BIOGENIC GAS IN DELTAIC DEPOSITION ENVIRONMENT IN KAPUAS RIVER, WEST KALIMANTAN AND ITS UTILIZATIONS FOR LOCAL COMMUNITY

By :

Hananto Kurnio and Yudi Darlan [1]

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ABSTRACT

Biogenic gas within a deltaic deposition environment in the Kapuas rivermouth of West Kalimantan occurred in fine to very fine quartz sand reservoir of shallow boreholes of having the depth of 1-12 m below ground surface. This reservoir is covered by peaty layers of semi-impermeable property. During high tide, gas bubbling took place in the water column above the ground of these semi-impermeable layers.

Utilizations of biogenic gas had been done succesfully. These works were carried out through drilling, piping, gas storage and installations for gas stove and gas electricity generator of 500 watt capacity at chief village house as an example before widely used to the local community.

Keywords: Biogenic Gas; Deltaic Deposition Environment; Kapuas River; west Kalimantan, Utilization.

SARI

Gas biogenik dalam suatu lingkungan pengendapan delta di muara Sungai Kapuas Kalimantan Barat terdapat dalam reservoar pasir kuarsa berukuran halus hingga sangat halus pada kedalaman bor dangkal 1-12 m di bawah permukaan tanah. Reservoar ini ditutupi oleh lapisan gambut semi-impermeabel. Selama pasang naik, gelembung gas teramati dalam kolom air di atas permukaan lapisan semi-impermeabel ini.

Pemanfaatan gas biogenik telah dilaksanakan dengan sukses. Pemanfaatan ini dilakukan melalui pemboran, pipanisasi, penampungan gas dan instalasi untuk kompor gas dan generator listrik berbahan bakar gas kapasitas 500 watt di rumah Kepala Desa sebagai contoh sebelum dimanfaatkan secara luas oleh masyarakat setempat.

Kata kunci: Gas Biogenik, Lingkungan Pengendapan Delta, Sungai Kapuas, Kalimantan Barat, Pemanfaatan

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1. **Marine Geological Institute of Indonesia**
   Jl. Dr. Junjunan No. 236 Bandung 40174 Indonesia, tlp. 62-22-6032020 ext.148,
   fax. 62-22-6032151, email address: hkurnio@yahoo.com, ydarlan@yahoo.com

INTRODUCTION

Biogenic gas is a type of gas produced by bacteria metabolism activities in an unaerobic environments of a deltaic deposition system. This gas occurs in a shallow depth of less than 100 meters, in Kapuas delta, with a rapid sedimentation rate, and abundant of organic carbon materials.

Marine Geological Institute of Indonesia (MGI), as a government research and development institute, has conducted a study of this alternative energy resource since 2001. The study aims to look for the source potential that could be developed and readily utilized for local community closed to the gas deposits. The assessment refers to China, Yangtze deltaic system in eastern coastal zone, that had been successfully utilized this gas for local residents and village enterprises (Qilun, 1995).

The history of biogenic gas study was started with gas exploration in Juwana waters, northern coastal zone of Central Java in 2001. This exploration used marine geological and geophysical methods to produce the map of gas distribution; such methods were consisted of single channel reflection seismic of shallow penetration (less than 100 meters) and high resolution analog images which were combined with offshore drilling to interpret the seismic analog records.

Since then, the gas exploration was conducted elsewhere in northern coasts of Java and southern coasts of Madura islands. These activities are in accordance with the government policy to find out alternative energy resources in remote areas where state electricity and fuel unavailable.

Study of biogenic gas in deltaic environment of Kapuas River in West Kalimantan was carried out since 2004 (Figure 1). Indications of such gases were obtained from this study, and analyses of gas samples brought to MGI office in Bandung by gas chromatography method resulted in more than 85 percent of methane gas content. Intense exploration efforts were conducted in the following year in 2005 to map the gas distribution in the Kapuas delta area. With combination of shallow seismic and offshore and coastal drillings, the gas was succesfully mapped which spread from coastal waters, less than 10 meters sea depths, towards the deltaic system onshore. It covers approximately 350 square kilometers delta area. It also covers populated deltaic islands where the Sepok Laut is the most prospect, while other islands are less prospect.

