BIOGAS OF ANIMAL FAECES IN ACEH BESAR DISTRICT: A PROJECTION TOWARDS RENEWABLE ENERGY DEVELOPMENT IN ACEH

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ABSTRACT

Aceh has a large potential of biogas energy development. According to Central Bureau of Statistic's data 2013, the total population of cattle in Aceh Province is 701,284. Since 2012, YKU Foundation has been developing a biogas energy program made of cow and designing a reactor which is simple and affordable by the community. It is constructed from polyethylene (PE) plastic 0.2 mm, with unit price IDR 10,000,000.- (around USD 909.09, with USD 1 = IDR 11,000). Animal waste of 100.000 cows would potentially yield biogas energy as much as 36.000 m^3 (27 million litres of kerosene) / year. If CO_2 emission factor = 2.5359, then CO_2 emission out of kerosene consumption is approximately 68.469.300 kg CO_2/year. From economical perspective, the saving of kerosene at amount of 2,250 kilo litres is equal to IDR 22.5 billion (USD 1.9 million) per month or IDR 270 billion (USD 23.48 million) per year. During 2014, YKU is being an implementing partner of USAID for Indonesia Clean Energy Development (ICED) Program, with the objective to increase people's energy independence and to preserve the environment, to support the improvement of the local economy, and ultimately to reduce the carbon emission as much as 281,000 kg CO_2 per year. It is eventually expected that these activities would contributes to Indonesia emission reduction efforts, and to widespread use of biogas energy specifically in Aceh, and throughout Indonesia in general.

Keywords: Biogas, Cow Faeces, Renewable Energy, Aceh

INTRODUCTION

The program of small-to-medium scale biogas energy development in Indonesia began in the early 1970s. The development aimed to utilize waste from biomass in order to find alternative energy sources outside firewood and kerosene. The program was less developed as the people were still able to purchase kerosene and gas that were still subsidized by the government. In addition, other energy sources, such as firewood was still widely available, especially in the rural areas.

Household biogas development began to gain attention, both from government and the public after the issuance of the Government's policy of reducing subsidies in gasoline since October 2005. Nowadays, the development of household biogas has been increasingly important as kerosene becomes scarce and expensive, more than IDR 10,000 or USD 0.87 per litre (USD 1 = IDR 11,500), LPG is expensive, i.e. IDR 80,000 or USD 6.95 per 12 kg. However, the current energy use patterns can not be detached from the consumption of fossil energy as there is not much energy option in Indonesia. This triggers environmental degradation (agriculture, forests, atmosphere), while the scarcity of fertilizer reduces soil fertility. Therefore, biogas energy development by **Yayasan Kemaslahatan Ummat** (**YKU**) or **Kemaslahatan Ummat Foundation** is one of the solutions to find alternative energy sources as well as conservation efforts.

Key Issues and Biogas Development Potential

Based on the data of "Aceh in Figures 2013", the total of cattle population in Aceh Province is 701,284. Assuming that the empirical data of average faeces generation was 10 kg/day/cow, the cows will generate faeces more than 7 billion kg or 7,000,000 tons of waste per day. Therefore, a cow has the potential to generate at least 0.36 m^3 of biogas, equivalent to 0.75 litre of kerosene. If it is considered that only one-seventh of the cow faeces production in Aceh processed through biogas fermentation, then out of 100,000 cattle will potentially generate 36.000 m^3 of biogas, or if the biogas generated is used as energy source, it can be compared to approximately 75,000 litres of kerosene per day, or 2,250,000 litres per month or 27 million litres per year. If emission of CO_2 is defined as the volume of energy used multiplied by CO_2 emission factor (2.5359), then CO_2 emission out of kerosene consumption is approximately 68,469,300 kg CO_2 per year. On the other hand, about 187.6 ton of CO_2 emission could be reduced per year.

