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**Article**

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## Biogas initiative from municipal solid waste in northern Thailand

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### Abstract

Biogas systems from solid waste landfill and their pipeline network have been constructed with a total biogas capacity of 1000 m<sup>3</sup>/day in two villages in Bantan subdistrict in northern Thailand. Two hundred households in two villages receive the benefits from biogas technology in many ways. It requires 217 m<sup>3</sup>/day of biogas to cover amounts of 100 kg/day of LPG that has been previously used. The heat energy cost is decreased from previously paid of 400 baht/month (12 USD/month) on LPG down to 100 baht/month (3 USD/month) with the existence of biogas as a cooking fuel. Biogas not only is used as energy source for cooking, but also contributes to the reduction of environmental pollutions produced by municipal solid waste. It helps in reducing methane (CH<sub>4</sub>) release to atmosphere by 400 kg equivalent to 10,000 kg CO<sub>2</sub>. Local communities gain new knowledge in biogas technology and its benefits. Major success to the biogas program comes from the collaboration between the solid waste disposal center, households, and government department. Biogas energy surely offers an alternative source of heat energy for households and agricultural applications.

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*Keywords:* Biogas; Renewable energy; Cooking fuel; Solid waste

### 1. Introduction

Thailand currently faces rising energy demand. In response, Thailand has set out to increase the use of alternative energy consumption in all sectors due to the national policy in the alternative energy development. The plan concentrates on the use of alternative energy produced in the country in order to reduce the dependency on energy consumption from fossil fuel. [1] reported that the alternative energy consumption in Thailand was 11,731 ktoe in 2017, an increase of 6.2% from the previous year and shared 14.53% of the total final energy consumption. This affected on the decrease of energy imports, as amount of 155,787.68 million Baht (4868 million USD), and also the decrease of CO<sub>2</sub> emission as amount of 35.98 million tons. Heat energy consumption was the highest with the share of 62.4% of the total final alternative energy consumption, followed by electricity and biofuels (ethanol and biodiesels) with the share of 21.1% and 16.5%, respectively. [2] stated that Thailand must increase the use

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of alternative energy to 30% of the total energy consumption by 2036 and reduce dependency on fossil fuel and energy imports.

Pakham village and Maeyui village are located in Bantan subdistrict, Hod district, Chiang Mai province in northern Thailand. There is an Integrated Solid Waste Disposal Center situated in this area. These massive solid waste generates environmental pollution concerns. These concerns include bad smell, wastewater, flies, and insect caused by the solid wastes. These problems make it difficult for people residing in this area to live their normal lives well under such conditions. This solid waste landfill is capable of handling solid waste 500–600 tons/day. This center can produce biogas from solid waste as much as 70,000 m<sup>3</sup>/day. Biogas of 30,000 m<sup>3</sup>/day is used for generating and selling electricity to the grid. Therefore it still has biogas of 40,000 m<sup>3</sup>/day left and neglected. The center does not have any plan to collect and make use of the remaining biogas. There are 200 households from Pakham village and Maeyui village stating the interest to make use of the remaining biogas. The solid waste landfill and disposal center is located approximately 7 km from Pakham village and 11 km from Maeyui village. Bantan Subdistrict Municipality (BSM), people in the local communities and the Integrated Solid Waste Disposal Center (ISWDC) made an effort to find a suitable solution to decrease pollutions caused by a solid waste landfill. They finally came up with a plan to build the biogas network system to reduce pollutions, and at the same time to supply available biogas to households for a cooking fuel and others in nearby communities [3]. Biogas technology has been well developed and commonly used for heat and electricity generation in many parts of Thailand [4,5].

Bantan Subdistrict Municipality (BSM), who was in charge for handling administrative work in this area, realized the problems and steps that must be taken to resolve the environmental concerns and make local communities and the Integrated Solid Waste Disposal Center (ISWDC) live pleasantly together. Therefore the biogas production from solid waste project was established in Pakham village and Maeyui village. Biogas network system was constructed to supply adequate biogas for households in these two villages. This project received over 9.7 million baht (300,000 USD) from sources to build biogas plant along with its equipment and pipeline network from solid waste landfill to households in nearby communities. Biogas would be distributed to 200 households in two villages; 100 households from Pakham village and the other 100 households from Maeyui village. Biogas would be used as a cooking fuel. Since heat energy used for cooking in typical households is liquefied petroleum gas (LPG), biogas would be distributed to households as a cooking fuel to replace LPG. Pakham Biogas Group (PBG) and Maeyui Biogas Group (MBG) were established to manage the use of biogas among their members. Each household, who take part in this biogas program, must pay 100 baht/month (3 USD/month) for the right to use biogas. This payment would be used for project management and maintenance of biogas system. This biogas system helps local community to reduce the heat energy expense. At the same time it certainly helps in reducing the environmental pollution from municipal solid waste.

