Biogas Utilization in KPBS Pangalengan: History and Challenges

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Abstract. Pangalengan has been known as business centre of dairy farming in southern Bandung area since Dutch colonization. The Dairy Farmer Cooperative of South Bandung (KPBS) Pangalengan is organizing the collection of raw milk from dairy farmer and sent them to further production system. There are three districts i.e. Pangalengan, Kertasari and Pacet. In this paper, we highlight the history and challenges of biogas utilization in the Pangalengan working field. Although utilization of biogas from dairy manure was long time ago initiated in the area, coverage of biogas application is still as low as 14%. A breakthrough is required to tackle the challenge. We introduced fostered village program in a collaboration between university and the farmer cooperative to ensure continuity of the biogas program.

1. Introduction
Utilization of biogas from waste is important for providing a renewable local-source energy in a dairy farming area. It also environmentally friendly methods to reduce organic content in the dairy farming waste [1]. Biogas is produced during anaerobic fermentation of manure. Composition of biogas depend on percentage of fat, protein, and carbohydrate in the substrate used. It usually consists of 50-75% methane and 25-45% carbon dioxide [2]. With energy content of 4800-6700 kcal/m³ [3], the biogas is potential to replace subsidized gas for cooking, even further for electricity generation in an energy self-sustained farming.

International Renewable Energy Agency (2020) showed that the biggest producer of biogas in the world is United States with capacity of 2368 MW [4]. In Asia, China becomes the top ones with biogas capacity of 799 MW. In Indonesia, biogas has been introduced since the 1970s. The utilization was accelerated in 1981 during biogas development projects funded by Food and Agriculture Organization (FAO) [5]. In 2019, the biogas capacity of Indonesia reached 22 MW. The capacity was same since 2015, which indicate deceleration on biogas installation. Meanwhile, National Energy Masterplan (Rencana Umum Energi Nasional, RUEN) mandates 5.5 GW bioenergy contribution on new and renewable energy mix and specifically 489.8 billion metrics cubic as biogas by 2025 [6]. Data show that realization of the target on 2019 is only 25.67 billion metrics cubic. Therefore, it is mandatory to re-accelerate the biogas utilization.
As centre of dairy farming, Pangalengan and Lembang in Bandung area, West Java, Indonesia has high potential for biogas utilization. Pangalengan area is known as the earliest dairy farming in the West Java region. Therefore, this work highlights history of biogas utilization in Pangalengan area and its challenges.

2. History of Biogas Utilization in Pangalengan Area

Utilization of biogas in Indonesia can be traced since 1970s. Here, we describe the biogas application in Pangalengan in three milestone periods, i.e. before 1980s, 1980s - 2010, and 2010 up to now. Dairy farming in Pangalengan can be classified into three periods i.e. before 1945, 1945 to 1975, and after 1975, based on number of cows, land occupancy, and technology used [7]. However, biogas technology in the world just been developed in early 1900s and intensive biogas utilization in Indonesia began since 1980. Therefore, we set 1980 as a milestone. Biogas Rumah (BIRU) project was started on 2009 as a second wave of biogas project in Indonesia. The program entered Pangalengan area on late of 2010, which then set as the second milestone of biogas in the area.

2.1. Before 1980s

Since 1860s, Fries Holland dairy cows have been imported to Pangalengan, West Java, Indonesia and managed by Dutch companies i.e. De Friesche Terp, Almanak, Van Der Est, and Bigman [8]. The dairy product from those companies was then collected and marketed in Bandoengche Melk Centrale (BMC) in Bandung city. Biogas was not generated in the farming at that time because the technology itself was developed in Europe on early 1900s.

In 1911, Dutch quickly adopted the biogas technology by installing digester in Bandung city (well-known as Inhoftank in Tegallega) which produce gas, electricity, and fertilizer from domestic waste [9]. The name of Inhoftank came from Germany engineer, Karl Imhoff, where his digester design was used in the installation. He had experience on installing waste treatment system in German. When Japan entered Bandung, the plant mainly produced biogas for military vehicles. After 1945, the plant was abandoned.

In 1950s, biogas became a trend in India and China. Widespread dissemination of biogas digesters in other developing countries stems from 1970s. In Indonesia, the manure-based biogas technology development was leads by universities, notably the Bandung Institute of Technology (ITB) [9]. Using two metal oil drums of 200 L as a digester and a gas holder, the system became susceptible for corrosion and leads to a shorter lifetime of the biogas plants. However, to our knowledge, there are no on-line reports available on biogas application in Pangalengan area until this period.

