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Special

Biogas development in Indonesia: household scale

Evaluation of Indonesian transition pathways in biogas utilisation

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TRANSrisk project

The objective of TRANSrisk (www.transrisk-project.eu) is to explore low emission transition pathways and analyse the possible associated risks. A key feature of TRANSrisk is that it brings together quantitative techniques (such as models) and qualitative approaches (such as participatory consultations with stakeholders). This combined approach enables identification of possible low emission transition pathways which are technically and economically feasible, and acceptable from a social and environmental viewpoint.

Are you a stakeholder or researcher involved or interested in bioenergy? Feel free to join the discussion and share your thoughts and insights with the TRANSrisk project. For more information, please contact Takeshi Takama, an associate of TRANSrisk partner The Stockholm Environment Institute (SEI), Oxford, UK (takeshi.takama@sei-international.org), and working for environmental consultancy *su-re.co*, based in Bali, Indonesia (dr@su-re.co).

Renewables in Indonesia

According to Indonesia's National Energy Policy established through Governmental Regulation No. 79 of 2014, renewable energy is targeted to achieve 23% of Indonesia's total energy mix by 2025. Bioenergy will be one of the main options to meet this target. Indonesia has abundant resources of organic feedstock, such as animal manure and crop waste (agriculture is a key economic sector in Indonesia).

In general, Indonesian farmers practice mixed farming, i.e. they do not only have plantation land (about 0.5 to 1 hectares on average), but they also raise livestock. In addition, the composition of livestock varies widely based on the geographical location. For example, in Western Indonesia, a mixed livestock of cattle and poultry is common, while in Eastern Indonesia many farmers have a combination of cattle and pigs. Traditionally, farmers put the manure in an open area storage site to be processed as fertiliser[1] for their plantation land, or it is thrown into the rivers for sanitary purposes.

Transition pathways

This article will focus on mapping the costs and benefits of biogas technology implementation on a household scale, and this is compared with the current dominant form of cooking fuel, i.e. fuel wood. Both options focus on household-level application. There are some experiences with biogas plants in Indonesia. One of the examples, the biogas programme named BIRU, was initiated through a collaboration between the Ministry of Energy and Mineral Resources (*ESDM*) and the SNV Netherlands Development Organisation.

The installation of household-scale biogas technology is summarised in Figure 1, consisting of an integrated system of a fix dome, a main gas valve and post-manure treatment.[2] Biogas production generally contains 50% of CH_4. Manure-based biogas production can help to not only reduce methane (CH_4) and carbon dioxide (CO_2) emissions, but also improve the water quality of rivers. By collecting and processing animal manure, the remaining organic carbon (as well as

