# REDUCTION OF METHANE EMISSION TO THE ATMOSPHERE THAT INFLUENCE GLOBAL CLIMATE THROUGH BIOGENIC GAS UTILISATION IN RECENT BIG RIVER MOUTHS, WITH PARTICULAR CASE IN INDONESIA

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## ABSTRACT

Biogenic gas is a natural gas produced mostly in swamp areas of recent large river deltas. The gas composes mainly methane (CH4) of more than 95 percent; other gases such as CO2, H2S and NO2 are less than 5 percent. Methane gas emissions directly to the atmosphere will contribute to global warming; due to its residence period 21 time than other glass house gases (GHG) such as CO2.

Utilisation of biogenic gas would indirectly prevent global warming, because its methane content would be converted to CO2 which of more environmental sound. Utilisation of this alternative energy had been successfully done in a deltaic island of Kapuas River mouth – West Kalimantan. The gas was used to ignite a special low pressure design stove and a generator of 500 Watt capacity. The gas is trapped in a fine sand reservoir of approximately 11 meters thickness and capped by one meter impermeable clay layer. The reservoir is interpreted as a paleo-beach sand.

A policy to utilise biogenic gas in mangrove forests would much reduce methane emission to the atmosphere, due to very large distribution of mangrove in tropical regions. Global emission from mangrove areas in the world is estimated $1.95 \times 10^{12}$ g CH4/year or almost 2 million tons per year.

Key words: methane emission, biogenic gas utilisation, recent big river mouths, Indonesia

## INTRODUCTION

## BACKGROUND

According to United States Environmental Protection Agency (USEPA), methane is a greenhouse gas that remains in the atmosphere for approximately 9 – 15 years. Methane is over 20 times more effective in trapping heat in the atmosphere than carbon dioxide (CO2) over a 100 year period and is emitted from a variety of natural and human influenced sources. Human influenced sources include landfills, agricultural activities, coal mining, stationary and mobile combustion, wastewater treatment, and certain industrial process.

Methane is also a primary constituent of natural gas and an important energy source. Efforts to prevent methane emissions or methane utilization can provide significant energy, economic and environmental benefits. Marine Geological Institute of Indonesia (MGI) in an effort to look for an alternative energy for remote areas, has conducted a study on potentiality of biogenic gas formed in Recent deltaic environment of big rivers of Indonesia as an energy source for rural community surround the gas potency. Biogenic gas is composed of more than 95% methane and other gases such as CO2, H2S and N2 less than 2%.

MGI'S study revealed that methane gas of biogenic origin is formed in deltaic setting of large river mouths. As a part of biogenic gas, methane in nature could be produced by methanogenic bacteria in an anaerobic environment condition, abundances of organic carbon element, and very rapid sedimentation process to immediately trap the generated gas. The best biogenic gas formation, based on MGI's research, is in Kapuas River delta system in West Kalimantan or Borneo. In this setting, based on subsurface geological data, the gas was trapped in sand of paleo-coastal dune and paleo-distributary channel that had already been buried subsurface.

## AIMS

Big river coastal zone is selected due to biogenic gas potentiality for local usage. In terms of economic value of industrial scale, this alternative energy in remote area is of limited resource. The potential gas is trapped in sand lenses of limited dimension; thus, it only could be used for locals. Any commercial used of this limited resource, based on our techno-economy study, would disadvantage for hydrocarbon industry.

Research and development of biogenic gas conducted by MGI aims to fulfil alternative energy needs for remote areas. This program is in accordance with Government policy to look for substitute of fossil fuel that has limited reserve. The R & D of this potential alternative energy is directed to utilize biogenic gas for coastal communities closed to its existence. Coastal communities live in deltas of recent big river of Indonesia hopefully will be beneficial utilizing this alternative energy. Utilization of biogenic gas environmentally would reduce methane emission – as one of many glass house gases (GHG) – which further has global impact in prevention of global warming. Combustion of methane (CH4) will produce carbon dioxide (CO2) and water (H2O). Even though the combustion produce another GHG, but its effect for global warming is much reduced, because methane is twenty one time more hazardous for global warming than carbon dioxide.

