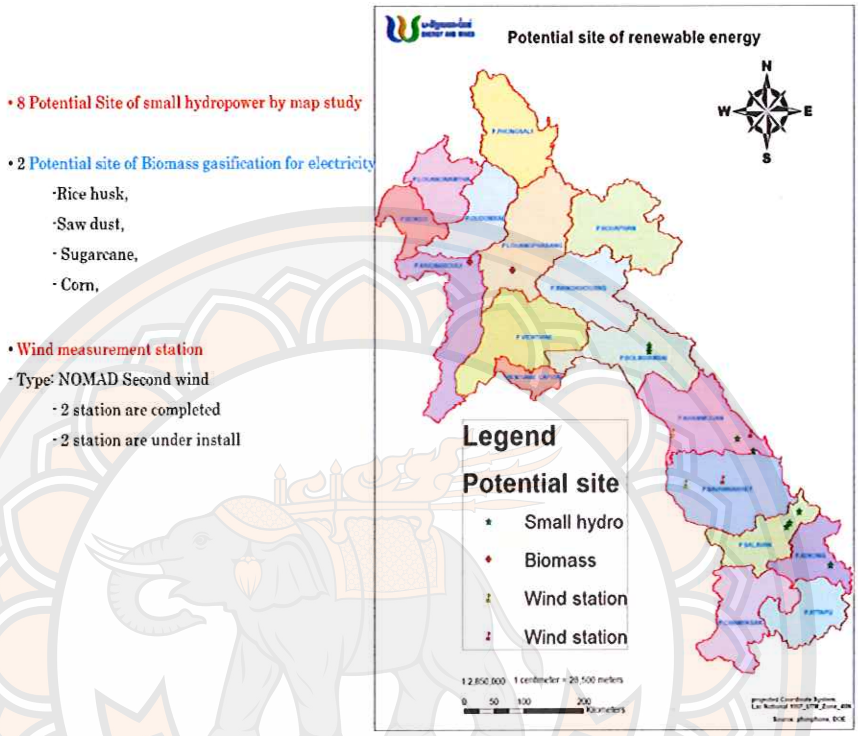

Figure 2 Potential site of renewable energy of Laos

Therefore there is a need for a sustainable energy alternative for the communities. So, this study provides an overview of the opportunities and feasibility of Biomass Gasified Power Generation to be a solution for electrical demand in the rural areas, far from grid connection transmission line.

Objective

1. To analysis potential of biomass gasified power generation system in Xayaburi province, Lao PDR

2. To analyze the economics of biomass gasified power generation. In Xayaburi province, Lao PDR.

Methodology:

Potential

Type of biomass, that can be the fuel for feed stock the system in Phadam village, Phiang district, Xayaburi province in Lao P.D.R

Table 1 Production (Ton), In Xayaburi Province, LAO PDR [3]

Year	Corn	Maize	Cotton	Peanut	Sesame	Orange
2006	180	92,420	70	4,985	1,170	6,000
2007	1,680	192,760	60	3,295	1,540	3,830
2008	1,400	220,905	70	4,120	1,550	6,535
2009	375	296,550	50	1,900	1,450	5,860
2010	370	284,400	125	5,430	1,640	11,835
Average	**801**	**217,407**	**75**	**3,946**	**1,470**	**6,812**