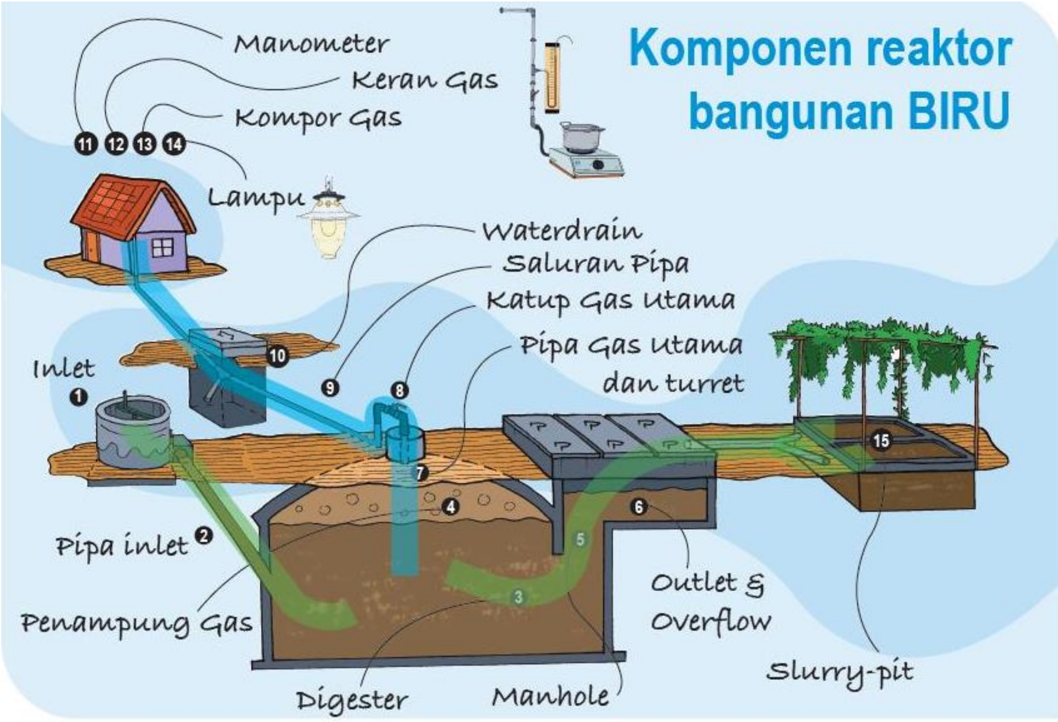

Figure 1. Reactor components of BIRU installation. 1. Inlet (mixing tank); 2. Inlet pipe (optional to be connected to toilet); 3. Anaerobic digester; 4. Gas storage; 5. Manhole; 6. Outlet and overflow; 7. Main gas pipe and turret; 8. Main gas valve; 9. Pipeline; 10. Water drain; 11. Pressure Gauge; 12. Gas tap; 13. Gas stove with a rubber hose pipe; 14. Lamp (optional); 15. Bio-slurry pit.

phosphates and nitrates) in digestate, commonly known as bio-slurry, can be submitted to agricultural soils that are increasingly degraded. Up until now, chemical fertiliser is still frequently used by the farmers. With a biogas installation, the use of chemical fertilisers could be reduced.

In general, bio-slurry will be produced everyday after biogas production, as manure will be a daily input to the digester. In the case that the mix ratio of manure and water is 1:1, the composition of bio-slurry is 93% water and 7% dry matter. The NPK content in this liquid bio-slurry is about 0.25% (N), 0.13% (P), and 0.12% (K). Liquid bio-slurry can be immediately applied by farmers to the lands. Solid bio-slurry takes around 40 days before application due to a natural drying process, and is used during soil processing and the mid-growing season.[3]

Another positive aspect of using biogas is that it minimises health issues (such as respiratory problems and eye illness) that occur due to burning of firewood. However, some parts of areas in Indonesia still depend on fuel wood usage for cooking, and this practice is likely to continue due to cultural and economic factors. Also, limited training for maintenance of existing digester systems might contribute to the current low use of biogas.

Household scale of fuel wood usage

According to Statistics Indonesia, it is recorded that between 2005 and 2010 about 40% of total Indonesian households used traditional biomass (firewood) as their primary cooking fuel, with a peak of around 49% in 2007.[4] Firewood users were mainly located in rural areas of Indonesia. Although the Indonesian Government has established a fuel substitution programme to incentivise the use of LPG, rural areas were still untouched. The main reason is that firewood is easy to be collected from the local environment, or purchased at low cost. This condition leads to a high number of premature deaths annually as women spend hours per day in the unhealthy cooking environment. The utilisation of fuel wood in terms of tree branches will remain because of its abundant availability, and less need for maintenance as compared to biogas production.

Evaluation of biogas and fuelwood utilisation at household scale

The implementation of biogas technology at the household scale is foreseen to spread among as many as possible households in Indonesia, especially for people living in rural areas. Using biogas for cooking will positively impact health, especially for women and children, and mitigate climate change through among others CH_4 and CO_2 emissions reduction. Also, biogas utilisation will enhance the water quality of the rivers, since there will be no animal dung discharged to rivers. In addition, using biogas provides economic opportunities for households, as biogas production pre-empts the household from purchasing fuel as well as fertiliser.