Associated Social and Economic Challenges

With the background and key issues mentioned above, it is illustrated that the utilization of biogas energy has the high potential of social and economic empowerment, as far as there is a party that is willing to initiate and develop this potential to have an added value for the people. Let us go back to the simple calculation above. Assuming that the price of kerosene is around IDR 10,000 per litre, by the utilization of biogas energy, Aceh Province potentially will save energy use of kerosene at IDR 2,250,000 x 10,000 = 22.5 billion rupiah or USD 1.9 million per month. Based on these calculations, the potential availability of energy source using cow waste is quite large, that is IDR 750 million (USD 65.22 million) per day or IDR 22,5 billion (USD 1.9 million) per month or IDR 270 billion (USD 23.48 million) per year. A fantastic figure!

Besides, traditional cattle by the citizen of Banda Aceh City are still letting the cows walking around the city. The faeces are spreading on the roads and municipality government keeps struggling to cleans-up the faeces and this also yields organic waste to be disposed to the landfill (TPA Gampong Jawa).

In this paper, YKU presents a program that combines the activities of the technical application and community development. It is expected to result biogas utilization of animal waste, and answering social challenges to make these activities sustainable and implemented independently by the society in the future.

Objectives

The program objectives are to increase people's energy independence while at the same time to preserve the environment and to support the improvement of the local economy through the development of household biogas in a sustainable manner. Indicators of change that will be seen:

- At least 20 units of biogas reactor are installed with a capacity of at least 4 m^3 each.
- Increased capacity of communities in the development of biogas energy as well as organic fertilizer (bio-slurry) for improvement of agriculture and livestock.
- The utilization of electrical energy and biogas are sustainably operated and managed.

The program that has been carried out since 2012 is being continued with ICED Program (Indonesia Clean Energy Development Program). Indicators of achievement of ICED program are:

- Almost 300 tons of CO_2 emissions reduced out of 23 units of biogas reactor installed.
- At least 600 Watt x 20 reactors = 12 kW of clean energy power generator installed.
- 2,400 m^3 biogas or equal to 1,500 litres of kerosene per month produced.
- 40 households benefited new renewable energy resources out of 3 villages in 3 subdistricts.
- Two tofu factories will eliminate the use of 144 m^3 of firewood per year with 2,920 m^3 biogas.
- At least 3,000 people in 3 villages are well informed about the program as well as 30,000 people out of 500,000 of Banda Aceh – Aceh Besar population through mass media publication.

Beneficiaries

The program would have direct and indirect beneficiaries. The direct beneficiaries are:

- 20 farmers plus 20 connected households (HH).
- Total of around 250 people (with the assumption 4 to 5 family members per HH).
- Two tofu factories.
- One boarding school.

While indirect beneficiaries are:

- Stakeholders of Aceh Besar Government, i.e. around 50 government officials from district and subdistrict offices will be advocated and well aware about the program.
- Around 3,000 people from 3 villages will be informed through socialization. The following is area map of YKU Biogas Program.

METHODOLOGY

In the attempt to answer the challenge of utilizing alternative energy, YKU is applying a simple biogas technology of organic waste, both animal faeces, waste of tofu factory, and human waste.

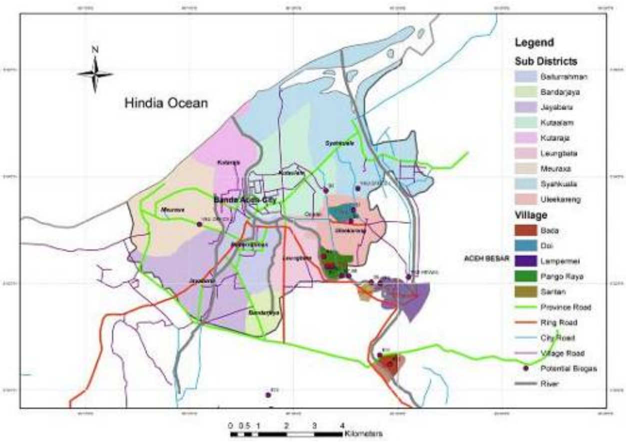

Figure 1. Map of Beneficiaries in YKU Biogas Program

Strategy

In this case, the strategy used by YKU to carry out these activities comprised of three strategic approaches:

1. Application of simple technology that is easily maintained by the community.
2. Manufacturing biogas reactor prototype through a pilot-project.
3. Community development, i.e. to involve the community by providing technical training, the implementation of biogas reactor installation, up to maintenance processes.