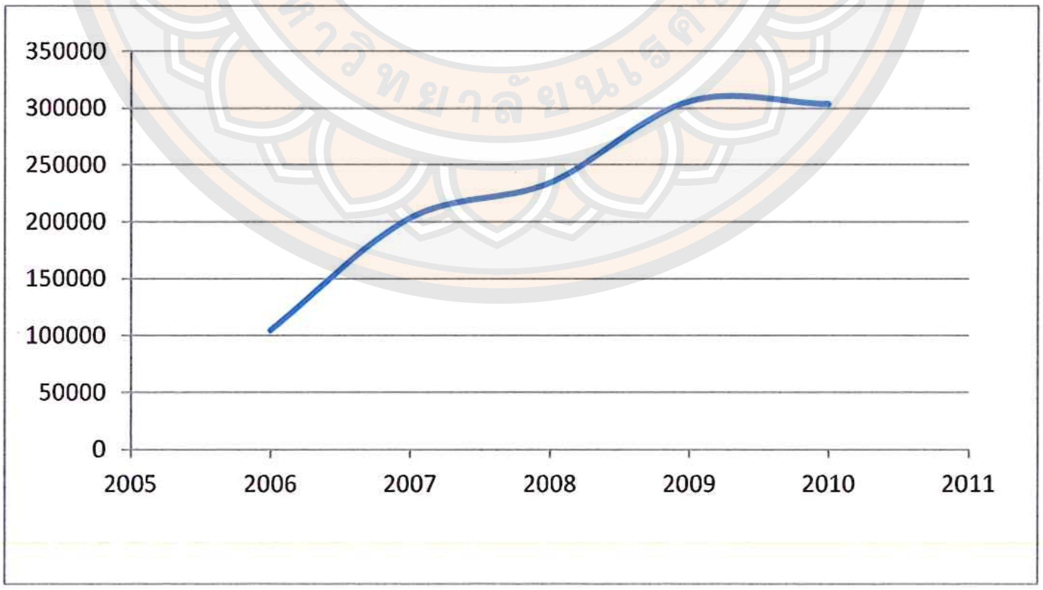

Figure 3 Potential of biomass available in Xayaburi

After analyzed on the potential of biomass available in this area, show by the Figure 3. We can found the potential of biomass can increase on each year, especially during 2006-07 increase 93%, and 2007-08 increase 15%, and 2008-09 increase 30% from agricultural harvesting. So we can conclusion, potential of biomass available agriculture in Xayaburi Laos. has increased in every years and had a lot of garbage from agricultural results, to have a tendency can produce fuel gas to by using residual from agricultural to be biomass gasified power generation system in feasibility.

Table 2 Potential of biomass in Xayaburi Lao PDR.

Biomass	Energy	
	MJ	KWh
Maize	4532.083	1258.912
Corn	16.69771	4.638253
Total	4548.780	1263.550

Conclude: From table 2 we can see the potential of biomass to produced a fuel gas had only Maize and corn to selecting, because their biomass residual had a lot, an appropriate of the higher and lower heating value, second of the wood. Thereby the fuel gas to produce biomass gasified power generation system is using biomass residual from Maize and Corn and wood chip to responding the energy demand In Pardam village Piang district Xayaburi Province Lao PDR.

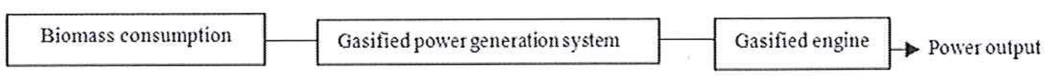

Figure 3 Flowchart of Biomass process converting

Quantity of biomass fuel for the BGPS can be considered by the flow of energy conversion following. From the system perspective, the technical performance of biomass energy production plants were characterized by the overall conversion efficiency, which dictated the required biomass amount for a given power output and, at the same time, was strongly dependent on the adopted technology and the plant size.

As a consequence, for the purpose of this work, the plants were simply modeled as black boxes having a transfer function between the input biomass flow rate, M, (t $year^{-1}$) and the net power output, P_o, (kW_e). More specifically P_o results directly proportional to the biomass amount M, the biomass low heating value (LHV) (kJ kg^{-1}) at dry basis, and the plant energy conversion efficiency η_e, and inversely proportional to the plant annual operating hours, OH (h $year^{-1}$), as shown in Figure 4.

$$P_o = \frac{M * \eta_e * LHV}{3{,}600 * OH} \qquad [Eq. 1]$$

M = 218,208 T/year

M = 218,208,000 kg/year

η_e = 0.2%

OH = 7,008

LHV = 17-19 KJ/Kg

P_o =? (kW_e).

