Chapter 4

Distributed Generation System

4.1 Site Selection and Survey

The Energy Research and Development Institute (ERDI), Chiang Mai University is contracted by Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, Thailand to oversee the study, development and installation of an electricity generation system from biomass gasification in Union of Myanmar. The Myanmar Engineering Society (MES) is the official representative assigned by the Energy Planning Department (EPD).

A kick-off meeting between the DEDE, ERDI, and MES was held on the 20th August 2007 in Yangon. Brief information on background and objectives of the project was delivered. During the meeting, the parties agreed on building collaboration for this project and forthcoming energy related projects.

The MES has issued a letter suggesting 4 potential sites in the Twantay Township area for evaluation as shown in Appendix A. The 4 sites are (i) Nyaung Da Gar, (ii) Sann Ywar, (iii) Kha-Lok, and (iv) Dagoon Daing. They were chosen from a number of suitable villages that have potential for development and demonstration of the unit. The ERDI team surveyed and selected a suitable site for the project. The site selection process consists of site visit, data collection, data interpretation, and conclusion.

4.1.1 Twantay Township

Twantay township is located 25 km away in the west of Yangon at latitude 16˚ 42′ 25″ and longitude 95˚ 56′ 18″, as shown in Figure 4.1. Normal form of transport is by road with a distance of about 50 km. Most part of the town is green area. Agriculture, especially rice farming and fishing are main occupations.

The town has plenty of biomass. Among the most suitable biomass resources include rice husk, rice straw, bamboo and wood.

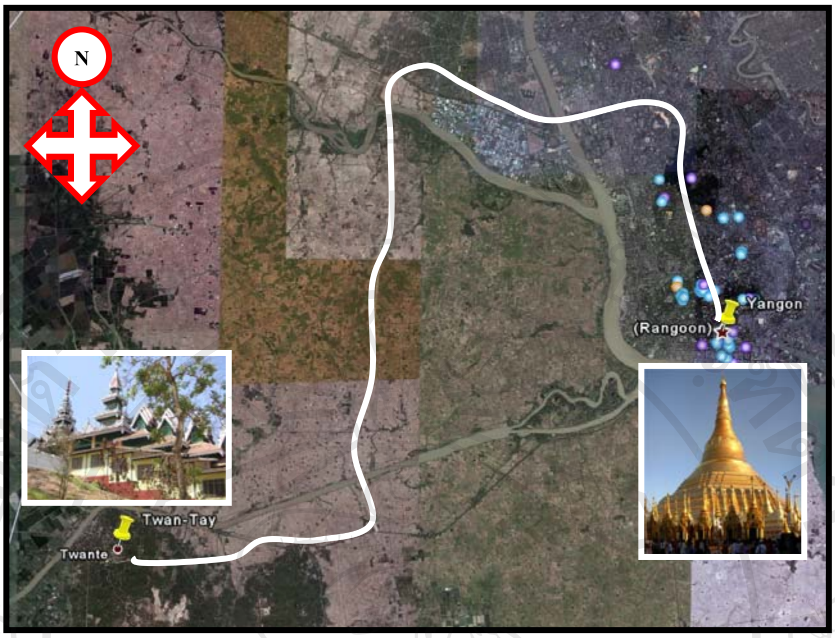

Figure 4.1 Twantay Township and road transport to Yangon

4.1.2 Site visit

Sites visit to Twantay Township was undertaken after the kick-off meeting. Location of the 4 sites can be shown in Figure 4.2. A meeting with local coordinators was arranged for site investigation.

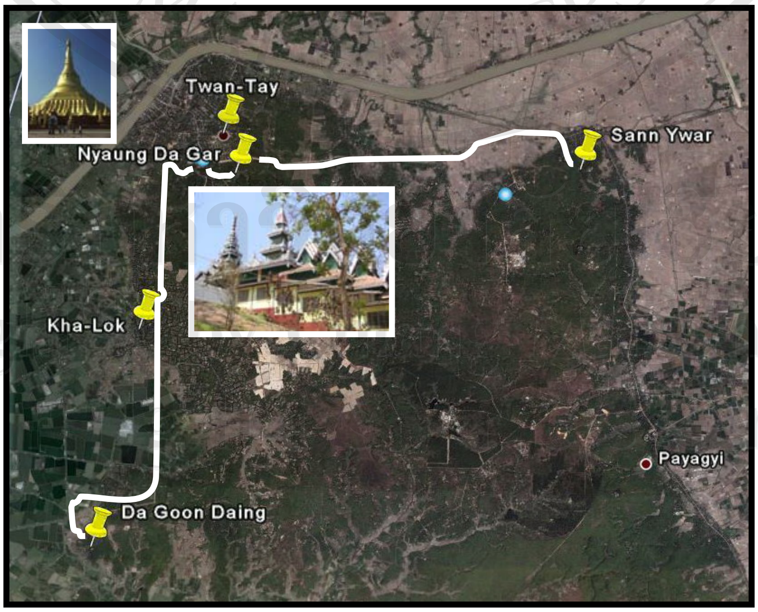

Figure 4.2 Location of the four purposed sites

4.1.3 Data collection

Basic data collection was carried out for every site. The data collected is summarized and shown in Table 4.1. Samples of agricultural residues suitable to use as fuels were also collected and sent for analysis in Thailand.

4.1.4 Data interpretation

Each item of the data collected was then ranked, based on its influence to the success of the project. Scale 1 means low influence while Scale 4 is interpreted as strong influence. Results from the interpretation can be shown in Table 4.2.

