

# FEASIBILITY STUDY OF PURIFIED BIOGAS INTO GAS BOTTLING IN INDONESIA

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*Abstract— In 2007, Indonesian government applied a program called as “Zero Kero” as an effort to save the government budget in terms of providing subsidies and as a step to diversify energy supplies to reduce the country's dependence on petroleum. It basically convert the fuel used for household cooking from kerosene to liquefied petroleum gas (LPG) sourced from natural gas. In the other hand, Indonesia produces 66-67 million waste in 2019 with organic waste reached 60%. Most of this waste is thrown away in landfill and left abandoned. Meanwhile, organic waste can actually be reprocessed, one of them as a main source of biogas plant. The gas then will be filtered, compressed and liquefied as a replacement of LPG. This paper will conduct a feasibility study of biogas bottling from organic waste in Indonesia.*

**Keywords:** Biogas, LPG, Biogas Bottling, Biogas Plant, Organic Waste

## 1.0 INTRODUCTION

Fuel used for household stove in Indonesia until 2007 still uses subsidized kerosene by the government. Data from the Central Statistics Agency (BPS) in 2007 stated that the use of kerosene for household purposes reached 9.9 million kiloliters per year. The kerosene to natural gas conversion program was carried out by the government in that year as an effort to save the government budget in terms of providing subsidies and as a step to diversify energy supplies to reduce the country's dependence on petroleum. This program, referred to as the "Zero Kero" program, has saved the budget of around Rp. 25 trillion (US \$ 1.76 billion). Natural gas is packaged in several types of bottles with 3 kg green bottles as subsidized bottles and intended for the poor [1].



Figure 1. Illustration of Ordinary 3 kg Natural Gas Bottles [2]

Although the budget savings from kerosene subsidies are significant, natural gas subsidies continue to increase from year to year. Natural gas subsidies are part of government

policy to continue to support domestic gas consumption, especially for households [3].

Since its adoption in 2007, the "Zero Kero" program has been implemented and became one of the main drivers of Indonesia's consistent increase in natural gas consumption at the household level. Government spending on natural gas subsidies in 2015 is expected to reach Rp28 trillion (US \$ 1.97 billion) [3].

Officially, subsidies are only given for 3kg bottles as a way to provide energy access to households with low income. However, in reality PT Pertamina as government's single distributor claims to also sell natural gas bottle of 12kg below its economic price, and make a loss of Rp21.8 trillion (US \$ 1.5 billion) between 2008 to 2013. To overcome this gap, PT Pertamina adopted a price adjustment scheme to increase prices gradually for natural gas (non-subsidized) with scheduled price increases will be conducted every six months since September 2014 [3]. Since then PT Pertamina has been make price adjustments on several occasions. Based on 2015 data, in January, the price of 12 kg gas was raised to Rp.134,700 (US \$ 9.5). On January 19, prices were lowered to Rp. 129,000 (US \$ 9.1). In March, prices were raised to Rp.134,000 (US \$ 9.4), and in April, 12 kg gas prices recorded at Rp142,000 (US \$ 10.03) [3-16].

The first 12 kg natural gas bottle was produced in 1968 as an effort to utilize the side product of petroleum oil. This product was later named as LPG (liquified Petroleum gas) which was used as a trademark by PT.Pertamina [17].

LPG (Liquefied Petroleum Gas) is a factory-made of natural gas that has been liquefied by certain compression. This gas is used as cooking fuel it is clean, safe, volatile and does not give serious damage to the ozone layers [18].



Figure 2. Illustration of Ordinary 12 kg Natural Gas Bottles [19]

The government through PT. Pertamina issued an alternative policy by producing a new variant of 5.5 kg and 12 kg of gas bottles called Bright Gas. This type of bottle offers several advantages over conventional gas cylinders, which are [20]:

1. Double Spindle Valve System Features  
This valve causes the bottle twice safer in preventing leakage on the tube head
2. More comfortable to lift than ordinary bottles  
This is because the Bright Gas bottle has an empty weight of 12.6 kg for the 5.5 kg bottle so it is very light to carry

Bright gas is chosen by the upper middle class household consumers and business markets, especially in the fast food sector with business profits above US \$ 20,682 / year [20].



