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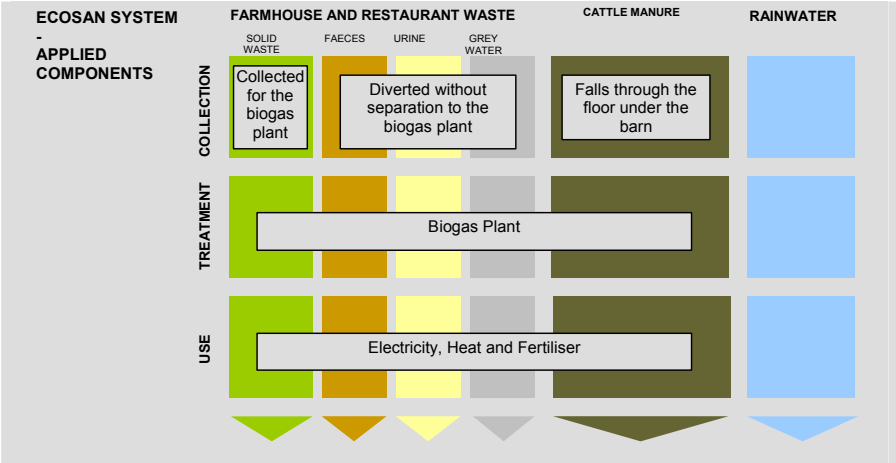
Biogas-ecosan project Waldmichelbacherhof

Bessenbach, Germany



1 General Data

Type of Project:
Combined farm, households and restaurant

Project Period:
Start of construction: 1994, start of operation: 1996

Project Scale:
Four families (14 people) and a restaurant
200 Ha land, 280 cattle and 50 horses
Total investment: 200,000 euro

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Planning Institution:
TBW-Technologie, Bau- und Wirtschaftsberatung GmbH-Frankfurt/Main, Germany and Krieg&Fischer Ingenieure GmbH, Goettingen, Germany

Executing Institution:
Johann Wolf GmbH & Co Systembau KG, Osterhofen, Germany

Supporting Agency:
Landratsamt Aschaffenburg, Amt fuer Landwirtschaft

2 Objective of the project

To collect, treat and reuse human and animal excreta and organic waste combined with the gain of electricity and heat energy.

3 Location and general conditions

The family-owned farm and restaurant "***Waldmichelbacher-hof***" is located in Bessenbach, near Aschaffenburg, Bavaria, Germany. It occupies 200 ha of land, where 170 ha are used for grazing and fruit trees and 30 ha are used to grow fodder crops (e.g. maize and oat) for cattle and horses, and to grow field crops for the farm-owned bakery and distillery.

Figure 1: Waldmichelbacherhof Farm *(Photo: www.waldmichelbacher-hof.de)*

At present the farm has 280 cattle and 50 horses. These cattle and horses live in the barn during the winter and outside on grazing land in summer.

The farm produces hornless cattle for meat production and breeding purposes. Each week one cow is slaughtered, and the meat is sold in the farm shop and the restaurant.

The restaurant serves up to 260 guests. Four families (14 persons) live and work for the farm.

4 Technologies applied

The farm collects, treats and re-uses the liquid and solid organic waste from the farmhouses, restaurant, shop, distillery, cattle and horse barn, and the slaughterhouse in a biogas plant. The system consists of the following components:

- Conventional *lowflush toilets*
  They are installed in the restaurant

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and farm houses (low-flush buttons but no urine diversion).
In the planning phase the planning institution had recognized that there would be no need to install urine diversion toilet, as the urine can be used together with the anaerobically digested watse (water) as fertilizer.

- 1 concrete wastewater storage tank of 100 m3
  Beside acting as a storage tank it also functions as a pre-mixing tank for the wastewater from the restaurant, farmhouses, the small distillery on the farm, horse urine (stable run-off), horse dung and meat processing waste.
- 1 collection channel (500 m^3 usable volume) which is located under the cattle shed.
- 1 heated and insulated anaerobic digester (280 m^3 volume, fully mixed)
  The heating to 40-44^{0}C is accomplished by internal heat exchangers on the walls and the floor of the digester using "cooling" water from the biogas CHP engines.
- 1 anaerobic digester for storage of digested waste and biogas (1500 m^3 volume, not mixed, not heated, not insulated)
- 2 CHP-generator units (HJS-Dual fuel co-generators, each one with 37 kW electricity generator and 74 kW of heat recovery through cooling water and exhaust gas heat exchanger)