From: equation of power output:

$$P_o = \frac{218{,}208{,}000 * 0.2 * 17.19}{3{,}600 * 7{,}008} = 29.735 \text{ kWe}$$

Policy

The promotion and development renewable energy is one of priority policy of Government to stabilize energy supply and to assist in the social and economic improvement of the country.

The Laos government supports domestic and foreign entrepreneurs and investors to invest in energy project at the village level. The development of renewable energy result while responding to the needs of the local people contribute to the process of becoming self – sufficient in energy supply and for the development energy exports. Renewable energy development involves participation of public and private sector.

Being a predominantly agriculture - base economy Lao PDR generate substantial amount of waste from agriculture and forest production and processing such as sugarcane biogases, risk husk, corn cob, wood waste and etc. Also, with growing urbanization, main cities are also generating significant amount of solid waste. At present, there is no large-scale exploitation of this resource for energy generation. In addition community forest could also sustainably develop to supply fuel for energy generation. There resource could potentially generate power productive used and other modern energy service in both urban and rural area either for off- grid or grid connected systems. The government recognizes the used of these agriculture and municipal solids waste to form part of overall energy mix to ensure energy security of the country.

Technology

Study the technologies of biomass gasified power generation plant Installed and successful in southern of Laos. Type of down-draft gasified in the most suitable for the engine gases, because it give low tar gases and easy to operate. In this project, the down-draft gasified is designed for the electricity of 30 KWe. Many parameters such as fuel properties, gas flow rate, gases properties should be known or assumed before the design can be carried out, the 30 KWe dual fuel diesel engine consume the biomass at around 40 kg/hr. this means the volume of the biomass fuel tank and hopper can be estimated when the running time is assumed. In this study, at least 100 hr of the test is performed. Therefore at least 4000 kg of biomass chip (wood).

Economic

This study using corncob to produce electricity, by the gasification power generation system has capacities is 30 KWe of project, during 25 years and rate at 9%. Can a be analyzing by uses parameters of economy; production consists of cost of energy, payback period, net value (NPV), and internal rate of return (IRR). The equation represent the effective interest rate, n the useful life of the asset, Bj and Cj the total benefits and the costs of the jth year, and C0 its initial capital cost at the year0.

Table 3 Economic of Gasification project in Xayaburi province Laos

List	Gasification project used corncob 25 years
Investment cost	1,529,000 BTH
O & M cost	442,632 BTH
Total cost	1,529,000 BTH
NPV	3,121,866 BTH
IRR	8%
BC ratio	4,88%
Payback period	15.3 years

After analyzed economic of Gasification project in Xayaburi province Laos, can see had the feasibility to applying of gasified power generation system, for utilization produced electricity at worthily, by the. Net present value (NPV) = 3,121,866 BTH, Internal rate of return (IRR) = 8%, BC ratio = 4, 88%, and payback period = 15.3 year.

Results, Discussion and Conclusion: After studying and analyzed of biomass gasified power generation system In Xayaburi province Lao PDR. Provides an overview of the opportunities and feasibility to successful of Biomass Gasified Power Generation to be a solution for electrical demand in the rural areas, far from grid connection transmission line by the separating is 3 ranges of the studied.

- Potential: the analysis quantity and calculate of potential biomass sufficiently from agricultural residues for to be a materials converting to gasifier power generation system, and especially using corncob had available in the area. And also management the waste system have lots from crop residuals, is impacting to in communities.

- Policy: The Laos government supports domestic and foreign entrepreneurs and investors to invest in energy project at the village level. The development of renewable energy result while responding to the needs of the local people contribute to the process of becoming

➢ Self – sufficient in energy supply and for the development energy exports. Renewable energy development involves participation of public and private sector,

➢ Carry out biomass resource assessment and prepare a list of priority projects.

➢ Formulate a framework to stimulate private sector investment in power generation from various source of biomass.

➢ Carry out pilot demonstration to test the framework developed and at the same time to demonstration the technical viability of a specific biomass – based technology in the country.

