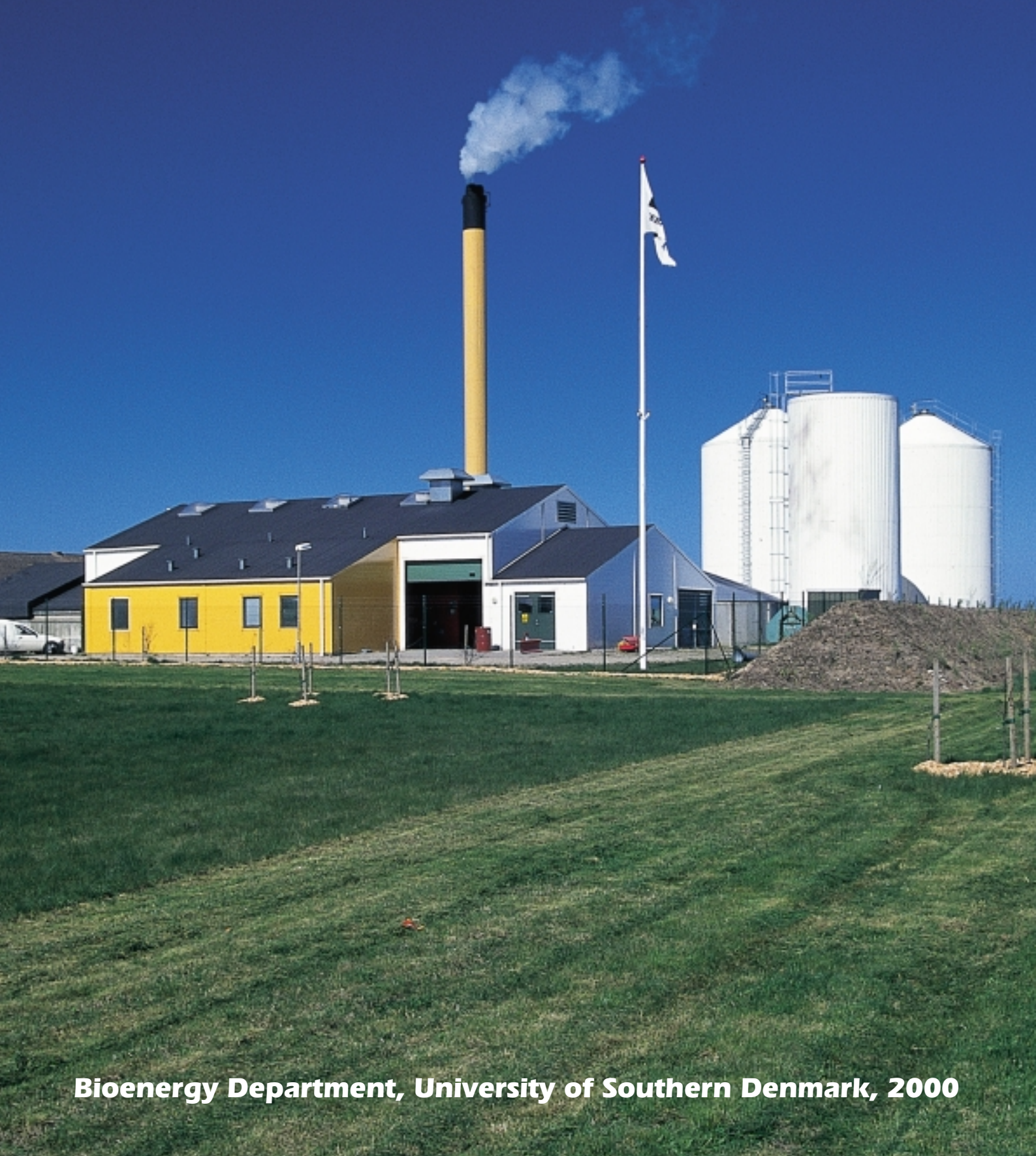


Danish Centralised Biogas Plants

- Plant Descriptions





The Lemvig plant is one of the largest biogas plants in the world.



The biogas plant in Hashøj demonstrates combined biogas/natural gas fuelled CHP plant.



The plant in Studsgaard has positive experience with co-digestion of slurry, organic waste and source separated household waste.

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Danish Centralised Biogas Plants - Plant Descriptions

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Preface

Considerable efforts in developing the biogas technology has been carried out in Denmark since 1988, with successive biogas development programmes accomplished, financed and supported by Government.

The first biogas plants were only designed for generating energy. Later it occurred that the plants make a significant contribution to solve a range of problems in the fields of agriculture, energy and environment. Consequently, increased attention has been paid to these issues, and centralised biogas plants are now considered as integrated energy production, manure and organic waste treatment and nutrient redistribution facilities.

Some 20 centralised biogas plants are currently in operation in Denmark.

This has led to Denmark having a unique level of know-how in the fields of construction and operation of centralised biogas plants. In addition to this, the Government supported follow-up programmes that have secured comprehensive documentation of production results.

The plants and the operation experience gathered are set out in the present report. All plant descriptions are based on 1999 data.

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May 2000.

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The biogas programme in Denmark 1998-2001

The special biogas programme being implemented now and until the end of 2001 is intended as a contribution towards the realisation of plans of action in respect of energy conservation, the reuse of waste, and the improvement of the water environment. The programme focuses on, among other things, operating economy, biogas from domestic waste and the improved distribution and utilisation of farmyard manure. It is also designed to create more movement in the establishment of new biogas installations.

By Johannes Christensen & Jens Bo Holm-Nielsen

Since 1987, the Danish Ministry of Food, Agriculture and Fisheries and the Danish Ministry of the Environment and Energy have jointly financed a development and demonstration programme. Support for research and development has also been forthcoming from the Energy Research Programme and the Development Programme for Renewable Energy. Biogas technology has since developed significantly in Denmark, helped along the way by government energy plans, by more specific biogas plans of action and the above-mentioned R&D programmes. Many different institutions, companies and individuals have made contributions to the results achieved. It has been teamwork in which the interests of energy conservation, the environment, industry, and agriculture have become united.

There is need to continue the work by improving the function and efficiency of biogas plants, and create improved economic and organisational framework conditions to further the establishment of new installations in accordance with the plans outlined in the government's energy plan - Energy 21.

At the moment, the wider adoption of biogas installations has stagnated, especially where new centralised biogas installations are concerned. Instead, new farm biogas plants are being installed in connection with large-scale pig farming. From a production point of view, actual progress is quite good and will accelerate in the coming years.

There will still be a possibility of expanding the recovery of landfill gas and the production of biogas based on domestic and industrial waste. However, by far the largest potential can be found in farmyard manure and slurry based biogas plants and therefore this area is of special significance for the development of the biogas industry.

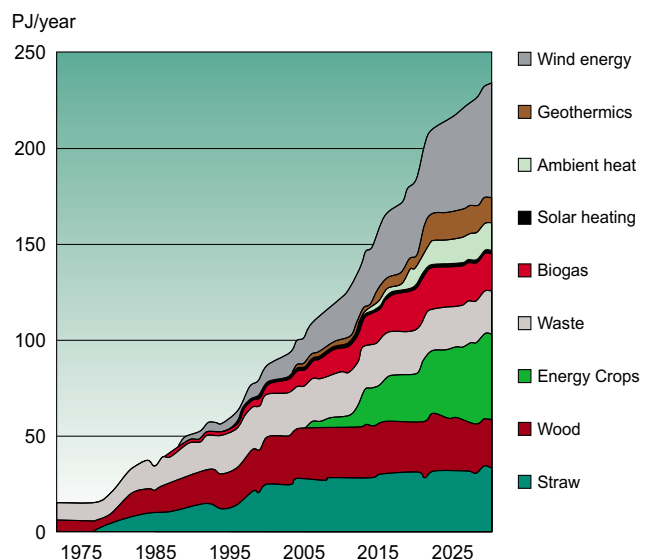
Main objective

It was decided to progress the special cross-ministerial biogas programme during the period 1998-2001. The advisory Biogas Group was given the responsibility of implementing the programme, which consists of a number of follow-up, development and information activities undertaken by different institutions primarily within sector research and The Agricultural Council of Denmark. The total budget for the period is DKK 12 million.

The government therefore continues to give significant support to the biogas area for research and development work, and in the form of support for installation investments. In addition, there is a special electricity subsidy and indirect support in the form of tax exemptions in connection with the consumption of heat generated from biomass. Without these support measures no renewable energy sources would be capable of economic survival.

Behind this state support is the desire to see biogas technology contributing to the realisation of some of the main objectives of society. There are three part-objectives:

1. Achieving the objectives laid down in Energy 21, where in the long term 35 percent of energy supplies will come from renewable sources. An annual 20 PJ of this energy is to come from biogas, corresponding to an eightfold increase in relation to the 1998 biogas production. The whole of the biogas area is included, but the main effort will be directed towards installations based on the digestion of farm manure.



Renewable energy development until year 2030. Source: Energy 21, the Danish Governments Action Plan for Energy.

2. Helping to increase the reuse of organic domestic waste, of waste water sludge and other suitable types of waste. The objective of the plan of action for waste - Waste 21 - is to use 100,000 tons of organic domestic waste in biogas installations during the year 2004. In the longer term, the objective is 350-400,000 tons.
3. Clarifying the extent to which different types of biogas installation are able to contribute to the fulfilment of the requirements of agriculture in the utilisation of livestock manure in relation to Water Environment Plan II. Action Plan II for the development of organic agriculture points to biogas installations as a means of ensuring the recycling of nutrients from organic waste - a central issue in being able to convert a major part of agriculture to organic production.

In addition to the three main objectives named above there are also possibilities of providing more jobs and increasing exports. Export activities are in progress but these must be further supported, primarily through well-functioning reference installations on the home market.

Areas of activity

State research and development activities must be coordinated with the development carried out by companies who operate in the market. Biogas plant is by no means a new technology, but one that to a certain extent has made a breakthrough, commercially and in terms of development. The public sector must therefore concentrate on what the various players on the market cannot themselves undertake. Significant parts of the technological development of the plant itself can be more appropriately left to the companies who supply the equipment, for it is this they have to sell and compete on.

The programme covers a number of more general conditions in relation to the social economic function of biogas installations when seen from the point of view of energy supply and the environment, but there the division of labour is not clear-cut. Agriculture, the district heating sector and public authorities must also make a contribution if biogas installations are to be further developed and adopted more widely. Finally, the more fundamental parts of process and technological development will need state funding.

This article focuses on some of the more essential activities included in the Biomass Programme 1998-2001. The programme is quite flexible in its approach, which means that tasks which subsequently emerge can also be included on the agenda.