## 2. Biogas program initiative

Because of high energy prices in the country, Thailand strategic plan for alternative energy development strongly advocates the production of alternative energy for the national use and contains a key target to increase the alternative energy share of the total energy consumption to 30% by 2036. To achieve that target, Thai government persuades all sectors to produce and use the alternative energy. For example, financial subsidy for alternative energy projects and the introduction of feed-in tariff (FIT) program have been offered to entrepreneurs who produce electricity from alternative energy such as biogas.

Pollutions produced from solid waste were big concern to people who live in nearby area. Bad smell, wastewater and insects really affect the living standard of all people in villages. Biogas plays a huge role in problem-solving process to pollutions from solid waste. A major focus of biogas system is on community-based biogas production for local use only, and on reducing pollutions produced by solid waste landfill.

Regarding the supporting groups to this biogas project from municipal solid waste, Energy Conservation Promotion Fund (ENCON), Office of the Permanent Secretary (OPS) from Ministry of Energy, Integrated Solid Waste Disposal Center (ISWDC), Bantan Subdistrict Municipality (BSM), and Pakham Biogas Group (PBG) and Maeyui Biogas Group (MBG) are responsible for providing sufficient funds to make the biogas project happen. These funds were used for management of project, construction of biogas system and its equipment, pipeline network for two villages, and biogas stoves for all 200 households who participate in this project. Energy Technology for Environment Research Center (ETE) from Chiang Mai University was responsible for managing the project timeline

from beginning to the end of the construction of the biogas system. The key to the success of this biogas project was the collaboration between all parties mentioned above.

The primary source of heat energy used for cooking in most households is liquefied petroleum gas (LPG). To replace LPG use with biogas, it is necessary that the biogas system together with pipeline network must be built in Bantan subdistrict. OPS, ISWDC, BSM, PBG, and MBG provided a total of 9.7 million baht (300,000 USD) for construction of two biogas plants for two villages, their pipeline network, biogas stoves, and all technical supports. Biogas pipeline network were 7 km in distance for Pakham village and 11 km in distance for Maeyui village as shown in Fig. 1. All main pipelines, HDPE pipe of size 6 inch in diameter, were put beneath the soil surface. New biogas stoves were provided to all households, who joined this project, to replace LPG stoves. To prolong the use of biogas system, members of two villages were trained with the basic knowledge of biogas technology, e.g., operation of biogas system, biogas leakage inspection, maintenance, and biogas safety issues.

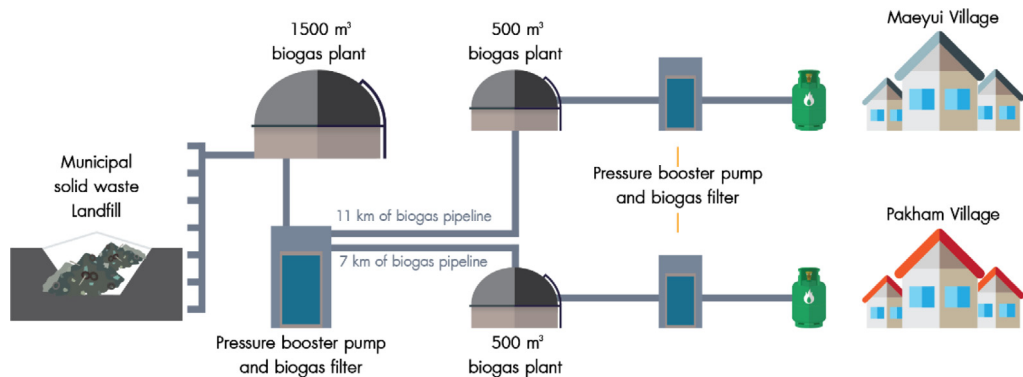


Fig. 1. Biogas system and pipeline network in Pakham village and Maeyui village.

Two biogas plants were built in Bantan subdistrict. One plant has capacity of 500 m<sup>3</sup> of biogas built at Pakham village supplying 100 households. The other biogas plant with capacity of 500 m<sup>3</sup> was built at Maeyui village supplying 100 households as well. Two villages have a total biogas capacity of 1000 m<sup>3</sup>/day, in which it helps in decreasing the release of methane (CH<sub>4</sub>) to atmosphere by 400 kg/day equivalent to 10,000 kg CO<sub>2</sub>. Each households uses LPG as an energy source for cooking with the average of 0.46 kg/day equivalent to 1 m<sup>3</sup>/day of biogas (1 m<sup>3</sup> of biogas = 0.46 kg of LPG) [6]. Thus there is sufficient biogas to supply all 200 households who participate in this biogas project.

