ENERGY RESILIENT VILLAGE POTENTIAL: LESSONS LEARNED FROM RENEWABLE ENERGY OF LIVESTOCK WASTE IN BOYOLALI, INDONESIA

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ABSTRACT: Indonesian Government (2014-2019) is committed to supply additional 35,000 MegaWatts of Electricity to support electricity needs of Indonesia. This plan is due to the gap of energy supply as demands from economic development, such as residential, business and industry activities increase. This study aims to assess how far Selo Sub-District has been able to be an energy resilient village. To analyze this, we took a survey at two villages that adopted biogas technology to provide energy at household levels. Despite the adoption is still slow (limited), we recognize the promising results of biogas adoption (3.6 households/year), particularly at the later stage of adoption. There are three factors that affect the implementation of rural biogas adoption, among others, the availability of resources, financial collaboration between governments and non government organizations and participation of stakeholders. These three factors are found in Selo although in a different condition. Rural biogas development in Selo Sub-District Boyolali shows a potential for an energy resilient village. In a wider context, the ability to provide energy at village scale level can be promising news.

KEYWORDS: biogas; renewable; energy; rural

1. INTRODUCTION

Under the President Jokowi, Indonesian Government (2014-2019) is committed to supply additional 35,000 MegaWatts of Electricity to support electricity needs of Indonesia. This plan is due to the gap of energy supply as demands from economic development, such as residential, business and industry activities increase. Many of these uses are located in urban areas where demands are much higher relatively than in rural area. Considering the large extent of Indonesia, the problem on electrity supply is not only about meeting the demands, but also about distribution. Therefore, master plan on electricity should consider how some remote areas to have abilities to provide it's own energy demands.

In the near future, Indonesia will have more limitation on fossil fuel based energy. Therefore, Indonesia is also committed to increase it's renewable energy supply. That is through considering several renewable resources to supply energy. Luckily, Indonesia is rich for renewable energy supply. This is from very large scale production, such as geo-thermal power plant, until a very small scale, such as biogas digester at a rural community level. Other types of renewable energy potential for Indonesia include hydro, winds, solar, biofuel, sea wave, etc.

Now, taking into consideration both the idea of renewable energy and also distribution of energy, there is an important need for remote village area to be able to supply their energy independently. Aside from that, it is also important to consider how a village to be more self-reliant on energy supply. There are many villages that have very good resources for creating their own energy supply, such as micro hydro power plant and biogas from livestock dung and waste.

In this study we define an energy resilient village as a village that has had enough energy supply either through a supply from external and from it's ability to meet the gap of energy demand based on resources that it has. Some villages located along the coast may have strong wind and water current that can be used to supply wind energy and wave energy.

Rural areas in Indonesia suffer from energy supply. According to Ministry of Rural, Disadvantage Regional Development and Transmigration (Kemendes PDTT), there are about 15,000 villages are not electrified. The idea of energy resilient village is also in line with the strategy of Kemendes PDTT, to provide enough energy supply to rural areas in Indonesia. This goal is challenged by the condition where many rural areas are located remotely.

Therefore, the remaining problem is to understand how a village can supply it's own energy. Another question is that what are pre-requisite conditions where a village can be considered as a energy resilient village? What will be the factors to enhance a capacity to be energy resilient village. This paper seeks to answer these questions using the case study of Selo Sub-District, Boyolali, Central Java. Selo Sub-District is selected in this research, since some communities have started to produce it's own energy from 1998 and have continued until now.

The rest of this paper will lay out current theory and success story of rural biogas development in other countries. This is followed up with information of regional characteristics of Selo and research methods used in this study. Results are presented, followed with discussions about the potential of energy supply.

2. LITERATURE REVIEW

2.1 Renewable Energy and Rural Development

Since most of the developing countries have their population live in rural area (over 60%), if poverty in rural area was reduced than it is more possible to reduce poverty in the country generally. "Energy has been universally recognized as one of the most important inputs for economic growth and human development" (India Energy Portal 2012, p. 1). One key requirement to reduce rural poverty is through rural development and modern energy services in rural area (United Nation, 2010). Modern energy services are energy produced from modern energy sources, for examples electricity, natural gas, clean cooking fuels and mechanical power, which help human well-being (Modi et al., 2005: 8–9).

