Biogas Implementation as Waste Management Effort in Lembang Sub-district, West Bandung District

Husnul Aris Alberdi, Saut A. H. Sagala[1], Yasmina Wulandari[2], Steven Lodewyk Srajar[1], Deni Nugraha[1]

[1]Institut Teknologi Bandung, Jalan Ganesha No. 10 Bandung, Indonesia
[2] Resilience Development Initiative, Jalan Imperial 2 No. 52 Dago Asri, Bandung, Indonesia

Abstract. As population and economic activities increase, the demand for energy will significantly increase too. In the near future, Indonesia will have more limitation on fossil fuel based energy. Therefore, Indonesia has to find other sources of renewable energy. In other hand, rural areas in Indonesia suffer from energy supply. Therefore, there is a need to have a resilient village. Kampung Areng in Cibodas Village, Lembang Sub-district is one of the locations declared as an energy resilient village. This study focuses on Kampung Areng due to previous information and studies that shows that the farmers in this area are capable of generating renewable energy through conversion of animal waste using biogas digester. The biogas adoption was initiated also due to the Cikapundung river pollution issue, some people are pointing their hands at Kampung Areng as the source of these pollution at the upstream due to the irresponsible handling of animal waste. Thus, the idea of biogas digester adoption in this area could solve waste management issue and provide an alternative energy source for the communities. In this paper, researcher aim to identify the benefit and impact of biogas adoption in Cibodas Village, particularly on waste management.

1. Introduction

Energy is important resources for economic development and improvement of living conditions. In the past, Indonesia was oil exporter with several area production such as Balikpapan(1). However, Indonesia has already been an oil net importer since 2004, which likely will continue in the future. From 1980 to 2010, Indonesia Oil Consumption has increased, while its production has decreased. Since year of 2004, there was an energy deficit and Indonesia has been importing oil from other countries. If it not managing carefully, it could become a threat to energy security of Indonesia. In fact, Indonesia agency for assessment and application of technology predicted that Indonesia could be an net importer country for fossil energy (2). Therefore, Indonesia has to utilize other sources of energy, for instance new and renewable energy (NRE).

On the other hand, environmental problems are important issue in achieving sustainable development. The utilization of renewable energy resources could become an effective and efficient solutions to not only provide energy, but also produce less pollution and emission (3). One of environmental problems in Indonesia is waste management. As one of the countries with the highest population in southeast Asia about 220 million people and keep increasing in the last decade, the amount of waste produced is increasing. There are several factors that influence the waste management Indonesia such as regulation, capacity and technology of dumpsite, low public awareness, lack of infrastructure, and low priority from local government (4).

On the other hand, Indonesia has a target to achieve 23% of energy mix by 2025 (5). It is possible to achieve with potential of renewable energy of Indonesia. However, this ambitious target need

involvement of various stakeholder. However, it in contrast with un-equality of access to energy resources such as electricity, particularly for communities in rural area. It shown that the electrification ratio Indonesia is 91.2% in 2016 (6)and majority of the lower electrification rate are in eastern of Indonesia. In contrast, there are resources in rural area which can utilize to generate energy in form of renewable energy such as biogas, biomass, and biofuel.

Biogas utilization has begun since 1895 in England using sewage treatment installations to provide street light(7). Interest on biogas are depend on the priced availability of fossil fuels. However the interest began to revived in 1973 with mounting concern for environmental protection (8).There are several studies (9,10) show that Indonesia have potency and feasible to utilize biogas. It followed up by several biogas development projects in Indonesia. International and national organization involved in managing these projects with support from government of Indonesia.

Indonesia use biogas has started in 1970s and in 1981, Biogas Development Projects had been implemented with funding from FAO in several province Indonesia. Although, there is no significance effect in last decades, recently Indonesia government has developed several biogas projects. In Palembang, GoI build a biogas power plant using waste in dump site. In other places, POME was the main material to generate biogas. In rural area, the biogas generator is managed by a household or small community. They usually use livestock manure as resources for biogas. There are several provinces that have use this kind of biogas such as East Java, Central Java, East Nusa Tenggara, west java, and other places.