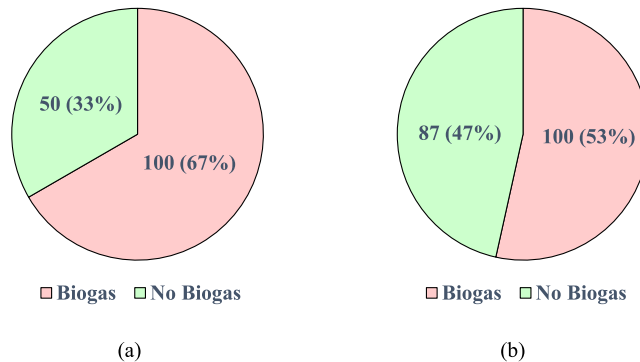


Fig. 2. (a) Numbers of households with and without biogas in Pakham village; (b) Numbers of households with and without biogas in Maeyui village.

According to the general information from [7], there are 150 households in Pakham village. Fig. 2(a) shows numbers of households with and without biogas energy in Pakham village. There are 100 households (67%) joining biogas program. The remaining 50 households (33%) has not made decision yet to participate the biogas program.

Another village, named Maeyui village, consists of 187 households. Fig. 2(b) shows numbers of households with and without biogas in Maeyui village. There are 100 households (53%) participating biogas program. The remaining 87 households (47%) has not decided yet to join the biogas program due to some difficulties such as distant location and lack of knowledge.

### 3. Outcome analysis

#### 3.1. Stakeholder relationships

There were serious concerns with environmental pollutions produced by municipal solid waste landfill situated nearby villages. People in two villages, Pakham village and Maeyui village, discussed this matter to the local government office. Bantan Subdistrict Municipality (BSM) consulted with Integrated Solid Waste Disposal Center (ISWDC) and Energy Technology for Environment Research Center (ETE) to find the best solution to resolve these pollution issues. BSM successfully convinced the local communities and ISWDC that the biogas system and pipeline network must be built to reduce pollution problems and to provide biogas to households in nearby villages for cooking fuel in replacement of LPG at the same time. The heat energy expense used for cooking in households was then reduced as a result of the use of biogas energy. ETE provided consultant on project management, technical and financial issues occurring during construction of biogas system. Pakham Biogas Group (PBG) and Maeyui Biogas Group (MBG) was originated to manager the biogas program in villages. Fig. 3 shows relationships between all stakeholders and how they take part in the program.

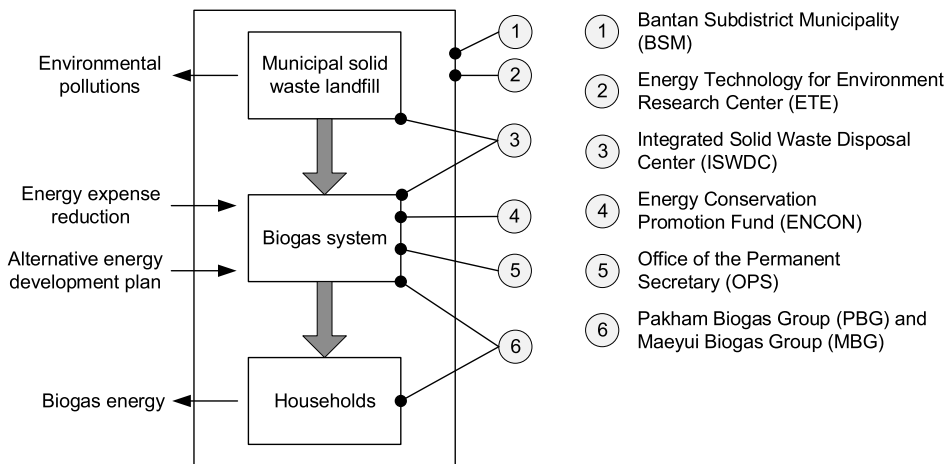


Fig. 3. Relationship of organizations involved in the biogas program.

