03 Biogas Grid for Agricultural Community in Mae Tha Sub-district, Mae On District, Chiang Mai, Thailand

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Abstract

The objective of this study was to analyze the possibility of biogas utilization in the community setting: Mae Tha Sub-district, Mae On district, Chiang Mai, Thailand. The total number of 1,500 households in Mae Tha Sub-district was used as population in this study. The community capability in biogas production was evaluated. The potential of the biogas utilization in terms of technicality and economics was analyzed using geographic information system (GIS) and economic indicators. The results showed that Mae Tha community was able to produce biogas and was suitable to allocate biogas grid in the scale of 3,000 m^3, with the radius of grid less than 5 km. If Mae Tha community would like to produce biogas for sale, the authors propose that the government may need to support about 30% of overall investment so that the sale price is comparable to the LPG market price 23.78 THB/kg Also, it was proposed that the support model may need to increase 5% yearly to maintain the competitiveness with the LPG price and hence suitable for community utilization

Keywords: biogas, biogas grid, community energy, economics

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Introduction

The Kingdom of Thailand has floated the liquefied petroleum gas (LPG) price, effective since 1 August 2017 to allow the complete trade liberalization (Energy Policy and Planning Office. 2017A). Before that time the retail price of LPG was flat at 20.49 THB per kg and the price had been regulated for over 30 years (Energy Policy and Planning Office. 2017B). Currently the LPG price in the world market is highly fluctuating. When comparing with the neighboring countries, retail LPG price in Thailand was lower except for Malaysia (Traivivatana. 2017). The different price of energy resource in each country depend on several factors including tax measure, fund collection system, or energy price subsidies. Thailand and many neighboring countries still have the subsidies, specifically, Thailand has LPG Fund to maintain the retail price to avoid the adverse effect on the cost of living (Energy Policy and Planning Office. 2017C). The LPG production inside the country is decreasing, opposite to the higher demand each year in Thailand (Energy Policy and Planning Office. 2015). This situation requires more LPG import, which may destabilize the energy consumption in the future. Utilization of biogas grid to substitute LPG consumption in the community with potential in biogas production might be a reasonable alternative for energy security planning in Thailand.

Mae Tha Sub-district is an agricultural community that located in Mae On District, Chiang Mai, Thailand. There are numerous number of livestock farms in Mae Tha consisting of dairy cattle farms, beef cattle farms, and pig farms. Accordingly, there are huge amount of animal manure that affects to environment and community members' health. Therefore, utilization of biogas grid by using animal manure in the community as substrate is an interesting alternative to solve the problem.

Objectives

1) To evaluate the potential of Mae Tha Sub-district, Mae On District, Chiang Mai, in producing biogas

2) To analyze the possibility in utilization of biogas grid in Mae Tha Sub-district, Mae On District, Chiang Mai

Research Scope

Population The local community members in Mae Tha Sub-district, Mae On District, Chiang Mai for 1,500 households and the 128 farmers owning livestock farms (dairy cattle farms, beef cattle farms, and pig farms)

Content This study was divided into 2 parts, 1) Evaluation of potential in biogas production from energy questionnaire and record on livestock farming; 2) Analysis of possibility in utilization of community biogas grid in terms of techniques using GIS to determine the suitability of community biogas grid location and in terms of economics using the following economic variables: Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP), and Cost of Energy (COE). Also, the sensitivity analysis was conducted under 4 scenarios: when the government sector supports the fixed cost of 100%, 70%, 50% and 30%, to determine the sale price rate if biogas grid was utilized in the community.

Research Methodology

The purpose of this study is to evaluate the potential of biogas production and utilization of the community in Mae Tha Sub-district, Mae On District, Chiang Mai, using technical and economic analysis as described below

1. Population and sample size

Community in Mae Tha Sub-district, Mae On District, Chiang Mai, for 1,500 households and the farmers who own the livestock farms for 128 farms (dairy cattle farms, beef cattle farms, and pig farms).

2. Research tools

2.1 Questionnaires for basic demographic information of the community sample and information of energy consumption of the community sample.

2.2 Record form for livestock farm information to investigate and analyze the characteristics of the community livestock farms.