4.1.5 Site selection

Dagoon Daing village was selected as shown in Appendix B; the most favorable of choice based on the total marks earned 52. A large amount of rice husk available with no cost (3 rice mills in village). They use stove. Fuel types are firewood, bamboo and rice husk. They occupation are Rice, Fishery, Bamboo, Beetle Nut, Agriculture and General Employee.

Dagoon Daing village is the most favourable choice based on the total mark earned. The first important point is that Dagoon Daing village has surplus supply of the rice husk for their current electricity need. In addition, the surplus is enough for the next few year of predicted electricity consumption. Dagoon Daing community had shown that they are ready and willing to support the project in every possible ways through their leaders to make the project a successful and sustainable one.

The project is an exemplary and model for contribution of technical scope to extend other areas in development stage. The selection of designated location is based on considerations with accessible to travel and populated, locally well-collaborate and able to set a centre of technical cooperation, efficient to share information related with project to others extend area and resourceful raw materials.

Table 4.1 Detail data of the four purposed sites

Detail of each place	Nyaung Da Gar	Dagoon Daing	Kha-Lok	Sann Ywar
1. Location				
1.1 Latitude	16° 41' 58"	16° 37' 59"	16° 40' 16"	16° 42' 3"
1.2 Longitude	95° 56' 30"	95° 54' 55"	95° 55' 29"	96° 0' 19"
2. Road distance from Yangon (km)	48	55	52	38
3. Other facilities or industries in the community	1 x Ceramic kiln 1 x Ceramic center	10 x Water pump for fish farms	5 x Water pumps for orchard farms	-
4. Biomass available (Monthly)				
4.1 Rice husk (kg) Rice mill [no]	15,000 [2]	20,000 [3]	5,000 [1]	15,000 [1]
4.2 Bamboo (kg)	10,000	1,000	5,000	7,000
4.3 Rice straw (kg)	10,000	15,000	1,000	10,000
4.4 Wood (kg)	5,000	5,000	5,000	2,000
5. Road condition surrounding the area for biomass transportation	Local and partially paved road, hilly.	Local and partially paved road	Local and partially paved road	Local and partially paved road
6. Estimated electricity consumption (kWh)				
6.1 Current	20,000	10,000	3,000	2,000
6.2 Future	10,000	7,000	3,000	1,500
6.3 No. of household	1,000	1,000	700	500
7. Energy data of each site				
7.1 Price of diesel (USD/gal)	3	4	4	3

Table 4.1 Detail data of the four purposed sites (Continue)

Detail of each place	Nyaung Da Gar	Dagoon Daing	Kha-Lok	Sann Ywar
7.2 Availability of diesel (gal/month)	200	200	200	100
7.3 Experience with electricity	Some houses are connected to the national grid with the price of 25 Kyat/kWh	Own a small diesel generator but not often used due to high diesel price	Private electricity distribution was available. Now it is not in operation due to low community support.	A 5 kW diesel generator was available in the village with battery charging service (300 Kyat/ charging)
8. Attitude and eagerness of the community to support the project				
8.1 Leader	Full support from Myanmar Ceramic Society	Strong support from Monks and Head of the community	Medium support from Head of the community	Medium support from Monks and Head of the community
8.2 Villagers	Villagers show minor interest in the project due to the national grid is available.	Villagers have strong interest and full support.	Villagers show minor interest in the project since many of them own diesel electric generator.	Villagers have interest in the project.
8.3 Basic knowledge in management and technical support	Educated villagers are available	Educated villagers are available	Educated villagers are available	Educated villagers are available

Table 4.2 Weighting and decision making table

Community name	**Nyaung Da Gar**	**Dagoon Daing**	**Kha-Lok**	**Sann Ywar**
1. Road distance from Yangon	3	1	2	4
2. Other facilities or industries in the community	4	3	2	1
3. Biomass available				
3.1 Rice husk	3	4	1	2
3.2 Bamboo	4	1	2	3
3.3 Rice straw	2	4	1	3
3.4 Wood	2	4	3	1
4. Road condition surrounding the area for biomass transportation	1	4	2	3
5. Estimated electricity consumption				
5.1 Current	3	4	2	1
5.2 Future	1	4	2	3
5.3 No. of household	3	4	2	1
6. Energy data of each site				
6.1 Price of diesel	4	2	1	3
6.2 Availability of diesel	3	2	1	4
6.3 Experience with electricity	3	4	2	1
7. Attitude and eagerness of the community to support the project				
7.1 Leader	3	4	1	2
7.2 Villagers	2	4	3	1
7.3 Basic knowledge in management and technical support	4	3	1	2
Total Mark Earn	**45**	**52**	**28**	**35**

4.2 Biomass Analysis

4.2.1 Potential biomass as fuels in Myanmar

From the survey, potential biomass resources available in Dagoon Daing are wood, bamboo, rice straw and rice husk, as shown in Figure 4.3. Samples of these biomass fuels were collected and later sent for proximate and ultimate analyses, heating value, density, ash composition and ash fusion temperature.

Figure 4.3 Potential biomass resources

4.2.2 Fuel Analysis Methods

Two types of analyses are proximate and ultimate analysis. These are useful for defining the physical, chemical and fuel properties of a particular biomass feedstock. These analyses were initially developed for coal and widely available from commercial laboratories. They are described in detail in the publications of the American Society for Testing Materials (ASTM).

The proximate analysis is relatively simple and can be performed with a drying oven, a laboratory furnace and a balance. The ultimate analysis involves more advance chemical techniques.