On the other hand, Subroto et al (2007) found out that biogenic gas of commercial scale is those occurred in hydrocarbon basins with characteristics of more than 99% methane and carbon isotopic composition range between -61 and -67 ‰. Study of biogenic gas in East Java Basin and Sulawesi found out that geologically the gas trapped in Plio-Pleistocene sediments. Plio-Pleistocene sediments are characterized by high rates of sedimentation, low geothermal gradients and high organic matter content. Commercial biogenic gas requires early formation of stratigraphic or structural trap, adequate early seals, and rapid sedimentation. Early trap formation due to biogenic gas can only accumulate at a free gas phase. According to Subroto et al (2007), a free gas state form when biogenic gas generation exceeds gas solubility in the pore fluid.

## METHODS

Research and development of biogenic gas by Marine Geological Institute of Indonesia is carried out firstly by mapping of the potency. The area chosen is selected based on gas indication observed or information from local people. The method used for potency mapping is marine geology and geophysics. This method is consisted of imaging of subsurface geology using shallow penetration of very high resolution seismic. To assist in interpret sediment sequences of seismic record, drillings are also implemented especially at ship tracks of seismic.

Method for the utilisation is adopted biogas technology developed by dairy farmer. The difference is the gas source. Gas source instead derived from caw manure, it's derived from natural biogenic origin gas.

## INDONESIAN TERRITORY RESPONSE ON GLOBAL CLIMATE CHANGE

State Ministry for Living Environment (2007) has estimated that the whole territory of Indonesia will experience temperature increase. For the Capital City Jakarta average temperature increase is 1.42° C at July, while at January 1.04°C for every century. Region south of equator, such as Java and Bali Islands, pattern of dry and wet seasons will change; thus, it is causing increase risk of flood during wet season and crises of water shortage during dry season.

National Coordination Agency for Survey and Mapping (2002) has conducted sea level rise research on some locations and measured sea rise of 8 millimeter / year. If business as usual, without efforts to reduce emission of glass house gases, it is estimated that by 2070 sea level rise would be 60 centimeters.

Decrease of rain fall due to climate variability and seasonal change followed by temperature increase has given significant impact on water reserve. At El Nino Southern Oscillation (ENSO) events, water level in the dams were getting lower far below normal condition, especially during dry seasons at June to September. This condition was causing electricity shortage; especially in Java where electricity needs are mostly supplied by hydro-power. During ENSO's events 1994, 1997, 2002, 2003, 2004, and 2006; electricity production from 8 dams in Java were below capacity.

The temperature increase especially during El Nino's 1997 had also causing serious problem to coral reefs. The event had destroyed 18% of coral reef ecosystem in southeast Asia. Coral bleaching had taken place in eastern of Sumatra, Java, Bali and Lombok. At Seribu Archipelago of Jakarta Bay, 90-95% coral reefs at sea depth 25 m has suffer such phenomenon.

According to Department of Marine and Fishery, in two years (2005 – 2007), Indonesia has lost 24 small islands. The majority of the submerged islands due to sea water erosion worsen by mining activities for commercial purpose.

## RESULTS

After mapping of gas resource distribution was done and its potency and prospect was known, a pilot plant had been constructed at a house of head village in the island of Sepok Laut which belongs to Kapuas River delta system West Kalimantan. At the beginning a jetting drilling had been carried out at the house village front yard. The drill was executed at a gas bubbling point of the yard during high tide. Sediments in the drill hole consisted of organic clay from ground surface until 1.0 m depth. Immediately below the clay was found quartz sand of fine size and good sorted at 1.0 until 12.0 m depth. The sand is interpreted as gas reservoir which is abundances in carbon organic materials. Below the sand are clay, peat, and marine clay until depth of 39.0 m. After cased and screened, the drill hole was made permanent by concrete and then connected by PVC pipe to the installation in the head village house.