KAPUAS DELTA

The deltaic deposition environment of Kapuas River in west Kalimantan consisted of upper delta plain, lower delta plain and marine environment (Figure 2). At the coastal zone, the lower delta plain can be classified into distributary channels, swamps, deltaic islands and coasts.

The marine environment is composed of delta front and prodelta; the delta front environment is characterized by sandy sediments derived from river bed load. While prodelta sediments are suspension materials deposited in shelf of weak marine influences (Kurnio *et al*, 2009).

The deltaic deposition environment was assessed through earthgoogle for Recent surficial geomorphology and drillings for subsurface geological conditions. Drilling works were carried out in Recent distributary channels, swamps of deltaic islands, distributary mouth bars and delta front.

Distributary Channels

Distributary channels consists of active and non-active channels. Based on sediment distribution mapping in the channels (Darlan et al, 2005), the active channel was composed of sandy sediments; while non-actives were made of silty and muddy sediments with rich in organic materials. In the Kapuas River

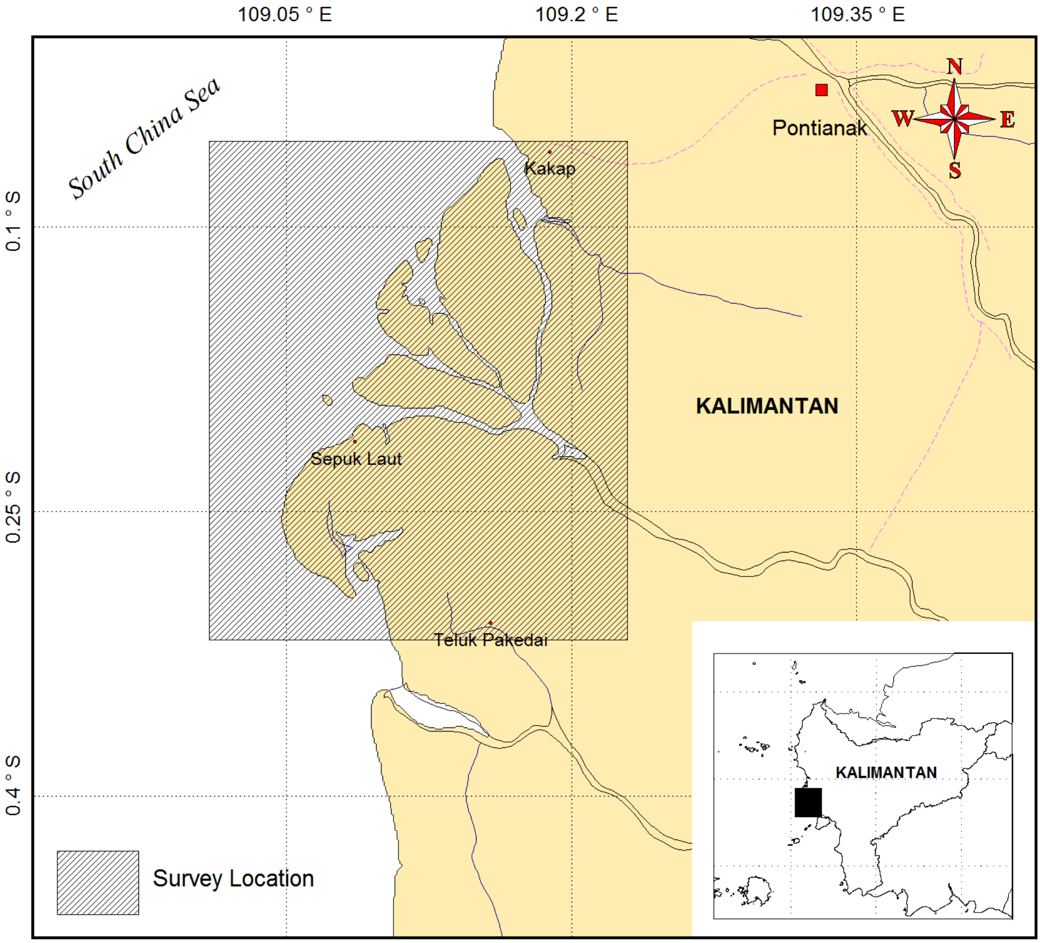

Figure 1. Location study of Kapuas Delta (red box dot lines)

delta, these channels formed populated deltaic islands.