The proximate analysis determines the moisture, volatile matter, ash and fixed carbon contact of a fuel, using standard ASTM tests. Moisture is analyzed by the weight loss observed at 110˚C. The volatile matter is driven off in a closed crucible by slow heating to 950˚C and the sample is weighed again. The proximate analysis generally includes moisture content measured on a wet basis, MC_{wet}, where

$$MC_{wet} = (\text{wet weight} - \text{dry weight}) / \text{wet weight} \qquad (4.1)$$

Sometimes, moisture content is reported on a dry weight basis, MC_{dry}, where

$$MC_{dry} = (\text{wet weight} - \text{dry weight}) / \text{dry weight} \qquad (4.2)$$

The ultimate analysis gives the chemical composition and the higher heating values of the fuels. The chemical analysis usually lists the carbon, hydrogen, oxygen, nitrogen, sulfur and ash content of the dry fuel on a weight percentage basis. A standard ASTM method is available for measuring the slagging temperature for ash.

The heat of combustion is determined by the composition of the biomass and in fact can be calculated with considerable accuracy from

$$HHV = [34.1\ C + 132.2\ H + 6.8\ S - 1.53\ A - 12.0\ (O + N)]\ kJ/g \qquad (4.3)$$

$$HHV = [146.6\ C + 568.8\ H + 29.4\ S - 6.6\ A - 51.5\ (O + N)] \times 10^2\ Btu/lb \qquad (4.4)$$

$$LHV = HHV - 0.00114\ (HHV)\ (MC) \qquad (4.5)$$

Where C, H, S, A, O and N are the wt% of carbon, hydrogen, sulfur, ash, oxygen and nitrogen in the fuel. The calculate value agree with the measured value with an absolute error of 2.1% for a large number of biomass materials.

One of the most important physical characteristic of biomass fuel is the bulk density. The bulk density is the weight of biomass packed loosely in a container divided by the volume occupied. Clearly, it is not an exact number, depending on the exact packing of the particles.

The basis fuel parameters important in gasifier design are

- Char durability and fixed carbon content
- Ash fusion temperature
- Ash content
- Moisture content
- Heating value

The choice of a fuel for gasification will in part be decided by its heating value. The method of measurement of the fuel energy content will influence the estimate of efficiency of a given gasification system. Reporting of fuel heating values is often confusing since at least three different bases are used:

- fuel higher heating values as obtained in an adiabatic bomb calorimeter. These values include the heat of condensation of the water that is produced during combustion. Because it is very difficult to recover the heat of condensation in actual gasification operations these values present a too optimistic view of the fuel energy content;
- fuel higher heating values on a moisture-free basis, which disregard the actual moisture content of the fuel and so provide even more optimistic estimates of energy content;
- fuel higher heating values on a moisture and ash free basis, which disregard the incombustible components and consequently provide estimates of energy content too high for a given weight of fuel, especially in the case of some agricultural residues (rice husks).

The only realistic way therefore of presenting fuel heating values for gasification purposes is to give lower heating values (excluding the heat of condensation of the water produced) on an ash inclusive basis and with specific reference to the actual moisture content of the fuel.

The heating value of the gas produced by any type of gasifier depends at least in part on the moisture content of the feedstock. Moisture content can be determined on a dry basis as well as on a wet basis. High moisture contents reduce the thermal efficiency since heat is used to drive off the water and consequently this energy is not available for the reduction reactions and for converting thermal energy into chemical bound energy in the gas. Therefore high moisture contents result in low gas heating values. In downdraft gasifiers high moisture contents give rise not only to low gas heating values, but also to low temperatures in the oxidation zone, and this can lead to insufficient tar converting capability if the gas is used for engine applications. The gas heating value (engines need gas of at least 4200 kJ/m^3 in order to maintain a reasonable efficiency) and of the tar entrainment problem, downdraft gasifiers need reasonably dry fuels (less than 25 percent moisture dry basis).

The amount of volatiles in the feedstock determines the necessity of special measures (either in design of the gasifier or in the layout of the gas cleanup train) in order to remove tars from the product gas in engine applications. A general rule if the fuel contains more than 10 percent volatile matter it should be used in downdraught gas producers.

Ashes can cause a variety of problems particularly in up or downdraft gasifiers. Slagging or clinker formation in the reactor, caused by melting and agglomeration of ashes, at the best will greatly add to the amount of labour required to operate the gasifier If no special measures are taken, slagging can lead to excessive tar formation and complete blocking of the reactor. A worst case is the possibility of air-channeling which can lead to a risk of explosion, especially in updraft gasifiers.

Bulk density is defined as the weight per unit volume of loosely tipped fuel. Fuels with high bulk density are advantageous because they represent a high energy-for-volume value. Consequently these fuels need less bunker space for a given refueling time. Low bulk density fuels sometimes give rise to insufficient flow under gravity, resulting in low gas heating values and ultimately in burning of the char in the reduction zone. Inadequate bulk densities can be improved by briquetting or pelletizing.

4.3 Biomass Gasification System

The biomass gasification system is to produce electricity from rice husk. The system consists of Downdraft gasifier reactor, cyclone separator, water scrubber, gas cooler, Carbon fiber filter, fine filter units and gas damper as shown in Figure 4.4.