5 Type of reuse

- The farm is an example for the implementation of an ecosan closed-loop system with only a minor amount of nutrients added or removed.
- Cattle and horses gain nutrients from the fodder. The cattle are slaughtered on-site and consumed in the restaurant.
- The manure and waste from the cattle, inhabitants and restaurant guests are mixed to produce fertilizer and biogas.
- The fertilizer is used on the farmland (no other fertiliser is added)
- The electrical energy generated is used in the restaurant and the farmhouse. Any surplus is fed into the general electricity grid.
- The heat energy is used for the buildings, hot water and also to heat the digester content to 36-37°C (mesophilic conditions).

6 Project History

The farm *Waldmichelbacherhof* is located far from the sewer network (2.5 km away). In 1994 the farmer planned to add an on-site slaughterhouse to the farm. There were three wastewater management options:

- constructing a local decentralised wastewater treatment plant for the wasterwater generated from the restaurant and slaughterhouse.
- constructing the connection to the town sewer on his own cost
- implementing a closed loop ecosan sanitation system with a biogas plant

The first option was discarded because of relatively high operating costs (e.g. for aeration approximately 100,00 euro).

The second option was also considered not favourable - apart from the high cost for the pipeline and sewer discharge permit costs, the pipeline would have to cross parcels of land owned by about 150 owners (each having small parcels of land along the way). The permission would have been very time consuming.

The farmer chose the last option, the biogas plant. It was favourable as it was beneficial for the farm; had low operation costs, fertilizer, heat and energy production. The plant was constructed in 1994 and began to operate in 1996.

7 Costs

The total investment cost was 200 000 Euro (it includes retro-fitting work, e.g. installation of a new mixer and heat exchanger, building a shed over the digester) in 1993.

The expenses to keep the plant in operation are as follows:

- Oil exchanger for generators every 400 operating hours (negligible cost)
- New co-generation modules every 15,000 to 20,000 operating hours at a cost of about 4,000 to 5,000 Euro
- Spare parts for maintenance

The operation of the biogas plant has been beneficial for the farm in terms of income and savings:

- Saving on fertiliser used (estimated to be 20,000 Euro)
- Annual saving resulting from on-site electricity production (23,400 Euro in 2004, based on an average tariff of 14 cent per kWh)
- The annual income from electricity excess selling when production exceeds demand (5,300 in 2004, based on 10.23 cent per