Lembang sub-district is one of the area that develop of biogas on small scale for communities in rural area. It located in West Java Province. In Cibodas village, particularly Kampung Areng, in Lembang, majority of the population are cattle farmer. The biogas is generated from cow manure as their sources of energy due to quite many number of small scale cattle farm in this area. Small scale farm has disadvantaged that it difficult to handle the waste of cows wisely (11). Development of biogas in this area also was part of solution of in maintain the quality of water in Cikapundung river which passes Kampung Areng. The cow manure from cattle farm assumed to affected the quality of water because it did not maintain well.

This study focuses on Kampung Areng in Lembang District due to previous information and studies that shows that the farmers in this area are capable of generating renewable energy through conversion of animal waste using biogas digester. It is supported by the fact that almost every household in Kampung Areng are cow farmer and has enough manure to supply and support the development of the biogas digester in the area. The biogas adoption was initiated also due to the Cikapundung river pollution issue, some people are pointing their hands at Kampung Areng as the source of these pollution at the upstream due to the irresponsible handling of animal waste. Thus, the idea of biogas digester adoption in this area could solve waste management issue and provide an alternative energy source for the communities. In this paper, researcher aim to identify the benefit and impact of biogas adoption in Cibodas Village.

2. Methodology

This research uses a mix of qualitative and quantitative approach. The selected region as a case study in this research is Lembang district, West Bandung regency. There are 775 biogas installations that have been built by Hivos and the House Energy Foundation (YRE) in Lembang district, Kab. Bandung Barat. Tools used are questionnaires, in-depth interview and observation. Questionnaires are spread to 81 respondents from different neighbourhood: RW 07, RW 17, RW 05, RW 04, RW 02, RW 16, RW 10, RW 14 and RW 11; in-depth interviews are done to seven key informants which are: head of neighbourhood (RW 07), women's group, ex-leader of farmer group, Energi Persada, garbage bank manager, and current treasurer of farmer group; observations are done in the cowsheds which have biogas reactors. Secondary data used are list of reactor recipient from ESDM and list of reactor recipient from BIRU program.

For this study we collected data from 79 respondents from total 125 household who have bio-digester. Respondent must be more than 17 years old, in assumption they could understand which our question and become the beneficiary or user of bio-digester.
The quantitative analysis will use descriptive analysis that will explain the condition of object of study thus it easier to understand. In addition, content analysis supports the descriptive analysis to get deeper understanding about biogas implementation in Lembang, particularly in kampung Areng.

3. Literature Study

3.1. Waste management in rural area

Agriculture are usually the main livelihood in rural area particularly in developing countries. The waste from agriculture are often did not manage well particularly with limited infrastructure in rural areas in developing countries. Agricultural activities usually produce organic waste including animal manures, food processing waste, crop/plant waste, and other organic waste from industries. However, it could this waste could be valuable resources if manage carefully.
One of agricultural waste is animal manure who produce daily by cattle. The large amount of animal manure has negative impact on the environment if not managed carefully. If it treated poorly, animal manure could become major source for air and water pollution (12) and this often occurred in rural areas in developing countries. In develop countries, there are some limitation in choosing management strategies for utilization animal manure (13) such as:

1. Public acceptance (nuisance or environmental concern)
2. Acceptable integration into agriculture
3. Quality control of residues being applied
4. Logistic and organization
5. Satisfaction of environmental regulation
6. Economic viability
7. Sustainability

Environmental factor become important aspect in choosing strategies in managing animal waste. Th management strategies for waste management which minimizing water pollution, air, emissions of ammonia, and pathogens could be a solution in managing animal manure(13).

Anaerobic digestion of anima manure is one of method in managing this waste. This process usually will produce to main products: a biogas that could be fuel for stove or generate electricity and substrate which could be used as fertilizer.