2.3 Geographical information system to analyze the possible physical geo-location of the community biogas grid in the community (Perpiña-Castillo. 2016).

3. Data acquisition processes

3.1 In this study, data was collected during 1-31 May, 2014.

3.2 Data collected in this study comprised of basic demographic information and also the energy consumption information of the community, i.e. geography, climate, population number, household numbers, occupation and characteristics. The energy consumption information included electric bill, farming activity-related fuel bill, transportation fuel bill, and cooking gas (LPG).

3.3 Data collection of livestock farms information using record form having livestock farm information, farm characteristics, type of farm, number of livestock, dung waste management, sales pattern, and geographic coordinate of the livestock farms.

4. Data analysis

4.1 Evaluation of potential in biogas production

1) Analysis of basic demographic information of the community was carried out from the questionnaire to determine the community context and the characteristics of energy consumption of the community.

2) Analysis of livestock farm information was carried out from the record form. The raw data of the farm numbers, the livestock numbers, and the livestock production system to determine the amount of the biogas possibly produced from the farms.

4.2 Analysis of possibility in utilization of community biogas

1) Analysis of technical possibility using GIS in order to collect farm coordinates and analyzed for biogas grid characteristics (Lakota. 2013).

2) Analysis of economical possibility using the following economic variables: NPV, IRR, PP, and COE.

3) Sensitivity analysis was conducted under 4 scenarios: when the government sector supports the fixed cost of 100%, 70%, 50% and 30%, to determine the sale price rate if biogas grid was utilized in the community.

Results and discussion

1. Evaluation of potential in biogas production

1.1 Analysis of basic demographic information of the community

The basic demographic information and energy consumption pattern of Mae Tha Sub-district showed that it has population of 4,860 members, within 1,500 households. The Mae Tha Sub-district has energy expenditure about 55 million THB per year, from electricity, gasoline, and LPG. The average LPG usage is 0.2 kg/day/household.

1.2 Analysis of livestock farm information

From the study, the area survey having potential in producing renewable energy has shown that Mae Tha Sub-district is the farming community. It has numerous livestock farming including dairy cattle, beef cattle and pig farming. The researchers analyzed the biogas potentially produced from these farms, as shown in Table 1, the number of livestock farms and the capability of biogas production in Mae Tha Sub-district.

Table 1 The number of livestock farms and the capability of biogas production in Mae Tha Sub-district

Livestock Farms	No. (farms)	No. (animals)	Biogas tank size* (M^3)	Biogas produced* (M^3/day)	LPG equivalent* (kg/day)
Dairy cattle	60	1,865	3,000	1,500	690
Beef cattle	45	807	700	350	161
Pig	23	2,480	500	250	115
Total	**128**	**5,152**	**4,200**	**2,100**	**966**

*(National Science and Technology Development Agency. 2001)

The area survey of dairy cattle farming to characterize the farming pattern and collect the farming coordinates had revealed the total farming area of dairy cattle for 113 Rais, in which encompassing 60 farms, 1,865 dairy cattle, and 10 dung tanks. The farming pattern was half-sheltered half-free-range in designated area. Altogether, the available dung could be used in biogas grid system with the size of 3,000 m^3. The biogas volume will be 1,500 m^3/day or equivalent to LPG of 690 kg/day. From this information, therefore, Ma Tha Sub-district community was capable of running biogas grid for the community size of 1,500 households.

2. Analysis of possibility in utilization of community biogas

2.1 Analysis of technical possibility using GIS

The geographic coordinates collection and GIS analysis of all farms to evaluate the potential of the biogas grid installation has shown that the milk cattle farms are located around the community setting area. The housing setting are condensed within the nearby area, with the population of 1,500 households within the radius of 5 km. In order to design and designate the installation location of the biogas system, the technical possibility was analyzed for biogas grid utilization in Mae Tha Sub-district community. Also, from report on development of biogas grid standard and the utilization potential of local biogas grid in community and/or industry area, it was found that the suitable size of the biogas pipeline system should be in the radius of 5 km, where the households are condensed within this proximity. The biogas system should produce more than 2,000 m^3 of biogas to meet the criteria of the suitability set by Energy Research and Development Institute–Nakornping Chiang Mai University [ERDI-CMU] (2016).