2.2. Between 1980s to 2010s

In 1981, the biogas project from Ministry of Agriculture supported by Food and Agriculture Organization of The United Nations in a Technical Cooperation Programme was initiated in Indonesia. It was considered as the first major wave of biogas project. Objectives of the program was setting up demonstration units, providing training, and preparing biogas program in the integrated rural development. Bali was set as focal development center. A demonstration of 200 fixed dome plants were installed [10]. However, high construction cost of the plant and high availability of subsidized kerosene hinder wide adoption of the technology.
Figure 1. Concrete fixed dome Biogas reactor was installed in Unit Usaha Swa Karya Kartika, Pangalengan (Adisasmito & Sukandar, 1994).

Following the major project, sporadic biogas reactor was installed in Pangalengan Area. In 1994, Adisasmito & Sukandar installed concrete fixed dome biogas reactor in Unit Usaha Swa Karya Kartika, Pangalengan (Figure 1) [11]. With volume of 33 m$^3$, the reactor handled manure from 50 dairy cows. The produced biogas was used to substitute cooking woods, kerosene, and lighting in the farming with potential saving up to 2 million rupiah per year.

Until 2000s, there are no significant improvement on biogas utilization due to wood availability and subsidized kerosene. However, increasing price of kerosene due to economic crisis made biogas become interesting alternative. Between 2002 to 2004, various organization developed and installed biogas plant. Institut Teknologi Bandung and Padjajaran University developed and installed plastic bag digesters in Pangangalengan. The digester consists of 4 m$^3$ plastic digester and 2.5 m$^3$ plastic gas holder [10].

In 2003, a business start-up under Business Incubator Center of Institut Teknologi Bandung, Cipta Tani Lestari, tried to accelerate plastic-based biogas reactor installation in Pangalengan area. Plastic bag digester was chosen due to its low capital cost which is suitable for farmer. From 2003 to 2005, they have installed about 35 reactors. Despite low installation cost, the plastic-based reactor easily broken. Therefore, The Cipta tani Lestari is developing a notable fiberglass-based reactor known as TENARI Biogas Reactor.

It was noted that from 2006 to 2011, there are 796 reactors were installed in Kabupaten Bandung through Government funding, including in Kecamatan Arjasari, Cilengkrang, Pasirjambu, Ciwidey, Kertasari and Pangalengan [12]. The West Java Province through Energy and Mining Office has been installing 750 biogas plants till the end of 2007. By the middle of 2008, another 369 biogas plants were installed. Almost all plants are plastic bag digesters, with some fixed domes as well [10]. Easily-broken plastic bag digester seems discourage the farmer in Pangalengan to further adopt the biogas technology [13].

2.3. Between 2010s to 2020s

“Biogas Rumah” (Household biogas) program can be considered as the second major wave of biogas utilization in Indonesia. The program, also known as its acronym BIRU program, started from May 2009 as collaboration between Dutch and Indonesia governments. The Humanist Institute for Development Cooperation (HIVOS) was appointed by the Dutch government as program manager, with technical assistance from the Netherlands Development Organization (SNV). Yayasan Rumah Energi and the Ministry of Energy and Mineral Resources Republic Indonesia became the coalition partners from Indonesia side. Target of the program was installing 10,000 bio-digester by the end of 2013 [14]. Typical concrete fixed-dome reactor they built is shown in Figure 2. By September 2020, they already installed 24,945 biogas reactors in 12 provinces.
West Java Province is one of target for the BIRU program. From 24 October 2009 to February 2015, they installed 1,283 reactors in the West Java Province (out of total 14,173 installation) [15, 16]. The distribution of reactor included dairy farmers from KPSBU Lembang Bandung Barat, KPGS Cikajang Garut Selatan, KUD Tanjungsari Sumedang, KPS Gunung Gede Pangrango Sukabumi, and other area such as Cianjur, Sukabumi, Bogor, Depok, Serang Banten, Cariu, and Bekasi [17]. In first semester of 2017, the BIRU program reported three cooperation which actively gave financial support for the biogas reactor installation, i.e. Koperasi Peternak Sapi Bandung Utara (KPSBU), Koperasi Peternak Sapi Cianjur Utara (KPSCU), and Koperasi Peternak Garut Selatan (KPGS).

In Pangalengan area, the BIRU program significantly increases the biogas adoption. In 2009, it was reported that 7 farmers in Pangalengan have received biogas reactor from government [18]. The BIRU program in 2017 also cooperated with Perum Jasa Tirta II, Pangalengan to install the fixed dome concrete biogas reactors.

