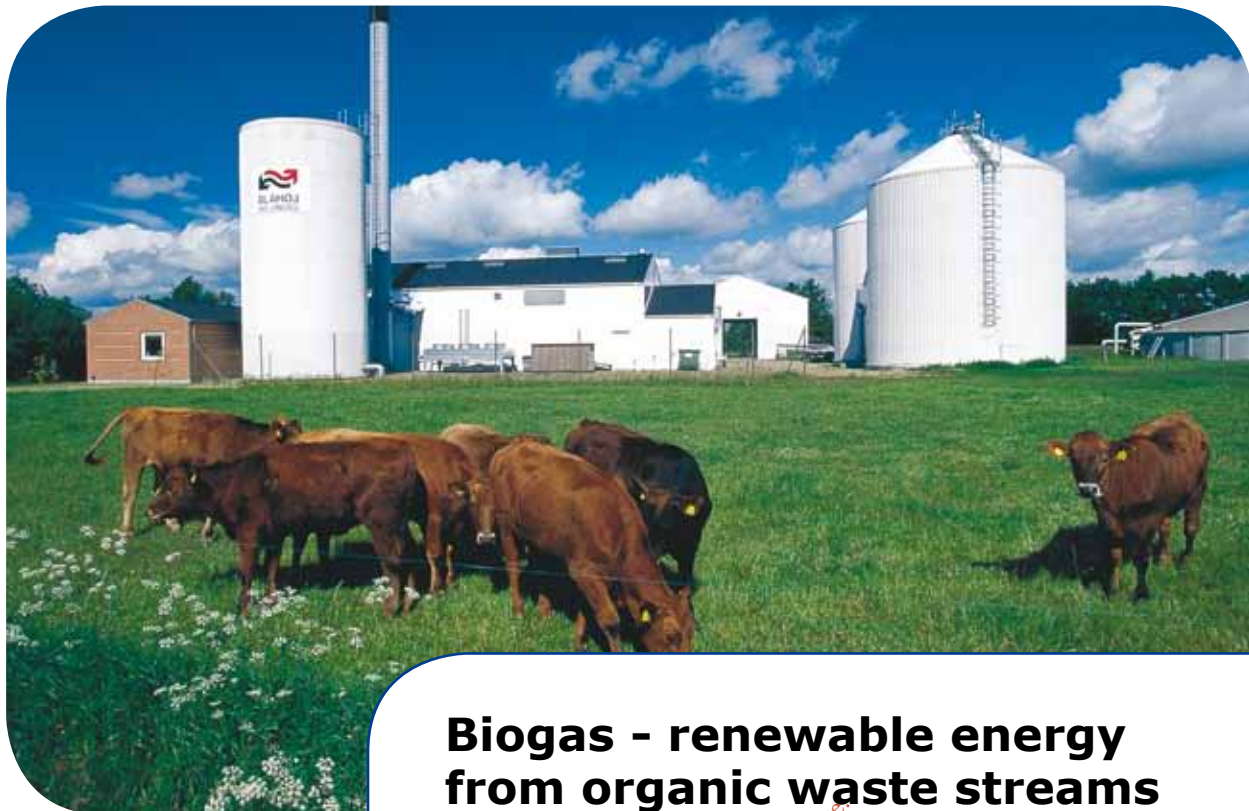


# Attachment 5

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## Biogas - renewable energy from organic waste streams

There is increasing focus on protecting the environment and exploiting renewable energy sources. It is now mandatory to treat industrial and agricultural waste streams before discharge. This applies to farms with livestock, food processing plants, breweries, palm oil mills, starch factories, ethanol distilleries, paper mills and municipal sewage treatment plants. The most cost-efficient method to degrade the organic matter in the waste streams is a biological process without oxygen called anaerobic digestion. Besides breakdown of the organic matter the anaerobic process also produces biogas. Biogas contains 50-70% methane ( $\text{CH}_4$ ), 30-50% carbon dioxide ( $\text{CO}_2$ ) and 0.1 to 3.0% (1,000 to 30,000 ppm) hydrogen sulfide ( $\text{H}_2\text{S}$ ). If the  $\text{H}_2\text{S}$  is removed biogas can be a significant resource as renewable substitute for oil and gas.



### Why it is necessary to reduce the $\text{H}_2\text{S}$

$\text{H}_2\text{S}$  will form sulfur dioxide ( $\text{SO}_2$ ) and sulfuric acid ( $\text{H}_2\text{SO}_4$ ) during combustion which results in a very aggressive corrosion. The corrosion will literally reduce the downstream equipment's lifetime by years! This is why gas engine manufacturers require that  $\text{H}_2\text{S}$  in the clean gas must not exceed 100-250 ppm. Otherwise, the operating costs for change of engine oil, spark plugs and other maintenance will increase significantly. Furthermore, there will be high costs for repairs and income lost during overhauls and break downs. Air quality standards are another driver as combustion of un-cleaned biogas will result in acid rain from emissions of sulfur dioxide ( $\text{SO}_2$ ).