Figure 3. Bright Gas 5.5 kg Illustration [21]

## 2.0 BIOGAS PRODUCTION

Indonesia produces 66-67 million tons of waste in 2019, with organic waste reaching around 60% or 40 million tons [22]. Most of this garbage will end up in landfills and just be abandoned. By 2021, it is predicted that Jakarta's landfill will be exceeded its capacity [23].

Organic waste itself can be reprocessed, one of which as raw material for biogas. Biogas is a natural fuel which has a high calorific power value within the range of 13,720–27,440 kJ Nm<sup>-3</sup> for methane concentrations of 40 and 80%. It runs under four steps of production: hydrolysis, acidogenesis, acetogenesis and methanation [24]. Biogas can be obtained from fruit and vegetable solid waste which are common product from kitchen waste. These materials are widely diverse therefore sorting systems and methods used for quantifying the waste are necessary as an effort to improve the gas qualities. A data from study shown that

biogas yield from banana waste has the better methane content compared to potato with CH<sub>4</sub> yield of 0.53 m<sup>3</sup>/kg waste [25, 26].

Biogas reactor is a machine used for biogas production at anaerobic condition [27] with some possible procedures which are [28]:

1. Single-stage/ two-stage/ multiple stage procedures
2. Wet anaerobic digestion/ dry anaerobic digestion
3. Mesophilic (35-37 °C)/ thermophilic (55-60 °C) methanisation (methane anaerobic digestion)
4. Dis-continual / continual service.

There are several types of digester including fixed dome, floating dome and balloon digester[29].

The capital and O&M cost of the pilot project example of biogas reactor in Georgia can be seen in the following table:

Table 1. Capital and Operation and Maintenance Costs of a Thermophilic Model Bioreactor [30]

Category	Date of Construction		
	2005 (Model 4)	2005-2010 (Model 5)	2010-2015 (Model 6)
Volume, m <sup>3</sup>	6	6	6
Capital cost of 1 m <sup>3</sup> , USD	600	450	390
Total capital cost, USD	3600	2700	2340
Annual O&M costs, USD	72	54	46,8
Specific daily biogas production, m <sup>3</sup> /m <sup>3</sup>	2	4	6
Daily biogas production, m <sup>3</sup>	12	24	36
Heat content of biogas, MJ/m <sup>3</sup>	22,5	22,5	22,5
Capacity of bioreactor, kW	3,125	6,25	9,375
Daily heat production, kWh	75	150	225
Annual biogas production, m <sup>3</sup>	4380	8760	13140
Annual heat production, MWh	27375	54750	82125

## 3.0 BIOGAS AND BOTTLING COST PRODUCTION

By using the Table 1 approach [30], we obtain the following analysis:

Table 2. Biogas and LPG Cost Production Year 1-3

Category	Model 6		
	Year 1	Year 2	Year 3
Total capital cost, USD [30]	2340		
Annual O&M costs, USD [30]	46.8	46.8	46.8

Category	Model 6		
	Year 1	Year 2	Year 3
Specific daily biogas production, m <sup>3</sup> /m <sup>3</sup> [30]	6	6	6
Annual biogas production, m <sup>3</sup> [30]	13140	13140	13140
Annual methane gas production, m <sup>3</sup> [31]	7884	7884	7884
Annual methane liquid production, m <sup>3</sup> [32]	29.2	29.2	29.2
Annual methane liquid production, kg [32]	53.48	53.48	53.48
Annual 5,5 kg bottle production, bottles	10	10	10
Price of gas refill per bottle 5.5 kg, USD [33]	3.54	3.54	3.54
Total cost, USD	2386.8	46.8	46.8
Total cost , USD/bottle	245.46	4.81	4.81
Subsidy from waste management company, USD/bottle	3.46	3.46	3.46
Profit/Loss, USD/bottle	238.46	2.19	2.19

As the production cost of a single 5.5 kg is US \$4.81, selling the gas refill at market price at US \$ 3.54 will be not profitable. Therefore, a subsidy from waste management company is needed. This company has tasks to collect organic wastes from community and charge them at certain price. The wastes will be then processed at biogas plant.