Economic analyses

The economic follow-up programme and the collation of operating experience gained from both farmscale and centralised biogas installations are in progress, thus the way the production and operating economy of established plant are developing is under good control. Economic analyses and model calculations are being carried out in this connection in order to illustrate the significance of cost reductions, billing, different plant concepts, etc. The purpose here is to

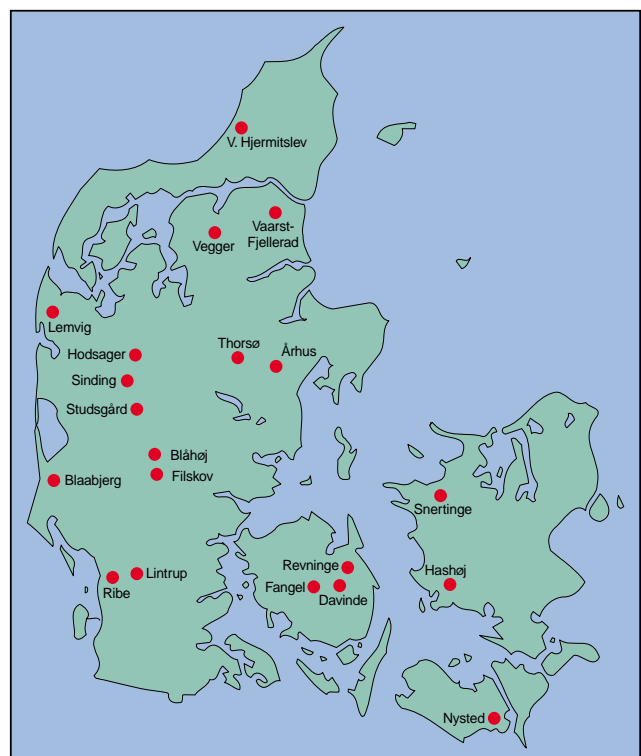
provide a basis for the various decision makers involved. There is also need for information that can be used for administrative and political purposes. The recently adopted reform of the policy on electricity supply in Denmark means that the billing rules for biogas installations will have to be scrutinised more closely before the end of 2003.

The economic development will of course determine the rate at which wider adoption takes place, which types of plants appear, which financing and organisational models become dominant. Large variations in earnings can be anticipated and risk evaluation takes on a special significance.

The economic consequences for farmers and authorities, and the possible supplementary treatment of the degassed manure are expected to become factors of more importance. On the municipal side it is essential to be able to evaluate the economic patterns arising from domestic waste and sludge treatment taken together livestock manure and its relation to biogas installations. The programme is intended to initiate the development of better methods and the compilation of enhanced databases for analysing the social and environmental-economic consequences of biogas installations.

More gas from manure

The results of research suggest among other things that through comminution around 20% more gas from manure can be obtained than is possible today. If this does show itself as a practical possibility at not too high a cost, it will have much impact on biogas economics. Work is being carried out on upscaling the experiments with a view to demonstrating the



20 centralised biogas plants are in operation in Denmark. As most of the livestock production takes place in the western parts of the country, this is also where most of the biogas plants are found.

practical possibilities. The aim is to transfer the results to both existing and future plants, provided of course that the system does prove to be economically advantageous.

The programme is also aimed at increasing knowledge on winning gas from livestock manure, including the possibility of being able to predetermine the gas potential. In practice there are large variations, because of feed, collection and storage methods for example. For this reason, investigations have been started to shed more light on these conditions.

Integrated waste treatment

The programme will help improve and clarify the technology, economy, and the organisational conditions surrounding the use of domestic waste and sludge in agriculturally-based biogas installations through goal-oriented technological development and the establishment of new demonstration plants. Considerable experience in this area has already been gained, but more work is necessary, specifically on the sorting of domestic waste - primarily with the object of avoiding plastics, and with techniques for separating plastics that cannot be avoided.

The development work itself is to be undertaken by municipalities, the waste disposal sector and plant suppliers. The primary role of biogas programme activities will be to document results achieved and operating experience in a form that creates a decision-making basis for future integrated waste treatment.

In the same connection there must be closer analysis of the role biogas installations can play in the recirculation of nutrients as a factor in the more widespread adoption of organic agriculture and horticulture.

Domestic waste and sludge are what can be called "problem products" in the sense that they might contain substances which burden the environment. Steps must also be taken to ensure that no germs can be present to spread disease. Investigation and analysis are needed in both areas and the programme is designed to help the process. Further investigation must be devoted to the significance of biogas installations in connection with the prevention of contagious disease among livestock.

Distribution and use of nutrients

Centralised biogas plants provide good possibilities for the redistribution and better utilisation of nutrients in livestock manure and waste. The Biogas Programme 1998-2001 develops and further documents these possibilities in the light of the now stricter requirements of Water Environment Plan II. This work is aimed especially at:

- The preparation of a nitrogen report on untreated and degassed manure in order to quantify the effect on washing out and nitrogen loss including that which occurs when transferring the manure from stable to field using different spreading strategies.

- The preparation of a follow-up programme for nutrient transformation by using separation plant in connection with biogas installations, with special focus on the phosphorus burden on agricultural soil.
- The possibilities of using the potential of improved nitrogen utilisation of degassed manure seen in the light of legislation which reduces permissible amounts of nitrogen fertiliser.

The motivation of farmers in taking part in the wider use of centralised biogas plants largely depends on what can be documented and demonstrated, i.e. they must be shown that there are marked practical and economic advantages in treating farmyard manure in this way.

Information

The information and dissemination activities will be continued and adapted to the needs of the Danish biogas sector, the authorities, and decision-makers in general - in an international setting.

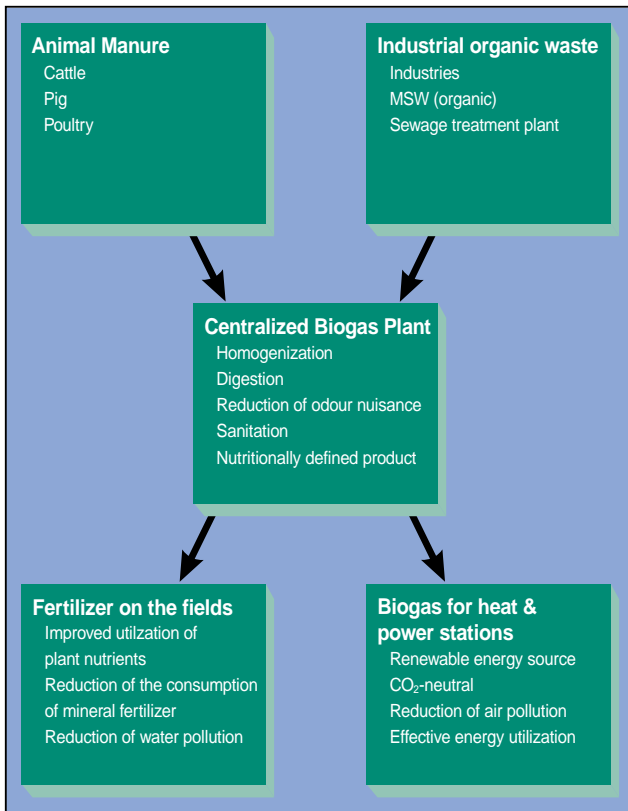
Regular seminars will be held for operations managers at which specific facets of management will be discussed and at which there will be opportunities to exchange experience. There will also be regular seminars on the economic side for managers and chairmen of centralised biogas installations. Here such matters as operating economy, financing, maintenance strategies and plant improvements will be discussed.

Information is also being issued through articles in "Dansk Bioenergi". Detailed background reports from various other areas of activity are also being issued.

The promotion of new installations

The reform of the policy on electricity supply in Denmark, adopted on 3 March 1999, to a certain extent clarified future billing rules for biogas-based electricity and heat. Experience from already established centralised biogas installations shows that normally it is very time-consuming to plan and finance an installation. The planning time can often be 2-3 years. Authority requirements have gradually increased in significance concurrently with the sector becoming an important factor in energy supply. Therefore a proposal under consideration is to create a team of experienced board members from established installations to advise new initiators so that they avoid the obvious traps in setting up new projects.

Some existing installations, even quite new ones, have suffered from technical defects that have led to many difficulties. An appeal must be made here to suppliers and consultants to make sure that the quality of installations prevents the teething troubles that give rise to a poor reputation, and uncertainty on the part of future owners. The biogas programme will continue to include the offer of detailed technical assistance and the discussion of new installation projects with a group of experienced managers and technicians for the purpose of establishing quality assurance and the transfer of experience.



The main streams of the Centralised Biogas Plant integrated concept. Source: Centralized Biogas Plants; From idea to reality (Danish Version); Danish Energy Agency Nov. -95.

The interest of farmers in taking the initiative and accepting the responsibility for centralised biogas installation is less clear than it was 5-10 years ago. It was then advantageous for farmers to provide the required manure storage capacity in a centralised biogas installation. This capacity has now been created, but new requirements concerning the agricultural environment again direct the interest of farmers to phosphorus distribution, increased nitrogen utilisation in cultivation, and less emission and odour from pig production and manure spreading.

However, biogas installations still offer a number of advantages which up to now have perhaps not been made sufficiently visible, but which are so good that they would at least stimulate the desire of farmers to become suppliers to biogas installations. Others can assume the responsibility for establishing and operating them. "Others" in this context might be already established biogas companies who would benefit from being able to expand. Initiatives might also come from equipment suppliers or from waste disposal companies perhaps in cooperation with a financing institution.

Common to the new organisation models is that from now on satisfactory economic conditions can be created, to the extent that money can be earned from biogas. The main objective of the biogas programme is thus to contribute to the greatest extent possible in ensuring that such a commercial foundation can be created.

Vester Hjermitslev

Vester Hjermitslev biogas plant was started up in 1984 as the first centralised co-digestion plant in Denmark. The plant was built as a consequence of the energy crisis and as an example of energy self-sustainability. The enforcement of the environmental legislation increased the farmers motivation to join a centralised co-digestion plant, and to solve agricultural and environmental problems related to intensive animal husbandry.

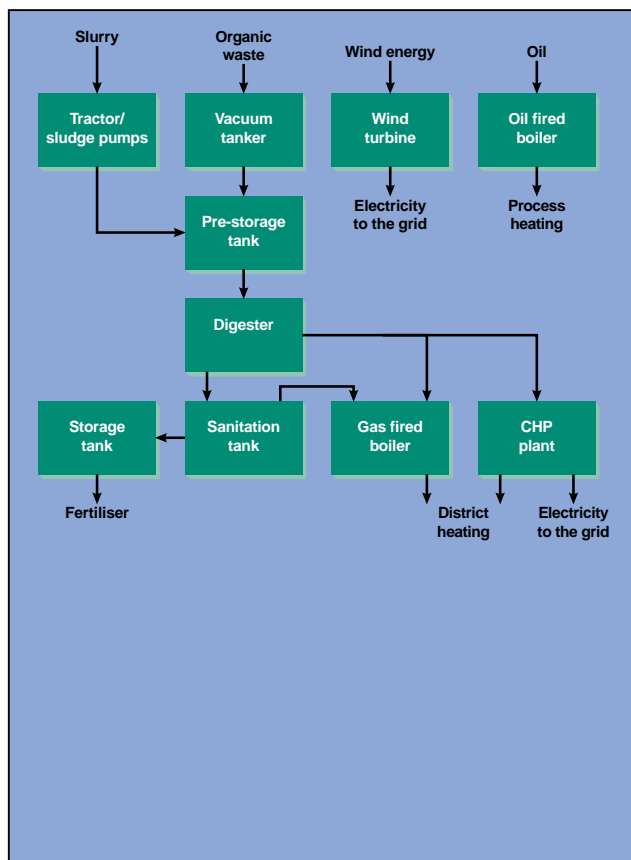
The plant is owned by Vester Hjermitslev Energiselskab, an independent institution, and was built by the North Jutland County Council, together with a wind turbine, as part of the "Village Energy Project". The aim was to demonstrate the advantages of decentralised energy supply, based on local resources. The first years of operation were experimental years, marked by serious operating problems leading to extensive reconstruction in 1987-88 and 1991.