Simple Technology

YKU applies a simple reactor biogas technology to process the organic waste.

Materials

Plastic biogas reactor consists of 4 (four) chambers:

1. Inlet chamber for raw materials intake.
2. Processing chamber or digester.
3. Outlet chamber for collecting the slurry.
4. Gas reservoir

Inlet and outlet chambers are made of masonry, while the digester and the reservoir are made of poly-ethylene material (PE) or fibreglass. See Figure 2.

Apart of those four chambers, there is also a regulator that serves to regulate the gas pressure. If the gas is not consumed, the gas pressure in the reservoir tank and digester gas would be high. In the long run, this pressure will damage the plastic. To reduce gas pressure, then the regulator is used.

Regulators can be made simply of a used plastic bottle. The bottle is connected with T-shape pipe connector. This T would connect, one end to the digester and another one to the reservoir, while the third line is inserted into a bottle with holes in the top and filled with water.

Design

YKU has modified a reactor design which is very simple and economical (more affordable by farmers), as shown in Figure 3 below. It should be noted that the reservoir (chamber 4) is not reflected in this figure.

Installation

The installation of the biogas reactor unit can be briefly described as follows (Source: Environmental Service Program (ESP), December 2008):

1. Cut PE sheet with a size of 5 m (for reservoir) and 7 m (for digester). PE-Plastic that is available in the market is usually a double plastic sheet. See Figure 4.
2. Heat or press both ends and edges of the plastic using plastic heater. If the heater is not available, candle could be used, but it should be more careful not to over- heat the PE as it will leak. Leave a hole about 30 cm in diameter in the middle part for inlet pipe and one more hole for outlet pipe. See Figure 5.

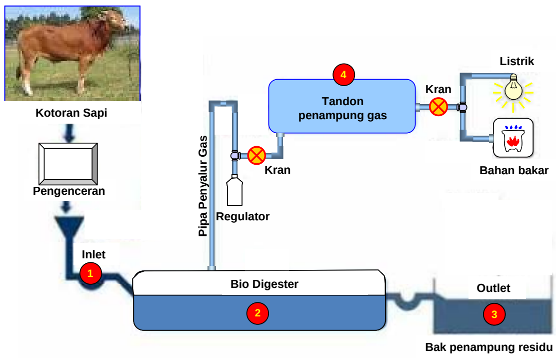

Figure 2. General Biogas scheme of Cow Faeces

3. Tie both holes for inlet and outlet with rope. Blow the plastic using a blower or a bicycle pump that inflates plastic perfectly (Figure 6). To test for leaks along the plastic connection and inlet/outlet holes, make a mixture of detergent and water, then slowly pour

