Assignment 3:

BIOGAS

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1. Introduction

Biogas is a renewable natural gas produced by anaerobic digestion (AD) from organic matter. It can be produced from manure or collected from landfills, for example.[1]

2 Feedstocks

In landfill sites, methane and other gases are formed due to wet organic waste decomposing in anaerobic circumstances in a compact pile. Methane is many times stronger greenhouse gas than CO2 and thus it is important to capture the landfill gas instead of allowing it to escape into air. The consistency of a landfill gas varies highly depending on waste and conditions.

Biogas produced in a small-scale digester from manure is an excellent energy source for livestock farmers. Manure can be converted into biogas in an anaerobic digester and used directly for heating. [2]

Unlike biogas, bio-SNG (Synthetic Natural Gas) is produced by gasifying cellulosic materials, such as forestry residues and energy crops. The steps in producing bio-SNG are usually an initial gasification, gas conditioning, SNG synthesis and gas upgrading. It is possible to convert bio-SNG into liquid biofuels.[3]

3 Anaerobic digester

Manure, wastewater and residues from crop production and processing can be converted into biogas in an anaerobic digester. Digester can be small-scale, using manure from just one small farm, or a large-scale, a commercial plant of thousands of cubic meters. [1]
Anaerobic digester is an airtight tank which is heated to the required approx. 35 degrees temperature, where mesophilic bacteria thrives. It is possible to continue raising the temperature to around 49 to 60 degrees, which is the suitable range for thermophilic bacteria, but it is often not worth the extra gas produced, taking into account the energy required for the heating. [2]

Digesters can be divided into wet and dry digesters. Feedstock with dry mass contents lower than 15%, such as manure and sewage sludge, are fed to wet digesters. Energy crops with dry mass content between 20 and 40% are fed to dry digesters. [1]

In the fermentation process, microbes break down organic matter in the absence of air. First, complex organic waste is broken down by hydrolytic bacteria into sugars and amino acids, which are then converted into organic acids by fermentative bacteria. Acidogenic microorganisms convert the acids into hydrogen, carbon dioxide and acetate. Last, methanogenic bacteria produce biogas from acetic acid, hydrogen and carbon dioxide. [1]

There are two different ways to feed the digester: continuous flow or batch flow. A batch-load digester is fully filled and after a certain time emptied before another round. Gas production is uneven in a batch-load digester as the bacterial digestion is not at the same level constantly. This can be helped by having several digesters connected and loading them at different times. The more popular, continues flow digester is loaded daily. It does not produce as much gas per kilogram of manure but needs less space than a batch-load digester. [2]

Feedstock, digester type and the digestion temperature all affect to the digestion time, which ranges from a couple of weeks to a couple of months [1].

The remaining sludge can be utilized as a fertilizer [4].
4 Refining

Biogas can be combusted to heat and electricity as it is or it can be purified and processed into biomethane by removing other gases. Biomethane is suitable for gas grid injection or to be used as a transportation fuel. [5] Methane content of gas utilized for distribution grid or vehicle fuel must be very high, for example, the natural gas distributed in Finland is 98% of methane [6].

The content of biogas varies depending on the feedstock. While biogas normally contains 50 to 80 % methane, 20% to 50% CO2 and traces of other gases like hydrogen, CO and nitrogen, natural gas is more than 70% methane and the rest is other hydrocarbons, such as propane and butane, and traces of CO2 and other contaminants. [7]

The calorific value of crude biogas is around 5,0 – 5,5 kWh/m3n and of natural gas around 10 kWh/m3n. By processing biogas, the chemical content of natural gas can be nearly obtained. [6]
As explained in Trendsetter Report No 2003:3 [8]:

1: The gas is compressed under 10 to 15 bars and injected in a washing pressure tower into which the water solubilizes the carbon dioxide and the H2S of the biogas.

2: Then the gas is dried on 2 molecular screens under 250 bars.

3: The washing water is recycled by gas freeing in two steps:
- first, the recuperated gas of the highest gas-freeing, rich in CO2, H2S and CH4 is injected as raw gas into the pressure stages.
- secondly, the gas salted out in the lowest gas-freeing tour is sent back to the biologic filter where bacteria eat H2S.

4: The dry and pure gas is stocked at 250 bars into steel bottles that feed the filling
station.

5: The non-suitable gas is sent back to the beginning of the plant.
[8]

5 Vehicle fuel

There are around 14.8 million natural gas powered vehicles worldwide. They can run on compressed natural gas or liquified natural gas, which is more expensive and used in some heavy-duty vehicles. Dedicated vehicles run only on natural gas, whereas bi-fuel cars have two fuelling systems; one for gasoline and one for gas. Dual fuel vehicles are heavy-duty applications, which use diesel for ignition assistance.[9]

6 Biogas projects

6.1 GoBiGas

Göteborg Energi, a Swedish energy company, has an ongoing project called GoBiGas, aiming to start operating its plant this year. The feedstock for the biogas is pellets, chips and forest residues and the gas will be injected into gas grid and used in transportation. [10]

In the GoBiGas plant, the biomass is converted to a flammable gas by thermal gasification and then purified and upgraded in a methanation plant to Bio-SNG. The plant will be the world’s largest and it will generate around 800 GWh of power. [10]

Sweden already has a natural gas grid in some parts of the country, built for imported natural gas, which will likely expand. It is easy to distribute the biogas Göteborg Energi produces through the already existing gas grid. [10]
6.2 Gasum

Gasum, a Finnish gas company provides natural gas and biogas for distribution and transportation. One of their projects is refining biogas produced in a wastewater treatment plant in Suomenoja, Espoo. Three million cubic meters of biogas is produced from the sludge. After processed, the biomethane is injected into a gas grid. Helsinki has busses which utilize biogas as fuel. The Suomenoja plant produces around 20 GWh biogas in a year –this would be enough to fuel 55 buses in a year.[11]

Gasum has several gas stations all over southern Finland supplying natural gas and biogas. Natural gas is the most inexpensive fuel reaching only half prize of gasoline. Biogas is the cheapest fuel among the renewable fuels.[11]

7 Throughout the world

According to the Biogas to Energy 2012/2013 market study, there are over 10,000 operational biogas plants worldwide. The installed capacity is expected to increase from 4,700 Mwel to 7,400 Mwel between 2012 and 2016. Now, almost two thirds of the facilities are located in Germany, and new strong markets will evolve in other European countries, North America and Asia. [12]
8 References