Well observations located in the distributary channel, upper part (0 – 4 meters) consists of brownish sand of very fine size composed by dominant quartz grains of well sorted. This sand is characteristically of active channel deposit. Immediately below sand unit of 4 up to 20 meters was found mud and clay of dark gray color enriched in plant fragments, characteristics of non-active channel deposit. Thus, this sequence shows a shift of deposition environment from active channel (upper part) to non-active channel (lower part).

Swamps

Swamps are distributed in a lower deltaic plain of deltaic islands. Well observations, swamp deposits consists of mud and clay up to 49 m depth below sea bottom. Below this organic clay was deposited homogenous marine clay of greenish gray color of 46 meters thick (49 – 95 m). Closed to 100 m of bore depth, the lithology changed gradually

Figure 2. Recent deltaic deposition environment of the Kapuas Delta (from earthgoogle satellite imagery). Marine environment consist of prodelta, delta front and channel mouth bar; while lower delta plain composed of deltaic islands, distributary channels, swamp and coast. Upper delta plain was not discussed due to not located in coastal zone. Numbers are drilling locations.

into kaoline characteristics of weathered granitic basement rock.

Distributary Mouth Bar

Depositional environment of distributary mouth bar observed from well consists of sand up to 4 m of bore depth, sandy mud (4–10 m) and organic clay (10 - 20 m).

Delta Front

Delta front together with distributary mouth bar occurs in a marine environment. Observation of drilling data up to 11 m depth consists of sandy clay and sandy mud. Marine mud underlying the sandy sediments up to 13 m, followed by kaolinitic clay until 20 m of bore depth.

FORMATION OF BIOGENIC GAS

As mentioned earlier, biogenic gas consists more than 85 percent of methane (CH_4). Methane formation could be directly observed at bogs and swamp or marsh due to closed surface occurrences and emittences of