➢ Economic: After calculate assumption selecting the project of gasified power generation system has capacities is 30 KWe, on life time 25 years and Interest rate at 9%. Can a be analyzing by uses parameters of economy; production consists of cost of energy, payback period, net value (NPV), and internal rate of return (IRR);had a feasibility to successful, because that project is completes at the southern of Laos, by the using wood chip available, for convert fuel gasification system. So this study can conclusion of gasified power generation system. To applying corncob material available for utilization in Xayaburi Province Lao PDR.

APPENDIX D SOCIAL ACCEPTANCE

Questionnaire in Phadam Village, Phieng district, Xayboury Province, LAO PDR

ການສຳຫຼວດພື້ນທີ່ສຳລັບຕິດຕັ້ງໂຮງໄຟຟ້າຈາກແກສ໌ຊີວະມວນຂະໜາດ 30 kWe ແຂວງໄຊຍະບູລີ ສປປລາວ

ລະຫັດພື້ນທີ່............................ສະຖານທີ..

ໄລຍະທາງຈາກເມືອງຫຼັກ (..........................)...............................km

ເກນພິຈາລະນາ	ສະຖານທີ່					ໝາຍເຫດ
	5	4	3	2	1	
1. ແຫຼ່ງເຊື້ອເພີງຊີວະມວນທີ່ມານຳໃຊ້ເປັນເຊື້ອເພີງ						
▪ ມີ/ ບໍ່ມີ ປະລິມາຫລາຍໜ້ອຍປານໃດ						
▪ ມີທຸກລະດູ						
▪ ຫຼາກຫຼາຍຊະນິດ						
2. ໄລຍະທາງຂອງແຫຼ່ງເຊື້ອເພີງຊີວະມວນກັບສະຖານທີ່ຕິດຕັ້ງລະບົບ						
▪ ສະພາບເສັ້ນທາງ						
▪ ໄລຍະທາງເຖິງ diesel station						
3. ປະລິມານການໃຊ້ ແລະ ຄວາມຕ້ອງການພະລັງງານໄຟຟ້າຂອງຊຸມຊົນ (ເໝາະກັບ 30 kwe)						
▪ ຂະໜາດຊຸມຊົນ / ຈຳນວນຄົວເຮືອນ						
▪ ຄວາມຕ້ອງການໄຟຟ້າ						
▪ ໄລຍະທ່າງຂອງຄົວເຮືອນ						
▪ ບໍ່ຢູ່ໃນແຜນການເດີນໄຟ						
4. ຄວາມສົນໃຈ ແລະ ການພ້ອມຂອງຊຸມຊົນ						
▪ ທັດສະນະຄະຕິຂອງຜູ້ນຳຊຸມຊົນ						
▪ ທີມດຳເນີນການ						
▪ ແນວທາງການບໍລິຫານຈັດການ						
▪ Commitment ຂອງທີມງານໃນຊຸມຊົນ						
▪ ບຸກຄະລາກອນດ້ານເຕັກນິກ						
5. ແນວໂນ້ມໃນການຜະລິດໄຟຟ້າຢ່າງຕໍ່ເນື່ອງ						
ລວມ						

5 = ເໝາະສົມທີ່ສຸດ 1 = ບໍ່ເໝາະສົມເລີຍ

ມະຫາວິທະຍາໄລນະເຣສວນ ຈັງຫວັດພິດສະນຸໂລກ ປະເທດໄທ

ຄະນະວິທະຍາໄລພະລັງງານທົດແທນແລະເຕັກໂນໂລຊີ

ແບບສອບຖາມ

ພວກຂ້າພະເຈົ້ານັກສຶກສາຄະນະວິທະຍາໄລພະລັງງານທົດແທນແລະເຕັກໂນໂລຊີ (ມະຫາວິທະຍາໄລນະເຣສວນ ຈັງຫວັດພິດສະນຸໂລກ ປະເທດໄທ) ມີຈຸດປະສົງເກັບກຳຂໍ້ມູນຈາກບັນດາທ່ານ ກ່ຽວກັບການເພິ່ງພໍໃຈຂອງທ່ານເອງຕໍ່ນະໂຍບາຍ ການສຳຫຼວດພື້ນທີ່ສຳລັບຕິດຕັ້ງໂຮງໄຟຟ້າຈາກແກສ໌ຊີວະມວນຂະໜາດ 30 kWe ແຂວງໄຊຍະບູລີ ສປປລາວ

