The DMT Carborex® MS Small scale biogas upgrading plant

Introduction

As we are all aware, fossil fuels are depleting rapidly and the energy consumption is growing. Due to increasing fossil fuel prices other types of fuels become more interesting. Nowadays technology enables us to use renewable fuels in an economically profitable way. An easy technique to produce fuel is the digestion of green waste; sewage sludge, manure and agricultural waste from crops. Bacteriae will convert this waste to methane and carbon dioxide known as biogas. Biogas is seen as a renewable fuel without a carbon dioxide footprint. To enhance the usability of biogas it should be upgraded to natural gas quality which is done by removal of carbon dioxide from the biogas. This will increase the caloric value of the gas, and makes it suitable to be used as vehicle fuel.

Of the total production of biogas most is produced by the many small scale digesters. Often these produce small quantities of biogas (50-200Nm^3/h). For these plants it is not feasible to upgrade the gas to natural gas quality and inject this in the natural gas grid or use it as commercial fuel at a gas station. The cost for quantity and quality control together with the high performance security and gas transport/ injection makes it too expensive for small scale applications. However, other conditions apply when the gas is not used commercially but only locally within a small community or farm. Therefore small scale upgrading can be economical viable.

Typical biogas has a composition of around 65% CH_4 and 35% CO_2. To make the biogas suitable for use in agricultural vehicles the composition must become 85% or higher CH_4 and 15% or lower CO_2. Since the agricultural machinery can handle various gas compositions, quality control is less important. Upgrading biogas in an agricultural setting has various demands which are:

- Robust installation: only yearly maintenance
- Easy operation: start/ stop: stand alone
- Easy installation: plug and play
- Compact unit / Small footprint
- Economical viable
- Waste control
- Final upgraded product pressurized to 250bar
- Safe

DMT has developed a unique system using membrane separation which is based on the difference in permeation rate of the different gas molecules. Relative permeation rates for some gasses are given in the figure 1.

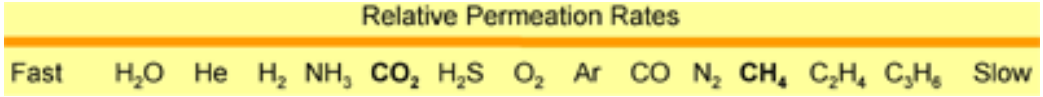

Figure 1: Relative permeation rates of various gasses through a membrane.

The membrane consists of a metal tube packed with hollow porous fibres. As the biogas flows through the fibres the CO_2 will pass through the pores of the packed bundle and will leave the metal tube through the CO_2 rich gas stream outlet. The methane will leave the membrane through the upgraded biogas out let and is ready for further processing, see figure 2.

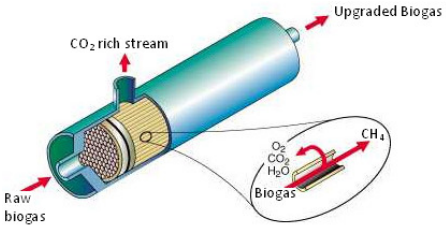

Figure 2: Concept of membrane separation

Process description

Biogas from the digesters will flow through an activated carbon filter to remove H_2S from the gas stream to prevent corrosion of upstream machinery. Typical H_2S concentrations in biogas are around 500 to 1000 ppm and these will be reduced to <1 ppm. Thereafter water will be removed from the biogas in two steps. First by cooling the gas so condensate can be removed. Second by leading the biogas through a desiccant to absorb water. Then the gas will be compressed to approximately 10 bars, and lead through the membranes where the separation takes place. The CO_2-rich stream will be emitted to the environment. The methane rich stream will go to a second compressor so the gas can be stored in cylinders at a pressure of 250 bar. Gas temperatures will increase during drying and compression. A chiller is used to cool the compressors. See figure 3. Figure 4 shows an impression of an installation at a farm.