3.2. Biogas implementation for rural development.

Rural area has many resources that could develop into energy. However, this potency particularly in developing countries is using traditional method. In several area Indonesia communities still use fire wood which contribute to carbon emission and lack of energy efficiency. To unleash this renewable energy potency in rural area is not easy task. There are several problems that usually challenge the development of renewable energy such as financial problem, coordination problem, awareness problem, and technological and knowledge problem.
The development of rural biogas in household level could come with several benefits simultaneously namely improve sanitation, enhance ecology in rural areas, produce more efficient and effective energy, decreases the greenhouse gas emission, and improve the agricultural products.
In rural areas in many developing countries, usually have abundant biogas fermentation resources (14). In addition, biogas is easier and simpler in utilizing it. In the last decades, biogas are growth quickly in many Asian, Latin America, and African countries such as in China, Nepal, Thailand, and Indonesia(7,14–16). In china, the development of biogas for commercial use has begun since 1921 in Guangdong province, however the popularity is increase when Chinese government promoted “biogas use in every rural family” and facilitated seven million bio-digester (17).

There are many types of biogas that categorize base on the main substrates (18) such as:

a. Natural Fertilizer (cattle slurry, pigs slurry, cattle manure, pigs manure, hens manure)
b. Plants (maize silage, rye, grass silage)
c. Products of the Agricultural Industry (brewers grains, grain decoction, potato decoction, pomace)
d. Other Substrates (waste fittings, gastric contents)
e. Grasses (mown grass)

In developing counties, most of bio-digester in rural area can be categorize into three major types namely fixed dome digester, floating drum digester (telescoping digeseter), and the plug flow digester (saused-bag or channel digester)(19,20). Each of this type have advantage and disadvantage in general (Table 1). The design of bio-digesters is varied base on several aspect such as geographical location, availability of substrate, and climatic conditions (19) . For instance, fixed dome model developed by China and floating drum model developed by India

Table 1 Advantages and disadvantages of three types of bio-digester

Digester Type	Advantages	Disadvantages
Fixed dome digester	• Low initial cost • Long useful lifespan • No moving or rusting parts involved • Compact basic design • Less land required • Low maintenance	• Requires high technical skill • Difficult to repair in case of leakage • Requires heavy construction materials • Amount of gas produced in not immediately visible
Floating drum digester	• Simple and easy to understand operation • Visible stored gas volume • Constant gas pressure • Relatively easy construction	• High material costs of extra steel drum • Short lifespan because of steel drum corrosion • High maintenance because of regular painting of drum
Plug flow digester	• Low cost • Ease of transportation • Low construction sophistication • Uncomplicated maintenance • Less subject to climatic variations for fixed dome	• Relatively short lifespan • High susceptibility to damage • Low gas pressure • Limited creation of local employment • High impact on environment

Sources: Cheng et al., 2014

In Indonesia, there are several studies show the impact of renewable energy in rural area. Biogas implementation in boyolali district could provide economic benefit for the communities as well as clean environment and organic fertilizer for the farmer(21). In addition, biogas have important role in providing energy resources for villages which have limited access(22). Furthermore, in Sumba Island, renewable energy namely biogas could provide platform in increasing the community resilience(23).

4. Location Study

Kampung Areng located in Cibodas village, Lembang sub-district, West Bandung District, at altitude 1260 meter above sea level. Cibodas has 2.959 household with some of them are dairy cattle farm. Cibodas Village is divided into 17 small neighbourhood (Rukun Warga). Some of small neighbourhood are have majority residence working as dairy cattle farmer. Majority of bio-digester in cibodas village are located in Kampung Areng (Figure.1). Most of the farmer have communal stall, thus in one stall have cows with different owners.

Figure 1 Map of Cibodas Village

Sources: Local Government of Cibodas Village

The development of bio-digester in Cibodas Village began with the research of a college student for Student Creativity Week. It continued with project from Hivos, a non-governmental organization from Netherlands. The project is Indonesia Domestic Biogas Program (IDBP) which started in 2009 in West Java Province. Through collaboration with ministry of energy and mineral resources and local partner Rumah Energi Foundation, IDBP or popularly called BIRU (*Biogas Rumah*) implemented in Cibodas village.