ເພື່ອຈະເປັນຂໍ້ມູນອັນສຳຄັນທີ່ຈະປະກອບເຂົ້າໃນການຂຽນບົດໂຄງການຈົບຊັ້ນຂອງພວກຂ້າພະເຈົ້າ, ເຊິ່ງໃນແບບສອບຖາມນີ້ໄດ້ຜ່ານການເຫັນດີຂອງພວກທ່ານ ແລະ ແບບສອບຖາມດັ່ງກ່າວຈະບໍ່ມີລາຍຊື່ຂອງຜູ້ຂຽນຕອບ. ສະນັ້ນ, ຈຶ່ງຂໍຄວາມກະລຸນາທ່ານຊ່ວຍຕອບຄຳຖາມລຸ່ມນີ້ຕາມຄວາມຄິດເຫັນຂອງທ່ານເອງ, ຫວັງຢ່າງຍິ່ງວ່າທ່ານຈະໃຫ້ຄວາມຮ່ວມມືແກ່ພວກຂ້າພະເຈົ້າດ້ວຍ.

I. ຂໍ້ມູນສ່ວນຕົວ

ຄຳຊີ້ແຈງ: ກະລຸນາໝາຍ ✓ ລົງໃສ່ ☐ ຂອງຄຳຕອບຄວາມຈິງຂອງທ່ານ.

1. ເພດ

☑ ຍິງ ☐ ຊາຍ

2. ອາຍຸ

☐ 20 ປີລົງມາ ☐ 21-30 ປີ ☐ 31-40 ປີ ☑ 41-50 ປີ

☐ 51ປີຂຶ້ນໄປ

3. ສະພາບໂສດ

☐ ໂສດ ☑ ແຕ່ງງານ

4. ລະດັບການສຶກສາ

☐ ວິຊາຊີບຊັ້ນຕົ້ນ ☐ ວິຊາຊີບຊັ້ນກາງ ☑ ວິຊາຊີບຊັ້ນກາງ ☐ ປະລິນຍາຕີ

☐ ອື່ນໆ (ລະບຸ) ....

5. ທ່ານໄດ້ປູກພືດຊະນິດໃດແດ່?