One of the problems is most of the population in rural area of developing country still use traditional energy source, such as fire wood, which contributes to carbon emission and has lack of energy efficiency. In the other hand, modern energy will triggers community's economic development and rural area development, because modern energy increases the productivity and efficiency of domestic activities, also small industrial activity. Access to modern energy services and rural development has a really close relationship (Barnes and Floor, 1996: 500; Chaurey et al., 2004). Definitions of access vary (Brew-Hammond, 2007). One of the common concepts used is the "energy ladder" (Barnes and Floor, 1996; Modi et al., 2005: 22–23). Energy ladder explains about the rank of development through community's type of energy source, means that community that depends on traditional energy source will be placed at the bottom of the ladder, while community with modern energy source will be placed at the top. From "energy ladder" concept, it can be concluded that Energy holds an important part in rural development, not only its availability, but also its access.

Rural area has a lot of potential and resources to create renewable energy source that have not been explored. Unfortunately, even though it holds a lot of potential, for rural area in developing country, creating a new way of life with renewable energy is not an easy task. There are several common problems that can be found in the implementation of renewable energy in developing area, such as financial problem, awareness, problem, and coordination between stakeholders. If the government able to tackle those problems, renewable energy development in rural area can be achieved and economic condition in rural area will be improved automatically.

Improvement in economic condition is not the only benefit that rural area will achieve if renewable energy is successfully implemented. There are other benefits other than that, such as new revenue source from the increase tax base for service improvement in rural community, new job and business opportunities through small industry activity, triggers product innovation, community empowerment, and the most of all is creates affordable energy (OECD, 2006).

2.2 Renewable Energy Implementation in Rural Area

In the following sub-sections, case studies from Philippines, Nepal and Guatemala are presented, to show related factors that contribute to the successful implementation of rural biogas. The case in Philippines show that the abundant biomass materials is the determining factors of succesful implementation of biogas adoption. In Nepal, collaboration between government and other organizations encourage the implementation of biogas. Lastly, case in Guatemala shows that a participation of stakeholders is needed to encourage the adoption of biogas.

2.2.1 Philippines: Exploring Available Resource for Renewable Energy

Philippines is an archipelago country and classified as developing country with large amount of population. Despite its conditions, Philippines is capable to meet the needs of its population by serving 97% public electricity for urban population and 65% public electricity in rural population (Bakhtyar et al., 2013). What needs to be underlined in this case is that, Philippines' ability to explore their potential energy source. Even though there are still a lot of rooms for improvement, but their willingness to explore their potential energy source can be an example for other developing countries. Philippines has several renewable energy sources, such as hydroelectric, wind, livestock waste, geothermal, solarcell, and one that is considered as future energy resource, electricity generation from storm, since Philippines is constantly exposed to heavy storms (National Power of Corporation, 2014; Bakhtyar et al., 2013). As for wind power, Philippines is theoretically able to produce 76,600 MW and technically 7404 MW of electricity, currently Philippines has produced up to 1,18 MW of electricity through wind power (Bakhtyar et al., 2013).

The largest energy resource in Philippines comes from water to produce hydropower based electricity. Philippines can technically produce 11,223 MW of electricity in small to large scale (DOE, 2012). The most commonly suitable energy source in Philippines has to be from livestock waste and vegetables waste for biogas production, Although there are only 653 biogas active biogas systems in several large farms in Philippines (ATM, 2010). As it has been written before, even though there all still a lot of rooms for improvement especially in terms of quantity, Philippines' effort to explore their renewable energy resource is a decent example for other developing country with the same characteristics as Philippines.

2.2.2 Nepal: Addressing Financial Challenges in Biogas Implementation

Before 1990, Nepal uses cattle dung cake to produce energy for daily domestic activities, but after that Nepal has started to convert to biogas from cattle manure, human excreta, and vegetable waste through anaerobic bioreactors (United Nations, 2010). Currently there are over 170,000 households with biogas in Nepal and Biogas Support Partnership (BPS) is the one that has given a significant contribution for biogas in Nepal (Gautam et al., 2009: 249-252). Financial problem is one of the most common situations faced by developing countries in their early time of renewable energy implementation. Nepal is one of the developing countries that has the same problem and has gradually succeeded to overcome the financial problem.

