# ANALYSIS OF USERS' PERCEPTION ON BIOGAS, CHARCOAL BRIQUETTE AND DRY SOLID WASTE USAGE IN KUPANG MUNICIPALITY

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**ABSTRACT**

This perception survey shows that the perception onthe utilization of biogas, charcoal briquettes and dry organic waste as fuel, tested by Geng Motor IMUT (GMI) is positive, in economic, social and ecological aspects. The strongest positive perception is on economic and ecological aspects. While in social aspect, it is not significant, where increased social interaction and the formation of networks and organizations are not proven in this study. The main influencing factors are the perceived object and situation. Economic analysis of the three technologies shows a positive and profitable feasibility. This can be seen from: 1) Positive NPV value with a calculation of 15 years for biogas with DePo BiMuT S-002 and 10 years for charcoal briquettes and dry organic waste with GMI F-003 biomass stove at 17% interest rates; 2) B/C Ratio with value above 1 (one); 3) Small value for payback period, or investment costs are paid off the fastest in the first year for charcoal briquettes and dry organic waste with the GMI F-003 biomass stove and the second year for biogas with DePo BiMuT S-002.

***Key words: perception, utilization, biogas, charcoal briquettes, dry organic waste, portable digester, DePo BiMuT S-002, Biomass stove GMI F-003.***

## INTRODUCTION

In the last decade, Geng Motor Imut (GMI) has been experimenting various technologies on renewable energy (EBT) in East Nusa Tenggara Province (NTT). IMUT itself stands for Mobilization, Innovation for Transformation, which reflects the spirit of this community of young people whose dream is to provide easy, accessible and environmentally friendly appropriate technologies using renewable energy sources. Therefore, GMI has developed household scale biogas technology, and with a portable horizontal digester using used drums (DePo BiMuT S-002), gas container using used inner tube, and BiMuTy X-005 biogas stove. Charcoal briquettes are produced using a single or parallel briquettes maker. The last two energy sources were tested at household level using biomass stoves GMI F-002 and GMI F-003. The main objective of their activities is not only to reduce waste, but most

importantly reduce community dependence on oil fuel and reducing greenhouse gas emissions (Geng Motor IMUT NTT, 2012).

Fatmawati (2012) estimated that 70 percent of rural household's waste weighing about 120-170 kg is organic such as leaves, twigs and vegetable craps. The remaining 30% is nonorganic waste such as metals, plastics, paper, and glassware. Kupang Sanitary Department (2013) cites WHO calculations that each person can produce 2.5 liters of waste per $day^{-1}$. Using this standard, Kupang produces 840,598 liters of waste $day^{-1}$, equivalent to 840.60 $m^3$ $days^{-1}$, consisting of 588.42 $m^3$ $days^{-1}$ organic and 252.18 $m^3$ $days^{-1}$ nonorganic waste. Moreover, there's also potential of livestock waste to be used in Kupang. This research was conducted to determine the perceptions of the use of biogas, charcoal briquettes and dry organic waste fuel which was tested by the GMI in Kupang.

**Research Hypothesis**

$H_0$ = There is no change in perception of utilization of biogas, chacoal briquettes and dry organic waster tested by GMI

$H_1$ = There is change in perception of utilization of biogas, chacoal briquettes and dry organic waster tested by GMI

## METHOD

1. Time and Place of Research

This research was conducted in June-August 2013 in Kupang Municipality, specifically in the location where users of GMI tested technologies were living,: (1) biogas with DePo BiMUT S-002 (portable digester using used drums and gas container using used inner tube and biogas stove BiMuT X-005); (2) charcoal briquettes and dry organic waste as fuel for biomass stove GMI F-003.

2. Research Variables

Identified independent variables are: economic, social and ecological benefits of the use newly tested technologies which enable users to convert from oil fuel (especially kerosene) to renewable energy, sourced from unused and easily found materials around households. Dependent variable is the perception of the users about the benefits of the change they made by converting from kerosene to EBT using new technologies developed and tested by GMI. Data on these variables were obtained from a survey on 30 households, who are users of the new technologies. Respondents were divided into 10 biogas users with DePo BiMuT S-002 respondents, 10 charcoal briquette users with GMI F-003 biomass stove and 10 users of dry organic waste with GMI F-003 biomass stove.