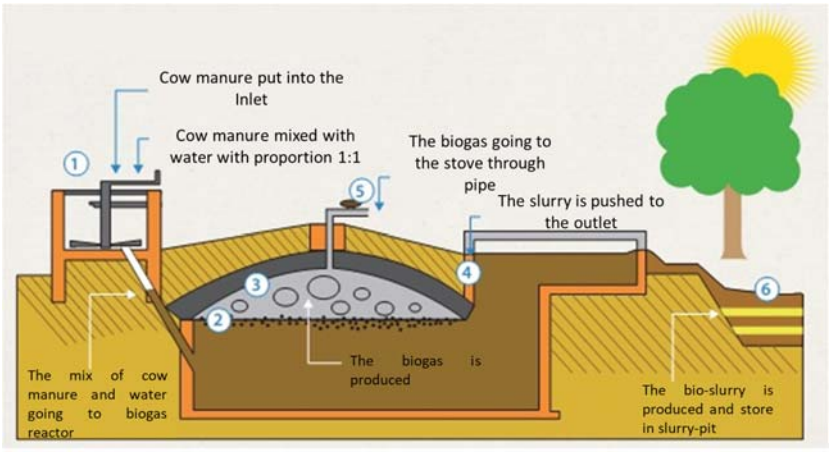

Figure 2 The process of bio-digester work

Bio-digester in Cibodas village are mostly fixed dome type (Figure 3). Majority of them are use bio-digester with size about 4 or 6 m^2. Most of bio-digester are aid from BIRU Program or Government of West Java Province. The beneficiaries are mostly graduated from elementary school. The bio-digester form government are distributed without payment from beneficiary. However, beneficiary from BIRU program pay for construction and services, although they get incentive as applied under the BIRU

Program. Under the BIRU Program, the beneficiary or potential user would get subsidized about 2 million IDR. Therefore, there are some limitation and differentiation of services from each program in its implementation process. Usually, bio-digester located near stall to make user easier in using it. The biogas will be connected to house or stall. If the distance of house to bio-digester is quite far, they will need more pressure from the bio-digester.
From 2004 to 2009 the adoption of biogas in Kampung Areng are relatively slow. After the implementation of biru program in the end 2009, communities begin to have interest in using biogas. The interest and adoption to bio-digester increasing with the 82 units biogas that given by government from 2011-2014. However, after the programs, the interest of communities decreased and some of bio-digester did not work well.

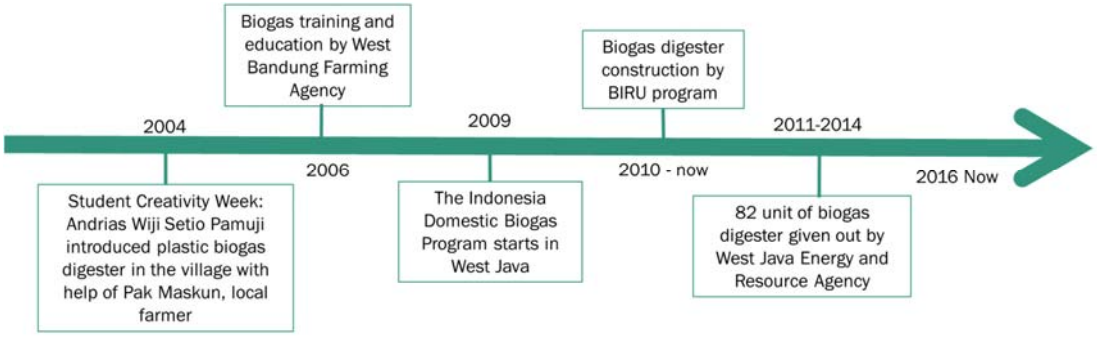

Figure 3 History of development bio-digester in Cibodas Village

5. Biogas as waste management

Biogas could provide benefit for environmental such as gives sustainable source of energy, soil enriching, re-utilize and treat variety of organic waste, and minimizes environmental impacts of greenhouse gas emission, and even could reduce land use problem for disposing organic waste (15). In Kampung Areng, the benefit is for waste management of cow manure. Due to limited waste management infrastructure, sometimes the cow manure could flush into the river which close to the area. Bio-digester have function that could replace waste management service, even give another benefit to cattle farmer.