5 cattle and pig farms supply slurry to the plant. The slurry is mixed and co-digested with flotation sludge from fish processing industry, tannery waste and smaller amounts of fodder waste. The process is mesophilic, at 37°C. The digested biomass is submitted to a sanitation process for 4 ½ hours at 57°C and transported to 2 storage tanks placed close to the fields and shared by the manure suppliers, or to their own storage tanks, as a valuable fertiliser. The content of macronutrients and dry matter is determined before delivering it to the farmers storage tanks. The



surplus is sold to 10 crop farms in the area, among them the local Organic Farming School.

The plant has its own CHP- unit, where the produced biogas is primarily utilised in the 2 biogas motors (840 kW +770 kW). Any overproduction is used in a gas boiler (250 kW).



Main data

Animal manure	41 tons/day
Alternative biomass	13 tons/day
Biogas production	1.0 mill. Nm ³ /year
Digester capacity (3 × 500 m ³)	1500 m ³
Process temperature	37°C
Gas storage capacity	50 m ³
Utilisation of biogas	CHP-plant/gas boiler
Transport vehicle	Tractor/15 m ³ vacuum tanker
Average transport distance	1.5 km
Investment cost ¹	12.4 mill. DKK
Government grant	4.3 mill. DKK
Contractor	Krüger Ltd.
Operation start-up	1984

1. Not incl. storage capacity.

Vegger

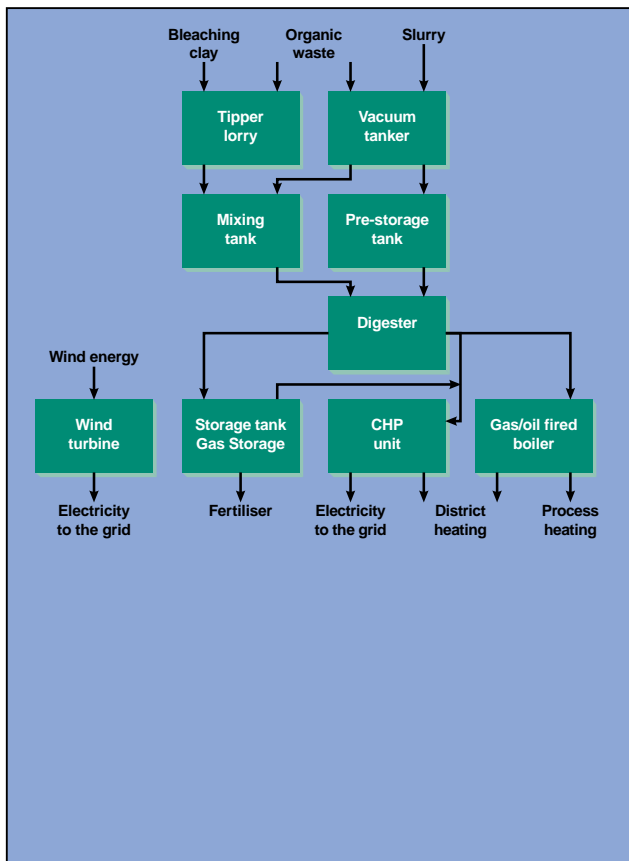
The centralised co-digestion plant in Vegger is owned and operated by Vegger Energiselskab, an independent institution. The plant was built in 1985/86 as a pilot plant, part of the "Village Energy Project". The aim of the project was to demonstrate the advantages of decentralised energy supply, based on local resources. In 1987 a trial of the reliability of the thermophilic digestion was carried out at the plant, with positive results.

From the beginning the plant had serious technical problems, resulting in major reconstruction projects in 1988-1991. As a result, a low pressure gas system was established, with an extra gas engine-unit and a larger gas boiler.

The biomass mixture consists of cattle manure supplied by 5 cattle producers, intestinal content from pig abattoirs, bleach clay from vegetable oil processing, organic waste from the fish processing industry, medicinal industry and food processing industry, and sewage sludge. The anaerobic co-digestion takes place at thermophilic temperature, 55°C. The biomass is heated partly through the heat exchanger systems and partly by heat pipes inside the digesters. Pathogen reduction is ensured by a guaranteed retention time of minimum 3 hours at the process temperature. After digestion, the biomass is pumped to a storage tank, covered with a gas-tight membrane (soft cover), where the remaining gas production is collected. The manure suppliers receive the digested biomass in their own storage tanks, or in a 3000 m³ shared storage tank, 3 km away from the plant.



The gas is utilised in a CHP-unit, consisting of three gas engines (390 kW + 890 kW +1550 kW). A standby gas boiler (1300 kW) is used for peak load heat consumption and in case of engine failure. The heat is sold to Vegger District Heating Plant and some is used as process heat. The electricity produced is sold to the grid.



Main data

Animal manure	42 tons /day
Alternative biomass	17 tons/day
Biogas production	2.1 mill. Nm ³ /year
Digester capacity (4 × 230 m ³)	920 m ³
Process temperature	55°C
Sanitation	MGRT of 3 hours at 55°C
Gas storage capacity	148 m ³
Transport vehicle	20 m ³ vacuum tanker
Average transport distance	5 km
Utilisation of biogas	CHP-plant/gas boiler
Investment cost ¹	13.4 mill. DKK
Government grant	2.9 mill. DKK
Contractor	WWW.Engineering Ltd./Vegger
Operation start-up	1986

1. Incl. wind turbine.

Davinde

Davinde biogas plant, built in 1987, is owned by Davinde Energiselskab A.m.b.a., which was the first example of co-operation between farmers to establish and operate a centralised biogas plant. The co-operative also operates a straw-fired heating system.

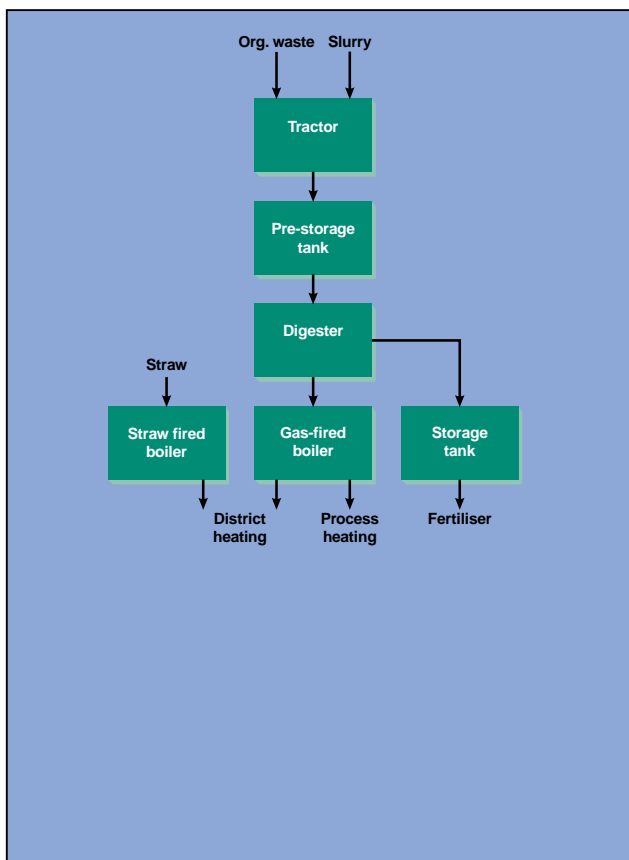
The co-operative, having 11 farmers as members, of which 6 also are slurry suppliers, was established with the aim of producing renewable energy from the supplied animal manure and straw from the members, and to sell the energy produced.

The manure is supplied from 3 pig farms and 3 cattle farms, and is mixed with small amounts of sludge and fish waste from 2 fish processing industries in the area. Two of the manure suppliers are also straw suppliers. The process is mesophilic (36°C) and takes place in a single reactor. No heat exchange takes place. Justified by the modest number of slurry suppliers and the types of alternative biomass added to the slurry, the biomass mixture is not sanitised.

The plant is of small scale and rather simple, which has helped to keep operational costs low. The agricultural advantages of the biogas plant consist of better distribution of manure and nutrients in the area and less odour nuisance when spreading. The homogenous and liquid consistency of digested biomass makes it suitable for applying with dragging hoses, with less loss of ammonia and nutrients. Each year the excess manure is sold to the arable farms in the area.



The biogas is used in a gas fired boiler to heat production. The heat is supplied to Davinde district heating system and a small part is used for process heating. A 11 MW straw fired furnace covers the remaining heat requirement.



Main data

Animal manure	25 tons /day
Alternative biomass	3 tons/ day
Biogas production	0.3 mill. Nm ³ /year
Digester capacity	750 m ³
Process temperature	36°C
Gas storage capacity	30 m ³
Utilisation of biogas	Gas fired boiler
Transport vehicle	Tractor/14 m ³ vacuum tanker
Average transport distance	5.7 km
Investment cost ¹	5.8 mill. DKK
Government grant	1.9 mill. DKK
Contractor	Krüger Ltd.
Operation start-up	1988

1. Not incl. storage capacity.

Sinding - Ørre

The biogas plant in Sinding was built in 1987-88 and is owned and operated by Herning Municipal Utilities. The construction of the plant is part of the energy policy of the Municipality of Herning to displace fossil fuels by local renewable energy sources

Together with the biogas plant, 31,500 m³ storage capacity for digested biomass was built. The storage tanks are owned by Herning Municipal Utilities and the 34 slurry suppliers can rent the needed capacity, in order to meet the legal requirement of slurry storage. The suppliers receive back digested biomass according to their needs and the surplus is sold to the crop farms in the area. The transport and distribution of digested biomass is done by the association of the slurry suppliers.

The digestion process is thermophilic, at 51°C, and takes place on two separate flow-lines. One of the lines processes animal slurry and organic waste from food processing industries in two of the three digesters. The slurry consists of 40 % cattle slurry and 60 % pig slurry. The organic waste mainly consists of intestinal content from abattoirs, dairy waste, bleaching clay from vegetable oil industry and other organic wastes. Pathogen reduction is ensured by a guaranteed retention time of 4 hours at the process temperature of 51°C.

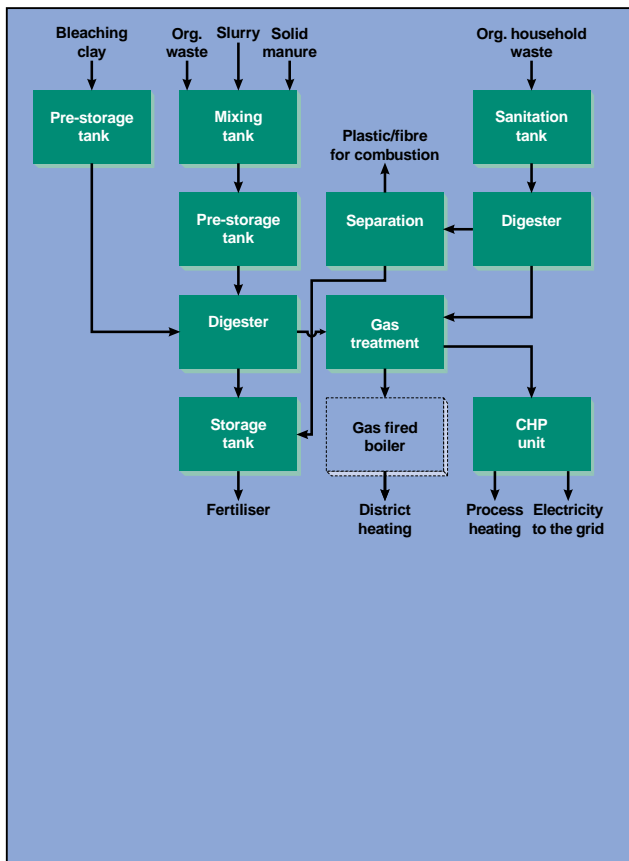
The second flow-line processes organic household waste. The household waste is mixed with slurry and digested in a separate digester. Before digestion, the



mixture is sanitised at 60°C for 2½ hours, according to the prescription of the law. A separation process removes plastic and other unwanted items from the biomass.

