BIOGAS IN THE SOCIETY
Information from IEA BIOENERGY TASK 37 Energy from biogas and landfill gas

BIOGAS FROM SLAUGHTERHOUSE WASTE: TOWARDS AN ENERGY SELF-SUFFICIENT INDUSTRY

SUMMARY

Using the biogas from animal by-products (ABP) digestion, the St Martin slaughter facility can cover most of its heat demand and some of the electricity requirements. In combination with heat from a geothermal power plant, the slaughterhouse fully covers its demand on thermal energy by renewable energy.

The combined slaughterhouse/biogas plant is located at St.Martin/Innkreis in the North-West of Austria. This biogas plant is processing all animal by-products which may not be further utilized such as blood, hind gut, stomach content and fat scrubber content. The electricity produced from biogas is fed into the national power grid and the heat is delivered to the slaughtering facility. The specific load profile of the slaughterhouse showed that only during 35% of time the heat produced by the CHP could directly be consumed in the slaughterhouse. Therefore, a hot water storage tank serves as buffer to match th steady heat production with the heat demand of the slaughterhouse. Thus nearly all of the heat produced in the biogas plant is used in the slaughterhouse covering 80% of its energy demand.

Photo 1: Biogas plant

- **Anaerobic digestion of slaughterhouse wastes (animal by-products).**
- **80% of the heat demand in the slaughterhouse is covered by the biogas driven CHP.**
- **A hot water storage tank uncouples heat supply from heat production.**
- **In combination with geothermal energy the complete heat demand of the slaughterhouse is covered by renewable energy.**
- **Reduction of disposal costs.**
- **Production of a valuable fertilizer.**

BACKGROUND

After the European Union banned rendered animal proteins from the feed chain in 1999, the costs for the treatment of Animal By-Products (ABP) increased considerably. Since the ABP-Regulation (Reg. (EC) No. 1774/2002) defined new treatment possibilities and laid down corresponding processing parameters, new pathways for the utilisation of slaughterhouse wastes were opened. Some biogas plants in the agro-industrial sector are using pasteurised ABP as co-substrates together with manure, catering waste and other energy crops. The biogas plant in St. Martin is operated only with ABP deriving predominantely from the adjacent pig slaughtering facility.
The slaughterhouse that owns and operates also the biogas plant slaughters approx. 2,000 pigs a day. There is a bovine slaughtering facility nearby and its ABPs are also available for digestion in the biogas plant, but – except for rumen content – are actually not used in the biogas plant due to capacity restrictions.
Anaerobic digestion of animal by-products allows to supply heat to the slaughtering facility and to reduce the disposal-costs of the pig slaughtering facility. After the implementation of a hot water storage tank 80% of the heat demand is covered. The remainder is covered by heat from a geothermal facility. The digestate is given off to surrounding farmers as a valuable fertilizer.

BIOGAS PLANT

Operation

The plant design corresponds to the classical concept of an agricultural biogas plant (Photo 1): two main fermenters of 600 m^3 resp. 1,000 m^3, a secondary fermentation tank (without heating, 1,000 m^3) and a storage tank (3,200 m^3) were constructed (Photo 2).
The biogas plant is operated with selected fractions of the pig slaughtering process such as pig blood, minced hind gut including content and fat from dissolved air flotation. According to the European Directive (1774/2002 EC) the material is crushed to a maximum particle size of 12 mm.
The substrate is pumped from the slaughterhouse to a buffer tank and subsequently pasteurised (70 °C/60 min). Before feeding , the substrate is cooled to 55 °C in order to minimise a possible damage of the bacterial biomass in the biogas fermenter. In average approx. 20 m^3 of slaughterhouse wastes per day are fed in parallel to the two digesters (Table 1). The biogas formed allows a production of approx. 4.7 MWh/d of electricity and 7 MWh/d of heat.
Rumen content from the neighbouring cattle slaughterhouse is delivered to the biogas plant and fed through a feeding screw directly into the smaller digester.
Both digesters are operated at mesophilic temperatures (35 °C). Higher fermentation temperatures will increase the amount of undissociated ammonia (NH_3) in the system, which is believed to be the toxic form of ammonia-nitrogen for micro-organisms. Therefore a higher fermentation temperature would increase the instability of the micro-biological community. Depending on the substrate composition ammonia-nitrogen levels vary between 4.5 and 7.5 g/L.
Blood (as the main source of nitrogen) is added in function of the ammonia concentration in the digesters. High levels of ammonia lead to high concentrations of volatile fatty acids, indicating a poor microbiological activity and leading to foaming problems. If fermentation problems occur anaerobic sludge (from a near-by sewage sludge digester) is used to dilute the fermenter content and re-inoculate the process. During disturbances blood is not used as substrate and is treated in a rendering plant until the stability of the digestion process has recovered.