In implementation of bio-digester in Cibodas Village have potency to be a solution in managing the waste, particularly cow manure from dairy cattle. If managing correctly, the potency of cow manure could utilize into biogas for cooking and electricity even become a fertilizer. This potency could be seen in table 1.

Table 2 Potency of cow manure utilize with bio-digester

Bio-digester Capacity (m^3)	Quantity (unit)	The maximum input of digester (kg)	Total volume of manure in bio-digesters
4	43	40	1720
6	31	60	1860
8	4	80	320
12	1	120	120
			4020

Based on the capacity of bio-digester, effectively, its could proceed about 4020 kg of cow manure, about 81,21% (table 2) of total cow manure produce by the cows. However, this calculation limited to the cow which owned by the beneficiary of bio-digester. Thus, there are high possibility the number of cow manure are more than this calculation because not all of the cattle farmer has bio-digester. Although, in some cases we find that some cattle farmer who did not have bio-digester, give their cow manure to neighbour who own bio-digester. This calculation has assumption that every single cow will produce about 15 kg/day of cow manure.

Table 3 Waste potentials of cows' manure

	Quantity of cows	The average of cows' manure	The possible amount of cows' manure that processed by bio-digester	The amount of cows manure that unprocessed by bio-digester
Value	330	4950	4020	930
Unit		kg	Kg	Kg
Presentage		100	81,21	18,79

From table 3, not all of cow manure are processed due to limited number of bio-digester. In addition some of bio-digester are not working due to various reason. Majority of them because some parts of the bio-digester are broken such as inset (figure 4) or the biogas pipe that connect bio-digester to stove so they did not use it. Other reasons are because they sell the cows, stove was broken and other various reason. Thus, the real capacity of bio-digester in processing the cow manure is reduced, only about 73 % of total cow manure could proceed into biogas and bio-slurry.

The unprocessed of cow manure could be a problem for environment as it will become a pollutant for water and air. It could pollute the soil even water of Cikapundung river near kampung areng that will use as water supply for Bandung city.

Figure 4 The inlet of bio-digester that have broken mixer

There are some challenge arises in implementation of biogas in Kampung Areng such as

1. Not all of the bio-slurry was used. Sometime they did not use the solid slurry because they did not have farm field and even liquid-slurry thrown away into ditch or near neighbour field farm. It happens because oversupply and limited demand of bio-slurry.

2. Some of the beneficiary of biogas project are still using LPG, particularly for bio-digester with smaller capacity (4 or 6 m^3) due to the stove can only use for 1-2 hour. Therefore, most of them still using LPG.
3. There is no monitoring of implementation of bio-digester particularly from government, thus some of bio-digester did not operated.

One of clear impacts of these biogas program is empowered the women in kampung areng. They usually did not have a clear job for their livelihood. Most of time they assist the husband in managing the cattle. However, they developed new product from bio-slurry. Some of them, farm worm with solid bio-slurry. It will produce worms which could be sold for agricultural purpose and fertilizer. Although this case is quite rare in Kampung Areng. In addition, the women in kampung areng also actively create waste bank. They developed the organization that will managed the waste in kampung areng so it could be sold.

6. Discussion

To maintain the biogas in small scale to sustain and keep working well are not easy. It need cooperation between user and provider in managing the bio-digester. There are many factors that could affect the user to did not use bio-digester such as broken parts of bio-digester, cows are sold, or family moved to other places. The bio-digester who developed on BIRU project tried managed these problem through several strategies.