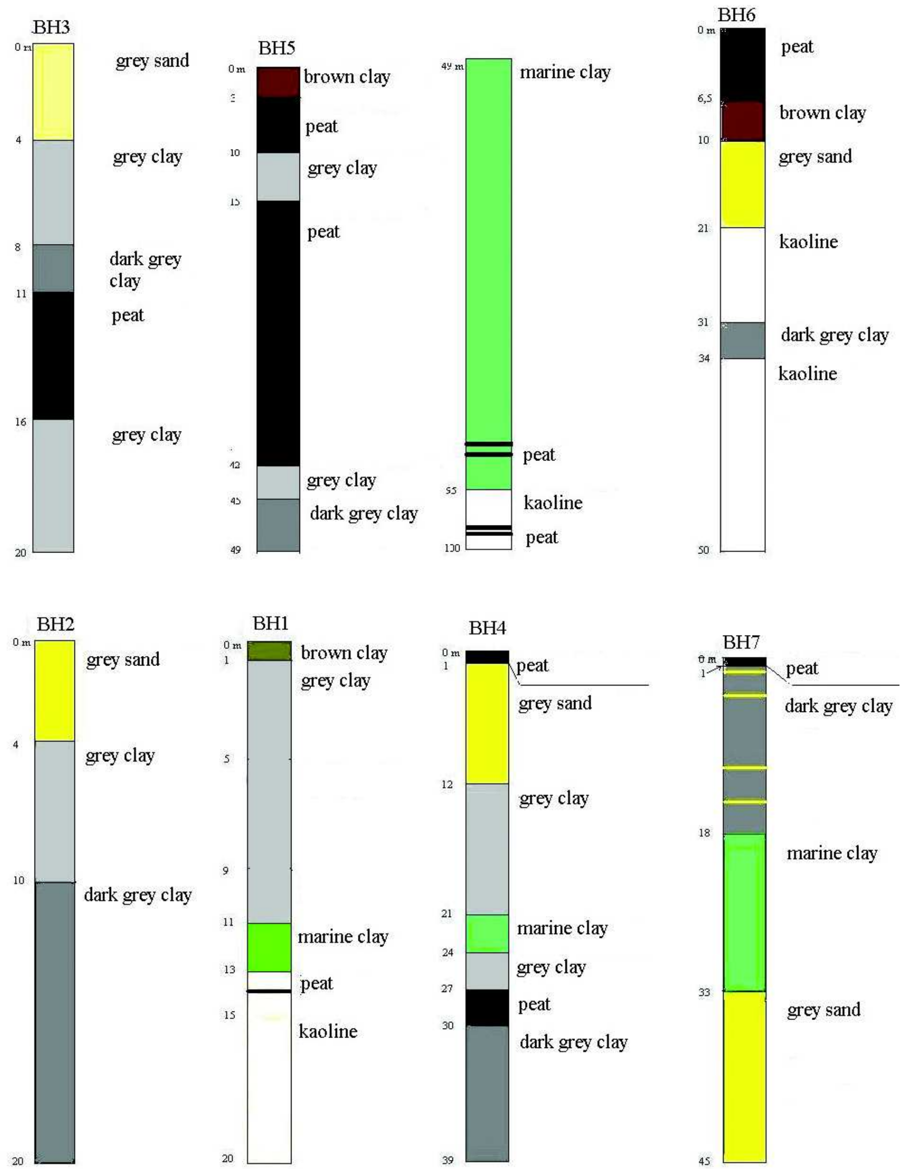

Figure 3. Well megascophic description of drill holes: BH 3 represents current distributary channel, BH 5 and 6 Recent swamp deposition environment, BH 2 distributary mouth bar, BH 1 Recent delta front, while BH 4 and BH 7 wells of biogenic gas deposits in village Chief front yard and Tanjung Gemuk approximately 2 km southwest of village chief house.

gas bubbling from the sediment (Rice and Claypool, 1981). At open marine sediments, methane formation is hard to be observed in the surface due to prerequisite condition required, dissolved sulfate must be totally eliminated from pore water. This condition is could only be reached after a period of burial of marine sediments up to 10 meters depth.

Micro-organism of methanogenic bacteria consume energy for growth and cell maintenance through metabolism of organic materials. This metabolism produces gases which include methane. Two general types of metabolism processes by micro-organism in a marine environment (Rice and Claypool, 1981), (1) respiration (either aerobic or anaerobic) utilized anorganic compound, and fermentation using organic compounds.

Figure 4 is a schematic section of an organic-rich sedimentation environment of open sea which described microbe ecosystem sequence. Interactions between sedimentological and ecological factors resulted in three distinct biochemical environments. Each environment is characterized by a dominant respiration metabolism feature. The three zones are: aerobic zone, anaerobic sulfate-reduction zone, and anaerobic carbonate-reduction zone (methane production). In each zone, the dominant microbe population exploits the environment and produces a new environment beneficial to another population. Thus, transition between zones as a geochemical consequence of environmental change stipulated by micro-organism.

According to Rice and Claypool (1981) as ecological sequence at Figure 4 obtained, the biochemical zone moved upwards with time, following new sediment additions at interface between water-sediment. As a consequence, the deposited sediment moved downwards through diagenetic environment sequence.

Aerobic zone in a marine environment normally developed in water column, and the uppermost part of sediment column. During aerobic respiration, the oxygen quickly depleted especially at areas of high sedimentation rate. When the oxygen totally eliminated, the aerobic organism could not developed.

In a marine environment, sulfate reduction is becoming the dominant respiration form after formation of anaerobic condition due to relatively high sulfate concentration in normal sea water (0.028 M). Only a few microbe species can tolerate H2S as a final product of sulfate reduction.

Under sulfate-reduction zone, CO_2 reduction is the dominant anaerobic respiration process which produce methane formation. It seems that speedy methane formation is started immediately after dissolved sulfate reached low concentration and sulfate reduction perfectly achieved. Several studies stated that methane was consumed at sulphate-reduction zone. Thus, balance between methane production and consumption is an important factor that control methane distribution in marine sediment.

Methane-producer micro-organism has very limited growth compared to sulphate reduction organism in the media used for further development. CO_2 reduction seems to be the most probable mechanism for biogenic methane formation, and it seems to occur for all methane produced in marine environment, even though it also can be produced through other processes.