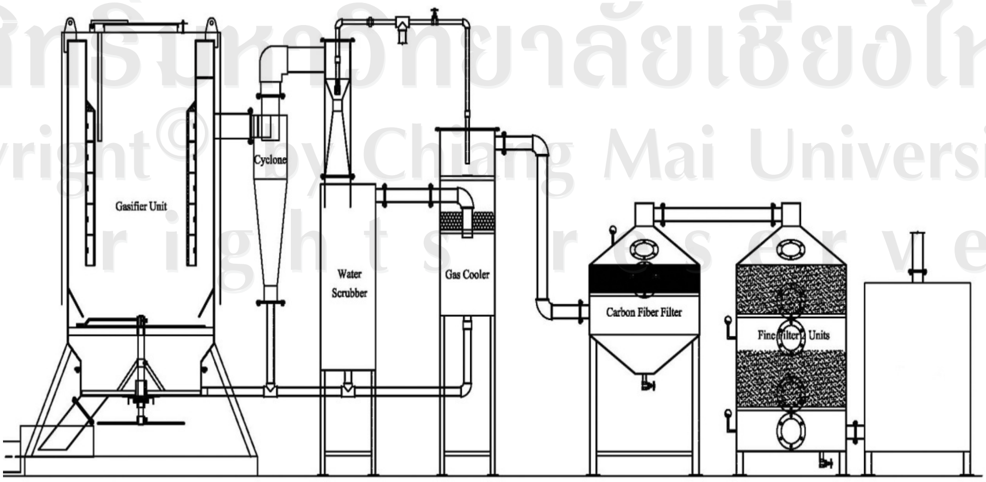

Figure 4.4 Rice Husk Gasification System

4.3.1 Downdraft gasifier system

In a downdraft reactor, biomass is fed at the top, and the air intake is at the top as shown in Figure 4.5. The reactor wall was made of firebrick. Air is supplied by means of a downstream suction blower or from an engine. The gasifier core was not provided with any throat or constriction to avoid fuel flow problem. Ash formed was removed from the gasifier continuously by an automatic, motor-driven ash removal system.

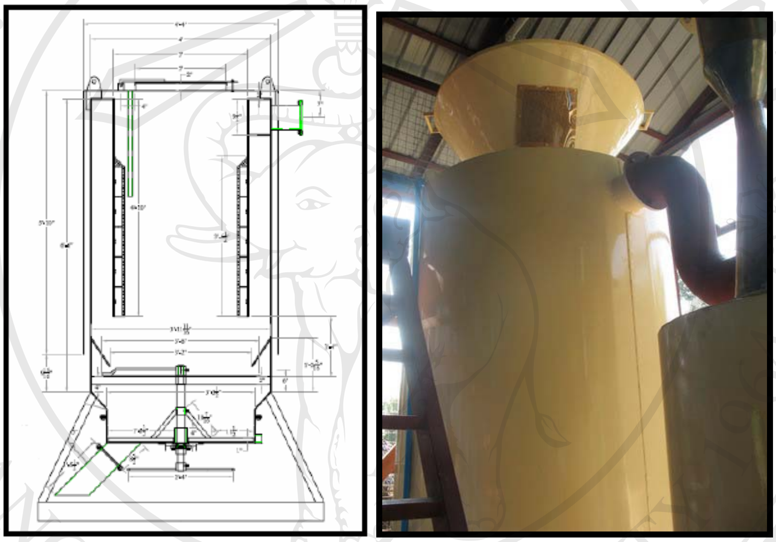

Figure 4.5 Downdraft Grasifier

4.3.2 Cyclone separator

The purpose of using cyclone is to remove tar and dust from the gas, the design is shown in Figure 4.6. It is the most extensively used type of collector for relatively coarse dusts because of high operational efficiency, simple construction and low maintenance cost. The separated dust leaves the cyclone at its base and the gas escapes at the top through a central exit. In cyclone the gas first flows along the wall in the direction of the apex, and then is reversed in direction and escape axially, whilst the dust moves with the outer current towards the apex.

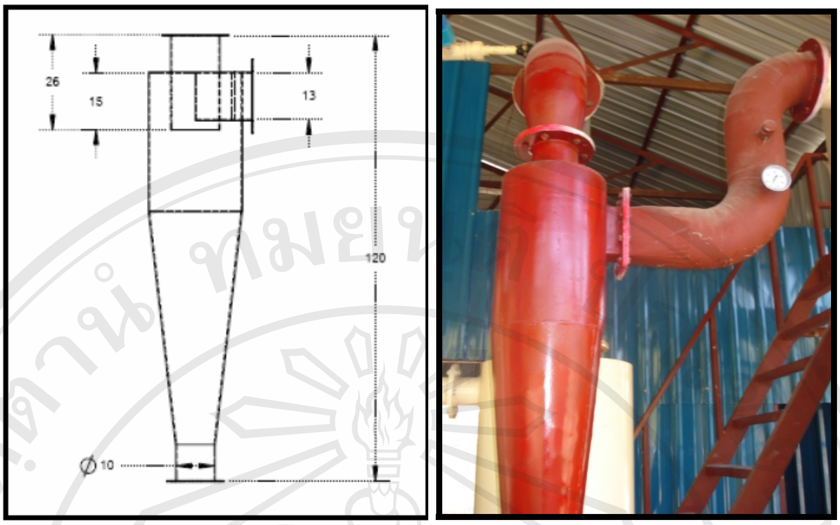

Figure 4.6 Cyclone

4.3.3 Venturi scrubber

The velocity of the contacting liquid both pumps and scrubs the entrained gas in an ejector venturi scrubber, as shown in Figure 4.7. Spiral spray nozzles impact axial and tangential velocities to the liquid jet. The contacting liquid must be removed after the scrubber by a suitable entrainment separator. Producer gas was passed through venturi scrubber to remove ashes and to condense tars.