Our study has shown that the distribution pattern of housing in Ma Tha Sub-district was along the community main road and was condensed within the same area, in the radius of no more than 5 km. This finding indicates that Ma Tha Sub-district is a suitable community for biogas grid utilization. One possible approach in biogas system design to allow sufficient amount for the community usage of 1,500 households is to designate one area with the biogas well size of 3,000 m^3 and with radius of utilization for 5 km. The spot of the biogas plant is shown in Figure 1.

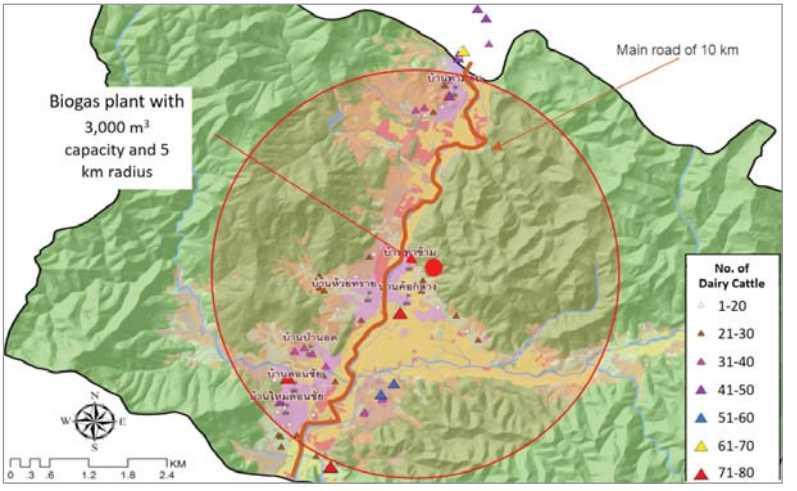

Figure 1 Milk cattle farm coordinates in Mae Tha Sub-district and proposed designated area for community biogas well

2.2 Analysis of economical possibility

The economical possibility was performed with the details as followings:

1) Investment Cost Analysis

The investment cost analysis of the community biogas grid with the size of 3,000 m^3, for 1,500 households was divided to be fixed cost analysis, i.e. the cost able to evaluate to money value without any change from usage, and variable cost, i.e. the cost able to change due to usage. The details of analysis are shown in Table 2.

Table 2 Investment cost of biogas grid size of 3,000 m^3 for 1,500 households

Items	cost (THB)
Fixed cost	
1) Biogas well, size 3,000 m^3	15,000,000**
2) Biogas quality improvement system, size 1,000 m^3/day	14,000,000**
3) Biogas pipelines, for 1,500 households	24,000,000**
4) Dung carriage truck, size 4,000 Liters, 1 truck	480,000
5) Labor cost for dung well, 50 well, 3,000 THB each	150,000
Total fixed cost	53,630,000
Variable Cost	
1) Yearly maintenance (THB/year)	200,000
2) Gasoline (THB/year) (Increase 2%/year)	180,000
3) Personnel (Increase 3%/year)	
- Executive, 1 person (THB/month)	18,000
- Finance officer, 1 person (THB/month)	15,000
- Technical officer, 1 person (THB/month)	15,000
- Mechanic, 1 person (THB/month)	15,000
- Truck driver, 1 person (THB/month)	8,000

** Cost of biogas well, biogas quality improvement system, and biogas pipelines were calculated according to biogas grid system developed by Energy Research and Development Institute-Nakornping, Chiang Mai University (ERDI-CMU. 2015)

2) Benefit analysis

Benefit analysis of biogas grid for the project period of 20 years has demonstrated the return of investment from the biogas selling to the community with the biogas size of 3,000 m^3 and production capability of 1,500 m^3 to be 750 kg/day of biogas

after quality improvement process or to be equivalent to 637.50 kg/day of LPG or about 600 kg/day (Energy Research and Development Institute-Nakornping Chiang Mai University [ERDI-CMU]. 2015).

3) Economic analysis

Economic analysis of biogas grid in the case area of Mae Tha Sub-district, Mae On District, Chiang Mai, has the requirements as followings:

- Biogas grid system of 3,000 m^3 for delivering biogas to the community member of 1,500 households.
- The biogas production yield, equivalent to 600 kg of LPG.
- Given discount rate (r) to be 7% (average minimum loan rate (MLR) of Bank of Thailand was 6.95%) (Bank of Thailand. 2017).
- Project duration was 20 years.
- Investment cost of the community was 100%.