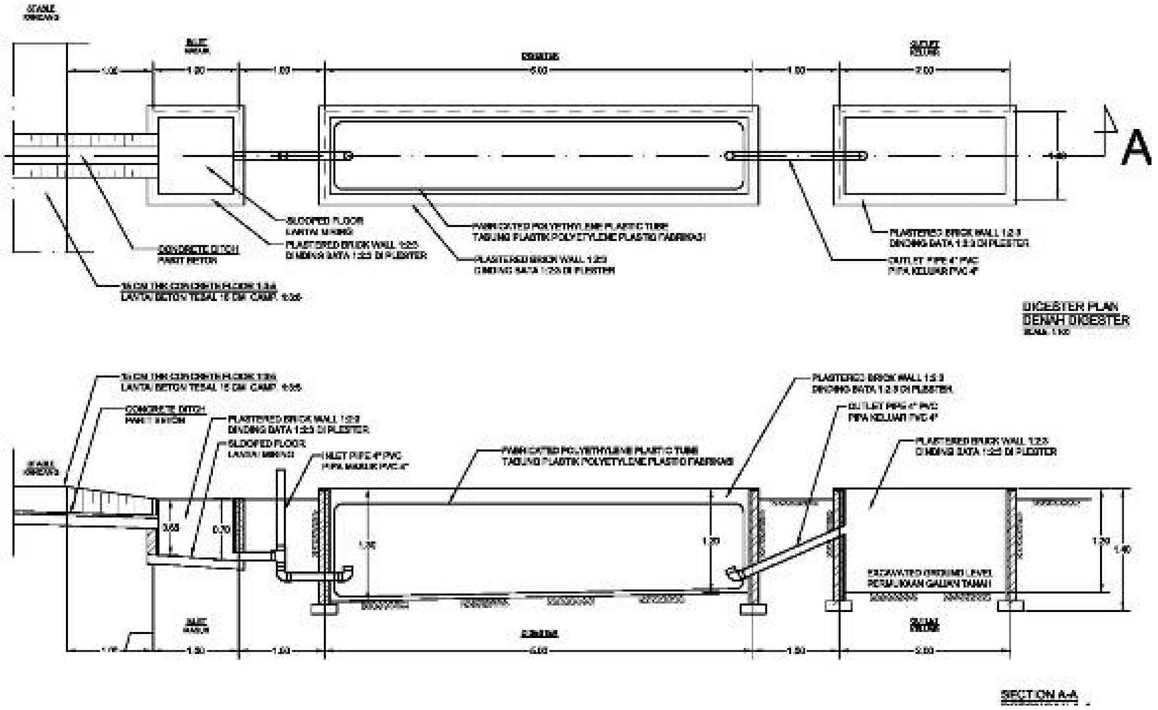

Figure 3. Simple biogas reactor design for cow faeces, modified by YKU.

Figure 4. PE plastic cutting

Figure 6. Leak test for digester.

Figure 5. Heating the edges of plastic

Figure 7. Tie inlet pipe with rubber tape.

over the plastic. Note if air bubbles appears, then reheat on the part that is still leaking. Next step, cut 4-inch PVC pipe for inlet/outlet, connect with the elbow and T as per design. Put the pipe into the inlet and outlet holes that have been made, tie the pipe with plastic using tie made of rubber. To protect rubber for its durability, seal the connection with rubber tape (Figure 7).

4. Dig a hole on the ground with appropriate size design, which is about 5 x 1 m and 1.3 m depth. Considering that Aceh is earthquake prone area, it is advised to make the construction of brick walls with the composition of cement-gravel-sand 1: 2: 3 and plastered, to protect the plastic. Once cement plaster dried, put digester plastic into digester pit. Make sure that the plastic is not bent, twisted, folded, or pierced by something (e.g. sticks, equipment, etc.) thus the plastic does not leak.
5. Put the rubber ring that is flanked by a PVC ring at the methane release hole. Connect with threaded shock inside and outside. Use PVC glue to reinforce this connection. Connect the PVC end with 0.25 inch PVC pipe. Use clamps to lock the connection, thus it would not move.
6. Using a blower or pump, fill the plastic with air to inflate digester perfectly. Once filled with air, close with PVC cap, hence the air does not flow out.
7. Fill inlet and outlet PVC pipe with water in order to prevent the air does not come out.
8. Digester is ready to be filled with cow dung

Engineering of Biogas Installation

The construction consists of inlet, digester, and outlet, as well as the biogas reservoir. Engineering at the inlet does not require special skills, because the function of the inlet is just to accumulate, stirring, and dilute the dung. In this case, the inlet is made of red brick and cemented with varying dimensions.

Digester is made with simple technique, i.e. made of PE-plastic materials with the capacity of 4000 litres. Another chamber is the reservoir for methane storage

Constructing the outlet is the same as the inlet, not requiring special skills, as the function of the outlet is to collect residual waste after processing in the digester. Outlet is made of red brick and cemented with a volume of about 2m·

Community Development

Community development is the key to the sustainability of this program. Installation of reactor unit is not a difficult task, however, to ensure that the reactor unit can be operated and maintained by a community properly, it requires outreach efforts, undertaken since the beginning of the activity.

In short, the community development performed by YKU is activities described below.

A. Early socialization and community selection process.
B. Trainings for facilitators, beneficiaries, and comparative studies.
C. Implementation of the biogas reactor construction by the community.
D. Socialization about biogas utilization.
E. Establishment of Beneficiary Groups for livelihood improvements.