Before being used, the gas was stored in a plastic tube of diameter 3 x 1 m and connected to specially designed low-pressure gas stove and gas generator of 500 Watt capacity, just enough for a small household in a remote area. At least, the biogenic gas electricity could replace communal organized electricity during daylight, because at night the electricity has been provided by the community itself using petroleum fuels.

The storage of gas is necessary because of its low production. The storage is of 3 x 1 m3 volume and is made of plastic tube. During gas sampling, 1 liter gas was captured in 1-2 minutes; it means that to fulfill 1 m3 volume, it requires approximately 16 hours. Thus, to fill in 3 m3 gas storage, it needs 48 hours or two days. Our plant is estimated capable to supply gas for 3 stoves simultaneously. For gas generator, the consumption was not figured yet, how long will it last for 3 m3 gas storage.

The installation was carried out in 2008, and until now it still works. Based on this experience and observation on mangrove condition in Kapuas Delta, methane production seems related to mangrove conservation. This habitat can preserve methane zone underneath. As long as mangrove habitat is preserved, the methane will continue to produce. Furthermore, under normal geological condition, 1,0 % organic matter in mangrove soil can be converted into methane through biogenic processes (Katz, 1995). This corresponds to 4.9 m3 CH4/%TOC/m3 sediment. In the study area, total organic carbon (TOC) is ranged from 9.82 % at the surface until 0.20% at drill-hole depth 40 m. This figure reveals the potency of biogenic gas accumulation in Kapuas Delta: 48.1 m3 CH4/%TOC/m3 sediment at the surface until 0.98 m3 CH4/%TOC/m3 sediment at about 40 m below surface. Specific density of methane is 0.5537.

The Indonesian's government through coordinating minister for economy, finance and industry has developed a program to utilize biogenic gas. For this purpose, the minister had formed a study group called gas working group (in Bahasa Indonesia Kelompok Kerja – Pokja Gas). The working group has classified biogenic gas as cluster gas. It puts together with flare gas resulted from petroleum exploitation well (Figure 1). Nowadays, the flare gas has been piped into households in the city, such as already done in coastal City of Cirebon – northeast of West Java Province.