3. Data analysis technique

Analysis of the perception of 30 respondents used a quantitative non-parametric analysis model with the "Sign Test", adapted from Hasan (1999) and Sarwoko (2007).

## RESULT AND DISCUSSION

A perception survey is a way to find out whether or not there is a change in perception among users of new technologies introduced by GMI. It is expected these technologies can be disseminated widely if a positive perception found among those early users. This will be used as a reference for wider community acceptance and further outreach for GMI.

According to Rachmat (2005), there are three factors that influence personal perception, namely: (a) *experience*, someone who already has experience about certain things will affect one's accuracy in developing perception. The more the experience on certain thing, the better the perception; (b) *motivation*, individual motivation on certain information will affect one's perception. Someone who has high motivation and expectations towards

something, tends to have a positive perception of the object; and (c) *personality*, that is efforts to externalize subjective experiences.

Survey questions were closed questions, upon which the respondents need to respond only with agree or disagree. The ***disagreed*** response showed that there was no change in perception about the economic, social and ecological impacts before and after using above technologies. While the response ***agreed*** described changes in perception before and after. It can also be said that the disagreed response means there is a negative perception, and the agreed response shows the change to a positive perception.

In order to analyze users' perceptions with a sign test, the answers agree to new technologies would be signed (+) and the answer disagree would use the sign (-). This research used kerosene as comparison because majority of people in Kupang City still use kerosene as fuel at the household level.

Economic feasibility is an important aspect in determining whether or not the technologies' applicability. Financial analysis is aimed to reveal the amount of capital and its utilization in application of the technologies. One way of doing this is by projecting its cash flow. Cash flow in biogas development consists of inflows and outflows. *Inflow* comes from the value of biogas produced (equal to the price of LPG and then converted to the price of kerosene) and the value of fertilizer produced when sold or cashed. The outflow consists of the expenditure of investment for the installation of the DePo BiMuT S-002 and operational costs. The difference between the two is a benefit or loss from the application of the biogas installation.

1. Perception on Biogas with DePo BiMuT S-002 utilization

From economic aspect, there is a change in perception among respondents (users) before and after using biogas with DePo BiMuT S-002. Results of the sign test analysis in Table 1 give an idea of H0 rejected because $\alpha >$ probability of sample results (X of P01, P02

and P03). This shows that their experience of using biogas with DePo BiMuT S-002 from animal waste as a substitute for kerosene, raised a positive perception from the economic aspect. This positive perception is in accordance with what was expressed by Rachmat (2005) that the cause of the emergence of a positive perception is due to individual satisfaction with the object, the existence of individual knowledge, as well as the individual experience.

Furthermore, respondents explained that the use of biogas reduced the household expenditure to buy kerosene (P01). This reduction allows respondents to use the spare for various other needs (P02). Other identified needs include adding nutritious food to children, education costs for family members, paying social costs (such as contributing to family grief and helping difficult neighbors). One of the challenges that still exists, though not an obstacle, is that there are family members who feel disgusted and do not want to jointly mix livestock manure into the digester.

Table 1. Result from sign test analysis on perception on biogas with DePo BiMuT S-002 utilization

| Question | Total Answer | | n | r or T | Value *p=0,5* | Value C | Conclusion |
|---|---|---|---|---|---|---|---|
| | Agree (+) | Disagree (-) | | | | | |
| P01 | 10 | 0 | 10 | 0 | 0.001 | 1 | **$H_0$ rejected** |
| P02 | 10 | 0 | 10 | 0 | 0.001 | 1 | **$H_0$ rejected** |
| P03 | 9 | 1 | 10 | 1 | 0.011 | 1 | **$H_0$ rejected** |

Note: ***p*** value compares to □ = 0,05 or **T** value with **C** value.

The use of biogas also provides business opportunities and income generation for respondent's households (P03). Some respondents started generating more income by selling liquid fertilizer (*Sludge*), or growing vegetables using own-produced liquid fertilizer (see Table 2). Liquid fertilizer (*sludge*) is obtained from the output of the DePo BiMuT S-002 installation which is obtained every 3 days. Within a month, a digester can produce 96 liters or 64 bottles (@ 1.5 liters) of liquid fertilizer at a price of Rp. 3,000 bottle-1 or Rp.172,800 a

month after deducting the price of the bottle (@ Rp. 300, -). Thus the results of liquid fertilizer sales can be obtained as well as a net profit of Rp. 2,073,600 a year. But there are also respondents who are still reluctant to sell liquid fertilizer because they feel it is only "cattle dung", so it is not worth selling. Additional benefit is increased savings (less expendes) due to the use of biogas.

