

Co-Digestion and Energy Production from Waste

1. Aim of the Project

The main aim of the project is to demonstrate the benefits of co-digestion of several types of waste treated in the same biogas reactor system and to disseminate successful Danish technology to Germany.



Photo 1: Top view of the biogas reactors

2. Introduction

The background is new experiences from large-scale biogas plants in Denmark where previously problematic waste was found digestible if digested in a mixture of other waste. Further more, the biogas yield - and therefore the energy output - has been found to be increased by co- digestion, a fact which increases the economic viability of biogas plants. Besides the demonstration of the concept of co-digestion the objectives of the project was to implement a new management system for control of biogas systems. For demonstration purposes a biogas unit was constructed in Frankenförde, Germany during 1994 and 1995. This plant is supplied by a combination of industrial waste and pig manure, and it went into full operation in 1995.

Frankenförde with a population of only 206, which sole industry is the project partner ISZ Vieh-und Fleisch GmbH, is located in the federal German state of Brandenburg near the City of Luckenwald at app. 50 km south of Berlin.

In this plant different types of organic industrial waste such as from slaughterhouses and from processing edible oil, is added to the pig manure. This results in increased biogas productivity (approximately 70%). Finally a small amount of source-sorted household waste was planned to be added to the biogas reactors in order to obtain information on a wide variety of different

waste types. Due to the location of the plant in a rural area, the effluent from the plant can be used directly as a fertiliser on farm land eliminating the need for compost or chemical fertilisers.

3. Technical Description

The two biogas reactors R1 and R2 (see figure 1) as well as the three pre-storage tanks, S1, S2 and S3 each have a capacity of 450m³. The storage of digested slurry is assured in 5 storage tanks, each with a capacity of 1520 m³. The digested slurry in the storage tanks is recycled: It is led directly into 1,300 ha of agricultural farm-land. The biogas is purified when passing the two columns of bog iron ore (gasreinigung) after which it is stored in a 75m³ membrane storage tank, 20 mbar (gasspeicher), and the excess gas is burned. The energy recovery takes place in a 150 kW_{el} generator (BHKW).

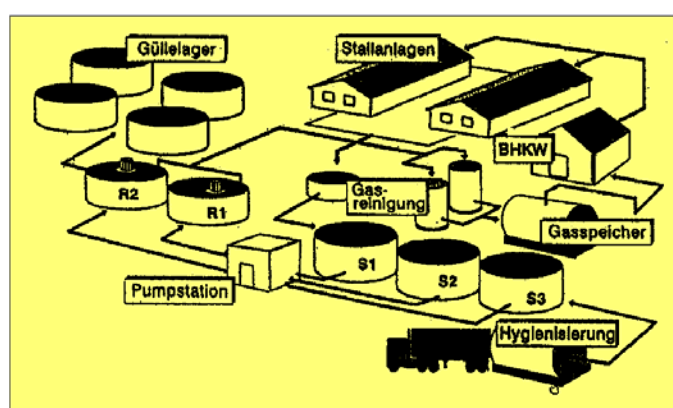


Figure 1: Schematic of the biogas plant

The produced biogas has a methane content of app. 70%, which is exploited in a gas engine/generator set combined heat and power plant. The energy contained in biogas with this methane content amounts to:

$$35.8 \times 0.7 / 3.6 = 6.96 \text{ kWh/m}^3.$$

30% are transformed into electric current (2.1 kWh) and 60% into heat (4.2 kWh). The remaining 10% are not exploitable.

To ensure a good hygienic quality of the residual product, the biogas process is run at a mesophilic temperature (37°C). The retention time is 18 days. Waste from the storage tank is pumped into the reactor approximately 3-4 times a day. The daily gas production is 1,840 m³ CH₄ on average.

4. Performance of the Biogas Plant

The aim of this project was to demonstrate the benefits of co-digestion whereby several types of waste are treated in the same biogas reactor system. The design amounts of the various waste streams co-digested and the estimated biogas production at the biogas plant in Frankenförde are given in Table 1. Due to delays in obtaining the approval to use the sorted municipal waste, it was decided to implement the Frankenförde plant with a combination of

industrial waste and pig manure only and to carry out the tests with sorted municipal waste later.

