# LARGE SCALE BIOGAS PLANTS - SOME EXPERIENCES

Michael Parsby
Institute of Agricultural Economics
Copenhagen, Denmark

## 1. INTRODUCTION

In the last decade considerable efforts have been made to study the biogas process and develop biogas plants for agriculture - primarily with the aim of producing cheap energy. In this context the interdisciplinary cooperation group, STUB, was formed in 1978 (dissolved in 1985).

The limited spread of individual biogas plants, which can also be seen elsewhere, is chiefly due to economic factors, while the biogical and technical operation is fairly stable.

The limiting economic factors are the present relatively low energy prices, the high construction and operating costs and the most often poor utilization of the produced energy.

On this basis the idea of large cooperative biogas plants was formed. Manure from several farms is used for biogas production and the energy is supplied to a large consumer - usually a district heating system. The adventages as compared with farm plants are guaranteed sale of the energy at relatively high prices and reduced unit costs because of economies of scale.

Increased costs are created however, mainly due to transport of manure and measures against increased risks of infection.

## 2. THE EARLY EXPERIENCES

The large biogas plant based on this concept was the Vester Hjermitslev plant, built in 1984 as part of the North Jutland County project: "Village Energy". The aim of the project was to

reduce dependence on imported energy, increase employment and strengthen the local business development. The total costs amounted to about 16 million DKK, of which more than 7 million was subventions, nearly half the amount granted by the EEC.

However, the economy of the plant was so poor that in October 1986 the Minister of Energy was requested to grant additional financial support for reconstruction and improvements. The Ministry formed a group for evaluation of the technology and economy of the plant. The report presented by the group showed that minor changes and repairs were neccessary, that the debts had to be reorganized and that the future economy would be doubtfull still.

These early experiences showed that large biogas plants are not immediately profitable under the existing conditions if the economy is based on energy alone.

3. ENVIRONMENTAL REGULATIONS

In 1985, the Danish Parliament passed the so called NPO-act implying restrictions on the handling, storing and spreading of animal manure.

The act intensified the interest in co-operative biogas plants since it transformed the agricultural and environmental benefits of CBP's to a potential economic value supplementing the value of the energy production.

Later, in 1987, the restriction were strengthened through the "Water-environment-plan" which aimed at reducing the nitrogen pollution of the ground- and surface water.

The measures with direct impact on Danish agriculture were:

- Extension of the storage capacity for manure to 9 months on farms with more than 30 animal units.
- Maximum limits of the number of animals per hectare. Cattle farms: 2,3 animal units per hectare (48 tonnes of manure per hectare). Pig farms: 1,7

C.U.'s per ha (28 t/ha). Other farms: 2,0 C.U.'s per ha.

- "Green fields". Minimum percentage of plant-covered fields in the autumn and winter months: 45% in 1988, 55% in 1989 and 65% in 1990.
- Spreading of liquid manure prohibited from harvest to November 1.st. and on frozen ground. Fields with plant-cover excluded.
- Liquid manure must be ploughed in before 12 hours after spreading.
- Systematic manure planning for all fields carried out by authorized persons. From 1988.

Among the potential benefits of large biogas plants are:

- Lower unit costs in large storage tanks as compared to individual storage on the farms.
- Flexibility in case of livestock increases/reductions.
- Organized marketing of surplus manure.
- Reduction of the total amount of active bacteria, etc., and weeds.
- Better utilization of plant nutrients because of more homogenous manure and better possibilities for sampling and description of the manure content.

Whether these potential agricultural and environmental benefits will be able to change the preliminary conclusions depends on the economic value of the benefits obtained and especially on how large a part of this value can be credited to the biogas plant.

## 4. THE BIOGAS PLAN OF ACTION

In May 1986 a report prepared by a group formed under the Ministry of Environment, the Ministry of Energy and the Ministry of Agriculture was presented. The title of the report was: "Co-operative Biogas Plants and the NPO-Plan of Action" and the aim of the report was among other things to spread public knowledge of CBP's as a way to meet the requirements of the environmental restrictions.

## 4.1 The Coordinating Committee

In November 1986 the Coordinating Committee for Large Biogas Plants was formed with farm owner Knud Øllgaard as chairman.

In May 1987 the group presented a plan of action for establishing and testing of large biogas plants. The aim of the plan is to provide a framework for a 3-4 year test, full-scale demonstration and follow-up programme to assist in determining whether it is technically and economically justifiable to start a major distribution of large scale biogas plants in Denmark.

The contents of the plan of action include:

- an experimental and demonstration programme involving both existing large biogas plants and a number of new plants.
- a follow-up programme recording and analysing the agricultural, environmental, technical, economic and energy related results of the demonstration plants.
- organizational and promotional activities ensuring continuous exchange and spreading of experience.
- experimental end research activities.

The demonstration plants receives financial support granted by the Ministry of Energy, while the follow-up programme is financed jointly by the three ministries and the Renewable Energy Steering Committee of the Technological Council.

The Coordinating Committee has made an organisation plan involving the forming of two working-groups, a secretariat and a number of specific projects. The working groups include a specialist group attending to the follow-up programme, the techno-economic evaluations and agricultural questions. The second group consists of representatives from the plants and attends the exchange of experience and the advisory service.

## 4.2 Criteria for demonstration plants.

The Coordinating Committee decides which plants are to be included in the test and demonstration programme. Existing plants

and plants already planned may be included and two calls for project proposals have been made.

A number of criteria is laid down for the selection of plants for the demonstration programme. The criteria include: the process, method of utilizing the biogas, size of the plant, manure storage facilities, transport system, manufacturer, organization, engagement of farmers, application of the energy, type of raw material, geographical localization of the plant, etc.