3. Recent condition and Challenges
Distribution of dairy cows in Pangalengan area is shown in Figure 3, which is potential as source of biogas [19]. Margamekar is the most populated village by 4647 dairy cows, followed by Margamukti village with 2589 cows. In average, each farmer has 3 cows with a limited area for digester installation. The limited area of farm often restricts installation of biogas reactor within its comfortable operation zone. Some of the farmer cease to use the reactor due to filling process of manure using bucket was considered as a bothersome work.
Figure 3. Potency of Dairy Cows for Biogas Utilization in Pangalengan Area (Virgana & Hamdani, 2020).

To increase the utilization of biogas, we are conducting community service activities in Margamulya, Pangalengan, cooperated with KPBS Pangalengan from 2019 to 2020. In the initial activity, a TENARI biogas reactor 4 m$^3$ in volume was installed in a dairy farm with 20 cows [20]. The biogas then distributed to the farm housing and three closest neighbour household as substitution of liquified petroleum gas (LPG) for cooking fuel. It was estimated that the substitution of LPG using the biogas save IDR 69,000 to 295,000 a month.

Figure 4 shows the typical consumption rate of biogas in the location. We found that low usage of biogas in the location mainly due to lack of produced biogas. Only one cooker can be used at a time. Also, there is an objection with odour released by the gas. To overcome the problems, we did second activity of community service by installed two additional 4 m$^3$ biogas reactors equipped by H$_2$S absorber (Figure 5.a and 5.b). Therefore, total volume of reactor became 12 m$^3$. Those reactors are supplying biogas to the farm housing and five neighbour households with potential saving up to IDR 885,000 a month.

Figure 4. Typical biogas consumption rate from the installed biogas reactor.
Adoption of biogas technology to farmer is challenging [18, 21, 22]. Dyah and Sriharti (2019) present the challenges of biogas development in West Java area, especially Subang, Sumedang, and Bandung area [23]. There are technical and social barriers. Damaged biogas stoves, far location of manure source from reactor, and low quantity of produced biogas often cause the farmer stop using biogas. Previous projects mostly left the biogas adopter farmers without continuous training, inspection and maintenance program. Having difficulty due to leaking reactor and damaged stove lead the farmer to abandon their biogas system. A continuous program is required to overcome this condition. It also needs to tackle social barriers such as availability of commercial LPG, reluctance to collect manure, and no available space to build the reactor. The BIRU project also identify barriers on the development of biogas in West Java province e.g. limited number of certified constructors of biogas, financial support mainly come from dairy cooperative only, limited area for installation, and difficult terrain condition. Socially, there is high dependency for free installation support from government [17].

In our case in Pangalengan, challenges for adoption of biogas technology seems to be installation cost and operability of the reactor. Small-scale animal husbandry businesses having 1-3 cows with dependency on milk income left the farmer in poverty line [24, 25]. To get decent life, they need to do another business e.g. sale of calves, heifers, bulls, or rejected cattle. Therefore, the small holder farmers hardly afford expensive biogas reactor like concrete fixed-dome or fiberglass. Alternatively, the small holder farmers can join a communal biogas reactor. It will reduce installation cost and overcome limited area restriction. Technically, operation of such communal reactor is handled by a competence operator. This approach in the past however was hindered economically by operational cost. Biogas users are reluctant to pay for the cost [26].

In term of operability, previous farmer’s self-installed fixed dome reactor was abandoned after several month operation. Collecting manure by bucket and filling the reactor consume farmer’s precious time to maintain the cows. To overcome the problem, our biogas plant was designed to collect the manure directly from manure wasting system. The bucket filling is not needed anymore, therefore reduce the burden of the farmer (Figure 5.c).

Further, biogas technology dissemination should emphasize on how to maximize its economic potential. Despite significant saving when using biogas, the usage does not increase the farmer income. Their income still depends on the price of dairy milk, which does not increase for years. By developing the biogas and its derivative products as secondary competitive source of income, adoption of the technology will increase significantly. The further utilization of biogas in Pangalengan area needs to consider the limited cattle and area of small holder farmer. Last important thing, we introduced fostered village program in a collaboration between university and the farmer cooperative for continuous monitoring and technology dissemination.
Figure 5. Photograph of (a) location preparation and (b) installed additional biogas reactor (c) schematic diagram of modified reactor feeding system.

4. Conclusion and Future Works

Biogas is potential for renewable fuel especially in Pangalengan area which populated by dairy farms. Despite long history on the dairy farming, utilization of biogas in the area just begins in 1980s. Many technical and social challenges cause low adoption of the technology. With the funding from both enterprise and government, the biogas technology become more familiar to the farmers. It will be great advantage to develop the biogas technology and its derivative product as secondary source income for the farmer. Further work needs to improve quality of the biogas to comply with a commercial standard.

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