Table 1: Waste Characterisation & Biogas Production

Type of waste	Source	Amount <i>tons/day</i>	Dry matter (volatile solids)		Biogas Potential $m^3CH_4/kgVS$	Biogas Production m^3CH_4/day
			<i>%VS</i>	<i>ton VS</i>		
Pig manure	Farms	40	3.48	1.4	0.21	294
MSW	Household	19	25	4.8	0.45	2,160
Total		59		6.2		2,454

Table 2: gives actual performance data of the operation of the plant based on design values of the the various waste components, their quality for anaerobic digestion and the production of methane and biogas with a retention time of 21 days.

Table 2: Design performance of the biogas plant

Biomass	Amount <i>tons/day</i>	VS%	COD/day	Red %	Methane Production Nm^3CH_4/day
Pig manure	30	4	1.2	55	231
Silage	1	25	0.4	65	91
Greased Sludge	5	25	2.8	90	882
Various liquid Industrial wastes	6		1.8	90	567
Total	42		6.2		1,771 to 2,700 Nm^3 Biogas

The Danish Technological Institute has been monitoring the daily production of methane as well as the daily input of bleaching soil as well as pig manure. The results from these measurements were as follows:

Table 3: Actual performance of the plant with a retention time of 18 days

	Pig Manure <i>m³/day</i>	Lipid Waste <i>m³/day</i>	Bentonite Bound oil <i>tons/day</i>	Total Load <i>m³/day</i>	Methane production <i>m³ CH₄/day</i>
Average Daily Production	35	12	3.3	50	1,840

From the above data it can be seen that the aim and objectives of the project have been attained using the shown combination of bleaching soil as well as pig manure.

It can thus be concluded that the estimated performance figures for the Frankenförde plant have been achieved, but that household waste had to be replaced by industrial waste. For production reasons it has been easier to continue with the mixed industrial waste streams in

this plant. Nevertheless, similar performance can be expected in case sorted municipal waste could have been used.

Energy Balance

A typical energy balance is given based on the gas production on November 1, 1995 being 2,550 Nm³/day. The methane concentration was measured to 70%, which gives a methane production of 1,785 Nm³CH₄/day. This results in a total of 17.75 MWh or 10.65 MWhth and 5.32 MWhel.

Environmental

The co-digestion of organic waste streams is an innovative technology to the reduction of methane/greenhouse gas emissions. Furthermore, the organic bound nitrogen in the effluent is released by anaerobic digestion as inorganic compounds to be taken up by plants.

The lab tests showed that the content of inorganic pollutants in the incoming and outgoing waste streams was not critical. The heavy metal content was below the prescribed limit for residual sludge. The percentage of organic material in the tested samples does not hinder the use of the effluents as fertiliser.

The content of PCB, AOX and PAHs in the biogas plants' wastewater did not surpass the permitted concentrations according to the relevant Regulations for Sludge.

5. Economic Performance

Due to the fees saved on waste disposal combined with a high and constant biogas production, which can be three times higher than conventional plants operated on manure alone, the plant shows solid economical results.

This technology can be disseminated practically all over the Europe where there are significant agro-industrial residues such as animal manures and other organic industrial wastes. Although it has not been possible yet to demonstrate the technology with mixtures of manure and the organic fraction of sorted municipal solid waste, it is believed that there will be no technical problem for such applications. Therefore, the market potential of this technology is considered as reasonably high.

6. Project Identifiers

Project:	BM/015/93-DK/DE
Owner:	Frankenförde Vieh & Fleisch GmbH (FVF)
Contractors:	DTI & FVF
Contact:	Danish Technological Institute Gregersensvej P.O.Box 141 DK - 2630 Taastrup Denmark Tel: +45 43 50 46 70 Fax: +45 43 99 34 14
Technology:	DTI, JyskBiogas A/S (for the gas engine) & BioContractors Aps (for mixer, PLC, pumps etc.)
Total Cost:	1,250,000 ECU
EC Support:	360,000 ECU