Table 2. Economic value from liquid fertilizer (*sludge) from* DePo BiMuT S-002

| **Details** | **1 week** | **1 month** | **1 year** |
|---|---|---|---|
| Volume of liquid fertilizer (litre) every 3 days twice a week filling, @ 12 litre) | 24 | 96 | 1,152 |
| Liquid fertilizer (bottle) every 3 days = twice a week filling x 8 bottle (@ 1.5 litre) | 16 | 64 | 768 |
| Price of a bottle of liquid fertilizer @1.5 litre = Rp.300,- | 4,800 | 19,200 | 230,400 |
| Liquid fertilizer sale @Rp.1.800,- litre-1 or @Rp.3.000,- bottles-1 | 48,000 | 192,000 | 2,304,000 |
| Liquid fertilizer sale netto @Rp.1.800,- litre-1 or @Rp.2.700,- bottles-1 | Rp43,200.00 | Rp172,800.00 | Rp2,073,600.00 |

***Source: processed from primary data.***

Total household income from using DePo BiMuT S-002 is the sum of savings in household expenditure on kerosene use compars to the utilization of biogas heat of Rp.37,909.09, - month$^{-1}$ plus sale of liquid fertilizer as a profit of Rp.172,800, - = Rp.210,709.09, - a month or Rp.2,528,509.09, - a year. Thus, when compared to the use of LPG, there will be savings of Rp. 1,988,509.09 (176.76 kg) a year and for kerosene there are savings of Rp. 1,556,509.09, - (345.89 liter) a year.

Conversion value of biogas heat production is 0.21 kg day$^{-1}$ from DePo BiMuT S-002 with other fuels, using the conversion value proposed by Wahyuni (2011) as shown in Table 3. It is equivalent to 0.12 kg LPG or 0.16 liters of kerosene or 0.13 liters of diesel or 0.21 liters of gasoline or 0.39 m3 of gas Kota or 0.91 kg of firewood or 0.32 kwh of electricity or 0.21 kg of charcoal. If using LPG and kerosene prices as of August 2013, the price of 0.12 kg

of LPG is Rp. 1,341.05 and 0.16 liters of kerosene as much as Rp. 723.

Table 3. Biogas Conversion Value from DePo BiMuT S-002 with Other Fuels

| **1 $m^3$ biogas converted to:** | | **0,21 kg = 0,26 $m^3$ biogas with DePo BiMuT S-002:** | **Unit** |
|---|---|---|---|
| LPG | 0.46 | 0.12 | kg |
| Kerosene | 0.62 | 0.16 | litre |
| Diesel | 0.52 | 0.13 | litre |
| Petrol | 0.80 | 0.21 | litre |
| City Gas | 1.50 | 0.39 | $m^3$ |
| Firewood | 3.50 | 0.91 | kg |
| Electricity | 1.25 | 0.32 | kwh |
| Wood Charcoal | 0.80 | 0.21 | kg |

**Source:** Processed from researcher's data using conversion value proposed by Wahyuni (2011)

***Investment Costs***. – The investment costs include all expenditure used to design and develop the Biogas DePo BiMuT S-002 (digester and its concrete steel support, gas reservoir from inner tube and BiMuTy X-005 stove) and the cost of purchasing 250 ml EM4 as starter to accelerate the formation of biogas in the digester. The life span of this installation is 15 years. The investment cost of the DePo BiMuT S-002 consisted of all costs incurred for the purchase of materials and labor cost is Rp.3,429,500, plus the cost of 250 ml EM4 of Rp. 5,000 (prices as of August 2013), so the total initial investment cost is Rp.3,434,500.

***Operational Costs***.- Operational costs included all costs incurred during the project. These costs consist of fixed costs and variable costs. Fixed costs consist of depreciation costs calculated 5% $year^{-1}$ of the total investment cost. Therefore, the depreciation of DePo BiMuT S-002 was Rp.3,429,500 x 5% = Rp.171,475, $year^{-1}$. Variable costs are all costs that directly affect biogas production, namely livestock manure and liquid fertilizer packaging utilities. With the highest assumption, ie feces are taken free of charge from a cage located far from home with a transport fee of Rp. 75,000 for starters (initial filling of digester = 8 to 10 sacks of feces, @ 25 kg) and Rp.7,500, - $day^{-3}$ filling. Whereas packing of liquid fertilizer uses a large used mineral water bottle at a price of Rp. 300 per bottle.