Herning Municipal Utilities have developed the system for treating household waste, and is holding an European patent on this.

90 % of the biogas production is utilised at a CHP-plant, in two biogas engines, producing 400 kW electricity to the grid and 700 kW heat, used for heating the biogas process and the main part sold to the district heating system of the City of Herning. The remaining 10 % biogas is utilised in a 730 kW biogas boiler at Sinding district heating plant.



Main data

Animal manure	117 tons/day
Alternative biomass	18 tons/day
Biogas production	2.4 mill Nm ³ /year
Digester capacity (3 × 750 m ³)	2250 m ³
Process temperature	51°C
Sanitation (slurry)	MGRT 4 hours at 51°C
Sanitation (household waste)	MGRT 2,5 hours at 60°C
Gas storage capacity	150 m ³
Utilisation of biogas	CHP-plant/gas boiler
Transport vehicle	2 × 13 m ³ vacuum tankers
Average transport distance	5 km
Investment cost ¹	26.2 mill. DKK
Government grant	8.9 mill. DKK
Contractor	Bruun & Sørensen Ltd.
Operation start-up	1988

1. Incl. storage capacity.

Fangel

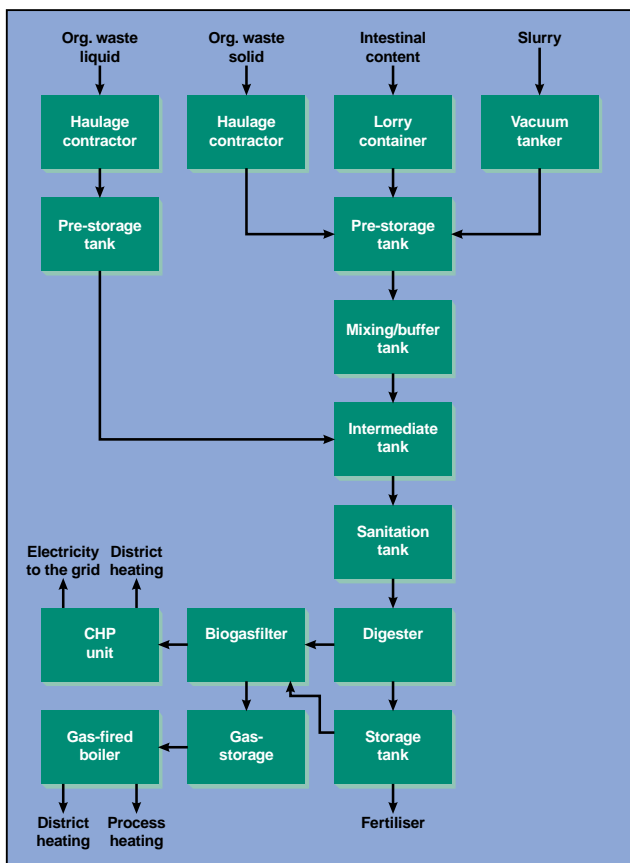
Fangel biogas plant was built in 1988-89. The plant underwent major reconstruction in 1999, which significantly improved performance and operational stability. The owner is Fangel Miljø- & Energiselskab A.m.b.a., with 26 slurry suppliers as members. The aim of the co-operative is to find an economically viable solution to the environmental problems related to the storage, handling and distribution of slurry from the intensive animal production of the area.

The plant is mesophilic (37°C), processing pig and cattle slurry and small amounts of poultry and mink slurry from 26 animal farms from the area. In addition to slurry, intestinal content and flotation sludge from abattoir, dairy waste, waste from the food processing industry, the tannery industry and the medicinal industry is supplied. The biomass is heated through the heat exchanger system and sanitised at 60°C for 3½ hours, before digestion.

After digestion, a part of the digested biomass is separated into fibre and liquid fractions. The liquid fraction is used in the biological gas purification filter. The main part of the digested biomass is transported to the de-centralised storage tanks, close to the fields. The co-operative has built 23 de-centralised storage tanks with a total capacity of 25000 m³. Bulk buying of the tanks gave a significant price discount for the farmers. The surplus of digested biomass is sold each year to the crop farmers in the neighbourhood.



The biogas plant is equipped with its own CHP - unit, where the biogas is used in a 1500 kW engine to produce electricity and heat. Any overproduction of biogas is used in a biogas fired boiler. The heat is sold to Odense Municipal District Heating and the electricity is sold to the grid.



Main data

Animal manure	124 tons/day
Alternative biomass	19 tons/day
Biogas production	2.2 mill. Nm ³ /year
Digester capacity ¹	3750 m ³
Process temperature	37°C
Pasteurisation	MGRT 3,5 hours at 60°C
Gas storage capacity	50 m ³
Utilisation of biogas	CHP-plant/gas boiler
Biomass transport vehicle	20 m ³ vacuum tanker
Average transport distance	6.5 km
Investment cost ²	25.3 mill. DKK
Government grant	10.0 mill. DKK
Contractor	Krüger Ltd.
Operation start-up	1989

1. 2 × 1600 m³ + 550 m³.

2. Incl. storage capacity.

Ribe

Ribe Biogas Plant was built in 1989-90 and started operating in 1990. The plant is owned by Ribe Biogas Ltd. The owners are the slurry supplying farmers, a food processing company that supplies organic waste to the plant, the regional power company and two investment companies. The aim of Ribe Biogas Ltd. is to establish and operate a biogas plant and to develop and promote biogas production technologies.

The biogas plant contributes to solving some major environmental and agricultural problems in the area, related to handling, storage and redistribution of animal manure, and brings some economic advantages for the farmers.

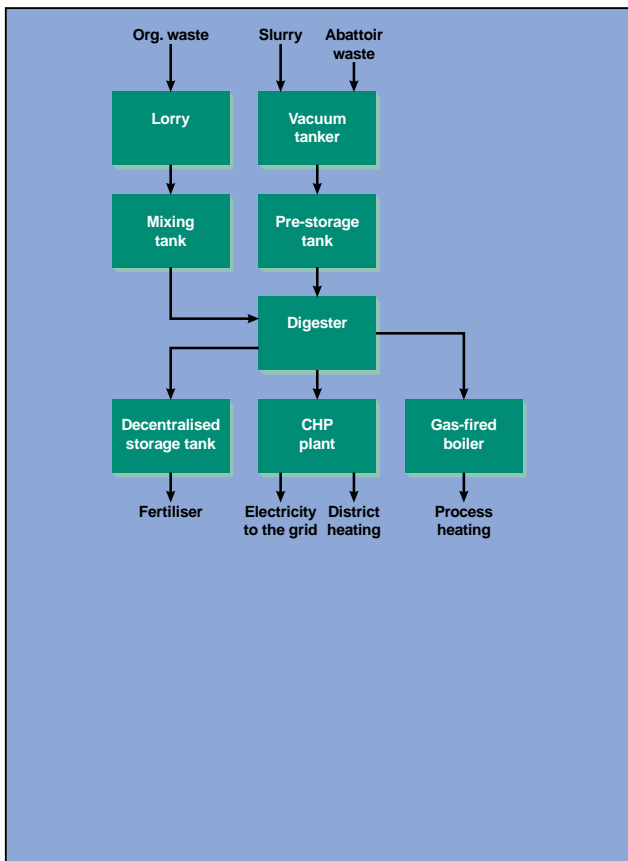
The plant receives cattle, pig, poultry and mink slurry from 69 livestock farms. The slurry is mixed and co-digested with intestinal content from abattoirs, digestible fatty organic wastes from food and fish processing industries and from medicinal industry and with sludge from poultry abattoir. The digestion temperature is 53°C (termophilic). A minimum guaranteed retention time of 4 hours at 53°C ensures efficient sanitation of digested biomass.

The digested biomass is returned to the slurry suppliers as a pathogen free, nutritionally declared, liquid fertiliser. The surplus is sold to about 72 crop farmers in the area. 25 decentralised storage tanks for digested biomass, with a total capacity of 50,000 m³, are shared by the slurry suppliers. The storage tanks



are placed close to the fields where the fertiliser is to be applied. This has significantly reduced the cost and time consumption for transport and has enlarged the application area for digested biomass. The tanks were constructed with 40 % investment grant from the Ministry of Agriculture.

The biogas is piped via a low pressure transmission system to the new CHP-plant at Ribe. The plant supplies the city of Ribe with electricity and heat, and was established in 1996/97, to replace three earlier coal-fired CHP- units. The gas engine is fuelled with a mixture of biogas and natural gas (dual-fuel). The biogas fuel has first priority.



Main data

Animal manure	352 tons /day
Alternative biomass	68 tons/ day
Biogas production	4.8 mill. Nm ³ /year
Digester capacity (3 × 1745 m ³)	5235 m ³
Process temperature	53°C
Sanitation	MGRT 4 hours at 53°C
Gas storage capacity	1000 m ³
Utilisation of biogas.	CHP-plant/gas boiler
Transport vehicle.	3 × vacuum tankers ¹
Average transport distance	11 km
Investment cost ²	45.3 mill. DKK
Government grant	12.9 mill. DKK
EEC-grant	4.8 mill. DKK
Contractor	Krüger Ltd.
Operation start-up	1990

1. 2 × 20 m³ + 1 × 30 m³.

2. Incl. storage capacity.

Lintrup

The centralised co-digestion plant in Lintrup is one of the largest biogas plants in the world. It was built in 1989-90 and rebuilt in 1999, when the plant converted from mesophilic to thermophilic process and a post-digestion phase was established. This way, the potential of biogas production of the plant was increased by almost 50 %.

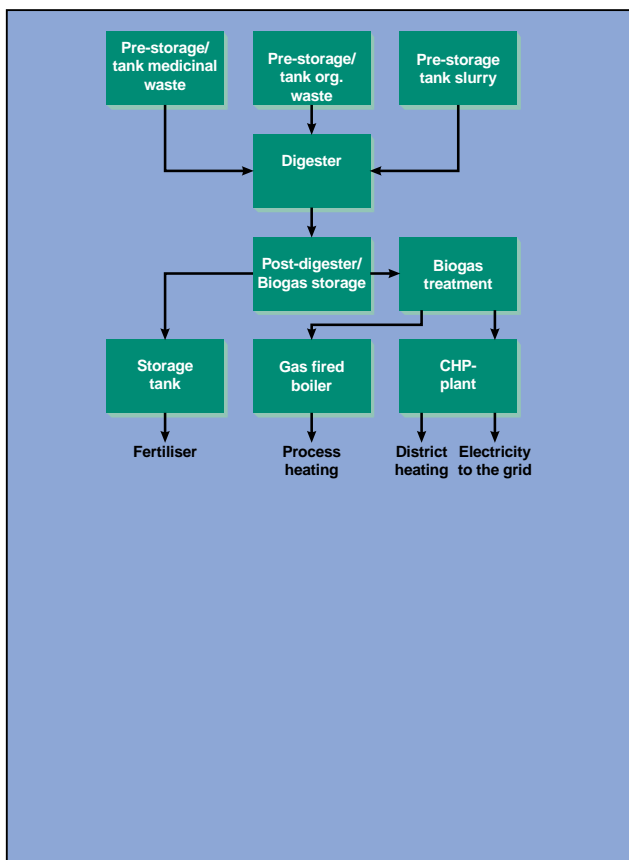
The plant is owned by LinkoGas A.m.b.a., an independent co-operative society with 66 farmers, the slurry suppliers, as members. The main aim of LinkoGas is to build and operate a manure based centralised co-digestion plant and thus to assist co-operative members in solving their problems concerning the legal demands of slurry storage capacity, handling and redistribution of the excess slurry and reduction of odour nuisance from slurry application.