Government of Nepal (HMGN) first initiated biogas program in 1974, with loans support from Agricultural Development Bank of Nepal (ADBN). In 1977, Gobar Gas Company advanced the development and promoted the large-scale dissemination of biogas technology (Mendis and van Nes, 1999:15-18). In July 1992, BPS started the biogas program with support fund from Directorate General for International Cooperation of Netherlands (DGIS) through Netherlands Development Organization (SNV). Under Ministry of Science and Technology's Alternative Energy Promotion Center, BSP has created four implementation phases with result of 172,505 biogas installation (Nepal, 2008: 7-9; World Bank, 2004a).

Community in Nepal also contributed in biogas production financial, one third of the cost is paid through the family providing labor and materials for the installation of the plant (Bakhtyar et al., 2013). Community are aware of the long-term benefits of biogas, so it is not too difficult to ask for their participation. Despite of community's economic condition, financial support availability is one of an important factor in biogas implementation; there are over 80 banks microfinance organizations offer loans for biogas systems (Bakhtyar et al., 2013).

Besides great cooperation between government and related organizations to addressed financial problems, Nepal also promotes user friendly biogas plant construction by using brick and mortar or concrete and soil that could be easily accessed locally (Ashden Awards, 2005). All in all, from the biogas story in Nepal, there are four factors that will significantly improve biogas production, among others: availability of biomass, availability of materials to build biogas plant, local awareness of the biogas benefits, and lastly is subsidies to purchase biogas plants.

2.2.3 Guetemala: Stakeholder's Participation for Improved Stove Technology to Reduce Wood Energy

To reduce the consumption of wood energy for domestic uses, Government of Guatemala has promoted stove technology improvement ever since (1970), started with Lorena Stove (United Nations, 2010). To promote the stove technology improvement, Ministry of Energy and Mines (MEM) has formed The National Group for Improved Stoves, which is a network of public and private institutions (United Nations, 2010). Excellent participation of stakeholders involved in the implementation of PEMF has allowed it to achieve a higher level of successthan other projects that promoted the Plancha Armada (United Nations, 2010).

Guatemala has 67% of population that relies on wood energy for cooking. Thus, as the implication, Guatemala has loses around 2,460 ha of forest every years (Alvarez et al., 2004: 1). First implementation of improved stove technology experienced a failure. It is a maintenance problem, most costumers are not interested to buy the new stove when the old stove has worn out; instead they go back to their old ways of cooking (Ahmed et al., 2005: 53). To encounter the previous failure, Government of Guatemala's Social Investment Fund (FIS) attempted to promote new prototype stove, named *Planca Armada. Planca Armada* is an example of the success story of improved stove technology in Guatemala, PEMF gas funded the installation of over 90,000 stoves (Alvarez et al., 2004).

Other factor that has contributed to improved stove technology implementation in Guatemala is their decision to decentralized FIS staff native to each of area that practices the improved stove technology implementation (United Nations, 2010). With their advance local knowledge they can address communities' needs in a more suitable way. Through specific concern on how stakeholders participate, Government of Guatemala achieves a better implementation of improved stove technology and reduces firewood utilization for their domestic activities.

3. LOCATION

3.1 Overview of Selo Sub District

Selo Sub District is located in Boyolali, Central Java. This district has 10 villages with total area 5607.8 Ha which consists of 5572.4 Ha of dry land and 35.40 hectares of paddy land. Based on Population Registration in 2013, total residents in this sub district is 27.198 people, which consist of 13.367 men 13.831 women -- an increase of 117 people (0.19%) against 2012. The number of household in Selo Sub District is 7.782 households with average of 3.5 people per household. The income of Selo in 2013 amounted to IDR 315.141.747 which came from property tax (BPS Kab. Boyolali, 2014).