***Economic Feasibility***.- Analysis of the financial feasibility criteria is used to assess the feasibility of the project. This study used several business feasibility criteria, namely NPV, Net B/C, and Payback Period. This analysis used a bank interest rate (discount rate) of 17%. The results of NPV value generated from the DePo BiMuT S-002 biogas installation is Rp.5,206,397, -. This means that the present value of the income received is positive for 15 years at a discount rate of 17%. The result of Net B/C value at discount rate of 17%, is 1.48. This means that with an expenditure of Rp. 1,000, - can produce a benefit of Rp. 1.48, - at an interest rate of 17%. While the return on investment or payback period obtained is 2.1. This means that all investment costs have been paid off in the second year and first month.

2. Perception on charcoal briquettes utilization with GMI F-003 biomass stove

Respondents' perceptions on economic benefit changed positively after using charcoal briquettes. The results of the sign test analysis in Table 4 illustrate that H0 is rejected because $\alpha >$ probability of sample results (X of P01, P02 αand P03). The main reason for this change because of decreasing household expenditure (P01). Additionally, the residual ash from burning is also used to wash dishes, which also means reduction of household expenses. The savings used for various household needs, such as food, education and what frequently mentioned is meeting social obligations (P02). The ease of making charcoal briquettes and the large economic benefits make respondents feel that charcoal briquettes offer significant productive economic business potential (P03), although still limited to selling to tofu-tempe home industries.

Charcoal briquettes can fully replace kerosene usage, with financial benefit. 1 kg of briquettes is equal to 54 briquettes. A result from GMI simulation showed that it takes 24 briquettes for a 6-hours cooking a day. If it is assumed that briquettes can completely replace the use of kerosene, then the household will no longer need to buy kerosene. Thus, if one household consumes 18 liters kerosene per month$^{-1}$, with the current price per litre of

Rp.4,500, a household can save an expenditure of Rp.81,000, or in a year of Rp.972,000.

Table 4. Result from sign test re. Perception of charcoal briquettes utilization with GMI F-003 biomass stove

| Questions | Total Answer | | n | r or T | p Value =0,5 | C Value | Conclusion |
|---|---|---|---|---|---|---|---|
| | Agree (+) | Disagree (-) | | | | | |
| P01 | 10 | 0 | 10 | 0 | 0.001 | 1 | **H0 rejected** |
| P02 | 10 | 0 | 10 | 0 | 0.001 | 1 | **H0 rejected** |
| P03 | 9 | 1 | 10 | 1 | 0.011 | 1 | **H0 rejected** |
| Note: p Value compares to a = 0,05 or T Value with C Value | | | | | | | |

***Investment Costs***, - The investment costs incurred for the utilization of charcoal briquettes are, the manufacture of biomass stove GMI F-003 and briquette molding equipment. The life span of these two tools is estimated at 10 years with a 5% depreciation of the total investment cost of Rp. 42,011.25, - year$^{-1}$. The cost required to manufacture the GMI F-003 biomass stove is Rp.289,891.67, - and a briquette molding machine with a 2-ton car jack is Rp.550,333.33.

***Operational Costs,*** **-** Operational costs consist of fixed costs and variable costs. Costs used for this process are allocated for purchasing charcoal (transportation costs), processing charcoal to printing. All costs required for operational costs are Rp.249,790.05, - year$^{-1}$.

***Economic feasibility***,- The results of financial feasibility analysis are as follows: The NPV value is Rp.2,524,262. This means that the present value of the income received is positive for 10 years at an interest rate of 17%. The resulting Net B/C value is at a discount rate of 17%, which is 3.00. This means that with an expenditure of Rp 1.00 can produce benefits of Rp. 3, 00, at an interest rate of 17%. While the return on investment or payback period obtained is 1.20. This means that all investment costs have been paid in the first year of the second month out of 10 years of use.

3. Perception on the utilization of dry organic waste fuel with GMI F-003 biomass stove

Respondents' perceptions about the economic benefits of the use of dry organic waste fuel changed after substitute it for kerosene. Table 5 shows results of its sign test analysis.