The plant receives slurry and solid manure, consisting of 53 % cattle and 47 % pig slurry, supplemented by digestible organic waste from fish and food processing industries, medicinal industry, abattoir intestinal content and sewage sludge from a waste water treatment plant. The biomass is heated to process temperature through the heat exchanging system. Admixture of sewage sludge implies the pasteurisation of the biomass feedstock. This is achieved through a minimum guaranteed retention time of 10 hours at the process temperature of 53°C, ensuring a pathogen reduction equivalent to pasteurisation. After thermophilic digestion, the biomass is pumped to an insulated post-digestion tank, where digestion continues at 42°C.



The slurry suppliers receive the amount of digested biomass corresponding to the nutrient consumption of their crops. The surplus, about 30 % of the digested biomass, is sold to 50 crop farms in the area. The biomass is transported directly to the 78 decentralised storage tanks, located close to the fields where the digested biomass will be applied.

The biogas is piped via a low pressure gas transmission system to Rødning CHP- plant and utilised in two biogas engines to produce electricity (max. 2037 kW) and district heating (max. 2600 kW). At the biogas plant, a combined biogas and oil fired boiler of 0,5 MW uses biogas for process heating.



Main data

Animal manure	410 tons /day
Alternative biomass	137 tons/ day
Biogas production	5.7 mill. Nm ³ /year
Digester capacity (3 × 2400 m ³)	7200 m ³
Process temperature	53°C
Post-digestion capacity	2500 m ³
Post-digestion temperature	42°C
Gas storage capacity	1000 m ³
Utilisation of biogas	CHP-plant/gas boiler
Transport vehicle	3 × 20 m ³ vacuum tankers
Average transport distance	7.5 km
Investment cost ¹	43.6 mill. DKK
Government grant	16.8 mill. DKK
Contractor	Krüger Ltd.
Operation start-up	1990

1. Incl. storage capacity.

Lemvig

Lemvig Biogas Plant is one of the largest biogas plants in the world. It was built in 1991/92 and is owned by Lemvig Biogasanlæg A.m.b.a. The members are the farmers supplying slurry to the plant. The aim of the co-operative is to build and operate a biogas plant that co-digests slurry, organic waste from food processing industries and sewage sludge and thus to help farmers solve the problems related to the storage and handling of slurry.

The plant receives slurry from 80 suppliers, 10 summer suppliers, and a variable number of occasional suppliers. The slurry consists of 40 % cattle, 59 % pig and 1 % mink and poultry slurry. The farmers received 40 % investment grants to build 60 decentralised storage tanks for digested biomass, corresponding to 9-12 months storage capacity. Six supplementary storage tanks were build close to the biogas plant, with a total capacity of 18,000 m³.

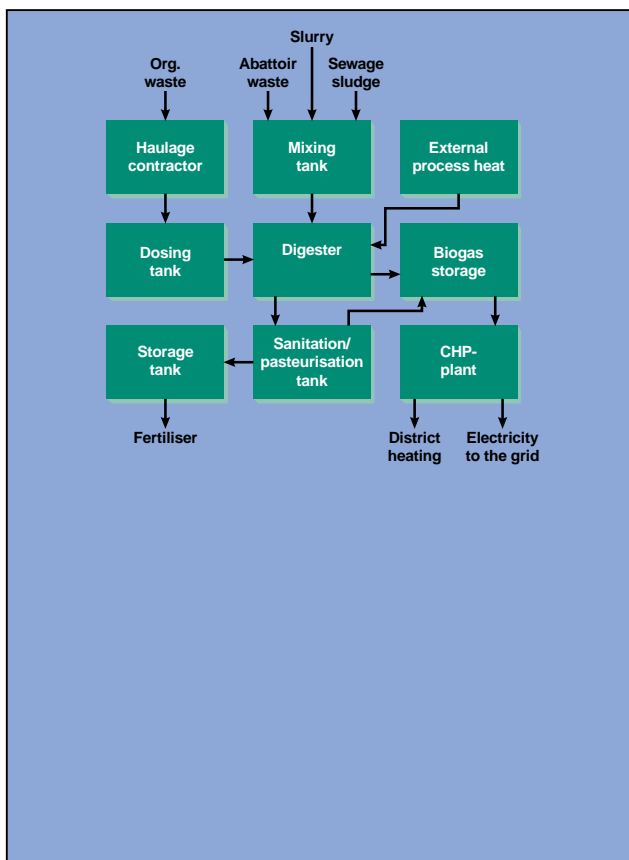
About 20 % of the digested biomass is sold to the crop farmers in the neighbourhood. Each slurry supplier receives back digested biomass equivalent with the livestock supplied. He is responsible for redistribution of the excess of slurry and for making the agreements with the crop farmers, while the biogas plant delivers it cost free.

The digestion temperature is 52,5°C (thermophilic). The biomass is heated up partially through heat exchanging and partially by using the excess heat from a wood industry line in the neighbourhood. The co-



digestion of sewage sludge imposes effective pasteurisation of the biomass mixture, which takes place in the sanitation tanks. A retention time of min. 10 hours at min. 52.0°C ensures effective pathogen reduction.

The biogas produced is transported via 4.3 km low pressure pipe line to Lemvig CHP- plant and converted to electricity and heat.



Main data

Animal manure	362 tons /day
Alternative biomass	75 tons/ day
Biogas production	5.4 mill Nm ³ /year
Digester capacity (3 × 2533 m ³)	7600 m ³
Process temperature.	52.5°C
Sanitation	MGRT 10 hours, at 52°C
Gas storage capacity	5000 m ³
Utilisation of biogas	CHP-plant
Transport vehicle ¹	vacuum tankers/trailer
Average transport distance	7.5 km
Investment cost ¹	55.2 mill. DKK
Government grant	14.2 mill. DKK
Contractor.	BWSC Ltd.
Operation start-up	1992

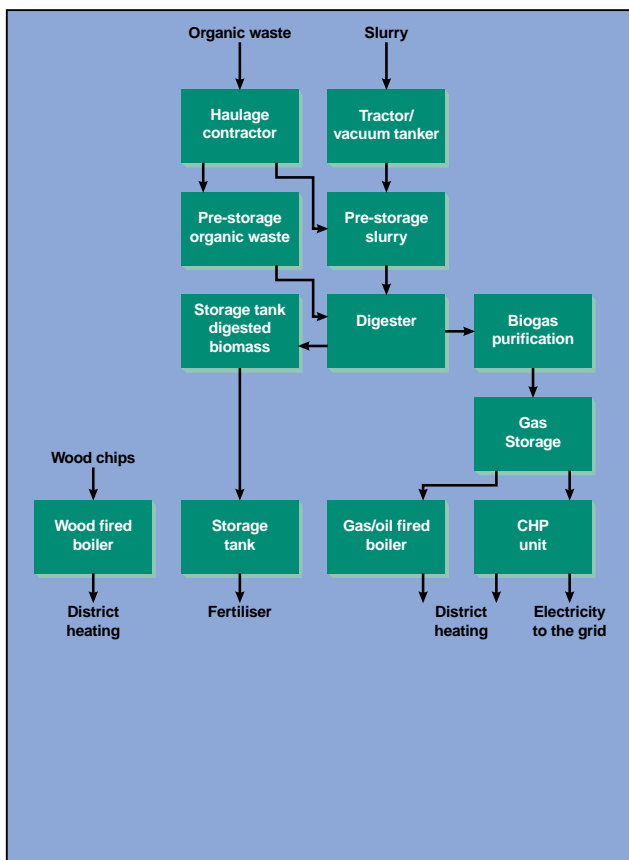
1. 3 × 20 m³ vacuum tankers and one 14 m³ trailer.
2. Incl. storage capacity.

Hodsager

The Biogas Plant in Hodsager was built in 1993 and is owned by a local co-operative society, Hodsager Energiselskab A.m.b.a., with the heat consumers and the slurry suppliers as members. The aim of the co-operative society is to build and operate a biogas plant to utilise the slurry and the digestible biomass resources of the local area to produce biogas for electricity and heat generation.

The plant receives slurry from 6 livestock farms in the area, consisting of 83 % cattle slurry and 17 % pig slurry. The slurry is co-digested with intestinal content from a pig abattoir and with fatty waste from fish processing industries and other organic waste. The process temperature is 37°C (mesophilic). Due to the small number of suppliers and the types of feedstock, there is no further sanitation of the supplied biomass. The content of macro-nutrients and the dry matter content in the digested biomass is analysed before returning it to the slurry suppliers' storage tanks.

The biogas plant is equipped with its own CHP-unit, consisting of a gas engine (640 kW- input power /220 kW- electric power) and a wood chip boiler. The electricity produced is sold to the grid. 141 heat consumers in Hodsager town are supplied with heat via the newly established district heating net. The gas motor covers 45 % of the heat consumption, supplemented by the wood chip boiler. A standby biogas/oil fired boiler is used during the peak heat consumption and in cases of engine failure.



Main data

Animal manure	42 tons /day
Alternative biomass	6 tons/ day
Biogas production	0.7 mill. Nm ³ /year
Digester capacity (2 × 440 m ³)	880 m ³
Process temperature	37°C
Gas storage capacity	100 m ³
Utilisation of biogas.	CHP-plant/gas boiler
Transport vehicle	Tractor/16 m ³ vacuum tanker
Average transport distance	3 km
Investment cost ¹	19.2 mill. DKK
Government grant	3.9 mill. DKK
Total design and consultancy	NIRAS Ltd.
Operation start-up	1993

1. Incl. district heating network and consumers connections.

Hashøj

The centralised biogas plant in Hashøj is owned by an independent co-operative, Hashøj Biogas A.m.b.a, with 17 members, all farmers and slurry suppliers. The aim of the co-operative was to build and operate a biogas plant to facilitate redistribution of animal slurry in the area and to provide investment grants for the establishment of slurry storage capacities. The plant is part of the demonstration programme for Danish biogas plants, aiming to demonstrate combined biogas-natural gas fuelled CHP-plant.

The biogas plant receives slurry from 10 pig farms and 6 cattle farms in the area. The process temperature is mesophilic, at 37°C. The biomass mixture consists of cattle and pig slurry, intestinal content from pig abattoirs, fat and flotation sludge from pig abattoirs, fish and food processing industries, dairies etc. Before digestion, the biomass mixture passes through the pasteurisation tanks for one hour, where effective pathogen reduction is ensured at 70°C.