In 2016, over 9.7 million baht (300,000 USD) funding required for equipment purchases and construction of biogas system were secured from ENCON, OPS, BSM, ISWDC, PBG and MBG. ENCON and OPS provided subsidy of 6 million baht (187,000 USD) which was 62% of the entire budget. ISWDC provided 1.6 million baht (50,000 USD). BSM gave 100,000 baht (3100 USD). PBG and MBG gave 2 million baht (62,000 USD). A 1500 m<sup>3</sup> biogas plant was built at ISWDC. Then biogas would be distributed to a 500 m<sup>3</sup> biogas plant at Pakham village for 100 households, and to a 500 m<sup>3</sup> biogas plant at Maeyui village for 100 households. ETE was responsible for checking construction and its report before financial subsidy would be paid from ENCON and OPS. All households, who connected their stoves to biogas pipeline, must pay a monthly fee to PBG and MBG.

#### 3.2. Utilization of biogas

The basic heat energy used for cooking in local community was LPG before the introduction of biogas. Each household commonly used LPG about 0.5 kg/day equivalent to biogas of 1 m<sup>3</sup>/day. It required 100 kg/day of LPG for 200 households from two villages. To cover these amounts of LPG, it needed 217 m<sup>3</sup>/day of biogas. After biogas

system has been introduced to communities, they are able to reduce the use of LPG by 36,500 kg/year comparable to about 950,000 baht/year (29,000 USD/year) in payment saving. Every household biogas member must pay a monthly fee of 100 baht (3 USD) to PBG and MBG for management and maintenance of biogas system purposes. With existence of biogas, each household can decrease the heat energy cost from previously paid of LPG of 400 baht/month (12 USD/month) down to 100 baht/month (3 USD/month) as a regular fee for biogas use.

### 3.3. Potential use of biogas

Pakham village and Maeyui village consist of 150 and 187 households, respectively. There are 100 households in each village joining in biogas program. Each household in these two villages merely uses biogas of 1 m<sup>3</sup>/day for cooking fuel. Each village has a biogas plant of 500 m<sup>3</sup> capacity. Thus there are plenty of biogas available to supply the remaining households who have not decided to join in the biogas program yet.

## 4. Discussion

### 4.1. Technical issues

Technical issues on biogas have been problems initially for people in community. The biogas problems include design, construction, operation, maintenance, and biogas safety. Local communities were not aware of biogas technology and its benefit. Biogas management and maintenance of equipment and parts were also big issues, consequently PBG and MBG were found to keep this program running smoothly. All main biogas pipelines were put beneath the soil surface as shown in Fig. 4. The warning signs are sited along the pipeline routes to notify where pipelines are. Water drain valves were positioned along biogas pipeline to drain water out of the system. PBG and MBG workers were advised to regularly drain the water out of pipeline in order to purify biogas. Since households were very far away from biogas plant, pressure booster pump must be used to ensure that biogas could be distributed to all households at a far distance. Finally, biogas stove was also provided to every household to replace LPG stove for cooking.



Fig. 4. Main biogas pipeline placed beneath the soil surface.

Many villagers did not fully understand the operation and safety of biogas system. Therefore, biogas safety was another important matter that needs to be paid attention. Training program on biogas safety was carried out to workers and people who worked closely with biogas system. Gas leakage detector was also installed at biogas plant to detect possible gas leak.

### 4.2. Expansion possibility of biogas program

Bantan subdistrict has 10 villages consisting of 2223 households. Each household uses heat energy from LPG for cooking equivalent to about 1 m<sup>3</sup> of biogas/day. Municipal solid waste landfill in Bantan subdistrict is so massive.



Only 30,000 m<sup>3</sup> from maximum yield of 70,000 m<sup>3</sup> of biogas has been produced and used to this point. This means there is still enough biogas available, should it be produced, to be distributed to more households in this area. At present, there are many households expressing interest to join the biogas program since it can help them reduce the cost of living on energy. More works have to be done before more biogas can be produced and supplied to the rest of households in this area.

## 5. Conclusions

Biogas systems from solid waste landfill and their pipeline network have been successfully constructed with a total biogas capacity of 1000 m<sup>3</sup>/day in two villages in Bantan subdistrict in northern Thailand. This potentially helps in reducing methane (CH<sub>4</sub>) release to atmosphere by 400 kg equivalent to 10,000 kg CO<sub>2</sub>. Two hundred households take part in this biogas project and obtain biogas for cooking fuel and running water pump for agricultural purposes. It requires 217 m<sup>3</sup>/day of biogas to cover amounts of 100 kg/day of LPG that has been previously used on a daily basis. Biogas energy helps each household in communities to reduce the energy expense on LPG from 400 baht/month (12 USD/month) down to 100 baht/month (3 USD/month). Biogas is not only used as a source of heat energy for households, but also helps in decreasing the impact of municipal solid waste landfill on environment. Local community gains a better understanding on biogas technology in addition. The collaboration between government office, solid waste disposal center and local community plays an important role to the achievement of the biogas energy from municipal solid waste.

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