3.2 Electricity in Selo Sub District

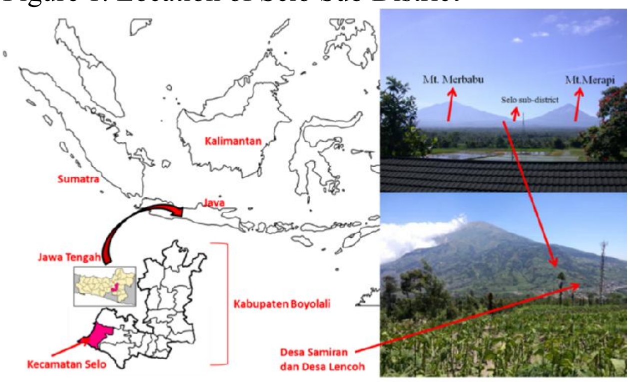
Electricity has begun to enter Selo Sub District since 1986 (KHA, 2009), but several village in this district got the electricity a few years ago. Electrical network that goes to Selo Sub District mostly come from PLN Area Network Services Boyolali, but there are several areas that get power supply from Borobudur Area Network Services due to its location that nearby to Magelang District. Source of electrical energy Boyolali and Borobudur is located in Java Madura Bali interconnection system (JAMALI) and both these sources do not yet have large-scale generating systems. In 2013, total electricity consumer in Selo rose by 60 customers (1.4%), compared to 2012. Samiran Village is the largest electricity consumer with 611 (13.6%), while the smallest village Tlogolele 349 (7.8%) (BPS Kab. Boyolali, 2014).

Selo Sub District, Boyolali represent areas with severe environmental damage. The forests of Mount Merapi and Merbabu decreased drastically due to uncontrolled logging activities. The wood was utilized by people as firewood and charcoal for cooking and other household needs. Despite there is existing supply of LPG subsidy from the government, public dependence on wood seems irreplaceable. Firewood is the cheapest energy source for the public. LPG was not able to replace this significant role (SLI, 2012).

3.3 Fuel in District Selo

Another energy source such as kerosene has halted its supply by the government since 2009 because the price continues to rise (BPS Kab. Boyolali, 2013). The facts on the ground show that biogas has a great potential to replace the role of firewood in the community. Cattle population in Selo is very high, on average each family maintains two cows (SLI, 2012).

Figure 1. Location of Selo Sub District



4. METHODOLOGY

4.1 Data collection

In order to gather direct information on biogas adoption of farmers in Selo, Boyolali, questionnaires and interview tools have been set up; and a field survey was held in July 2015, with a span of three days.

The questionnaires included questions on basic information on the farmer's household, energy consumption and costs of both biogas users and non-users. The survey also included questions on the benefits and costs adopters have experienced themselves. As the data originated from specific entities only, i.e. farmers who do not use biogas (N=5) and farmers who do (N=21), the collection method is performed in the form of homogeneous, purposive sampling. A 'Merapi Landcare' biogas facilitator provided the names of the farmers who had digesters installed. Then, ten non-biogas users were interviewed and twenty biogas users of which the digesters ranged from 4 m3 to 12 m3 in size. The interviews were semi-structured, in that the interviewee could provide more information if needed. Further, the interviews were held directly, in private, and inside their own households, in order to ensure all questions are properly understood and to minimize non-response (Dialsingh, 2008).

Another interview was also held to the Government of Selo (in Sub District, Village, and Neighbourhood Level), NGO (Sahabat Lahan Indonesia), and Mount Merapi National Park Ranger. The interviews included questions on basic information on the role of each parties and their contribution to biogas adoption in Selo.

Figure 2. Household Interview (Up) and Government Interview (Bottom)