UTILIZATION : A DISCUSSION

Utilization of biogenic gas had been tried in the house of village the chief of Sepok Laut Island – Kapuas Delta. The project was started with drilling in the front yard of the chief house. This bore hole location was selected based on the gas bubbling observed during high tide. Total depth of drilling reached 39 meters which consist of organic clay of semi-

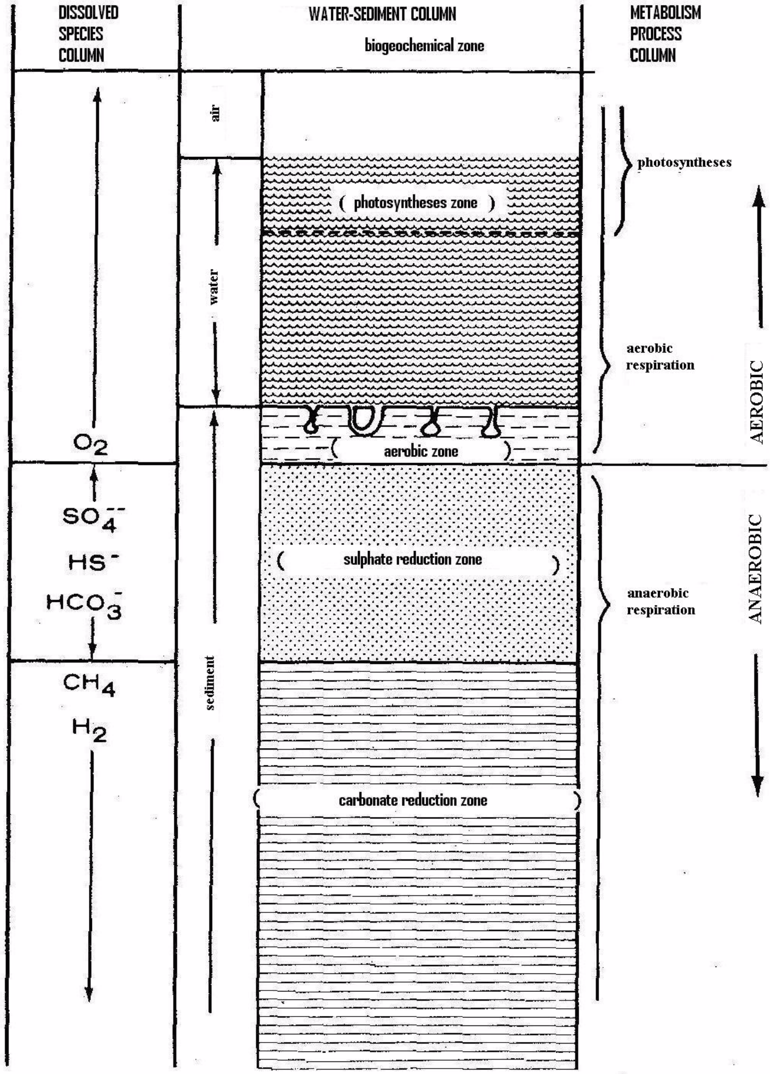

Figure 4. Diagrammatic cross section of organic-rich, open-marine environment showing succession of microbial ecosystems that lead to methane generation (Rice and Claypool, 1981).

permeable property from the ground surface to 1 m depth. Gas bubbling was observed emitted from this layer at high tide flooding. Below this clay, very fine to fine sand layer of 11 m thick was deposited. Its loose behavior and high organic content caused this sand is assumed as biogenic reservoir. Other sediment units underlying sand are mud (12-21 m bore depth), marine mud (21-24 m), sandy mud (24-27 m), wood and plant remnants possibly of mangrove origin (27-30 m) and brownish grey mud (30-39 m). Well of this utilized drilling can be seen in Figure 3.

In order to be exploited, the drill hole was made with PVC tube casing until 39 depth. The sand part of the casing (1-12 m drill