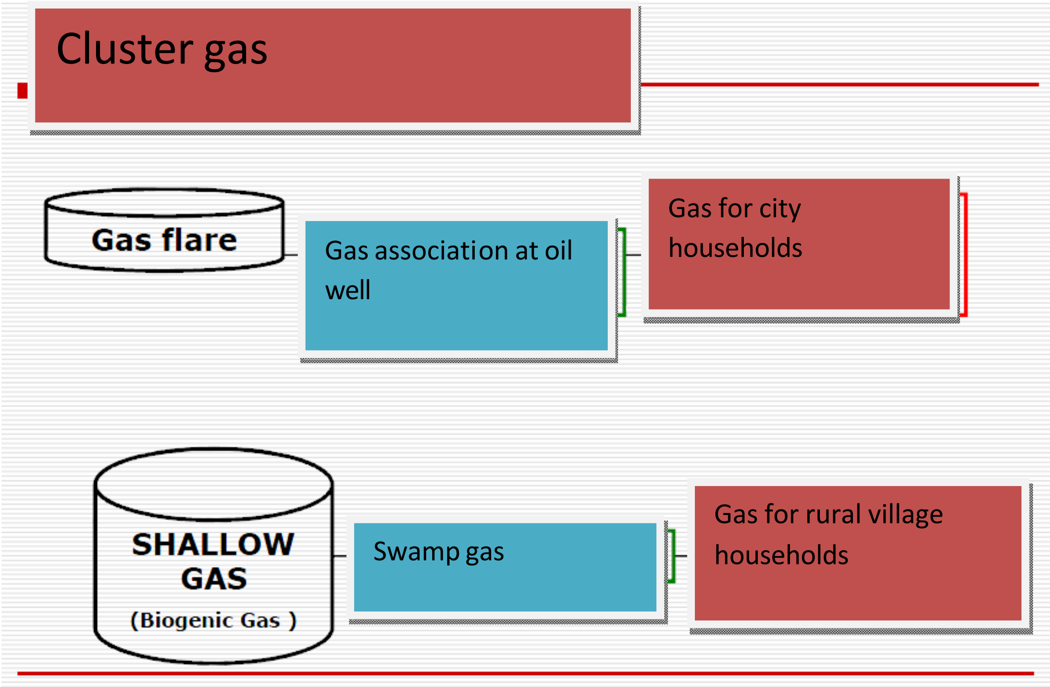


Figure 1. Classification of biogenic gas based on its utilization (Gas Working Group, 2008)

Biogenic gas as a shallow gas that is mostly found in swamps of large river deltas is planned to fulfill energy needs of rural households. This government program meant to anticipate energy crises experienced nowadays. Thus, exploitation of this shallow gas is a must, especially for areas that have this potency. To fulfill this task, the government through Marine Geological Institute of Indonesia has conducted a study to find out its potency. Many coastal areas of large river deltas throughout Indonesian territory, especially western regions had been surveyed. The program includes exploitation plan to support kerosene substitute by gas. This program is also guided into an energy independence village or in Indonesian "Desa Mandiri Energi" (Figure 2).

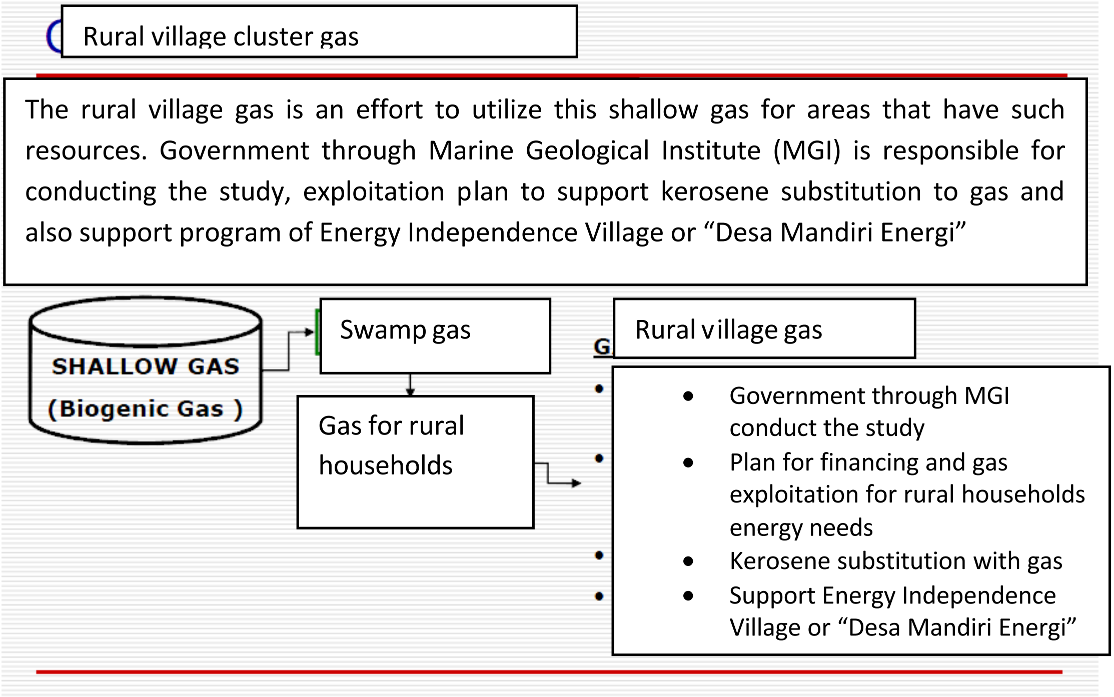


Figure 2. Biogenic gas program for rural villages (Gas Working Group, 2008).