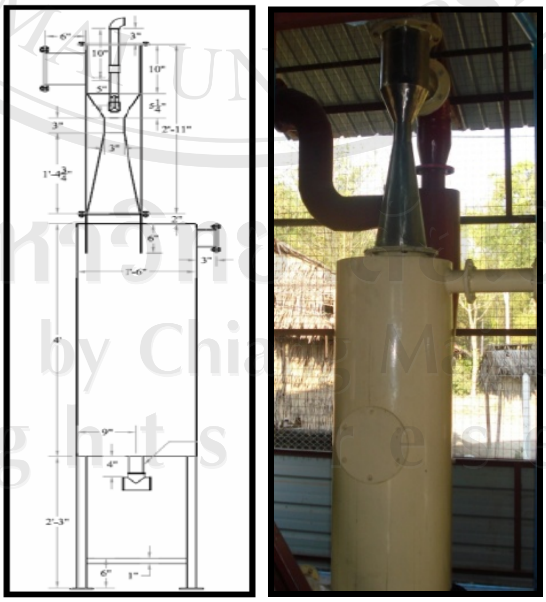

Figure 4.7 Venturi scrubber

4.3.4 Gas cooler

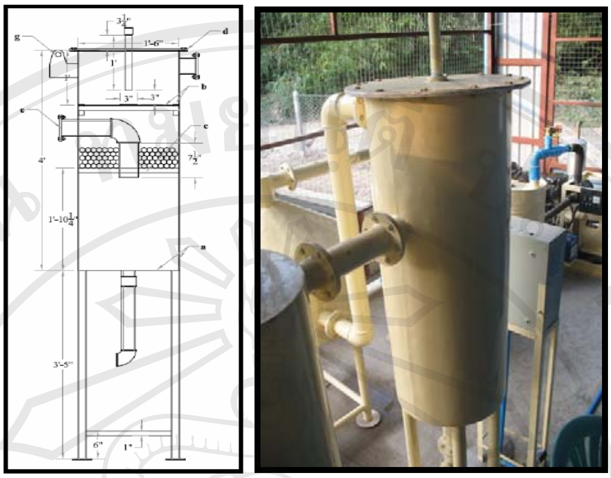

Figure 4.8 Gas cooler

Gases from the venturi scrubber were fed into the gas cooler. The cooler was filled with marbles (1″ or 0.254m diameter). On the top of this unit, there was a shower of cooling water. Water condensation helps to remove tar particles but yields a contaminated water condensate in the process. The detail drawing of the gas cooler is shown in Figure 4.8.

4.3.5 Carbon fiber filter

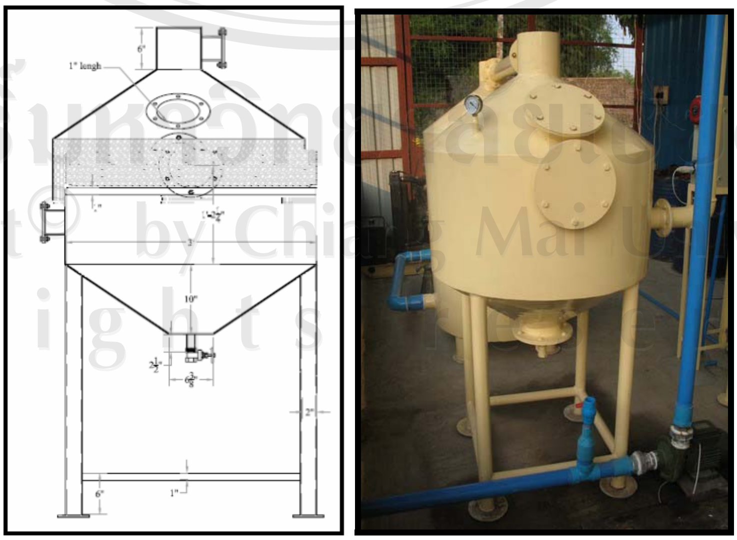

Figure 4.9 Carbon fiber filter

In the packed column some amount of water got entrained in the form of mist or droplets and was carried away by the gas. Also, some fine particulates still managed to get carried away with this gas. Pebbles of 1″ diameter size were used in the filter, as shown in Figure 4.9.

4.3.6 Fine filter unit

Gases from the carbon fiber filter were fed into this filter. This is the final mechanical filter which was filled with sawdust. The detail drawing of the gas cooler is shown in Figure 4.10. The packed bed materials were used to absorb additional tar, dust and vapors to get dry and clean gas. There are needs for periodic changing of the packing materials.