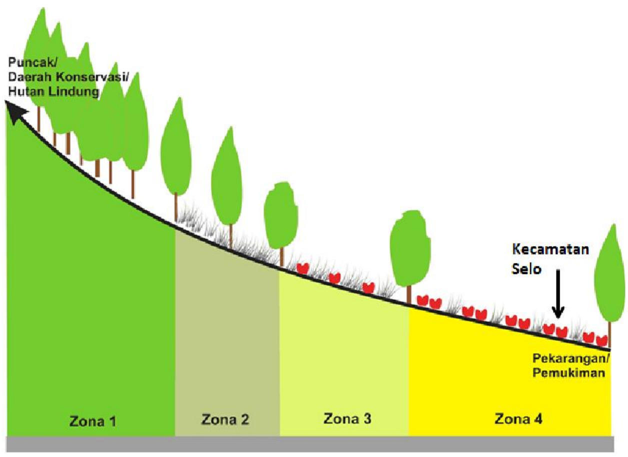
4.2 Data Analysis

This study uses qualitative and quantitative analysis. As for the qualitative, relationships between data collection and analysis methods are very closely linked. Data and information obtained in the study and then tested against a variety of concepts and theories that exist. The procedures of qualitative analysis was taken through the data reduction, data display, and conclusion drawing (Miles and Huberman, 1994). Relevant secondary data was also obtained from published and unpublished material, including the internet, to complement the primary data. The data collected from the questionnaire survey was analyzed using Statistical Package for the Social Sciences (SPSS) using descriptive statistics.

5. RESULTS

Based on interviews, Mount Merapi, which erupted in several years ago cause damage and lead to huge losses in agriculture, reaching IDR 72 billion. People who suffered losses most of the agricultural sector of horticulture for more than 1,100 hectares of crops in Selo, Cepogo, and Musuk. The worst damage experienced by farmers who are in Zone 3 in Selo, such as Lencoh Village, Klakah Village, and Jrakah Village which is only less than 7 km from the summit of Mount Merapi. On the other hand, livestock sector also suffered a loss that is from a population of 61 thousand of dairy cows and 81.5 thousand of cattle, cows affected by the eruption of Mount Merapi were around 28.504 thousand (Rahayu et al., 2013).

Figure 3. Zone Areas of Mount Merapi



Agriculture and cattle is the foundation of life for the people in the slope of Mount Merapi. But livestock and farming also had a negative impact in the form of environmental pollution due to non-optimized waste management. Each cow produces fresh dung every day as much as 15-20 kg and 10-15 liters of urine. On the other hand, the forests of Mount Merapi and Merbabu decreased drastically due to uncontrolled logging activities. The wood was utilized by people as firewood and charcoal for cooking and other household needs.

Based on interview with Sahabat Lahan Indonesia, biogas then chosen to be the solution to overcome this problem. Biogas adoption in Selo, Boyolali started from this last decade. Unfortunately, the development of biogas construction was not easy. People were reluctant to apply biogas because its expensive investment with a price range between 6-25 million (SLI, 2012). Through the program "Merapi Landcare Program" of Sahabat Lahan Indonesia, a new approach to biogas technology is more simple, inexpensive and fair distribution. For each unit of biogas with a capacity of 4m3 only require an investment of IDR 3 million.

Before using biogas, people in Selo spend money to buy LPG for IDR 60.000/month. Besides LPG, they also spend about 4-6 tie woods which is equivalent to one tree and the cost of IDR 120.000-180,000/month. Total energy costs on average in a month to reach Rp. 180000-240000/ month/ household. However, after using biogas at a cost of only IDR 3 million, farmers in Selo has been able to save costs between Rp. 180000-240000/ month/ household. It means that the initial investment will be paid off after the use of biogas in 13-17 months. Afterwards, they will enjoy free energy. On the other hand, the biogas unit turned out to prevent the trees are cut every month. If there are 100 biogas units in Selo means farmers do not cut down trees as much as 100 stems/ month or 1200 stems/ year (SLI, 2012).

The timeline shows an increasing in term of rural biogas adoption from 3 households at the beginning to 65 households in 2015. Thus, the adoption rate is about 3.6 household/year. Despite it's increasing adopters, the adoption rate is considered small. This is still a challenge faced in the implementation of biogas since the production of energy is small. According to Hnyine et al (2015), the biogas production in Boyolali District where Selo is located can be estimated to 1.5 TWh. That assumes if all livestock manure in Boyolali District is used for biogas production.

