BIOGAS
CHP

AALBORG
Denmark

Biogas is one of the most common renewable energy resources. It can be produced by the anaerobic fermentation of wood or agricultural waste, on landfills or in sewage plants. These last two ways of producing biogas are the most interesting for cities in their policies of promoting renewable energies. The use of biogas is also interesting economically as it is in 1999, already one of the cheapest renewable energy sources. It often is burned in combined heat and power plants, but it can also be injected in local, natural gas networks. In Aalborg, in Northern Denmark, a biogas plant utilising a combination of manure, industrial waste, and organic, house hold waste was finished in 1997. The biogas is utilised in a nearby co-generation unit.

GENERAL ASPECTS

Aalborg is situated at the border of Limfjorden, being by far the largest city in the north of Denmark, with a number of inhabitants in the municipality of approximately 160,000. Aalborg is the centre for employment and industry, in particular regarding telecommunications-, cement works, and distillery industries. Aalborg is also the centre for education in this part of Denmark hosting a big university. Here studies ranging from engineering to literature are going on.

Climatic data:
Degree days (Basis 17 °C): 3,560
Annual mean temperature: 7.8 °C

CONTEXT

The municipality of Aalborg is a part of the "European Sustainable Cities Project", supporting a practical transfer of knowledge and exchange of experience in the field of urban sustainability and Local Agenda 21 in Europe, and so helping to create a more sustainable living environment. A biogas plant was built in 1997. It receives farm slurry, industrial waste, and organic household waste. The average biogas production is 10,000 Nm^3/day. The biogas is utilised in a nearby 2 MW power, co-generating unit. Twenty-three percent of the investment was covered by grants from the European Union and the Danish government. The resulting simple payback time is calculated to be 7 years. The municipality of Aalborg is, in general, taking part in many different kinds of renewable energy projects. The municipality was the first in Denmark to approve a planning scheme for wind turbines. The objective is, that by the year 2005, 10 % of the consumed electricity in the municipality must be covered by wind energy. This corresponds to an amount of electricity of 120 GWh, which is supposed be produced by 80-120 wind turbines with an approximate nominal power of 750 kW. The objective of reaching the 10 % has caused some discussions with interest groups like sailors and environmental organisations. The involvement of these interest groups has been crucial for the final approval of the scheme plan.

EXPERIENCE OF AALBORG

The creation process

Already in 1991, a feasibility study regarding gasification of organic waste from the municipality of Aalborg combined with utilisation of the produced gas and fertiliser was undertaken. The study showed that a biogas plant project would be profitable if a grant could be obtained. At that time, the municipality did not want to invest the money, so an agreement was concluded between the two engineering companies (Jysk Biogas A/S and PlanEnergi) and the municipality that in the event of a biogas plant, privately owned and run, was constructed, the municipality would be willing to direct its source-sorted, household waste and industrial waste to the plant. A consortium was created, plans were made, and around new years 1992/1993, a confirmation of a grant was received from the EU-thermie programme. It was first assumed that the plant should replace a coal-fired district heating plant in Støvring, 20 kilometres south of Aalborg. On this site the heat demand would – even in the summertime – not be less than 2 MW. Unfortunately, unknown plans were already in progress concerning a natural gas-fired plant at that location. Therefore, new plans were made. PlanEnergi had earlier taken care of pre designs of a biogas project near the small villages Vaarst and Fjellerad, 15 kilometres from Aalborg. This project was abandoned due to the bad economy. But with the grant there was again an opportunity. The change in location meant that the biogas produced was to be fit into the existing natural gas-fired, co-generation plant supplying these two small communities. This fact had some advantages and disadvantages:

Advantages:

- The already present gas engine was bigger than the engine calculated for the old project
- The gas engine had a slightly higher electric efficiency
- No investment for a new gas engine

Disadvantages:

- Considerably smaller heat demand
- The gas engine was a pre chamber engine and therefore the biogas had to be compressed to 4 Bar. This required investments in compressing units and expenses for maintenance, cooling and running
- The engine had to be able to use both natural gas and biogas. The engine supplier (Bergen Diesel) had no experience in that matter.