The results of the sign test analysis illustrate H0 rejected because □ > probability of sample results (X of P01 and P02). This means that there is a positive change when respondents use dry organic waste as a substitute for kerosene. However, for P03, it is seen that H0 is *accepted* because □ ≤ probability of sample results. This P03 also meets the sign test requirements that if there is a balanced (= zero) n (+) value, then the statement is discarded or not discussed.

The main reason for positive perception is decreasing of household expenditure after using dry organic waste as fuel. Some respondents even claimed that there was no expenditure on kerosene anymore. Some stated that the use of kerosene was reduced by 80% (from 5 jerry cans to 1 jeringen per month).

Table 5. Result from sign test re. Perception on dry organic waste fuel utilization with GMI F-003 biomass stove

| Questions | Total Answer | | n | r or T | *p Value=0,5* | C Value | Conclusion |
|---|---|---|---|---|---|---|---|
| | Agree (+) | Disagree (-) | | | | | |
| P01 | 10 | 0 | 10 | 0 | 0.001 | 1 | **$H_0$ rejected** |
| P02 | 10 | 0 | 10 | 0 | 0.001 | 1 | **H0 rejected** |
| P03 | 5 | 5 | 10 | 5 | 0.623 | 1 | **Discarded** |

Notes: - p value compares to □ = 0,05 or T value with C value.
- P03 discarded because the (+) answer equals to (-) answer.

Savings above (from reduction of kerosene expenditure), was used for various household needs (P02). Mainly for food, especially buying vegetables, school fees, children's clothing and additional savings. But the respondents' perceptions about business opportunities from dry organic waste to kerosene substitutes did not change significantly (P03). Business opportunities are relatively small, because it is too easy to obtain raw materials. Although there were respondents who expressed a desire to collect and sell dry organic waste if there was a need (quite a lot of people used it), but the ideas and desires were not very optimistic.

***Inflows***,- The inflows of using of dry organic waste as fuel using GMI F-003 briquettes stove is mostly on reducing household expenses.

***Investment costs***,- Investment cost for the utilization of dry organic waste fuel is calculated only for the manufacture of GMI F-003 biomass stoves, which is IDR 289,892.

***Operational Costs***,- There's a single operational cost, which is to buy used oil or kerosene as a trigger for a flame. Because as a trigger the amount is very small (± 1.5 ml at a time), which in a year is calculated at Rp.2,430, -.

***Financial Feasibility,*** **-** The results of the financial feasibility analysis are as follows; The NPV value produced if a household uses a briquette stove and is fueled with dry organic waste is Rp.4,159,423. This means that the present value of the income received is positive for 10 years at an interest rate of 17%. Net B/C value generated at a discount rate of 17%, which is 14.35. This means that with an expenditure of Rp. 1,000, - can produce a benefit of Rp. 14.35. While the return on investment or payback period obtained is 0.30. This means that all investment costs have been paid in the third month. Financially, the use of dry organic waste is indeed very big advantages, compared to briquettes.

## CONCLUSION

1. The perception of the use of biogas, charcoal briquettes and dry organic waste introduced by GMI is positive, in economic, social and ecological aspects.
2. Economic analysis of the three technologies shows a positive and profitable feasibility. This can be seen from: 1) Positive NPV value with a calculation of 15 years for biogas with DePo BiMuT S-002 and 10 years for charcoal briquettes and dry organic waste with GMI F-003 biomass stove at 17% interest rates; 2) B/C Ratios with values above 1 (one); 3) Small payback period, or investment costs are paid off the fastest in the first year for charcoal briquettes and dry organic waste with the GMI F-003 biomass stove and the second year for biogas with DePo BiMuT S-002.
3. Utilization of biogas as fuel for cooking has the most potential to reduce carbon emissions of greenhouse gases, specifically converting the use of firewood, thereby reducing deforestation in Kupang.

## RECOMMENDATIONS

1. There is a need for deeper research on the comparison of various types of organic waste used for biogas to the quality of fuels and liquid fertilizers as well as the potential for processing ash produced from charcoal briquettes and dry organic waste.
2. Further research to find out the technical life span and amount time and materials used for different kind of dishes from DePo BiMuT S-002 and GMI F-003 biomass stoves.
3. In order to develop renewable energy innovation such as those developed by GMI, required policy support. Especially on the organic waste management strategy at the household level, as well as investment in equipment and skills for Kupang inhabitants.

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