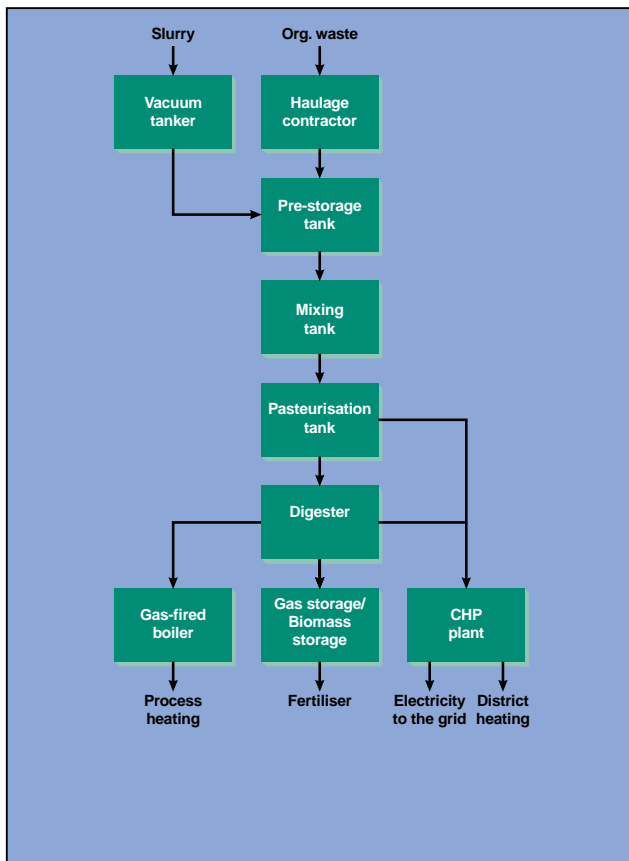
The farmers have overall positive experience of using digested biomass as fertiliser. The product smells less, is sanitised, homogenous and with a defined content of nutrients, which makes it easy to handle and to integrate in their individual fertiliser plans. 15-20 % of the digested biomass is sold each year on a contract basis to 5 crop farms in the neighbourhood.

The biogas produced is utilised for CHP- production at the newly established plant in Dalmoose, where two



biogas and natural gas fuelled engines supply 380 consumers in Dalmoose and Flakkebjerg with electricity and heat. The biogas represents about 38% of the fuel consumption.

During the running-in period, Hashøj biogas plant had a five year operational service management agreement with the plant suppliers, Krüger A/S, at a fixed annual price.



Main data

Animal manure	100 tons /day
Alternative biomass	38 tons/ day
Biogas production	3.0 mill Nm ³ /year
Digester capacity	3000 m ³
Process temperature	37°C
Pasteurisation	MGRT 1 hour at 70°C
Gas storage capacity	2200 m ³
Utilisation of biogas.	CHP-plant/gas boiler
Transport vehicle	One 20 m ³ vacuum tanker
Average transport distance	4 km
Investment cost ¹	21.8 mill. DKK
Government grant	5.1 mill. DKK
Contractor	Krüger Ltd.
Operation start-up	1994

1. Incl. storage capacity.

Thorsø

Thorsø Biogas Plant was built in 1993-94. The plant is owned by Thorsø Miljø- og Biogasanlæg A.m.b.a., and the owners are the farmers supplying slurry to the plant. The aim of the co-operative is to supply Thorsø town with renewable energy and at the same time improve the environmental aspects of agricultural practice in the area. The biogas plant contributes to redistribution of excess animal manure from the intensive animal husbandry in the region, and offers a cheap and sound recycling alternative for a range of suitable organic waste types.

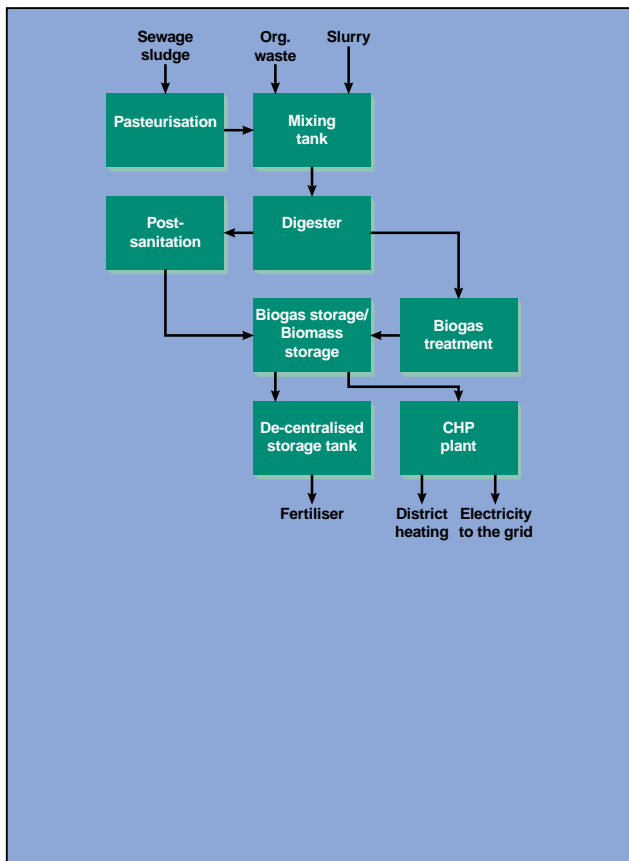
The plant receives slurry and solid manure from 75 livestock farms, consisting of 40% cattle slurry and 60% pig slurry and small amounts of poultry manure. The slurry is mixed and co-digested with intestinal content from pig and cattle abattoirs and with fatty waste from food and fish processing industries, and sewage sludge. Before mixing with the rest of the biomass, the sewage sludge is pasteurised separately, for 1 hour at 70°C. The digestion temperature is 53°C (termophilic). A minimum guaranteed retention time of 3½ hours at 53°C ensures efficient sanitation. Digested biomass is a pathogen free, nutritionally declared, liquid fertiliser.

The slurry suppliers received 40% investment grants to establish 9 month storage capacity for digested biomass, as required by law. The storage tanks are placed close to the fields where the slurry is applied. The farmers obtain cost savings for the transport of slurry and have the possibility to apply the fertiliser



on a larger area. About 30% of the digested biomass is sold to crop farmers every year.

The biogas is piped, via a low pressure transmission system to the new CHP- plant at Thorsø. The CHP-plant is the first one in Denmark equipped with a gas engine that can be fuelled either with pure biogas, or pure natural gas or a mixture of both. Biogas always has first priority.



Main data

Animal manure	230 tons /day
Alternative biomass	31 tons/ day
Biogas production	2.9 mill Nm ³ /year
Digester capacity (2 × 2325 m ³)	4650 m ³
Process temperature	53°C
Gas storage capacity	2790 m ³
Utilisation of biogas	CHP-plant
Transport vehicle	3 × 20 m ³ vacuum tankers
Average transport distance	7.5 km
Investment cost ¹	29.1 mill. DKK
Government grant	6.3 mill. DKK
Contractor	BWSC Ltd.
Operation start-up	1994

1. Not incl. storage capacity.

Århus Nord

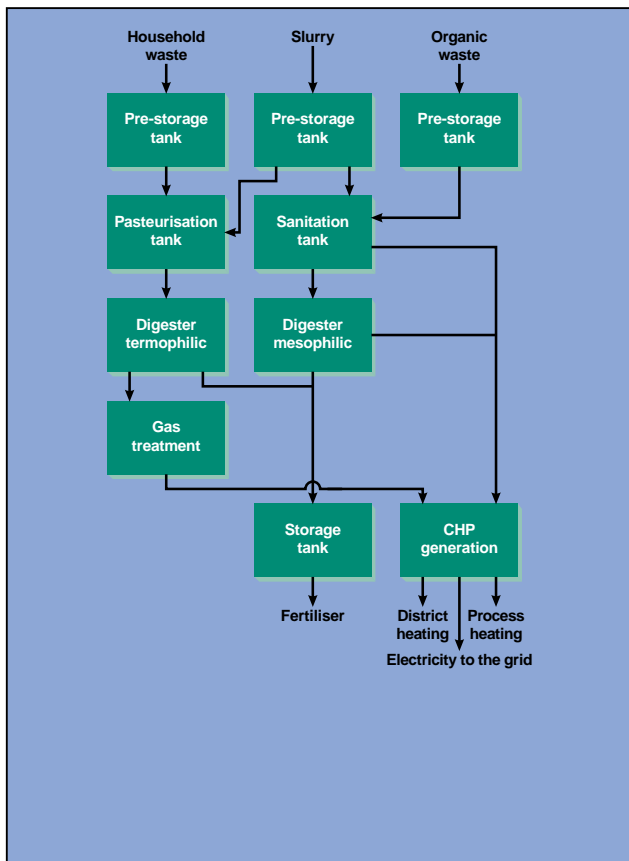
The biogas plant, built in 1994, is owned by Århus Municipality and operated by Århus Municipal Utilities. Its main function is production of biogas to fuel the CHP unit.

70 farmers supply slurry to the plant, consisting of 85% pig slurry and 15 % cattle slurry. The plant also receives intestinal content from abattoirs, flotation and protein sludge, waste from the medicinal industry, vegetable waste from agro-industries, tannery waste, and source separated, organic household waste. The plant is equipped with heat exchangers.

The process is divided into two flow-lines. The main flow-line is mesophilic, at 38°C, and co-digests slurry and organic waste. The biomass mixture is pre-sanitised at 58°C for 6-8 hours. The secondary flow-line is thermophilic, at 52°C, and processes household waste, slurry and some types of organic waste. Before digestion, the biomass mixture is pasteurised at 70°C for one hour. The digested biomass mixture is stored in the four storage tanks with a total capacity of 16,200 m³, and transported to the storage tanks of the slurry suppliers as a nutritionally declared fertiliser. The slurry suppliers' association is responsible for transport of the fresh and digested slurry. About 10% of the digested biomass is sold to 15 crop farms from the area. The transport of digested biomass is free of charge for the crop farms located within a 10 km radius, and a fee of 7 DKK/km is paid outside this radius.



The gas is collected in a double membrane gas holder and used in 3 × 1315 kW gas engines to CHP-generation. In order to be used in the gas engine, the sulphur is removed from the biogas to a level under 500 ppm, by passing the gas through a biological filter. The plant supplies 1100 households with district heating while the electricity produced is sold to the grid. About 20% of the heat is used as process heat.



Main data

Animal manure	346 tons /day
Alternative biomass	46 tons/ day
Biogas production	3.8 mill Nm ³ /year
Digester capacity ¹	8500 m ³
Process temperature slurry + org. waste	38°C
Process temperature household waste.	52°C
Pasteurisation household waste.	MGRT 1 hour at 70°C
Sanitation	MGRT 6-8 hours at 58°C
Gas storage capacity	370 m ³
Utilisation of biogas	CHP-plant
Transport vehicle	4 × 20 m ³ vacuum tankers
Average transport distance	5.5 km
Investment cost ²	54.2 mill. DKK
Government grant	10,8 mill. DKK
Contractor	C.G. Jensen Ltd.
Operation start-up	1995

1. 2 × 3600 m³ + 1 × 1300 m³
 2. Not incl. storage capacity.