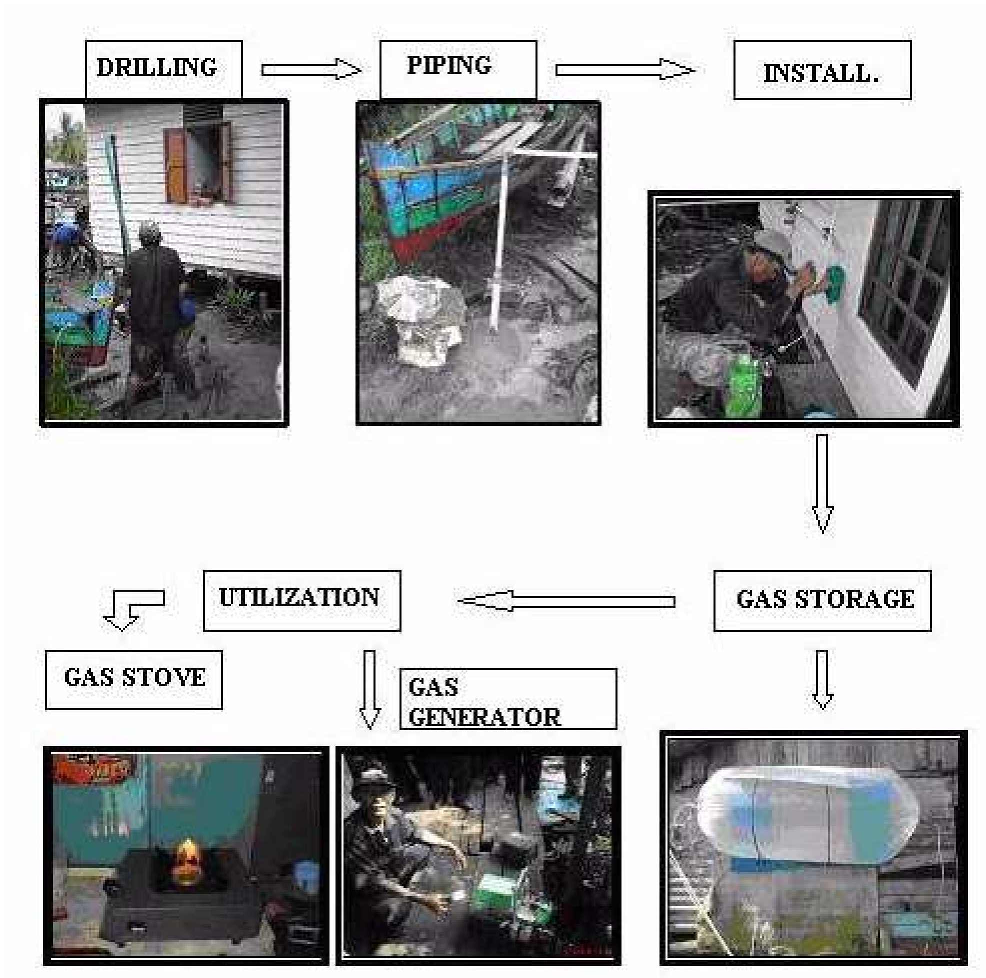

Figure 5. Scheme of biogenic gas trial and utilization in Sepok Laut Island

depth) was perforated to let the biogenic gas accumulated in the PVC tube. Before gas piping to the chief house, the drilling structure was reinforced with Portland cement.

The gas was chanelled to gas storage installation in the house before being used for gas stove in the kitchen and as fuel for gas generator for electricity purpose. This biogenic gas must be stored first due to low productivity; just to fill 1 liter plastic bag, it required 2 to 3 minutes. The gas was kept in storage of plastic tube of having a diameter of 1 meter and length of 3 meters.

The experiment was run for cooking showing the system was working well, boiling approximately 5 liters fresh water, it required 22 minutes compared to 20 minutes using LPG gas stove. For electricity it still need further study how much gas consumption is required for the electricity especially during the night. The 3 cubic meters gas storage didn't enough for the whole one night electricity.

Figure 3 shows well of drilling in Tanjung Gemuk location for approximately 2 kms south west from the chief village house that had not been utilized yet, instead of its high prospect. Gas bubbling was observed intensely in the water table inside the PVC tube. Total depth of drilling carried out by the second author survey team reached 45 meters, and the gas reservoir was also assumed to occur in sand layers of 33 to 45 m.

Technology used for biogenic gas utilization was simple that adopted from biogas technology utilized by dairy farmer. This technology is suitable for remote areas such as the Sepok Laut Island. Beside low technology for the utilization, it also require low cost for the installation. Biogenic gas trial and utilization is shown in Figure 5.

Gas stove used is a specialized design for low pressure stove developed by dairy farmer; while gas generator utilized was of capacity 500 watt imported from China.

CONCLUSIONS

The availability of alternative energy, in this case biogenic gas, for coastal community closed to the existence of gas deposits is the main objective of this study. We confident that this alternative energy can be used in the future, especially for coastal areas of Indonesia. The effort here is to help local community especially in remote areas to fulfill their energy needs especially this time where the price of oil and gas from hydrocarbon unaffordable by most people. The continuity of biogenic gas supply required continuous exploration of other gas traps in this Delta Kapuas area.

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