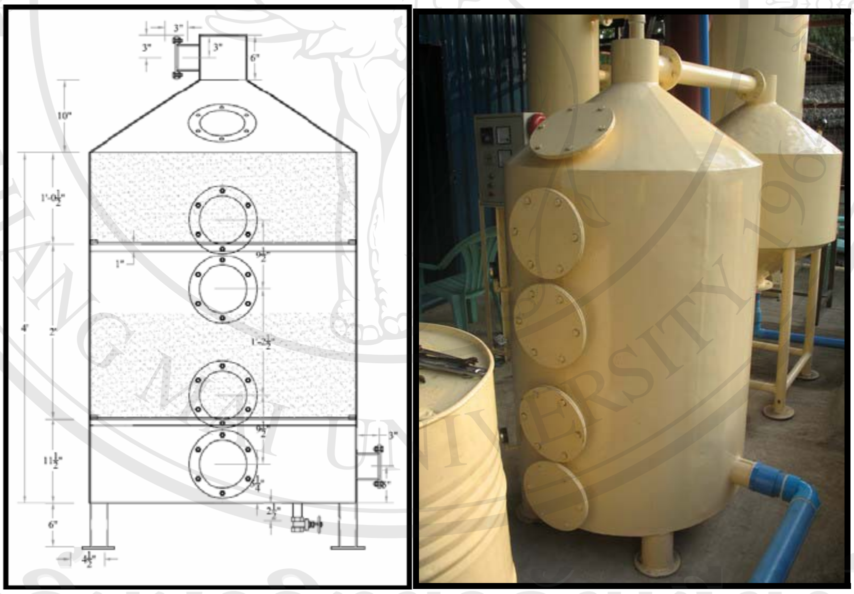

Figure 4.10 Fine filter unit

4.3.7 Gas damper

After passing the sawdust filter, the cleaned and cooled gas entered the gas damper, as shown in Figure 4.11.

Figure 4.11 Gas damper

4.3.8 Water pump

A water pump was used for spraying the water in the cleaning and cooling system. The water pump (1 HP) is shown in Figure 4.12.

Figure 4.12 Water pump

4.4 Electrification System

The electrification system installed consists of three main parts, which are engine, generator and electric control panel.

4.4.1 Engine

The engine used in the system is 4-cylinder, 2800 CC Mitsubishi 4M40, as shown in Figure 4.13. The engine was modified so that it can use both diesel and producer gases produced by the gasifier. An automatics governor is used to determine the amount of diesel used to keep the engine speed at 1500 RPM at all load, as shown in Figure 4.14.

Figure 4.13 Engine

Figure 4.14 Automatic governor

4.4.2 Generator

The generator installed is the Jewelway, Model JWX-50-4, 50 kW generator as shown in Figure 4.15. The produced electricity is 3 phase, 50 Hz. Maximum current is 90.2 Amp as indicated on the nameplate as shown in Figure 4.16.

Figure 4.15 Generator

Figure 4.16 Generator nameplate

4.4.3 Electric control panel

The electric control panel serves 2 purposes. The first task of the panel is to prevent any failure that may occur during operation. Four circuit breakers were installed. The second task of the panel is to monitor the electricity produced. There are four meters installed, which are Volt meter, Frequency meter, Current meter and kWh meter. The panel is as shown in Figure 4.17.

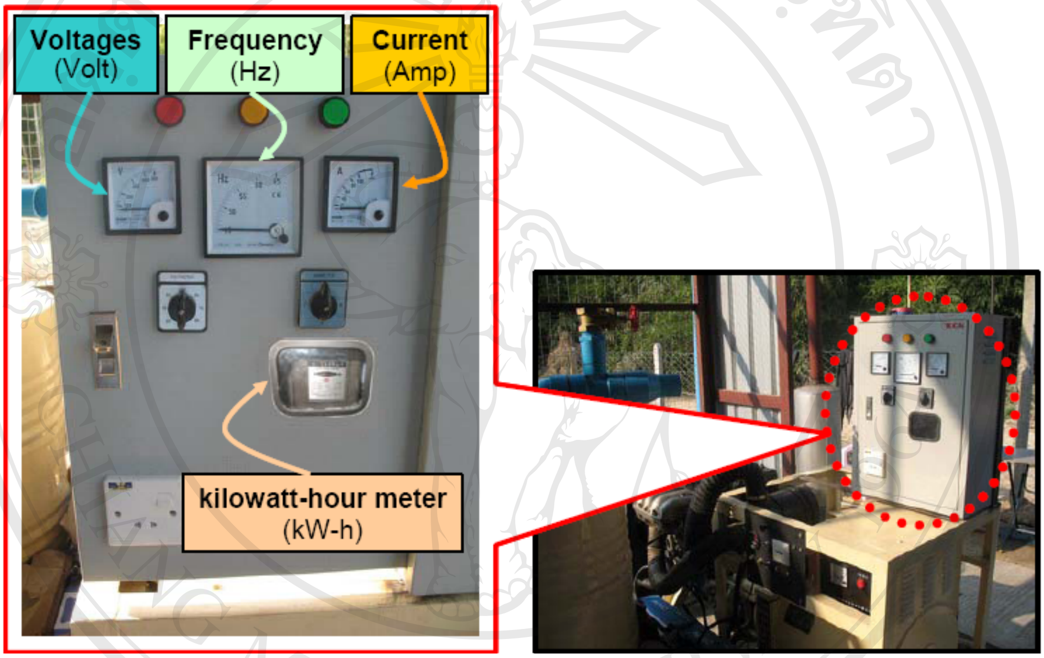

Figure 4.17 Electric control panel

4.5 Building

Figure 4.18 Picture of the building

A building was constructed on site to house the electrification system, control room and store biomass with floor area of 56 m², as shown in Figure 4.18.

4.6 System installation, Wiring and Testing

This is described installation of the system inside the building, as well as erection of electricity poles and wiring from the electrification system to villagers' households.