☑ ເຂົ້າ ☑ ສາລີ ☐ ຖົ່ວເຫຼືອງ ☐ ມັນຕົ້ນ

☐ ອ້ອຍ ☐ ປາມນ້ຳມັນ ☐ ຢາງພາລາ ☐ ໝາກກ້ຽງ

6. ປະລິມານການຜະລິດພາຍຫຼັງການເກັບກ່ຽວຕໍ່ປີ

☐ 500 Kg ☐ 1000 Kg ☐ 2500 Kg

☐ 3000 Kg ☐ 5000 Kg ☐ 10. 000 Kg

ແລະ ຫຼາຍກວ່າ ....Kg

7. ສິ່ງເສດເຫຼືອພາຍຫຼັງການເກັບກູ້

☐ ແກນສາລີ ☐ ແກບ ☐ ກາກອ້ອຍ ☐ ເສດກິ່ງໄມ້

8. ປະລິມານສິ່ງເສດເຫຼືອພາຍຫຼັງການເກັບກູ້

☐ 300 Kg ☐ 500 Kg ☐ 700 Kg ☐ 100 Kg

☐ 3000 Kg ☐ 5000 Kg ແລະ ຫຼາຍກວ່າ.............................. Kg

9. ການນຳໃຊ້ສິ່ງເສດເຫຼືອພາຍຫຼັງການເກັບກູ້

☐ ຂາຍ ☐ ເຜົາຖິ້ມ ☐ ໝັກເຮັດປຸ໋ຍ

☐ ແກນສາລີ ☐ ແກບ ☐ ກາກອ້ອຍ ☐ ເສດກິ່ງໄມ້

10. ຄວາມຕ້ອງການຢາກຈະຊົມໃຊ້ພະລັງງານໄຟຟ້າ

☐ ບໍ່ຕ້ອງການເລີຍ ☐ ຕ້ອງການ ☐ ຕ້ອງການຫຼາຍ

☐ ຕ້ອງການທີ່ສຸດ

11. ສະມາຊິກພາຍໃນຄອບຄົວ

☐ 3 ຄົນ ☐ 5 ຄົນ ☐ ເກີນ 5 ຄົນ

12. ຜົນປະໂຫຍດທີ່ຈະໄດ້ຮັບພາຍຫຼັງມີພະລັງງານໄຟຟ້າຊົມໃຊ້

☐ ໜ້ອຍ ☐ ຫຼາຍ ☐ ຫຼາຍທີ່ສຸດ ☐ ຈຳເປັນ ☐ ບໍ່ຈຳເປັນ

13. ຄວາມເຫັນພາຍຫຼັງຕິດຕັ້ງໂຮງໄຟຟ້າຈາກແກ໋ສຊີວະມວນຂະໜາດ 30 kWe ເພື່ອຕອບສະໜອງຄວາມຮຽກຮ້ອງຕ້ອງການຢາກຊົມໃຊ້ຂອງພະລັງງານໄຟຟ້າ

☐ ສົນໃຈ ☐ ບໍ່ສົນໃຈ ☐ ສົນໃຈຫລາຍ ☐ ສົນໃຈທີ່ສຸດ

14. ການມີສ່ວນຮ່ວມຂອງຄົນໃນຊຸມຊົນຕໍ່ກັບລະບົບໂຮງໄຟຟ້າແກ໋ສຊີວະມວນ

☐ ເຕັມໃຈເຂົ້າຮ່ວມ ☐ ບໍ່ເຕັມໃຈ ☐ ຕ້ອງມີເງື່ອນໄຂຈຶ່ງເຂົ້າຮ່ວມ

ການສຳຫຼວດພື້ນທີ່ສຳລັບຕິດຕັ້ງໂຮງໄຟຟ້າຈາກແກສ໌ຊີວະມວນຂະໜາດ 30 kWe ແຂວງໄຊຍະບູລີ ສປປລາວ

ລະຫັດພື້ນທີ່.................................ສະຖານທີ... [illegible]

ໄລຍະທາງຈາກເມືອງຫຼັກ (.............................)..................................km

ເກນພິຈາລະນາ	ສະຖານທີ່					ໝາຍເຫດ
	5	4	3	2	1	
1. ແຫຼ່ງເຊື້ອເພີງຊີວະມວນທີ່ມານຳໃຊ້ເປັນເຊື້ອເພີງ			✓			
15 ▪ ມີ/ ບໍ່ມີ ປະລິມານຫລາຍໜ້ອຍປານໃດ				✓		
16 ▪ ມີທຸກລະດູ				✓		
17 ▪ ຫຼາກຫຼາຍຊະນິດ			✓			
2. ໄລຍະທາງຂອງແຫຼ່ງເຊື້ອເພີງຊີວະມວນກັບສະຖານທີ່ຕິດຕັ້ງລະບົບ				✓		
18 ▪ ສະພາບເສັ້ນທາງ				✓		
19 ▪ ໄລຍະທາງເຖິງ diesel station			✓			
3. ປະລິມານການໃຊ້ ແລະ ຄວາມຕ້ອງການພະລັງງານໄຟຟ້າຂອງຊຸມຊົນ (ເໝາະກັບ 30 kwe)		✓				
20 ▪ ຂະໜາດຊຸມຊົນ / ຈຳນວນຄົວເຮືອນ			✓			
21 ▪ ຄວາມຕ້ອງການໄຟຟ້າ		✓				
22 ▪ ໄລຍະຫ່າງຂອງຄົວເຮືອນ			✓			
23 ▪ ບໍ່ຢູ່ໃນແຜນການເດີນໄຟ	✓					
4. ຄວາມສົນໃຈ ແລະ ການພ້ອມຂອງຊຸມຊົນ		✓				
24 ▪ ທັດສະນະຄະຕິຂອງຜູ້ນຳຊຸມຊົນ			✓			
25 ▪ ທີມດຳເນີນການ			✓			
26 ▪ ແນວທາງການບໍລິຫານຈັດການ			✓			
27 ▪ Commitment ຂອງທີມງານໃນຊຸມຊົນ		✓				
28 ▪ ບຸກຄະລາກອນດ້ານເຕັກນິກ			✓			
29 5. ແນວໂນ້ມໃນການຜະລິດໄຟຟ້າຢ່າງຕໍ່ເນື່ອງ		✓				
ລວມ						