After sales services is one of activities that they provide in maintenance and monitoring the bio-digester to work well. It will help user to keep their bio-digester to work well and could process cow's manure in producing biogas and bio-slurry. However, the bio-digester that given by government did not have this activity, thus some of bio-digester are did not working because some parts are broken and the users did not have capacity to repair it. It's a problem for the development of biogas as waste management solution of cow manure in rural area. It need to be addressed, particularly for government who give the bio-digester to user/cattle farmer to monitor the implementation and maintain this infrastructure.

Bio-slurry as by product of biogas have many benefits of community. For instance, bio-slurry is a potent organic fertilizer. It could help farmer to growth their plant using organic matter and provide a viable solution to nutrient depletion of many agricultural soils. Bio-slurry could boost agriculture and horticultural production. In Kampung Areng, the cattle farmer uses it for their plant in the field or use it as fertilizer for grass as the food for their cows. In some cases, they use it in the forest to maintain the growth of the grass. In addition, it could reduce the costs of cattle farmer who also have farm field.

Bio-digester could be a mandatory for cattle farmer in processing their cow manure particularly for farmer who have quite many cattle in rural area. It will be the best if the location of farmer spreading and they could distribute and sell their bio-slurry in their area.

however, if they location of stalls and bio-digester are agglomerated, the market system for bio-slurry need to be developed. The excess of bio-slurry need to be distributed to another farmer, but it did not happen well. The popularity of bio-slurry for fertilizer of agriculture plant still limited and did not enough to build interest of farmer to use it. Sometimes, the transport cost of bio-slurry is more expensive than the price of the product. If there is market system for bio-slurry, it would give the user to maintain their bio-digester.

7. Conclusion

This paper shows us the possibility of biogas or bio-digester specifically as an infrastructure for waste management of cow manure in rural area. Bio-digester could benefit the cattle farmer in utilizing cow manure as sources of energy and even fertilizer. Biogas in rural areascan become an important solution

in decreasing the waste (cow manure), as found in Kampung Areng, particularly for location of this neighbourhood close to the upstream of Cikapundung river.

There remain some challenges faced in the implementation of biogas digester. First, not all of the bio-slurry were was used. Second, some of the beneficiaries of biogas project are still using LPG, particularly for bio-digester with smaller capacity (4 or 6 m3) due to the stove can only use for 1-2 hour. Therefore, most of them still using LPG. Finally, there is no monitoring of implementation of bio-digester particularly from government, thus some of bio-digester did not operate well.

Therefore, through collaboration between government, INGO, union, and communities, farmer in Kampung Areng could get benefit and utilize the bio-digester. However, in some household the utilization of bio-digester is not working optimally after several years. There are several challenges such as the broken part of bio-digester, did not get enough cow manure (cows had been sold), and more friendly and easier other sources energy like LPG. However, based on this study, it possible to increase the capacity of bio-digester in Kampung Areng, Cibodas Village. Maintenance and monitoring of implementation of bio-digester could optimize the utilization of biogas. Creating a market for bio-slurry can give farmer more motivation in using the bio-digester.