4.6.1 System installation

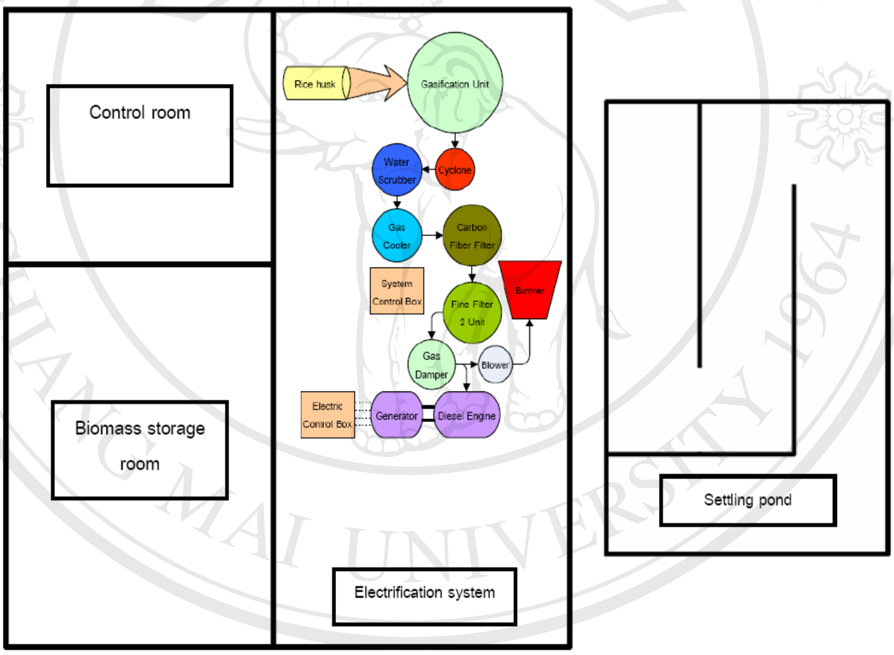

Figure 4.19 Installation of the gasification system inside the building

The gasifier system is installed in side the building, as shown in Figure 4.19. There are three main areas, gasifier-engine-generator system, control room and biomass storage room.

4.6.2 Electricity wiring and network

The power plant is located near the centre of the village. Lamp posts and power poles were erected with assistance from the villagers and electricity distribution lines were connected from the power plant to households in the village under supervision of qualified engineers and electricians. Each house was provided with a 20 W lambs as well as a switch. The network covered about 350 houses. About 40 lambs were also installed on concrete poles for road lighting. Details are shown in Figure 4.20, 4.21, 4.22 and 4.23.

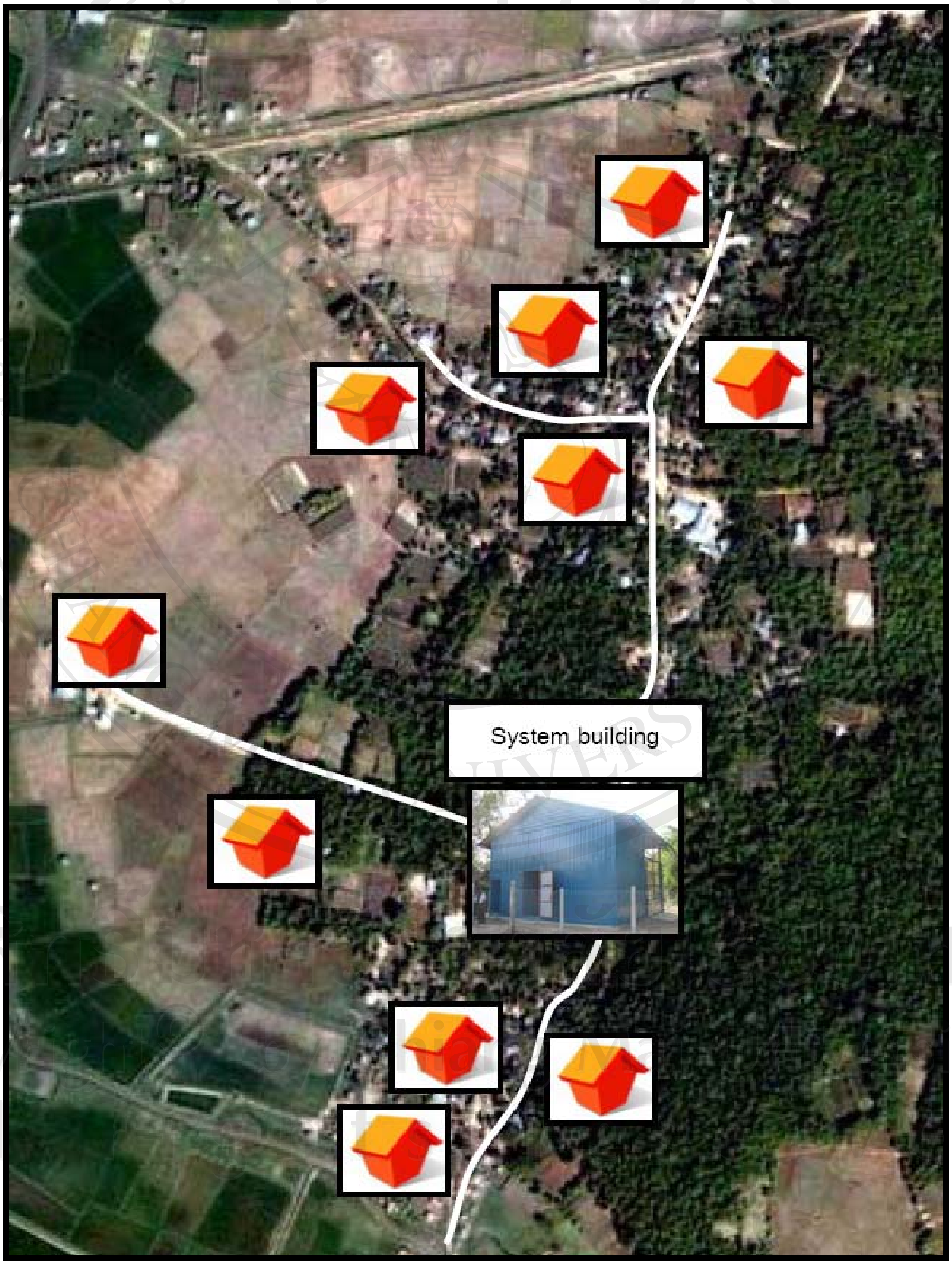

Figure 4.20 Electricity distribution lines and power plant location in the village