Nitrogen Recovery – Increasing Fermentation Stability

A pronaunced dependency between the ammonia-concentration and the biogas-yield was observed. With increasing ammonia concentrations degradation rate and methane production decreased while volatile fatty acids concentrations increased.
In laboratory experiments the performance of the full-scale plant was simulated. Increasing of the C:N-ratio by adding another carbon source did not improve gas production. However, removing of ammonia lead to a better performance of the process. The specific methane yield could be increased up to 20% with the additional benefit of a lower volatile fatty-acids concentration indicating a much more stable fermentation process.

Odour Emission

Processing of slaughterhouse waste requires an efficient exhaust air treatment. Due to odour emissions in the beginning of the operation, a new concept of odour reduction was developed (Figure 1). The plant had to be adapted by several measures:
The digestate storage tank (originally planed as an open

Photo 2: Biogas plant, Fermenter and Desulphurisation-column (in the front)

tank) was covered with pre-fabricated concrete sections in a gas tight manner.
Odour emissions of the storage tank could not be treated in a bio-filter system with good results due to a high content of non degradable gases in the exhaust air. Initially the fresh substrate was conveyed with a compressed air transportation system from the slaughterhouse to the storage tank located at the biogas plant. To minimise exhaust air the transportation system was replaced by pumps and the storage tank was closed hermetically and connected to the biogas collection system.
The exhaust air from the processing hall was divided into a stream with high odour nuisances (deriving from the pasteurisation and cooling unit) and a stream with low odour emissions (delivery of rumen content and general exhaust air in the hall). The high mass flow of low charged exhaust air is treated directly in a bio-filter system and the small air flow charged with a high odour load is pre-treated in an alkali-scrubber before being discharged to the bio-filter system.
The high ammonia- and H_2S-content in the biogas caused high SO_x and NO_x-emissions in the exhaust gas of the CHP. After installing an external desulphurisation unit (packed column operated at low pH-values, Photo 2) the concentrations of H_2S and NH_3 in the biogas are reduced substantially. Based on this improved biogas quality the engine of the CHP could be equipped with a catalytic converter in order to reduce NOx and CO-concentrations in the exhaust gas.

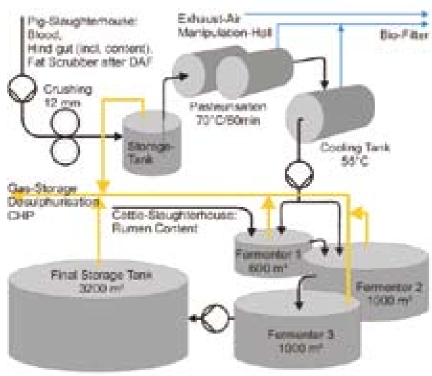

Figure 1: Concept of odour emission control

Demand site management of heat
Provided the biogas plants are fed continuously, methane is produced at a constant rate. The produced electricity may be delivered steadily to the national power grid. However, the thermal energy produced by the CHP could

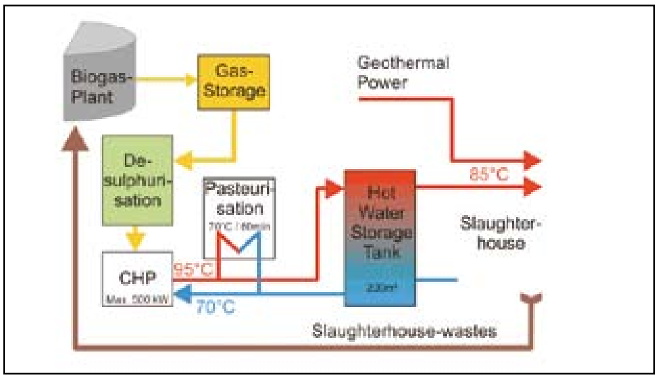

Figure 2: Energy-Flow chart, connection of the biogas plant to the slaughtering facility

fully be used during one third of the time only. Animals are slaughtered during working days in two 8 hour shifts, from 2 am to 6 pm. During that time (60 %) there is a peak heat consumption of the slaughtering facility exceeding heat production from the CHP plant.
With a hot-water storage tank, of a capacity of 200 m³ (Photo 3) heat production is uncoupled from heat consumption. Hence, heat produced on a constant rate in the CHP may be transferred from periods of low energy demand in the slaughterhouse to times with a demand exceeding production. As a result, nearly all the produced heat from the CHP is used in the slaughterhouse, covering approx 80 % of the energy-demand. The rest is covered by a geothermal power plant (Figure 2).

Photo 3: Hot water accumulator (200 m³)

Table 1: Average substrate mass streams (measured over 339 days)

monitoring over 339 days	Flotation fat (dislo-ved air flotation)	Pig Blood	Hind gut of pig (incl. content)	Bovine Rumen Content	Anaerobic Sludge (Sewage digestion)
Days of feeding	314 [m³/d]	278 [m³/d]	314 [m³/d]	160 [m³/d]	21 [m³/d]
Average per feeding day Average over monitoring period	6.15 5.62	3.69 2.98	5.12 5.10	10.0 3.77	19.0 1.02

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