5 = ເໝາະສົມທີ່ສຸດ 1 = ບໍ່ເໝາະສົມເລີຍ

6. ປະລິມານການຜະລິດພາຍຫຼັງການເກັບກ່ຽວຕໍ່ປີ

☐ 500 Kg ☐ 1000 Kg ☐ 2500 Kg

☐ 3000 Kg ☐ 5000 Kg ☑ 10. 000 Kg

ແລະ ຫຼາຍກວ່າ ....Kg

7. ສິ່ງເສດເຫຼືອພາຍຫຼັງການເກັບກູ້

☑ ແກນສາລີ ☑ ແກບ ☐ ກາກອ້ອຍ ☐ ເສດກິ່ງໄມ້

8. ປະລິມານສິ່ງເສດເຫຼືອພາຍຫຼັງການເກັບກູ້

☐ 300 Kg ☐ 500 Kg ☑ 700 Kg ☐ 1000 Kg

☐ 3000 Kg ☐ 5000 Kg ແລະ ຫຼາຍກວ່າ.............................. Kg

9. ການນຳໃຊ້ສິ່ງເສດເຫຼືອພາຍຫຼັງການເກັບກູ້

☐ ຂາຍ ☑ ເຜົາຖິ້ມ ☐ ໝັກເຮັດປຸ໋ຍ

☑ ແກນສາລີ ☐ ແກບ ☐ ກາກອ້ອຍ ☐ ເສດກິ່ງໄມ້

10. ຄວາມຕ້ອງການຢາກຈະຊົມໃຊ້ພະລັງງານໄຟຟ້າ

☐ ບໍ່ຕ້ອງການເລີຍ ☑ ຕ້ອງການ ☐ ຕ້ອງການຫຼາຍ

☐ ຕ້ອງການທີ່ສຸດ

11. ສະມາຊິກພາຍໃນຄອບຄົວ

☐ 3 ຄົນ ☐ 5 ຄົນ ☑ ເກີນ 5 ຄົນ

12. ຜົນປະໂຫຍດທີ່ຈະໄດ້ຮັບພາຍຫຼັງມີພະລັງງານໄຟຟ້າຊົມໃຊ້

☐ ໜ້ອຍ ☐ ຫຼາຍ ☐ ຫຼາຍທີ່ສຸດ ☑ ຈຳເປັນ ☐ ບໍ່ຈຳເປັນ

13. ຄວາມເຫັນພາຍຫຼັງຕິດຕັ້ງໂຮງໄຟຟ້າຈາກແກັສຊີວະມວນຂະໜາດ 30 kWe ເພື່ອຕອບສະໜອງ ຄວາມຮຽກຮ້ອງຕ້ອງການຢາກຊົມໃຊ້ຂອງພະລັງງານໄຟຟ້າ