Figure 4.21 Three-phase electricity lines from the system building

Figure 4.22 Electricity poles along the main road

Figure 4.23 Lamb posts along the main road

4.6.3 System operation

The system operation consists of three parts, which are preparation, system operating procedures and maintenance.

4.6.3.1 Preparation

Rice husk should be stored in the storage room to keep it away from moisture, as shown in Figure 4.24. There should be enough rice husks for one week operation.

Figure 4.24 Rice husk storage

Make sure that rice husk level is not lower than the level in Figure 4.25 at all time.

Figure 4.25 Rice husk level

Make sure the water level in the pond and the dust collector are as indicated in Figure 4.26. The water must be replaced once a month.

Figure 4.26 Water level in the circulating pond and the dust cooler

Always check the lubricant oil level, diesel level and cooling water everyday before starting the engine as shown in Figure 4.27. The lubricant oil must be replaced once a month. Make sure that the radiator is filled with water to prevent the engine from overheating.

Figure 4.27 Radiator, diesel and lubricant oil tanks

4.6.3.2 System operating procedures

Before starting the engine, the control panel must be turn off. The air control valve must be open as shown in Figure 4.28.

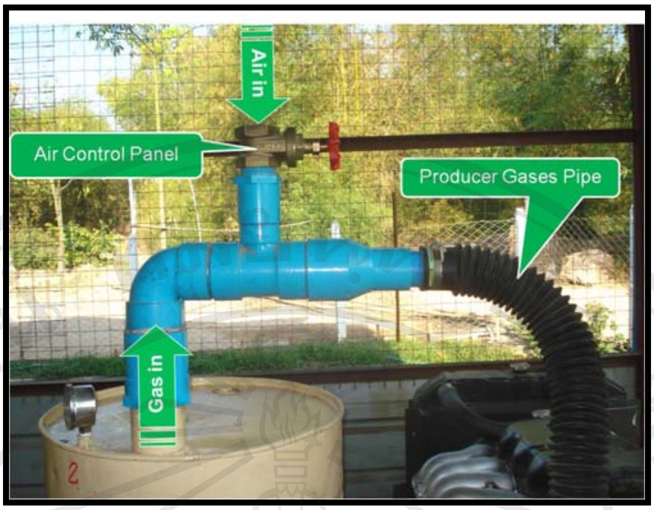

Figure 4.28 Air control valve

Starting the engine, turn the key to ON position. The green indicator must be brightening up, as shown in Figure 4.29. Turn the key to START position. The engine should be started. Wait 3-5 minutes, and then turn on the generator.

Figure 4.29 The key of starting engine

After the engine started for 3-5 minutes, the reactor can be ignited. As soon as the reactor is ignited, starting closing the air control valve to reduce fresh air from outside to the engine. Downing the air from the top of the reactor will accelerate the reaction. Turn on water pump.

After 15-20 minutes, the producer gases are ready they can be fed into the engine to replace diesel consumption. Care must be taken while replacing diesel with the producer gases. Make sure that the transition is smooth. One good indicator is that the noise of the engine must be stable and the frequency of the electricity is between 48-52 Hz. Turn on the automatic ash removal system as shown in Figure 4.30.

Figure 4.30 Ash removal system

Finally turn off the reactor, turn off the ash removal system and the water pump. Open the air control valve to let the fresh air into the engine and turn off the engine. Fill the reactor with rice husk to the 1/3 of the reactor height. This will keep the heat inside the reactor for next operation.

4.6.3.3 Maintenance

Daily maintenances are;

- Check the water levels in the pond and the dust collector
- Check diesel level, lubricant oil and water level inside the radiator
- Remove the ash floating at the pond and the tray, Figure 4.31
- Listen to the sound of the motors
- Check the electricity cable before starting the system
- Record the amount of diesel and rice husk used.

Figure 4.31 Ash at the pond and the tray

Monthly maintenances are;

- Remove all rice husk inside the reactor and clean the inside the reactor
- Clean all the inner of the pipe by removing any dust and tar
- Replace water in the pond
- Replace the rice husk and pebbles inside the filters, Figure 4.32.

Figure 4.32 Filters

4.6.3.4 The treatments and recycling program to the waste products

- Ashes, the products of down load gasifier, are utilized in Agriculture as raw for fertilizers.
- The tars which output from cyclone separator are using as a paints in boats for external cover to protect weathering.

- The Marbles are using in gas cooler coated with tars will be cleaned and recycling.
- The pebbles which are exhausted after running hours 200 in the carbon fiber filters will be collected and applying in road construction.
- There have to manage the saw dusts coated with tars from the yield of fine filter unit. There are applicable as filling agents and applying as putty in industries.

4.7 Test runs

The system has been tested to generate electricity to the villagers since 20 November 2007. It is scheduled to operate in the evening from 18:00 to about 24:00 everyday.