Figure 4. Timeline of Biogas Adoption in Selo Sub-District (1998-2015)

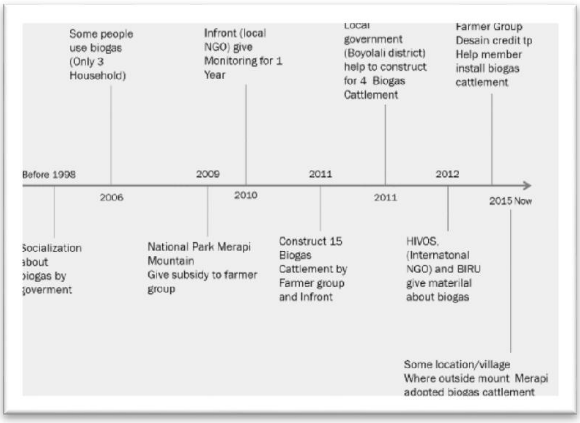
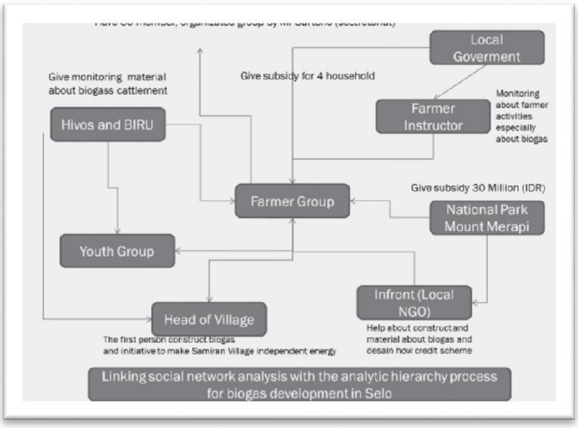


Figure 5. Biogas Digester at One of Villager's House

Figure 6. Stakeholder's Involvement in Selo Sub-District Biogas Adoption



The figure shows that external actors (Hivos, Biru, Infront, Local Government and National Park Mount Merapi) are needed to stimulate the adoptation of biogas. This is related with technology transfer and also initial cost for biogas installation. It is also important to acknowledge the role of farmer groups, head of village, and youth group througout this process. The external actors can be distinguished into non government actors, such as Hivos, Biru and Infront while government actors are National Park Mt Merapi and Local Government. Non government actors have technology that can be shared to the community while government actors can provide budgets and also local regulation to stimulate the process and projects of rural biogas adoption as described here.

"*National Park Mount Merapi provides subsidy for farmer groups (Mr Sartono Group) of 30 Million (IDR) for constructing biogas digester and with collaboration with Infront (Local NGO) to empowerment and monitoring how the construction biogas cattlement. Now, we also develop and empowerment biogas scheme in Samiran Village to other village in around mount Merapi*"

Vendro (National Park Officer)

This is also in line with the village mission to be a energy resilient village. The percentage of the user is quite high, about 30% of the households.

"*Samiran Village have mission to be Energy Resilient Village, especially for dailiy activies in household such as cooking. Currently, in Samiran Village , 30% people are the users of biogas*"

Marjuki (Head of Samiran Village)

The collaboration between actors, such as national park and Infront make a possibility to construct biogas since that means technology and costs are provided through this collaboration.

"*We have 70 member, National Park and Infront empowerment our group to make credit scheme to construct biogas cattlement. In the early of development, we construct 15 biogas cattlement (2011). Biogas give many profit based on farmer experience, with biogas farmer can saving money and enviromental more clean, and our forest more conserve cause we don't chop down tree"*

Sartono (Secretary of Farmer Group in Samiran)

This is supported by the argument of the local NGO that they monitor the process of implementation to make sure that biogas adoption is conducted properly.

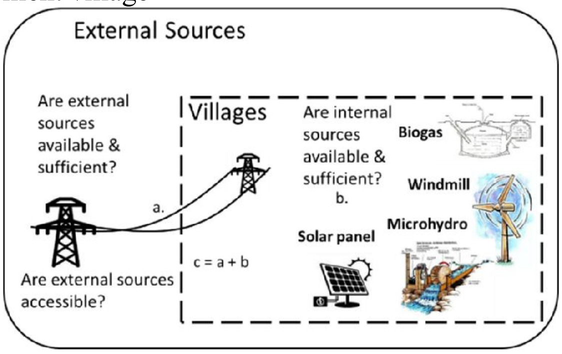
"*Infront give monitoring and material about how construct biogas cattlement and also how credit scheme for farmer group*"

Uyung (Director of Infront/SLI)

6. DISCUSSIONS

Selo Sub-Districts have provided an example where energy resilient village can be initiated. In other cases of Indonesia, micro-hydro power plant has also been used.