However, the initial costs of installing biogas technology still need to be evaluated. Since it requires to be integrated with cooking and a post-manure treatment system, the installation costs are quite high: between USD 400 and 700 depending on the size of the digester, according to the BIRU programme (Table 1).[5] This hinders the affordability of household-scale biogas technology. The regulated minimum wage in Indonesia, established per province, is about IDR 1.5 to 2.5 million per month (about USD 110 to 180 per month). However, farmers' incomes are not regulated, and are generally below the minimum wage. Therefore, the cost of a biogas digester is likely to be more than half of the annual income. In order to increase the use of biogas, an encouragement to apply for low-interest credit would therefore be required. The BIRU programme, in addition, offers a subsidy for farmers: they only need to pay 60-80% of the total installation costs.

Table 1. Range of size and price of biogas digester in the BIRU programme

Size (m^3)	4	6	8	10	12
Cows	3	4-5	6	7-8	9
Manure (kg/day)	30	45	60	75	90
Biogas production (m^3/day)	1	1.5	2	2.5	3
Cooking usage (hours/day)	4	6	8	10	12
Installation cost (USD)	436	482	535	612	673

The regular maintenance costs for household-scale biogas technology are insignificant. In general, the farmers just need to put attention to the gas pipelines to check for leakages. Hard maintenance of the digester operation will require a certified technician, as provided through the BIRU programme.

On the other hand, fuelwood usage for cooking seems to be more realistic, based on the high initial costs of the biogas technology. The fuel wood, particularly from tree branches, can be obtained cheaply or even for free, and only the inexpensive stove will need to be purchased. However, the environmental and society issue could arise: smoke production during the cooking process, and the labour-intensive work of firewood collection. These conditions could increase health problems, and affect mortality rates particularly for women and children.

The potential to reduce carbon emissions, and the side effects, of biogas transition pathways are summarised in Table 2.

Further research

Next steps of the research on biogas technology transition pathways in the TRANSrisk project include a (macro-)economic assessment with economic models, and research on factors which influence the implementation of biogas on the household-scale. This analysis will help to develop a better approach to reach a higher acceptance of biogas, and to increase awareness of the need for climate change mitigation among the Indonesian population.