RESULTS AND DISCUSSIONS

The development of biogas from animal faeces would have a number of benefits, both indirect and directly benefits.

Indirect Impact

Since the main products of this renewable energy development are biogas and organic fertilizer, the program would indirectly have positive impacts to the environment:

- contributes to forest, soil, and water conservation,
- reduces pollution,
- improves environmental sanitation,
- supports government policies in reducing fuel subsidies, also
- indirectly supports international programs that reduce the negative impact of the greenhouse gas effect.

The utilization of biogas in reducing the greenhouse effect occurs in three ways. The first, biogas is a substitution of fossil fuels for cooking and lighting. Second, the installation of biogas from animal faeces generates fermentation process that converts methane into CO_2, thereby reducing the amount of methane released into the atmosphere. The third, the application of biogas technology would have an impact on forest conservation, as logging activity can be reduced. With forest conservation, then CO_2 in the air will be absorbed by forests and processed through photosynthesis produces oxygen, which is against the greenhouse effect.

Furthermore, this effort can be proposed as part of the program of Clean Development Mechanism. Indeed, methane gas along with carbon dioxide (CO_2) included in the greenhouse gas, giving "greenhouse effect" that cause global warming phenomenon. By developing a biogas development program, the methane gas from cow manure produced will be converted and utilized as a source of energy, thereby reducing the production of methane gas released into the atmosphere and can play a positive role in solving the global problem of greenhouse effect.

Direct Impact

The impact directly felt by farmers is an alternative energy source in terms of:

- biogas would be used as fuel for cooking.
- power source of generator for electricity for lighting and other household necessities, such as water pumps, television, fans, and others.
- In addition, other direct impacts which can be benefited directly from the development of biogas is a ready-made supply of organic fertilizer.

If we calculate those direct impacts mathematically, it would possible not give a promising figures. However, YKU has three targets in order to make this program has a wider impact:

1. Semi-communal Reactor.

   A biogas reactor is targeted to be used not only by a family, but at least two families. For this purpose, YKU would establish beneficiary groups and conduct training, facilitating community groups, and mentoring includes capacity building in terms of technical management, operation, and maintenance.

2. Campaign and Socialization.

   The main target is to gradually change the mindset and energy use patterns of conventional energy consumption towards alternative energy consumption. Mentoring and facilitation processes would be performed by YKU, beyond the implementation of the ICED program.

3. Independent Community

   The implementation of the program would done with the selection process to recruit farmers and beneficiaries who have an interest and willingness to partner with YKU during the program and beyond. The target is to encourage the community independence in term of energy consumption. This would be performed by YKU through encouraging the people to contribute during construction of biogas reactor units in order to grow the sense of belongingness the biogas reactor. Thus, gradually the attitude of independence would be formed and slowly YKU would be releasing the facilitation to optimize the sustainability of the program.

Carbon Emission

According to Pusat Penelitian dan Pengembangan (Puslitbang) Permukiman, Ditjen Cipta Karya, Kementrian PU (Ministry of Public Works), the amount of CO_2 emissions out of human activity is calculated by a formula as follows:

$$ECO_2 = A \times FE$$

E_{CO2} = CO_2 emission

A = activity data (kWh of electricity, litres of kerosene, etc.)

FE = emission factor (kg CO_2/kWh, CO_2/litre kg kerosene, etc.)

The emission factors of some emission sources according to the empirical data are as follows:

- Gas Tube : 3 kg CO_2 / kg of gas
- Kerosene : 2.5359 kg CO_2 / litre
- Electricity : 0.719 kg CO_2/kWh

In addition, still according to Puslitbang Permukiman, based on empirical data, for the average household electricity use of 125 kWh (a family with an average income of IDR 500.000, - to IDR1,000,000, - per month), the estimate of CO_2 emissions are 90 kg CO_2 / month.