Economic Analysis has given the results of 5 indicators: NPV, IRR, PP and COE as shown in Table 3.

Table 3 Economic analysis of biogas grid

Indicators	Results
Net Present Value (NPV)	44,477,329 THB
Internal Rate of Return (IRR)	7.00 %
Payback period (PP)	9.00 years
Cost of energy (COE, kg (LPG equiv.))	17.21 THB

From the estimation of investment cost and return of investment under the requirements mentioned above, the sale rate of biogas equivalent to LPG was given to be 32.25 THB/kg and increase rate of 5% per year.

2.3 Project sensitivity analysis

From the economic analysis of the community biogas grid, it was found that if the community invested for 100%, it would have to sell biogas equivalent to LPG in the price no less than 32.17 THB/kg, and with the increasing sale rate of 5% per year. Given the situation of the current market price of LPG, which is 28 THB/kg, the LPG price seems to increase according to the market mechanism in the world. The sensitivity analysis of the community biogas grid recognizes the importance of the constantly increased sale rate of LPG and the problem of energy shortage in the future. Therefore, the government sector

should have a policy in supporting and empowering the utilization of renewable energy in the community. It could be a partial subsidy, and the author propose the following models:

Scenario 1: when the government sector support fixed cost for 100% (only biogas grid system and not the management cost)

Scenario 2: when the government sector support fixed cost for 70% (only biogas grid system and not the management cost)

Scenario 3: when the government sector support fixed cost for 50% (only biogas grid system and not the management cost)

Scenario 4: when the government sector support fixed cost for 30% (only biogas grid system and not the management cost)

Table 4 Economic analysis of biogas grid when the government sector supports the budget for 100, 70, 50 and 30%

Indicators	Project sensitivity analysis			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
NPV (THB)	1,369,942	14,286,325	22,892,658	31,498,990
IRR (%)	7.00	7.00	7.00	7.00
PP (year)	1.00	7.00	8.00	8.00
COE (THB)/kg (LPG equiv.)	4.94	8.62	11.07	13.53

From the estimation of investment cost and return of investment under the condition of Scenario 1, 2, 3, and 4, given IRR > 7%, the results showed that the community have to assign the buying-selling rate of the biogas equivalent to LPG to be no less than 4.25, 12.62, 18.20, and 23.78 THB/kg, and increase 5% per year.

Discussion and conclusion

The possibility of biogas grid utilization in Mae Tha Sub-district, Mae On District, Chiang Mai, Thailand, is suitable both technically and economically. The study used GIS to analyze the location of the biogas grid and the finding was in agreement with the study of Kamching (2017). The model is the installation of the centralized biogas system with the size of 3,000 m^3 and equipped with gas quality improvement system to yield biogas, which

is the most resemble to LPG. The pipeline radius is no more than 5 km for 1,500 households. The economic analysis suggests that if given the community investment for 100%, the biogas selling price will be more than the LPG market price. Therefore, to initiate the community to increase energy usage from biogas, the government sector should support the investment cost of no less than 30% of the fixed cost. The government should support the budget for studying the strategy to decrease the cost of biogas well, the standard of the quality improvement system for biogas, and the pipeline. These factors and also the promotion of the market competition will allow the government sector to use less budget in supporting the biogas grid. In addition, our result is in agreement with the finding of Thanarak (2017) that the supportive factors from the government sector in producing biogas affected the decision making of the people in choosing the biogas for household commodity. Using renewable energy like biogas in this case study, in the aspect of energy strategy, will therefore strengthen the energy security and decrease the energy crisis of the country.

Suggestions

1) There should be the study of biogas grid system management to sustain the operation

2) There should be the study of the community stakeholders, e.g. the biogas users, the farm owners, and the LPG retailers.

3) There should be the study of the biogas management when the biogas is not enough or over supplied in the community.

4) The economic analysis in this study based on current average minimum lone rate (MLR) of Bank of Thailand. If there is the increasing of MRL exceed 7%, it may affect to economic value of the project.

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