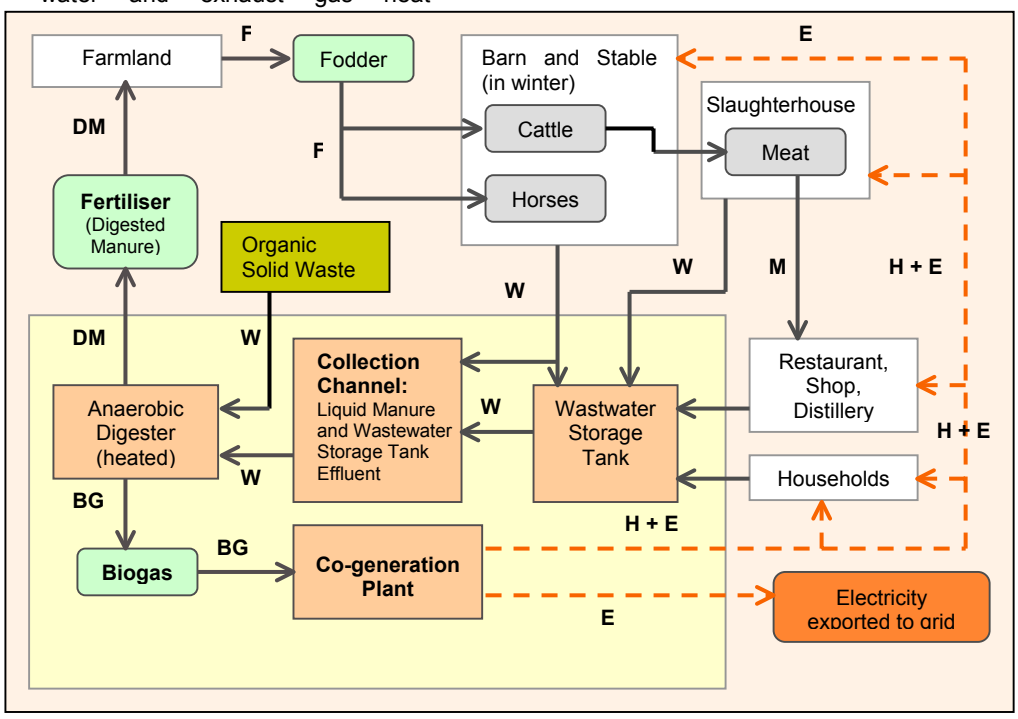

Figure 2: Simplified Diagram of the Main Mass and Energy Flows in Waldmichelbacherhof Farm (BG: Biogas, DM: Digested Manure, E: Electricity, F: Fodder, H: Heat, M: Meat, W: Waste (liquid or Solid) *(Adapted from: Münch. E, et al., 2005)*

kWh, which is by the electricity provider)

- Saving resulting from not having to purchase natural gas for heating of water all year round and heating buildings in winter (not yet counted)

8 Design information and technical specifications

The balckwater from the restaurant and farmhouse is collected in a storage tank. It has been calculated that the amount of sewage procduced is about 2.5 ML/year.

The cattle manure falls through the gaps in the barn floor in the collection channel. Once a week the wastewater from the storage tank is pumped into the collection channel using a submersible pump. This would flush out and mix the wastewater and the content of the collection channel.

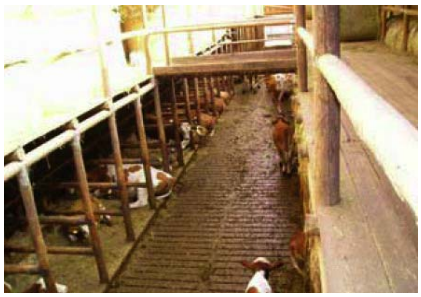

Figure 3: Collection Channel (under the barn floor) *(Photo: Wang)*

In the next cycle of the plant, the mixed contents of the collection channel are pumped to the anaerobic digester no.1 (280 m^3 heated and insulated anaerobic digester). The process takes place six times a day. In addition there is also a feeding device to digester no.1 for various organic solid waste such as straw and dung from the horses, solid organic waste from the restaurant and hot vegetable oil from the kitchen.

A second anaerobic digester tank (1500 m^3), which also acts as a storage tank for the digested manure/wastewater/ waste-mix and as a main gas holder, is placed in series to the digester tank no.1.

The hydraulic retention time in digester tank no.1 is 20 days and 3.6 months for the tank no.2. Both digester tanks have flexible covers for the biogas collection.

The biogas plant produces more biogas in winter than in summer, because most of the cattle are not in the barn in summer and the manure cannot be collected in the digester tanks. Generally 500 m^3 / day biogas is produced in winter and only 80-100 m^3 /day in summer.

The biogas is used for electricity and heat generation in a cogeneration plant.

Figure 4: Digester Tanks (*Photo: Wang*)

The digester tank operates on mesophilic condition at 36-37 ^{0} C.

9 Operation and Maintenance

Regural maintenances have to be carried out to keep the plant in operation:

- Regular spare parts maintenance
- Oil change for generators every 400 operating hours
- The co-generator modules have to be replaced every 15,000 to 20,000 hours of operation.

10 Practical experience and lessons learned, comments

The main problems in the operation of the plants were:

- The digester no.1 used to have a movable plate heat exchanger between the influent waste and the effluent digested manure using the so called "*Freese System*". The system did not function well and was removed in 1995. As a replacement fixed tubular heat exchangers were installed on the wall and the bottom of the cylindrical digester
- The project's target is to maximise biogas production for energy and heat production. This was achieved by adding straw to digester no. 1. But the practice had been causing mixing problems. In 2003/4 the problem was solved when a better mixer was installed in the digester no. 1.

11 Available documents and references

Wang D and Münch E, 2004: *Trip Report for Visit to Biogas-Ecosan Project near Aschaffenburg, Germany and Meet with Ecosan-China Experts*, UNESCO-IHE Institute for Water Education.

Münch E, et al., 2005: Evaluating Ten Years of Operation of the Ecosan System at a Family-Owned Farm and Restaurant in Bavaria, Germany, Paper submitted for the Third Conference on Ecological Sanitation, Durban South Africa 23-27 May 2005.

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