4.3 Techno-economic follow-up programme

The objective of follow-up programme is to ensure that the aim of the demonstration programme is attained. The essential part is the continuous follow-up on the technical and economic results of the plants. Further, basic data are collected including data on the system, the organization, investment and operating budgets, manure transportation system and agricultural factors.

The aim is to record and analyse information according to a uniform method in order to provide straightforward comparisons between the individual plants.

The technical documentation is based on a monitoring programme and on information and experiences from the operating staff at the plants. The monitoring programme includes dual monitoring of the gas production and guidelines for choice, installation and service on measuring equipment.

The economic documentation is obtained by the development and use of a common accounting plan designed especially for the demonstration plants. Analyses and evaluations of the operating results are made including the total costs, breakdown of costs, financing etc.

4.4 Research projects.

The action plan includes a number of specific projects, of which some have already been initiated. High priority is given to investigations of risks of infection caused by CBP's.

Other important subjects are the value and handling of manure and the impacts of CBP's on the nitrogen cycle. Other proposed projects include organic household-waste as a supplemental raw material, thermophilic processes, transport systems (also for solid manure), measuring techniques and finally international collection and publication of results.

## 5. PRESENT STATUS

Among the plants built before the demonstration programme was initiated the programme includes Vester Hjermitslev and Skovsgård while the participation of Vegger is not yet decided. The new plants include Davinde near Odense, Sinding near Herning, which is expected to be started in 1988 and Revninge near Odense, which is put into operation in 1988. A projected plant in Fangel also near Odense is recommended for support by the Co-ordinating Committee.

Other plants projected or planned are:

- Aakirkeby
- Give
- Hasle
- Holstebro
- Lemvig
- Lintrup
- Ribe

For these plants no decision has been made regarding support and participation in the demonstration programme. The Coordinating Committee awaits the results from the projects in progress, expectedly during the summer 1988.

### 5.1 Vester Hjermitslev

The first large biogas plant in Denmark was built in 1984 in Vester Hjermitslev in Northern Jutland. The capacity was 45 tonnes but due to economic and technical problems the plant was re-built in 1987/88 and the capacity extended to 60 tonnes per day. The plant now consists of a 200 $m^3$ thermophilic pretreatment tank and three 500 $m^3$ mesophilic reactors. The expected

biogas production is 1200 $m^3$ methane per day. The gas utilization system is of the LOCUS-type (Local Cogeneration Utility System) with a connected gas-motor, generator and heat pump.

5.2 Skovsgård

In autumn 1987 the Skovsgård plant was put into operation. Every day about 75 tonnes of manure from 12 farms is transported up to 11 kilometers to the plant in a specially built tank lorry.

The manure is heated to 55°C in a 250 $m^3$ hygienization tank, to reduce bacteria, virus, parasites and weeds. From the hygienization tank the manure is pumped to two 600 $m^3$ mesophilic reactors with a projected biogas production of 1800 $m^3$ per day. The gas--utilization system consists of a gasmotor with heat recovery and connected to a el-generator or a heat pump. (LOCUS). The system also consists of two windmills.

The investment costs amount to about 17,2 milion DKK.

5.3 Davinde (Odense)

The Davinde plant was officially inaugurated in February 1988. It is owned on a co-operative basis by 11 farmers of which 8 are suppliers of well over 40 tonnes of liquid manure per day and 3 are suppliers of about 2 tonnes of straw per day in the winter months. The plant includes a 800 $m^3$ mesophilic reactor and a straw boiler which produces heat delivered to the municipal district heating system. The biogas reactor is expected to produce about 1000 $m^3$ biogas per day and this target has already been reached.

The storage facilities are limited to about a weeks consumption of straw and about two weeks for manure. The manure is transported by a tractordrawn slurrytank.

The total costs of the plant have been about 5,3 milion DKK, of which 30% have been granted by the public. 25% of the price of straw will be payed in manure.

5.4 Sinding/Ørre (Herning)

The plant is designed for maximum load of 190 tonnes of organic material per day. The organic material include liquid and solid manure and slaughterhouse waste. The liquid manure is separated into a thin (1-2% TS) and thick (10% TS) fraction. The thin fraction is treated in a 55 $m^3$ anaerobic fixed filter while the thick fraction is mixed with the other waste and a part of the output from the anaerobic filter. The thick fraction is then treated in a two-step termophilic process. First, the material is hydrolyzed in about three days in a 700 $m^3$ reactor, and second the material is treated in two 700 $m^3$ digestors. The expected biogas production is about 5.000 $m^3$ per day (3250 $m^3$ of $CH_4$). The total investment costs are about 26 milion DKK, and the plant is expected to be put into operation in July 1988.

5.5 Revninge (Odense)

The plant is expected to treat 40 tonnes of animal manure and 6 tonnes of industrial waste per day. The organic material is treated in three completely mixed 220 $m^3$ mesophilic reactors. The expected gas production is 900 $m^3$ methane per day, and the gas will be distributed in a local gasnetwork and used for heating purposes. The investment costs are 10,5 milion DKK and the plant is put into operation at the end of 1988.

5.6 Fangel (Odense)

The Fangel plant is designed for 161 tonnes of organic material per day consisting of 143 tonnes of animal manure and 18 tonnes of slaughterhouse waste. The organic material is pretreated in a thermophilic reactor and then pumped to two 1600 $m^3$ mesophilic reactors. The expected gas production is burned in boilers for district heating. After the anaerobic digesstion the organic material is separated and the fibre fraction is used for compost production.

The total costs are 20.9 milion DKK, and the plant is expected to be in operation primo 1990.