According to Ogur, E.O.[34], 100 kg of organic waste will produce 24 m<sup>3</sup> of biogas, therefore a calculation analysis is obtained for a business model of waste management company as shown in table below:

Table 3. Waste Management Company Business Model Calculation

Category	Year 1
Annual biogas production, m <sup>3</sup> [30]	13140
Annual organic waste needed for biogas plant, kg/year	54750
Organic waste/household/year, kg/year	498.4
Total household collected, house	110
Operational cost per year, USD	1700
Subsidy cost for gas refill per year, USD	33.64
Service price charged per year, USD	2500
Service price charged per year, USD/household	22.73
Service price charged per month, USD/household	1.89
Company profit per year, USD	766.36
Company profit per month, USD	63.86

From the table above, we have to collect organic waste from at least 110 household with organic waste household production being 1.4 kg/day [35] with assumption there will be 2 people living in one house. The service performed is organic waste collection from house to house with a service price of US \$ 1.89/ month and the waste will be sent to biogas plant as a source of methane. However, the

calculation above is not yet considering the price for gas bottling.

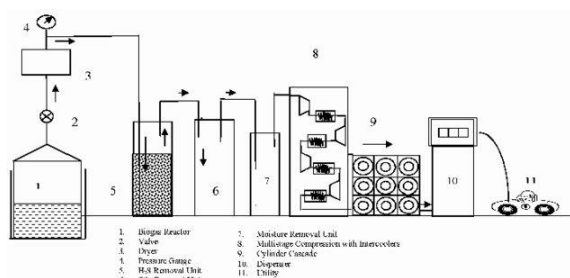


Figure 4. Schematic Layout of A Complete Biogas Reactor with a Bottling Plant [36]

In principle, after biogas is produced in a biogas reactor, this gas will be filtered mainly for emissions of H<sub>2</sub>S, CO<sub>2</sub> and humidity units. After that, the gas will be compressed in four stages. This gas is then ready to be sent to consumers through a dispensing unit as can be seen in the picture above [36].

According to ESDM, production cost for compression technology for natural gas is US \$ 0.29/liter [37] or equivalent to US \$ 0,148/kg [32, 37]. Using this approach, the following table is formed:

Table 4. Biogas and LPG Cost Production with Bottling Cost for Year 1-3

Category	Model 6		
	Year 1	Year 2	Year 3
Total capital cost, USD <sup>[30]</sup>	2340		
Annual O&M costs, USD <sup>[30]</sup>	46.8	46.8	46.8
Specific daily biogas production, m <sup>3</sup> /m <sup>3</sup> [30]	6	6	6
Annual biogas production, m <sup>3</sup> [30]	13140	13140	13140
Annual methane gas production, m <sup>3</sup> [31]	7884	7884	7884
Annual methane liquid production, m <sup>3</sup> [32]	29.2	29.2	29.2
Annual methane liquid production, kg [32]	53,48	53,48	53,48
Annual 5,5 kg bottle production, bottles	10	10	10
Price of gas refill per bottle 5.5 kg, USD [33]	3.54	3.54	3.54
Total cost (without gas bottling), USD	2386.8	46.8	46.8
Total cost (without gas bottling), USD/bottle	245.46	4.81	4.81
Subsidy from waste management company, USD/year	34	34	34
Subsidy from waste management company, USD/bottle	3.46	3.46	3.46
Gas bottling cost, USD/kg [32, 37]	0.148	0.148	0.148
Gas bottling cost, USD/bottle [32, 37]	0.814	0.814	0.814

Category	Model 6		
	Year 1	Year 2	Year 3
Profit/Loss, USD/bottle	- 239.28	1.37	1.37

Whereas the ROI can be seen from table below:

Table 5. ROI Calculation

ROI Calculation	
Investment Cost, USD	2340
Net Income, USD per year	13.7
ROI	0.59%

We can see that the ROI is very low therefore a self-company for biogas bottling is not profitable.

#### 4.0 CONCLUSION

In order to make the biogas bottling plant profitable, we have to collaborate with third parties such as NGOs and government to fund this project. Meanwhile, organic waste collected from 110 household will produce only 10 bottles of compressed liquid biogas per year. Therefore, large scale biogas production is needed with a wider coverage area.

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