The strategy to implement the program is conducted through steps as could be seen in Table 1.

Accidentally, possibly due to urgent energy needs, people closed to biogenic gas deposits have been utilized it in simple way. Gas bubbling at surface water is just piped into a stove in their kitchen for cooking (Figure 3). The pipe used is PVC or any other plastic pipe from gas sources. Sometimes, rural village's people can't afford to buy a gas stove. Simply, they just used the pipe which its end is used heat resistance iron tube and put it in a traditional brick stove (Figure 4).

TABLE 1. STRATEGY OF PETROLEUM CONVERSION TO SHALLOW GAS OR BIOGENIC GAS (GAS WORKING GROUP, 2008).

| NO. | GAS TYPE | SYSTEM | PLAN | CONVERSION LOCATION | INSTITUTES INVOLVED |
|---|---|---|---|---|---|
| SHALLOW GAS | | | | | |
| | RURAL HOUSEHOLDS | SHALLOW GAS UTILIZATIONS AS FUEL FOR HOUSEHOLDS | DISTRIBUTION NETWORK CONSTRUCTION OF SHALLOW GAS | 1. CENTRAL JAVA<br>2. JAMBI<br>3. WEST KALIMANTAN<br>4. EAST KALIMANTAN<br>5. SOUTH SUMATRA<br>6. EAST JAVA<br>7. WEST JAVA | MINISTRY OF ENERGY & MINERAL RESOURCES, LOCAL PROVINCIAL/CITY/REGENCY, INTERNAL MINISTRY |

Figure 3. Utilisation of shallow gas for rural households in Banjarnegara, Central Java (Foto courtesy of Gas Working Group).

Figure 4. Biogenic gas is directly used for cooking using iron tube at its end. The example is from a rural household in Sragen, also Central Java (Foto courtesy of Gas Working Group)

MGI office encourage people to use biogenic gas existed surround their place, such as had been done with a family in South Indramayu West Java Province. The office had donated a special design low-pressure stove to the family (Figure 5).

Figure 5. Visit to a house at south of Indramayu City – West Java Province. The residence has used biogenic gas as their energy source for daily cooking. A simple technology has been applied by the residence; the gas is piped through PVC tube from the source – a hand auger well, to an iron tube in the kitchen. The figure shows that the iron tube was replaced by a specially design low pressure stove donated by MGI.

## DISCUSSION

Basic concept for carbon trade in clean development mechanism nowadays is only focus on an effort to reduce one of many glass house gases, $CO_2$. For methane gas there is no clear basic concept, even though it always mentioned at every meeting of climate change either nationally or internationally. This is due to $CH_4$ emission claimed to be small, compared to $CO_2$ emission resulted from deforestation and fossil fuel combustion. Research on mangrove concluded that this view should be reconsidered; as the ecosystem releases $CH_4$ in large quantity, almost 2 million tons per year, to the atmosphere and having potential for global warming agent. Its global warming potential is 21 times greater than $CO_2$. According to Setyanto (2004), methane emission from paddy field is also potential for global warming. Agriculture extension and intensification tends to increase methane emission, and any effort to reduce paddy field methane emission has strategic value especially currently relate to demand raise of food.

Indonesian Government in response of future global warming has launched a National Action Plan in Facing Climate Change document. The President of the Republic of Indonesia, in the preface, stated that the National Action Plan document is a dynamic policy instrument that needed to be periodically evaluated, renewed, and corrected in accordance with the dynamic of climate change. He hopes that the Action Plan could be implemented accordingly and as a guide for all related government institutions, either in the Central or Local government, in putting into practice current or future development. Thus, the National Action plan is necessary to be put into Long Term Development program 2005-2025 or Middle Term (State Ministery for Living Environment, 2007). Program for energy sector in facing climate change is shown in Table 2.