Filskov

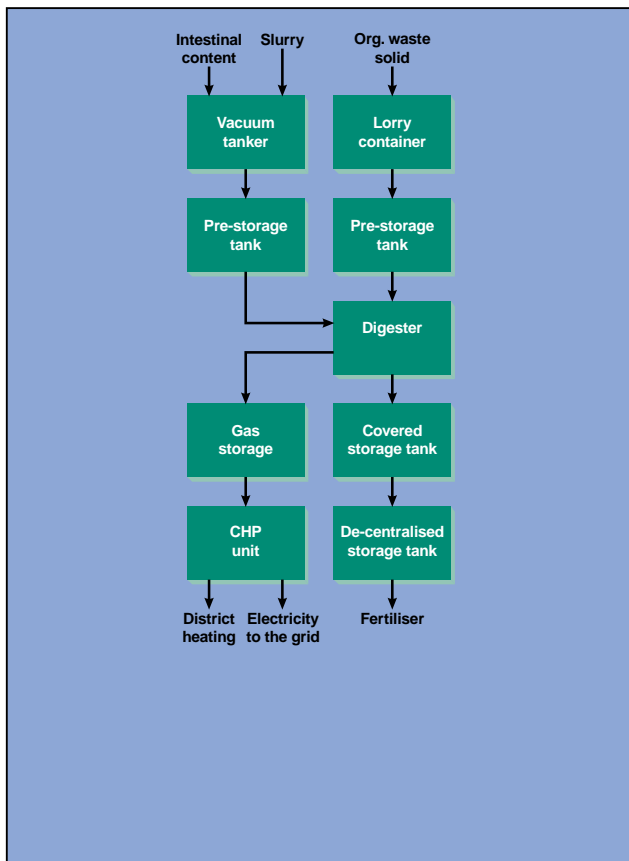
The Biogas Plant in Filskov was built in 1995 and is owned by a local co-operative company, Filskov Energiselskab A.m.b.a. The owners are the heat consumers and the slurry suppliers. The primary function of the plant is to produce biogas by anaerobic digestion of the digestible biomass resources of the area.

The plant was built in two phases. The first was the establishment in 1992/93 of a wood chip boiler, the district heating system and the district heating units in the houses (investment cost 12.0 mill. DKK). The second was the construction of the biogas plant, the CHP-plant in 1995, the decentralised storage tanks for digested biomass, the purchase of slurry transport vehicles etc (investment cost 11.2 mill. DKK).

The plant receives slurry from 11 livestock farms in the area, consisting of 95% cattle slurry and 5% pig slurry. The slurry is co-digested with intestinal content from cattle and pig abattoirs and with fatty waste from poultry and fish processing industries. The process temperature is 53°C (thermophilic). The hydraulic retention time is 10 days, followed by 35 days post-digestion in a 3000 m³ storage tank, covered with a gas-tight membrane. A minimum guaranteed retention time of 4 hours at the process temperature ensures effective pathogen reduction in the digested biomass. Before returning it to the storage tanks of the slurry suppliers or to the three shared decentralised storage tanks, the content of macro-nutrients and the dry matter content in the digested biomass are analysed.



The biogas is used at the plant CHP-unit in a 375 kW electric power gas engine. The heat is supplied to Filskov town to 140 consumers, via the new established district heating net, and the electricity is sold to the grid. The biogas motor supplies 45% of the heat consumption. The rest is supplied by the 1000 kW wood chip boiler. A standby 1600 kW gas and oil fired boiler covers the peak heat consumption during cold winters, and is used in case of engine breakdowns.



Main data

Animal manure	61 tons /day
Alternative biomass	18 tons/day
Biogas production	1.3 mill. Nm ³ /year
Digester capacity (2 × 440 m ³)	880 m ³
Process temperature	53°C
Sanitation	MGRT 4 hours at 53°C
Biomass storage	3000 m ³
Gas storage capacity	100 m ³
Utilisation of biogas	CHP-plant/gas boiler
Transport vehicle	20 m ³ vacuum tanker
Average transport distance	4 km
Investment cost ¹	23.2 mill. DKK
Government grant	2.5 mill. DKK
Total design and consultancy	NIRAS Ltd.
Operation start-up	1995

1. Incl. storage capacity, district heating network and installations.

Studsgaard

Studsgaard biogas plant was built in 1995, as a result of Herning Municipality's energy policy of displacement of fossil fuel by local renewable energy sources. The lay-out of the plant is based on the positive experience with Sinding - Ørre biogas plant. Both plants are owned and operated by Herning Municipal Utilities.

The main function of the plant is to produce biogas for heat and power generation by anaerobic digestion of slurry and digestible biomass resources, as well as to solve the problem of storage and redistribution of slurry in the area.

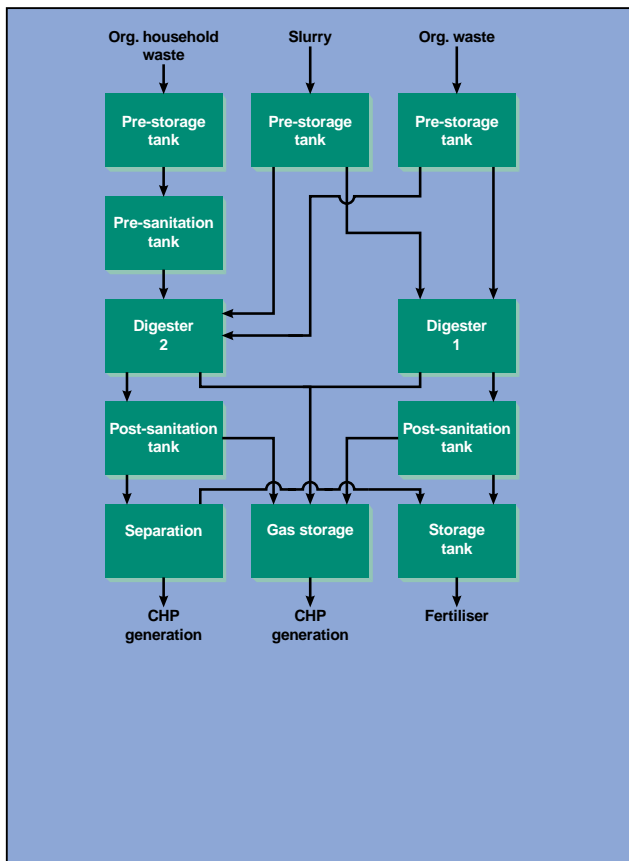
49 farmers supply slurry to the biogas plant, consisting of 22 % cattle and 78 % pig slurry. Five of the farms are connected to the plant by a slurry transport pipeline system. At the plant the slurry is mixed and co-digested with organic waste from food processing industries and with source separated organic household waste.

The household waste is mixed with slurry to make it liquid. The mixture is heated to 60°C for 2½ hours, before is pumped into a digester. After digestion, a simple separation removes plastic and other unwanted items from the household waste, guaranteeing a clean fertiliser to the farmers, without non-organic content. The digested household waste is mixed with the rest of the digested biomass and transported to the farmers' de-centralised storage tanks close to the fields where digested slurry is to be applied.



Herning Municipal Utilities have developed the system for treating household waste, and is holding a European patent on this.

The produced biogas is utilised at Herning- CHP plant for heat and power generation, in a 3370 kW gas engine. The produced electricity is sold to the grid and the heat is distributed through the district heating system of the City of Herning.



Main data

Animal manure	230 tons /day
Alternative biomass	36 tons/day
Biogas production	5.7 mill Nm ³ /year
Digester capacity (2 × 3000 m ³)	6000 m ³
Process temperature	52°C
Sanitation	MGRT 2.5 hours at 60°C
Gas storage capacity	170 m ³
Utilisation of biogas	CHP-plant
Transport vehicle	Vacuum tankers/slurry pipelines
Average transport distance	5 km
Investment cost ¹	55.7 mill. DKK
Government grant	13.9 mill. DKK
Contractor	Herning Municipal Utilities/Hedeselskabet
Operation start-up	1996

1. Incl. storage capacity.

Blåbjerg

The centralised co-digestion plant in Blåbjerg was built in 1995-96 and started up in marts 1996. The plant is owned by Blåbjerg Biogas A.m.b.a., whose members are the slurry-supplying farmers. The plant was established with the aim of supplying Nørre Nebel town with renewable energy, as well as to contribute to better distribution of excess manure from the intensive animal husbandry in the area.

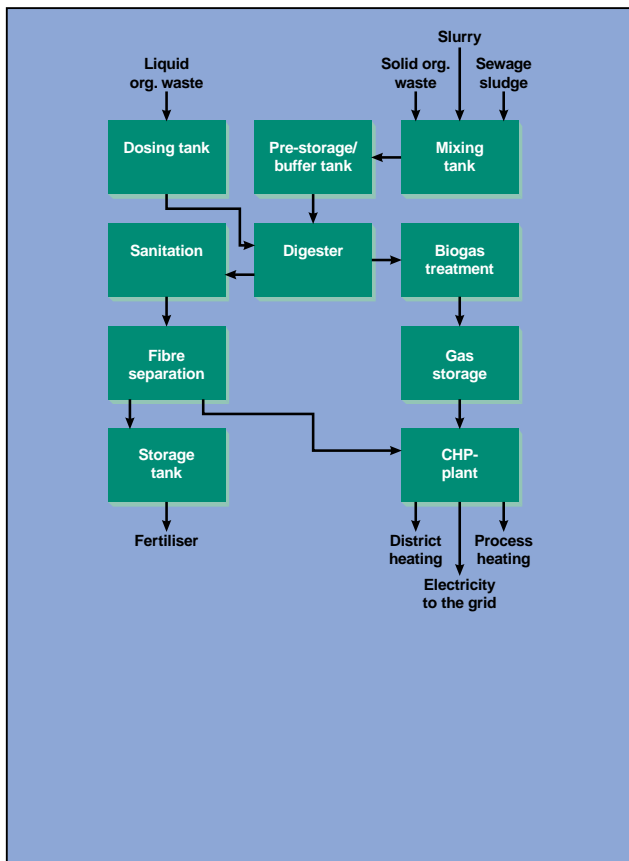
The biogas plant receives cattle and pig slurry from 49 suppliers. The slurry is mixed and co-digested with organic waste from food processing, fish processing, dairy and medicinal industry, and sewage sludge. The biomass mixture is heated up to the process temperature through the heat exchanger system.

The Blåbjerg plant concept includes some new solutions, attempting to make the plant more adaptable to various feedstock and to the environmental protection requirements. Through a combination of buffer tanks and pumping sequences, the biomass has a guaranteed retention time of 8 hours at the process temperature of 53.5°C. This ensures effective pathogen reduction and allows the plant to treat sewage sludge. After digestion, the fibre fraction is separated and used in the CHP unit for heat production, and the liquid fraction is returned to the farmers as a nutritionally defined fertiliser.

The biogas is utilised in two gas engines (3740 kW) at the new CHP plant at Nørre Nebel. The heat is distributed through the district heating system to 550



heat consumers in town and the electricity is sold to the grid.



Main data

Animal manure	222 tons/day
Alternative biomass	87 tons/day
Biogas production	3.1 mill Nm ³ /year
Digester capacity (2 × 2500 m ³)	5000 m ³
Process temperature	53.5°C
Sanitation	MGRT 8 hours at 53.5°C
Gas storage capacity	4000 m ³
Utilisation of biogas	CHP-plant
Transport vehicle	2 × 20 m ³ vacuum tankers
Average transport distance	5 km
Investment cost ¹	44.1 mill. DKK
Government grant	11.5 mill. DKK
Contractor	BWSC Ltd.
Operation start-up	1996

1. Incl. storage capacity.

Snertinge

The biogas plant in Snertinge was built in 1995 and is owned by Snertinge, Særslev, Føllenslev Energiselskab A.m.b.a. The aim of the co-operative is to build and operate a biogas plant and to produce renewable energy. The members are the slurry suppliers and the heat consumers from the three villages.