☐ ສົນໃຈ ☐ ບໍ່ສົນໃຈ ☑ ສົນໃຈຫລາຍ ☐ ສົນໃຈທີ່ສຸດ

14. ການມີສ່ວນຮ່ວມຂອງຄົນໃນຊຸມຊົນຕໍ່ກັບລະບົບໂຮງໄຟຟ້າແກັສຊີວະມວນ

☑ ເຕັມໃຈເຂົ້າຮ່ວມ ☐ ບໍ່ເຕັມໃຈ ☐ ຕ້ອງມີເງື່ອນໄຂຈຶ່ງເຂົ້າຮ່ວມ

มะຫາວິທະຍາໄລນະເຣສວນ ຈັງຫວັດພິດສະນຸໂລກ ປະເທດໄທ

ຄະນະວິທະຍາໄລພະລັງງານທົດແທນແລະເຕັກໂນໂລຊີ

ແບບສອບຖາມ

ພວກຂ້າພະເຈົ້ານັກສຶກສາຄະນະວິທະຍາໄລພະລັງງານທົດແທນແລະເຕັກໂນໂລຊີ (ມະຫາວິທະຍາໄລນະເຣສວນ ຈັງຫວັດພິດສະນຸໂລກ ປະເທດໄທ) ມີຈຸດປະສົງເກັບກຳຂໍ້ມູນຈາກບັນດາທ່ານ ກ່ຽວກັບການເພິ່ງພໍໃຈຂອງທ່ານເອງຕໍ່ນະໂຍບາຍ ການສຳຫຼວດພື້ນທີ່ສຳລັບຕິດຕັ້ງໂຮງໄຟຟ້າຈາກແກສ໌ຊີວະມວນຂະໜາດ 30 kWe ແຂວງໄຊຍະບູລີ ສປປລາວ

ເພື່ອຈະເປັນຂໍ້ມູນອັນສຳຄັນທີ່ຈະປະກອບເຂົ້າໃນການຂຽນບົດໂຄງການຈົບຊັ້ນຂອງພວກຂ້າພະເຈົ້າ, ເຊິ່ງໃນແບບສອບຖາມນີ້ໄດ້ຜ່ານການເຫັນດີຂອງພວກທ່ານ ແລະ ແບບສອບຖາມດັ່ງກ່າວຈະບໍ່ມີລາຍຊື່ຂອງຜູ້ຂຽນຕອບ. ສະນັ້ນ, ຈຶ່ງຂໍຄວາມກະລຸນາທ່ານຊ່ວຍຕອບຄຳຖາມລຸ່ມນີ້ຕາມຄວາມຄິດເຫັນຂອງທ່ານເອງ, ຫວັງຢ່າງຍິ່ງວ່າທ່ານຈະໃຫ້ຄວາມຮ່ວມມືແກ່ພວກຂ້າພະເຈົ້າດ້ວຍ.

I. ຂໍ້ມູນສ່ວນຕົວ

ຄຳຊີ້ແຈງ: ກະລຸນາໝາຍ ✓ ລົງໃສ່ ☐ ຂອງຄຳຕອບຄວາມຈິງຂອງທ່ານ.

1. ເພດ

☐ ຍິງ ☐ ຊາຍ

2. ອາຍຸ

☐ 20 ປີລົງມາ ☐ 21-30 ປີ ☐ 31-40 ປີ ☐ 41-50 ປີ

☐ 51ປີຂຶ້ນໄປ

3. ສະພາບໂສດ

☐ ໂສດ ☐ ແຕ່ງງານ

4. ລະດັບການສຶກສາ

☐ ວິຊາຊີບຊັ້ນຕົ້ນ ☐ ວິຊາຊີບຊັ້ນກາງ ☐ ວິຊາຊີບຊັ້ນກາງ ☐ ປະລິນຍາຕີ

☐ ອື່ນໆ (ລະບຸ) ....

5. ທ່ານໄດ້ປູກພືດຊະນິດໃດແດ່?

☐ ເຂົ້າ ☐ ສາລີ ☐ ຖົ່ວເຫຼືອງ ☐ ມັນຕົ້ນ

☐ ອ້ອຍ ☐ ປາມນ້ຳມັນ ☐ ຢາງພາລາ ☐ ໝາກກ້ຽງ