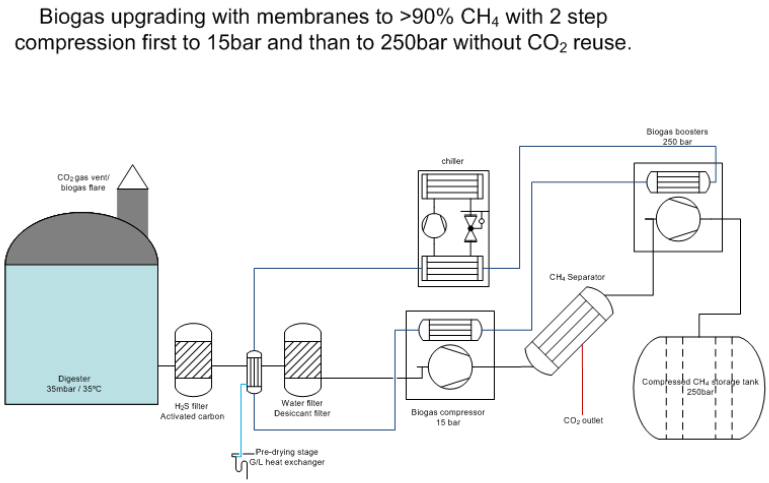

Figure 3: Schematic presentation of the DMT Carborex® MS Small scale biogas upgrading plant

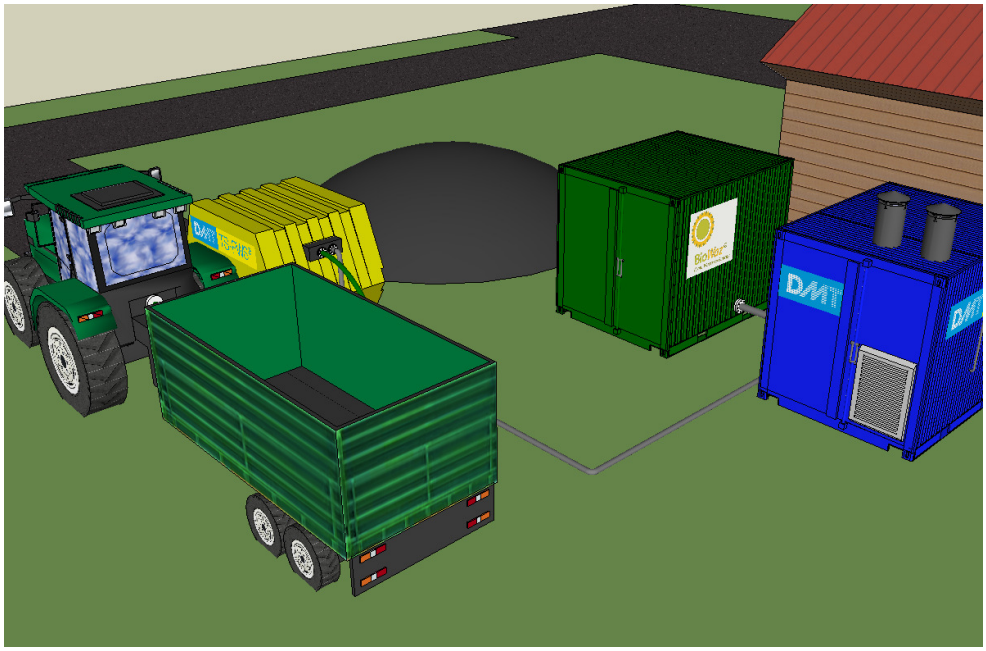

Figure 4: Impression of installation at agricultural setting

Economical features

Calculations show that small scale upgrading, using the DMT Carborex® MS is very lucrative. The table below shows the price in Euro cent per Nm^3 of the upgraded gas at a flow of 50 Nm^3/h and 200 Nm^3/h. The price is based on 7 years of operation at an interest of 8%. 1 Nm^3 of upgraded gas is equal to 1 liter of diesel. Utilization of waste streams are economically viable and become more and more attractive since diesel prices will rise due to depletion of fossil fuels.

Biogas flow presented	50 Nm^3/h	200 Nm^3/h
Cost price bio methane (Cent/Nm^3)	0.432	0.211
Payback time (Years)	7	4

Fuel for agricultural vehicles

The average tractor uses around 20 liters of diesel per hour during an average of 1200 hours a year. This results in 24000 liters of diesel per year. The annual production of bio-methane at a biogas flow of 50 Nm^3/h is approximately 260000 Nm^3. Because a normal cubic meter of CH_4 equals a liter of diesel around 11 tractors can be used all year long. At a biogas flow of 200 Nm^3/h around 45 tractors can be fueled. Excess fuel can be sold to gas stations, to reduce global fossil fuel consumption.