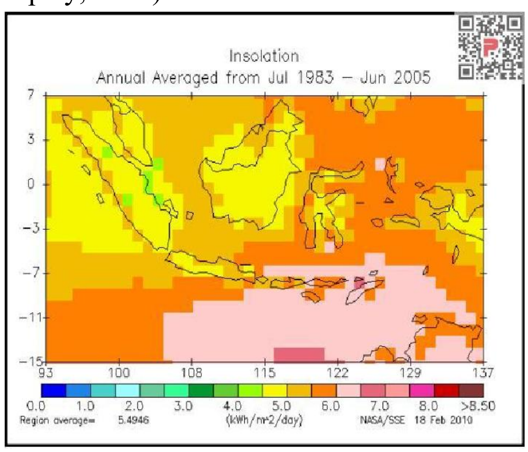
Figure 8. A model illustrating energy source for a resilient village



There are three possibilities of energy resilient village. First, scenario (a) where a village is completely dependent on external energy source. This is possible when supply from external sources are fully available and accessible. Second, scenario (b) where a village is completely dependent on internal energy source. This is possible when supply from internal sources are available fully available and accessible. Third, scenario (c) where a village has to have a combination between external and internaly energy supply.

In the case of Selo Sub District, the village is considered to be at third scenario (c) since it has been able to provide a little energy source while many sources of energy are still coming from external. This condition is commonly found in Java and Sumatra where external sources are available and accessible. However, there are conditions where a village can be remotely located and thus it is very less accessible from external sources. This is also the case for small islands that are isolated from other power line connection. Therefore, scenario (b) might occur and therefore, internal sources of energy are needed or play important roles. Beside Selo, other village in Indonesia shows an example of the utilization of micro hydro as the source of electricity.

Figure 9. Solar Resource Map in Indonesia (Source: Powerplay, 2014)



The internal energy source could might be able to depend on animal dung energy. As the livestock in Selo area is numerous, animal dung could act as the source energy supply. On the contrary, micro hydro cannot be applied as Selo is a water scarcity area.

The solar resource map (Powerplay, 2014) of Indonesia shows a 4.5 to 5.5 kWh/m2/day annual average global horizontal solar irradiance and a higher potential in the eastern region of Indonesia (5–6 kWh/m2/day). This number shows the potential of utilizing the solar energy as energy supply in Selo area. This statement is also supported by other research studies which argued that solar PV/battery is considered to have the least challenges for application and can be used accross Indonesia due to the abundance of solar potential [Boedoyo and Sugiyono, 2010; IWEC, 2011 in Blum et al., 2013).

Similar practice has been applied in Dheye, a mountainous village in Nepal. In Mustang area of Dheye, some households have used solar technologies such as solar photovoltaic (PV) for cookers, driers water pumping systems and water heaters. The project was supported by a government apex institution known as AEPC (Laudari et al., 2014).

7. CONCLUSION AND RECOMMENDATION

This paper shows how a village can obtain it's own resources to produce energy needed within the village. There are three factors that affect the implementation of rural biogas adoption, among others, the availability of resources, financial collaboration between governments and non government organizations and participation of stakeholders. These three factors are found in Selo although in a different condition. Rural biogas development in Selo Sub-District Boyolali shows a potential for an energy resilient village. The utilization of biogas in Selo Sub-District is an example where a village can be promoted to provide it's own energy sources, although partially. There are many available resources around a village that may not be utilized properly for energy supply, such as livestock waste (manure), solar energy, wind energy and hydro energy. Considering the small scale needed for a village size energy, these available resources can fulfill a village needs if managed well.

There are challenges to apply such technology although the technology can be considered 'simple' since they are available in the market and scale as well as skills are accessible and transferable. These challenges include initial cost to install the technology that may be difficult for a poor farmer. For example, the cost for installing a bio-digester, about IDR 5 million can be too expensive for a livestock farmer. If one wants to install other technology, such as solar panel, windmill and micro hydro, the cost can be much more expensive. However, at a village level, the budget can be taken from village budget or collective funding.

In the context of rural development, the ability to provide energy at village scale level can be promising news. With the spirit of Ministry of Rural, Disadvantage Regional Development and Transmigration to support electricity in 15,000 villages in Indonesia, resilient village can be promoted through the use of available material in the villages.

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