The amount of carbon emission reduced in one year during the implementation of ICED Program could be calculated as follows:

1. Biogas reactor 20 units would be utilized by 40 HHs, thus the total number of beneficiaries is 40 families. If it is assumed that the consumption of kerosene per HH is 2.5 litres / day, the total consumption of kerosene for 40 HHs is 100 litres per day, or 3,000 litres per month, or 36,000 litres per year.

   If 40 HHs are no longer buying kerosene, and as substitutes using biogas energy, then the value of E_{CO2} that can be reduced with the use of biogas is:

   - 36.000 x 2,5359 = 91.292,4 kg CO_2 per year.

2. Assuming the use of gas tube is 1 tube per HH per month (for 1 HH = 4 family members), or 12 kg / HH / month. Thus, for 40 families, the use of gas tube is 480 kg per month, or 5,760 kg per year.

   Similar with the use of kerosene, if 40 HHs will no longer purchase gas tube 12 kg, and as substitutes using biogas energy, then the value of ECO_2 or carbon emissions that can be reduced with the use of biogas is

   - 5.760 X 3 = 17.280 kg CO_2 per year

3. It would be too optimistic if biogas energy is targeted to replace the electricity consumption of households totally in a day at 125 kWh. Nonetheless, YKU noted that the use of biogas-powered electricity generators which were conducted during the pilot project was able to turn on the generator for 3 hours or 1/8 of a total of 24 hours. If the coefficient rate of 1/8 is used as the basic assumptions and multiplied with electricity usage of 125 kWh in a day, then the figure is around 15 kWh per HH per day as the maximum

capacity of biogas for electricity consumption. Thus, 15 kWh per day x 40 HHs = 600 kWH per day, or 18,000 kWh per month, or 216,000 kWh per year.

Under the usage of electricity for 3 hours per day for the 40 HHs of biogas energy, then the value of the ECO_2 that can be reduced is

- 216.000 x 0,719 = 155.304 kg CO_2 per year.

4. A tofu factory spent 3 m^3 of firewood per week at a price of about Rp 400,000,- or IDR 1.600.000,- per month. The price is equivalent to 20 kg of gas tube 12 kg, or 240 kg of gas consumption per month, or 2,880 kg per year. For two tofu factories that would use biogas energy, the gas consumption would be 5,760 kg per year.

   Then the value of ECO2 carbon emissions that can be reduced with the use of biogas is

   - 5.760 X 3 = 17.280 kg CO_2 per year.

Once again, those figures of carbon emission reduced are still relatively small. However, YKU as a local NGO would continue this program after ICED Program is completed and performs more extensive development, both in Banda Aceh and Aceh Besar, as well as in other areas in Aceh and throughout Indonesia, in partnership with other third parties.

In general, out of biogas reactor of 20 units and 40 HHs targeted beneficiaries, and 2 tofu factories, the output from this program is as follows:

Table 1. Carbon Emission Reduced

No.	Source of Emission (Equivalent)	Energy Consumption	Carbon Emission Reduced (kg CO_2/year)
01.	Kerosene	36.000 l / year	91.292,4
02.	Gas tube	5.760 kg / year	17.280,0
03.	Electricity	216.000 kWH / year	155.304,0
04.	Gas tube for 2 tofu factories	5.760 kg / year	17.280,0
		TOTAL	281.156,4

CONCLUSIONS

With short-term development plan (through ICED-USAID program), as well as long-term strategic plan, as described above, YKU expects the positive impact of these activities can really be addressed to the people in Aceh:

- Contribution of CO_2 emission reduction of almost 300 tons at the end of this project in 2014, contributes to emission reduction efforts, and is expected to continue to reduce further in the following years with the widespread use of biogas energy specifically in Aceh, and throughout Indonesia in general.
- Improving and expanding community energy independence, thus the people does not depend on fossil energy and electrical energy supplied by the Government.
- Beneficiaries obtain significant economic benefits as an added value, i.e. the transfer of conventional energy consumption costs to other productive

expenditure for additional family incomes, cost of education, health, and other costs of living.

- Local government also is saving the energy used by reducing amount of kerosene provided for community, and also the City of Banda Aceh would be cleaned of cow manure, as well as save the landfill from organic waste out of cow manure.

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