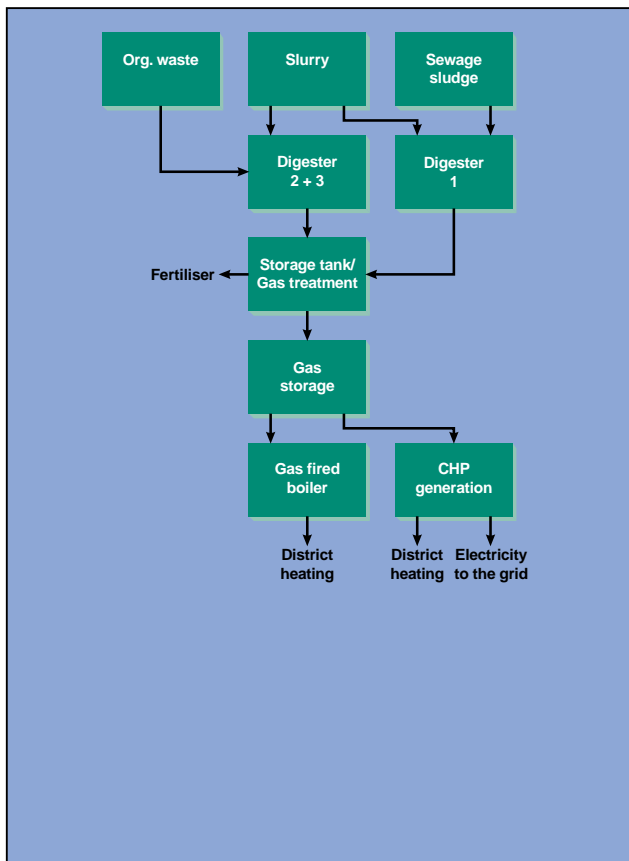
The biogas plant receives slurry from 11 farms in the area, consisting of 37% cattle and 63% pig slurry. The slurry is co-digested with fat and flotation sludge from food industries and the medicinal industry, small amounts of intestinal content from abattoir and with sewage sludge. The digestion process takes place at 52.5°C (thermophilic) on two flow lines: one for slurry and organic waste and the other one for sewage sludge and slurry. The admixture of sewage sludge implies effective pathogen reduction through pasteurisation. This takes place in the digester, by a combination of temperature and minimum guaranteed retention time, which in this case is of minimum 10 hours at 52.5°C.

The co-operative has built three storage tanks for digested biomass with a total volume of 8.500 m³. Two of the tanks are placed close to some large crop farms which receive the excess digested biomass, about 5,000 tons per year. This helps the farmers to meet the required storage capacity, and to transfer excess of slurry to the crop farms.

Connected to the biogas plant, a combined biogas (1330 kW input power/475 kW electric power) and



wood chip fired (1600 kW) CHP production unit was established. A standby combined oil and gas fired boiler (1750 kW) is used in case of gas engine breakdown. The wood chip boiler is used as a supplement to biogas during the peak energy consumption. The CHP-unit supplies 280 consumers with heat via the newly established district heating system. The electricity is sold to the grid.



Main data

Animal manure	66 tons/day
Alternative biomass	42 tons/day
Biogas production	1.6 mill. Nm ³ /year
Digester capacity (3 x 1000 m ³)	3000 m ³
Process temperature	52.5°C
Sanitation	MGRT 10 hours at 52.5°C
Gas storage capacity	200 m ³
Utilisation of biogas	CHP-plant/gas boiler
Transport vehicle	20 m ³ vacuum tanker
Average transport distance	5 km
Investment cost ¹	47,8 mill. DKK
Government grant	9.2 mill. DKK
Total design and consultancy	NIRAS Ltd.
Operation start-up	1996

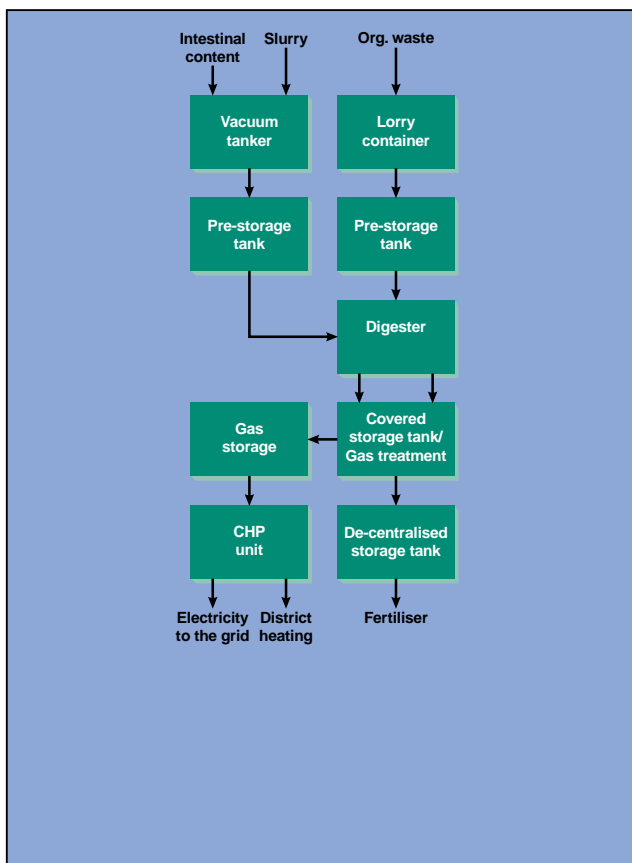
1. Incl. storage capacity, district heating network and installation in the houses.

Blåhøj

The Biogas Plant in Blåhøj was built in 1997 and is owned by a local co-operative company, Blåhøj Energiselskab A.m.b.a. The members are 171 heat consumers and 14 slurry suppliers. Its primary function is to produce biogas by anaerobic digestion of slurry and digestible biomass resources of the area, and to supply the heat consumers in Blåhøj with CO₂ - neutral energy.

The plant receives slurry from 14 animal farms, consisting of 91% cattle and 9% pig slurry. The slurry is admixed with 21% alternative biomass, mainly as flotation sludge from a poultry abattoir, and sludge from fish processing industries and from food industries. The process temperature is 53°C (thermophilic). A minimum guaranteed retention time of 5 hours at the process temperature ensures effective pathogen reduction. Digested biomass is returned to the decentralised storage tanks of the slurry suppliers as a homogenous, pathogen free and nutritionally defined fertiliser.

The biogas plant has its own CHP- unit, where the biogas is used in a gas engine (1500 kW-input power/550 kW electric power). The biogas engine, supplying the basic load of the heat consumption, is supplemented by a wood chip boiler, while a standby gas/oil boiler is used during the peak period of heat consumption. The heat is supplied to 171 consumers in Blåhøj town via the newly established district heating net, and the electricity is sold to the grid.



Main data

Animal manure	70 tons/day
Alternative biomass	17 tons/day
Biogas production	1.4 mill. Nm ³ /year
Digester capacity (2 × 660 m ³)	1320 m ³
Process temperature	53°C
Sanitation	MGRT 5 hours at 53°C
Gas storage capacity	1200 m ³
Utilisation of biogas	CHP-plant/gas boiler
Transport vehicle	20 m ³ vacuum tanker
Average transport distance	5 km
Investment cost ¹	33.4 mill. DKK
Government grant	6.9 mill. DKK
Total design and consultancy	NIRAS Ltd.
Operation start-up	1997

1. Incl. storage capacity, district heating network and installations in the houses

Nysted

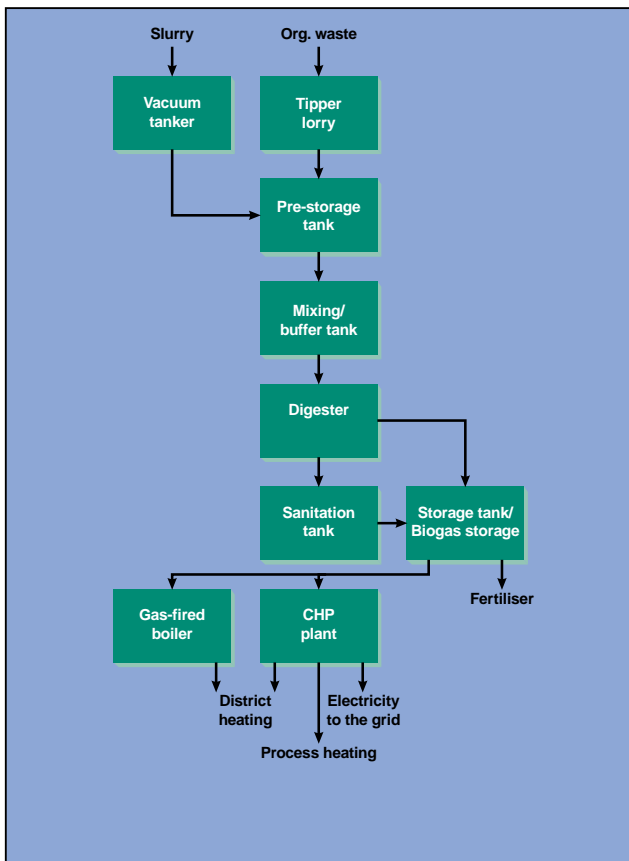
Nysted biogas plant was built in 1997-98, as a further development of Hashøj biogas plant concept. The plant is owned by Nysted BioGas A.m.b.a., where the members are the farmers, slurry suppliers. The main interest of the co-operative members in the biogas plant was exploitation of the digestible biomass resources of the area and improvement of the environmental image of the agricultural sector. Animal production in the area is dominated by pig farms, so reduction of odour nuisance from slurry application was another incentive.

The plant is mesophilic (38°C), with a post-sanitation phase of minimum guaranteed retention time of 8 hours at 55°C. The plant receives slurry and manure from 36 animal farms, consisting of 82 % pig slurry, 17 % cattle slurry and 1% poultry manure. The slurry is mixed and co-digested with organic waste from the sugar industry, medicinal industry and tannery, fat and flotation sludge from abattoir, fruit and vegetable waste and smaller amounts of other organic wastes. The plant is also able to process source separated household waste. On top of the storage tank there is a double membrane gas storage balloon, which also collects the gas production emerging from the storage tank.

Connected to the biogas plant, a CHP- unit was established, to utilise the biogas in a 2300 kW biogas engine. The electricity produced, corresponding to the yearly consumption of 1300 households, is sold to the grid. The heat is distributed via the district



heating system to 150 heat consumers in Kettinge town. A combined biogas and oil fired boiler complements heat consumption in the cold season. The excess heat is cooled away during the summer season.



Main data

Animal manure	180 tons/day
Alternative biomass	31 tons/ day
Biogas production	2.6 mill. Nm ³ /year
Digester capacity	5000 m ³
Process temperature	38°C
Sanitation	MGRT of 8 hours at 55°C
Gas storage capacity	2500 m ³
Utilisation of biogas	CHP-plant/gas boiler
Transport vehicle	2 × 18 m ³ vacuum tankers
Average transport distance	7 km
Investment cost ¹	43.7 mill. DKK
Government grant	8.5 mill. DKK
Contractor	Krüger Ltd.
Operation start-up	1998

1. Incl. storage capacity.

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Centralised biogas plants offer integrated solutions to many problems related to agriculture, energy generation and environmental protection.

Development of biogas technology in Denmark has been supported by a range of governmental initiatives over the last 10 years, leading to consolidation and maturation of the bioenergy industry.