Organising and financing

Due to general problems for biogas plants in Denmark, it was harder than expected to obtain loans financing the project. The solution was to make the municipality give a guarantee for a loan, which would open a passage for a reasonable loan. A row of conditions were attached to this municipal guarantee, which was given in June 1993. As a desirable side effect, this tied the municipality closer to the project. One of the conditions from the municipality was, that the ownership of the biogas plant should be a collective provision. Therefore, "Vaarst-Fjellerad Biogas amba" (limited liability) was founded in February 1994, by 16 farmers. The final financing of the project was as follows[1]:

Grant, EU	750,000 €
Grant Structural Directorate, DK	282,000 €
Loan, "Kommunekredit"	2,100,000 €
Bank loan	1,000,000 €
Suppliers Credit	402,000 €
Total	**4,534,000 €**

[1] Here one € equals 7.46 Danish Kroner

The construction work began in July 1994, but organisational problems between the partners arose. These problems were so important that construction was halted until November 1996. Technical problems during construction delayed the project further, but finally in August 1997, the plant started running. With the grants and the sales price of the gas to the co-generation plant, the simple payback time is calculated to be approximately 7 years. This is based on "full load" production, where the profit is approximately 440,000 €.

Description of the plant

The biogas plant is working at the "termophile" temperature at approximately 53 °C. The consumed heat and power by the plant is produced by a small, Jenbacher gas engine (co-generation unit), utilising a minor part of the produced biogas. The delivery of the manure from the farmers is done with a lorry tanker which is owned and operated by the plant. Due to odour problems, the unloading of the manure and slaughterhouse waste takes place inside a closed hall. The tanker is thoroughly cleaned after every transport because of risk of infection at the next visited farmer. Bleaching clay used in the food industry has a dramatically positive impact on the biogas production. This, together with fatty wastes, form a substantial part of the basis for the plant. The capacity for organic household waste is, in a separate reactor, 10-15 tons/day – but the present flow of this source is only 1 ton/day. This is due to the lack of regions in the city where the waste is sorted in the kitchens. The rest of the biomass is pig- and cow manure from 16 surrounding farmers, who are the owners of the plant. Although the separate line for the processing of household waste has a limited capacity, it plays an important role in the experiments carried out by the municipality of Aalborg in the field of recycling and management of organic waste.

Animal manure	40,000	tons/a
Slaughterhouse waste	9,000	tons/a
Household waste	360	tons/a
Biogas production	3.6 mil.	Nm^3/a

Technical specifications for the biogas plant (1999):

The biogas plant is situated 2 kilometres from a combined heat and power plant which is utilising the biogas. If biogas is not available, natural gas from the North Sea is utilised. The reason for the long distance between the biogas plant and the co-generation unit is due to tight restrictions concerning distance to neighbours and aesthetic concerns. The biogas at the biogas plant is compressed to 4 Bar. This is due to the demand from the gas engine to work 100 % on biogas. (The calorific value for the biogas is 6.5 kWh/Nm^3). Low pressure systems should, in general, be preferred because:

- compressors and their maintenance are expensive.
- compressing increases the need for cooling.

The small, co-generating unit at the biogas plant is operating at 200 mBar provided by a small, simple blower. No cooling or drying is necessary here.

Total available power	2.0	MW
Total available heat	5.0	MW
Production of electricity	9,000	MWh/a
Production of heat	12,000	MWh/a
Consumption of biogas	3.6 mil.	Nm^3/a

Technical specifications for the co-generation unit[2]:

EVALUATION AND PERSPECTIVES

The problems in the creation process of the biogas plant, which included both economical and organisational problems, have been multitudinous. This is the reason for the long creation period. Nevertheless, the biogas plant today is a reality, receiving a small amount of source sorted, organic, household waste from the municipality, manure from the 16 farmers, and industrial waste from, among others, a slaughterhouse. The biogas plant represents a potential for receiving up until 15 tons a day of household waste from the city of Aalborg.

The siting of a biogas plant is not in any way easy. In Denmark, fear of noise and smell from neighbours causes a minimum distance of 500 metres from residential areas. Moreover, the site must have an appropriate position for distribution of heat to the town. Finally, the required quantities of manure and waste should be available within a radius of 10 kilometres. A biogas plant is not, for example like a biomass incineration plant, only an energy producer. In addition, it contributes to solving a number of environmental problems which can briefly be summed up to the utilisation of waste and optimised utilisation of manure and waste as manure for agriculture. In regards to this, one has to consider the success achieved in this case. Finally, it can be added that a biogas plant can also be vital for optimal utilisation of energy crops.

FOR FURTHER INFORMATION

PlanEnergi - Nordjylland
Per Alex
Jyllandsgade 1
DK - 9520 SKØRPING
Tel: +45 96 82 04 00
Fax: +45 98 39 24 98
E-mail: nord@planenergi.dk

This case study was prepared by Energie-Cités in co-operation with the engineering company PlanEnergi and the municipality of Aalborg. It received funding from the ALTENER Programme of DGXVII of the European Commission.

[2] The figures are based on a daily biogas production of 10,000 Nm^3/day