**BIO**  
**GASCLEAN**

the key to efficient  
and successful  
utilization of biogas

## BioGasclean has the optimal solution for your biogas plant

BioGasclean supplies a full range of biological H<sub>2</sub>S removal systems; from small gas cleaners to the world's largest biological gas cleaners at ethanol distilleries and paper mills. The gas cleaners can be designed to handle any flow and H<sub>2</sub>S content in the raw biogas. Typically the H<sub>2</sub>S is reduced to 100-250 ppm but BioGasclean can reduce to lower values if required.

The process is 100% biological and operating costs 80-90% lower than chemical gas cleaning systems as the BiogasCleaners neither consume caustic soda nor require frequent media replacement such as iron sponge, activated carbon, etc. The availability is above 98 %. The only residue from the process is a valuable liquid fertilizer. Therefore, a gas cleaner from BioGasclean is not only economically but also an environmentally sound investment.

BioGasclean offers 4 types of gas cleaners:

- Tanks built on-site** for high H<sub>2</sub>S loads
- FRP tanks** for medium and larger H<sub>2</sub>S loads
- Containers** for medium H<sub>2</sub>S loads
- ECO scrubbers** for small H<sub>2</sub>S loads



- ▲ 7 x 1.6 MW gas engines  
at Kruger Landfill, Quebec, Canada  
6,500 m<sup>3</sup>/h - 3,820 scfm - 1,300 ppm H<sub>2</sub>S
- ▲ 3 x 1 MW gas engines  
at KLK Mandau, Sumatra, Indonesia  
1,200 m<sup>3</sup>/h - 710 scfm - 2,500 ppm H<sub>2</sub>S
- ◀ 8 x 1 MW gas engines  
at Shakarganj Mills, Pakistan  
5,000 m<sup>3</sup>/h - 2,940 scfm - 30,000 ppm H<sub>2</sub>S
- ▼ Shakarganj Mills, Pakistan







## How it works

At the inlet to the scrubber tank atmospheric air is injected into the raw biogas as the biological H<sub>2</sub>S removal process is aerobic, i.e. requires oxygen. The packed bed houses the bacteria which oxidize H<sub>2</sub>S to sulfate. The scrubber liquid is trickling down the packed bed and provides moisture and nutrients for the bacteria. The effluent from the scrubber tank is a liquid fertilizer which is recycled together with the treated water and biomass from the anaerobic digester.

## Simple and robust design

The BiogasCleaner is an advanced fully automated bio-trickling filter and comprise the following 3 main systems:

**The PTU** - Process Technique Unit - is the machine room and contains circulation pumps, air blowers, PLC controller board, etc., installed in a customized housing of reinforced fiberglass (FRP) or modified shipping container.

**The scrubber tanks** are manufactured in FRP or mild steel with an acid-proof liner. The diameter and height of each tank is tailor made to each project. In many projects one tank is sufficient; in other projects 2 or more tanks are required. The tanks are supplied with ladder and roundbar. If the location is outside the tropical zone the tanks are insulated and the gas cleaner supplied with a heating system.

**The packing media** is manufactured in plastic (PP - polypropylene) and forms a packed bed inside the tanks.



▲ *Roi Et Flour, Thailand*  
700 m<sup>3</sup>/h - 410 scfm - 3,000 ppm H<sub>2</sub>S

▲ *Minnesota Municipal Power Agency, Minnesota, USA*  
3,900 m<sup>3</sup>/h - 2,290 scfm - 2,500 ppm H<sub>2</sub>S

▲ *Maabjerg Bioenergy, Denmark*  
3,600 Nm<sup>3</sup>/h - 2,120 scfm - 3,000 ppm H<sub>2</sub>S



Sinar Permatang Mulia,  
Sumatra, Indonesia  
- 2,000 m<sup>3</sup>/h  
- 1,180 scfm  
- 2,500 ppm H<sub>2</sub>S



### BioGasclean's QSR® system secures maximum availability

BiogasCleaners with on-site tanks and FRP tanks are constructed with the QSR® - Quick Sludge Removal - system. During QSR® cleaning the tank is filled with water and pressurized air is injected in the bottom of the tank so the packing media is washed like in a big washing machine. The QSR® system makes it possible to clean the tank for sulfur and gypsum sludge without emptying the tank for packing media. It is a unique assurance against revenue loss from long interruptions of power and heat production.

### BioGasclean's MUW® system gives lowest operating costs

In many projects treated water from the anaerobic digester is used as scrubber liquid and nutrient source as this gives ultra-low operating costs. In order to prevent scaling and clogging inside the scrubber tank the waste water is first pre-treated with sulfate from the biological process in MUW® (Make-Up-Water) tanks. The calcium and magnesium reacts with the sulfate and settle in the MUW® tanks before the treated water is pumped into the scrubber tank.

### BioGasclean A/S

BioGasclean is specialized in biological desulfurization of biogas and landfill gas. The company develops, manufactures and markets advanced fully automated bio-trickling filters for H<sub>2</sub>S removal. At the end of 2013 BioGasclean has approx. 125 plants in operation or under construction in 35 countries and supplies clean renewable fuel to more than 300 MW gas engines.



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