Table 2. Overview of potential side-effects of biogas transition pathways

Contribution to carbon emission target	Biogas	Firewood	Remark
CH_4	**+**	**-**	**Biogas** – will help to achieve Indonesia's emission target. **Firewood –** will contribute to higher methane emission due to firewood burn.
CO_2	**+**	**-**	**Biogas** – will also help to save carbon dioxide emission due to manure utilisation in biogas production. **Firewood** – will increase carbon dioxide emission and risk of respiratory problem of farmers.
N_2O	**-**	0	**Biogas –** bio-slurry generally contains high amount of nitrogen which could help enrich the soil. As a consequence, N_2O emission would increase. **Firewood –** the ashes will slightly increase N_2O emission.
Nutrient excretion			
N, P, K	+	+/-	**Biogas –** the nutrients will be available from bio-slurry which is produced after manure digestion. The bio slurry contains essential dry matter (N,P,K) which is required by soil. **Firewood –** wood ash, which is produced after burning firewood, could be slightly added to compost to enrich its nutrients. If the wood ash is too much, it will ruin compost mixture.
Soil Organic Matter	-	0	**Biogas** – after producing biogas, the treated manure which known as bio-slurry usually contains lower organic matter component compare with untreated manure (before producing biogas). Thus, H_2S production in bio-slurry will be very low. **Firewood** – after wood burned, there will be only ashes produced.
Possible side-effects	**Biogas**	**Firewood**	**Remark**
Chemical fertiliser demand	-	+	**Biogas** – will likely reduce chemical fertiliser application as bio-slurry is already available after biogas production. **Firewood** – as firewood has already existed years ago, farmers who do not use biogas will still need chemical fertiliser. Organic fertiliser commonly has higher price than chemical. Thus, they prefer to use chemical fertiliser.
Pathogen contaminants	+/-	0	**Biogas –** While biogas production is ongoing, the operational temperature will reduce the pathogens gradually so that in bio-slurry, the pathogen will be in very small amount. Up until now, mostly, single mixture of manure is still in use for producing biogas, even though the farmers have mixture livestock. **Firewood** – the ashes would unlikely contain pathogens.
Potential explosion	0/-	0	**Biogas** – since the biogas has low pressure, risk of explosion is also minor. Up until now, there is no case about biogas stove explosion in Indonesia. However, there is theoretical risk of explosion if certain amount of gas, around 6-12% of CH_4, is mixed with air. As a result, open fire or smoking is prevented when working in biodigester.[6] **Firewood** – has none explosion risk.
Hydrogen sulphide (H_2S) production	0/-	0	**Biogas** – H_2S presents together with biogas production. However, the amount of of H_2S is very small, research reported as 'traces' or less than 1%[7]. Even if the H_2S is produced in significant quantity, it can be detected by smelling unpleasant odour within biogas production. An alternative to removed H_2S is by bubbling the gas into lime-water[8]. **Firewood** – has no H_2S production.
Animal welfare – stable space	-	0	**Biogas** – requires investments for farmers' livestock so that the space could be integrated with anaerobic digestion to distribute manure as main input **Firewood** – Stable space is not required for farmers who use firewood for cooking.
Human health	+	-	**Biogas** – potentially to have very low risk in health problem due to manure management and its utilisation to the environmentally products: biogas and bio-slurry. Also, hygiene and sanitation will be improved through the bio-digesting process. **Firewood**- High risk in respiratory problems and eye illness as smoke produced while cooking.
Income	+ / -	0/-	**Biogas** – has potential to increase the income because it could be allocated to their savings as they do not need to buy fertiliser or fuel for cooking. However, installation system might be costly in the beginning. **Firewood** – will likely remain the same as current condition or even lower because some farmers need to purchase firewood. In addition, the price would potentially increase due to lower availability as population grow. Some other farmers get it freely from their closest field. If environmental degradation by deforestation is severe, it may affect agricultural activities and hence may reduce the income of farmers.
External expertise	+	0	**Biogas** – biogas experts are likely to increase because there is a potential demand in biogas technicians for system maintenance. **Firewood** – there is no experts required to collect firewood.
Cultural/gender/religious effects	+/-	0/-	**Biogas –** there are different mixture of livestock in certain area of Indonesia due to various culture and religion. In order to increase social acceptance of biogas user, it is

			importance to consider their manure availability and preferences: cows, pigs, and/ or hens. **Firewood –** there is none or very low cultural/religious effects of firewood usage except weak cooking preference for special occasion. Mainly the use of firewood is because of the availability. Firewood collection are mainly done by children and women, so the firewood options affects negatively to the gender issue and child education.
Time expenditure for farmers	+/-	0/-	**Biogas –** managing manure as the input into digester usually done once after cleaning the cages. Then mix the manure with water, ratio 1:1. Mixing process for now takes time because it is done manually. **Firewood –** firewood collection usually takes time around 30 minutes and 1 hour per day. In general, this activity requires short time to finish as firewood are collected from the closest field, or sometimes if the branches are limited, the farmers need to go to forest.

Symbols indicate (+) positive, (-) negative, (+/-) uncertain/unknown or (0) neutral/insignificant effect of the biogas transition scenario.

Source: TRANSrisk project, 2016

Notes

[1] Some of the farmers added certain type of soil worm (Lumbricus Rubellus) and organic waste, then mix them in every two weeks in a month, so that the fertiliser has an added value and potentially could be sold for a higher price, as there is a high demand in the market. However, some other farmers can also apply bio-slurry directly to the land.

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