References

1. Tarigan AKM, Samsura DAA, Sagala S, Wimbardana R. Balikpapan: Urban planning and development in anticipation of the post-oil industry era. Cities. 2017;60(2017):246–59.
2. BPPT. Indonesia Energy Outlook 2017. Fitriana I, Anindhita, Sugiyono A, Wahid LMA, Adiarso, editors. Jakarta: Badan Pengkajian dan Penerapan Teknologi; 2017.
3. Dincer I. Renewable energy and sustainable development: a crucial review. Renew Sustain Energy Rev [Internet]. 2000;4(2):157–75. Available from: http://linkinghub.elsevier.com/retrieve/pii/S1364032199000118
4. Meidiana C, Gamse T. Development of Waste Management Practices in Indonesia. Eur J Sci Res. 2010;40(2):199–210.
5. Pemerintah Republik Indonesia. Rencana Umum Energi Nasional. Jakarta: Ministry of Energy and Mineral Resources of Indonesia; 2017.
6. Perusahaan Listrik Negara. Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) Perusahaan Listrik Negara. Jakarta; 2017.
7. Mengistu MG, Simane B, Eshete G, Workneh TS. A review on biogas technology and its contributions to sustainable rural livelihood in Ethiopia. Renew Sustain Energy Rev [Internet]. 2015;48:306–16. Available from: http://dx.doi.org/10.1016/j.rser.2015.04.026
8. Deublein D, Steinhauser A. Biogas from Waste and Renewable Resources [Internet]. Weinheim: WILEY-VCH verlag GmbH & Co.; 2008. Available from: http://doi.wiley.com/10.1002/9783527621705
9. Bajgain S. Feasibility of Biogas in Sumba. Jakarta Selatan; 2011.
10. van Ness WJ, Tumiwa F, Setyadi I. Feasibility of a National Programme on Domestic Biogas in Indonesia: Final Report. SNV Netherl Organ Netherl. 2009;(January).
11. Widodo TW, Hendriadi A. Development of Biogas Processing for Small Scale Cattle Farm in Indonesia. Proceeding Int Semin Biogas Technol Poverty Reduct Sustain Dev Beijing, 17-20 Oct 2005. 2005;(October):255–61.
12. Holm-Nielsen JB, Al Seadi T, Oleskowicz-Popiel P. The future of anaerobic digestion and biogas utilization. Bioresour Technol. 2009;100(22):5478–84.
13. Westerman PW, Bicudo JR. Management considerations for organic waste use in agriculture. Bioresour Technol. 2005;96(2):215–21.
14. Ni JQ, Nyns EJ. New concept for the evaluation of rural biogas management in developing countries. Energy Convers Manag. 1996;37(10):1525–34.
15. Aggarangsi P, Tippayawong N, Moran JC, Rerkkriangkrai P. Overview of livestock biogas technology development and implementation in Thailand. Energy Sustain Dev [Internet]. 2013;17(4):371–7. Available from: http://dx.doi.org/10.1016/j.esd.2013.03.004

16. Cheng S, Li Z, Mang HP, Huba EM, Gao R, Wang X. Development and application of prefabricated biogas digesters in developing countries. Renew Sustain Energy Rev [Internet]. 2014;34:387–400. Available from: http://dx.doi.org/10.1016/j.rser.2014.03.035
17. He PJ. Anaerobic digestion: An intriguing long history in China. Waste Manag [Internet]. 2010;30(4):549–50. Available from: http://dx.doi.org/10.1016/j.wasman.2010.01.002
18. Kazimierowicz J. the Effect of Substrate on the Amount and Composition of Biogas in Agricultural Biogas Plant. Pol Akad Nauk. 2015;(Iii):809–18.
19. Rajendran K, Aslanzadeh S, Taherzadeh MJ. Household biogas digesters-A review. Energies. 2012;5(8):2911–42.
20. Plöchl M, Heiermann M. Biogas Farming in Central and Northern Europe : A Strategy for Developing Countries ? Agric Eng Int. 2006;VIII(8):1–15.
21. Hnyine ZT, Lubis W, Sagala S, Yamin D. Analysing the economic benefits of rural biogas adoption in Selo Sub-District, Boyolali, Indonesia. Bandung; 2015. (Working Paper Series). Report No.: 8.
22. Sagala S, Lubis W, Vitri R, Rianawati E, Nugraha D, Ameridiyani A. Energy Resilient Village Potential in Boyolali, Indonesia. RDI Work Pap Ser. 2015;(7):1–15.
23. Al-faruq U, Sagala S, Rianawati E, Currie E. Assessment of Renewable Energy Impact to Community Resilience in Sumba Island. In: Anwar H, editor. Masyarakat Tangguh Bencana. Bandung; 2016.