Table 2. Execution of National Action Plan in Facing Climate Change – Energy Sector (State Ministery of Living Environment, 2007).

| Number | Activities | Time Frame | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2007-2009 | Responsible Institution | 2009-2012 | Responsible Institution | 2012-2025 | Responsible Institution | 2025-2050 | Responsible Institution |
| a | Energy Generator | 1. GHG inventory and reduction potential<br><br>2. Insentive and fiscal reduction for technology of GHG low emission<br><br>3. Geothermal potency inventory overlaying with conservation forest<br><br>4. Plan for implementation of CCS technology<br><br>5. Plan for turbin construction using renewable energy (solar, wind, biomass, geothermal) in accordance with local characteristics<br><br>6. Substitution of energy sources with low emission alternative (such as natural gas) | Ministry of Energy and Mineral Resources, Financial Ministry, Ministry of Living Environment, local government | 1. Continuation of inventory of GHG low emission technology<br><br>2. Construction of electricity generator using renewable energy accordance with local charactristics<br><br>3. Infrastructure development for CCS technology<br><br>4. Continuation of substitution of energy sources with low emission energy (natural gas) | Ministry of Energy and Mineral Resources, Financial Ministry, Ministry of Living Environment, local government | 1. Continuation of activities of previous period<br><br>2. Operational of CCS technology<br><br>3. Reduction target of 30% emission to BAU (by using CCS technology) | Ministry of Energy and Mineral Resources, Financial Ministry, Ministry of Living Environment, local government | 1. Continuation of activities of previous period<br><br>2. Reduction target of 50% emission to BAU | Ministry of Energy and Mineral Resources, Financial Ministry, Ministry of Living Environment, local government |

In Indonesia, mangrove forest areas are decreasing rapidly from about 8 million hectares at 15 to 20 years ago until 2.5 hectares recently (Cifor, 2011). Although mangrove forestry area only covered 0.7 % of total forest, the habitat could release 10% of total carbon emission in the world. Carbon in this ecosystem is mostly kept in the soil underneath mangrove forest. In this wet soil ecosystem, carbon storage could reach 800 – 1,200 ton per hectare (Cifor, 2011). Carbon emission to the atmosphere is much lower compared to terrestrial forests; this is due to plant degradation of mangrove does not emit carbon to the air. Other tropical vegetations will emit directly 50% of its carbon content.

In excess of carbon emission resulted from organism metabolism activities to the atmosphere is in itself a pollution which gave negative impact to the environment, which further would influence global scale climate. Accumulations from small changes would be directed onto great changes. Carbon emission could take forms of CO2 (carbon dioxide) from organism respiration and CO (carbon monoxide) from fossil fuels or petroleum. Other activities such as garbage burning (Indonesian context), smoking, emits of methane (CH4) natural gas, glass house gas such as HFC (hydrofluorocarbon) or PFC (perfluorocarbon) and others also contribute to carbon gas increase in the nature.

Mangrove forest has density four times than other tropical forest, thus, its carbon storage capacity is much greater. Mangrove forest and tidal swamp absorb atmospheric carbon and locked it into soil for hundredths until thousand even million years.

Due to its great carbon absorb capacity, mangrove habitat could act as carbon sinks for atmospheric carbon dioxide. The gas is taken up by the growing trees and is kept into its wood. Migration process of carbon dioxide from the atmosphere into vegetation and seas is termed carbon sequestration.

## CONCLUSIONS

Utilisations of biogenic gas could reduce methane emissions to the atmosphere. As one of many green house gases, methane is over 21 times more effective in trapping heat in the atmosphere than carbon dioxide (CO2) over a 100 year period.

Methane emission could be reduced by its utilisation as an alternative energy in remote areas, such as has been done by remote communities encouraged by Indonesian’s Government.

A policy to utilize biogenic gas in mangrove forests would much reduce methane emission to the atmosphere, due to very large distribution of mangrove in tropical regions.

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