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Focus on biogas

In this issue, Bioenergy Research focuses on biogas. The reason for this choice of topic is a brand new centre for manure technology, which is currently being established at the Danish Institute of Agricultural Sciences in Foulum. Researchers at the institute will work closely with private companies, and a large biogas and manure separation plant will be constructed to allow full-scale tests to be carried out.

The project has been on the drawing board for many years, but now it looks like it will finally materialise. Denmark will get a centre for manure technology, which, if all goes well, has the potential to develop into an international power centre for biogas and modern manure treatment technology.

The centre will be located at the Foulum Research Centre - the largest unit under the Danish Institute of Agricultural Sciences. Most of the Danish research in domestic animals and plants takes place at this centre, which also has an international unit and an information department. The centre's neighbour is the Agro Business Park - a research park that houses a number of private companies.

The Danish Institute of Agricultural Sciences is in the process of establishing a knowledge centre for manure technology in Foulum, and at the beginning of next year, the contractors will begin digging in preparation for a large biogas and manure separation plant. The plant will make the research centre self-sufficient in energy, and at the same time companies and researchers can use the plant to perform full-scale tests of their ideas.

In a concurrent project, the Agro Business Park promotes collaboration between private businesses and research institutions within manure treatment, and also works on establishing exhibition and centre facilities where companies and institutions can exhibit their products.

photo: forskningscenter foulum

International centre for manure technology

The Danish Institute of Agricultural Sciences, the County of Viborg and the Agro Business Park are in the process of establishing an international centre for manure technology in Foulum. The centre will be based on three cornerstones: a business-oriented sector for business and network development, a knowledge centre for manure technology and a biogas and separation plant for tests.

By Michael Støckler

The Agro Business Park, the Danish Institute of Agricultural Sciences' closest neighbour in Foulum, is a research park that houses a number of private companies. Over the next two years, the Agro Business Park will be working on a project to promote collaboration between private companies and research and knowledge institutions in the field of manure treatment. In addition, the Danish Institute of Agricultural Sciences has decided to establish a knowledge centre for manure technology as well as a biogas and separation plant in Foulum (see pages 4-6). Together, these initiatives will be the start of an international power centre for manure treatment technology with experts from both the private and the public sectors. The intention is that private companies should be able to use the centre for tests and documentation of their processes and products as well as for promotional purposes.

Agro Business Park where a part of the new centre for manure technology will be located. The centre has two target groups. One group consists of researchers whereas the other group consists of private companies, the agricultural sector and public authorities.

The parties are currently working on the framework for exhibition and centre facilities where companies and institutions can exhibit their processes and products and at the same time test them under controlled conditions at the new facilities that are being established by the Danish Institute of Agricultural Sciences.

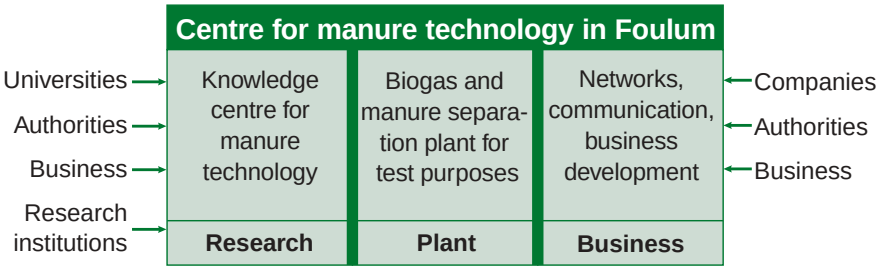
The first stage of the project at Agro Business Park will involve the creation of networks, and a number of companies have already been contacted with a view to collaboration with the centre on different development projects.

Manure separation technology

Animal production in Denmark is extensive, and the production of pigs in particular is expected to increase considerably in the coming years. The geographical distribution of the production and the size of the farms necessitate the development of technologies for the separation of the manure in order to ensure practical and appropriate use of the nutrients.

A large number of companies are involved in manure separation andmanure treatment techniques. Different companies have worked hard for a number of years on finding solutions to the problems, with varying degrees of success.

Some plants for high and low technology treatment of manure have been



Structure of the Centre for manure development in Foulum. The Danish Institute of Agricultural Sciences is in charge of research and facilities relating to the biogas and separation plant, whereas the Agro Business Park together with the County of Viborg handles the business aspects.

developed and tested, but a lot remains to be done. The long-term goal must be to offer tailored solutions to individual farmers or farmers' associations to make sure their needs are met. The result would be the development of a wide range of potentially relevant technologies.

The handling and use of the products from the separation process is one of the areas requiring a considerable amount of work. The resultant fractions and products should be easy to use and handle appropriately.

Animal residual products

The use of biogas plants is a potentially important element in the treatment and handling of manure. In the process of treating manure in biogas plants, the organic matter in the manure is used for the production of electricity and heating, but manure has a low energy content. It is difficult to make the biogas plants economically viable unless waste or other types of biomass with high energy contents are added to increase the gas production. For a number of years, different types of waste and fatty products have been used to increase the gas production, but these resources are limited, and it is necessary to find alternative products.

A number of animal residual products are very interesting in this context. They have a considerable gas potential and could be used to good advantage in biogas plants. The animal products have a high protein content that results in the release of ammonium during processing in the biogas plants. However, this ammonium inhibits the biological decomposition in the biogas reactors, and therefore the amount of animal product that can be added without causing operational problems is limited.

Many companies have tested plants that gradually remove the ammonium as it is produced as a result of the breaking-down of the proteins, but the technology is not yet fully developed. Much more work needs to be done to develop the technologies, and there is still insufficient documentation of the efficiency and profitability of the plants.

photo: torben skøtt/biopress

Close cooperation between researchers and the business sector is necessary to develop the high-tech solutions for manure treatment that have been the focus of attention in recent years.

Pre-treatment

Different types of coarse biomasses that are available in the agricultural industry can be used as an alternative to animal products. Such biomasses require pre-treatment to ensure a high gas production and utilisation of the organic matter. A number of new projects have been launched in this area, and a lot of development work is expected to be carried out in the coming years.

The development of new technologies for the treatment of different types of biomasses such as corn, beets, grass and millet has considerable potential. There is a need for new technologies for the treatment of these biomasses to make them suitable for cost-effective energy production. A number of methods and techniques are suitable, and many have either already been tested or are under development. The functionality and efficiency of the technologies must be documented, which is a time-consuming process for both private companies and impartial bodies.

Denmark at the forefront

Denmark has been a leading country in the biogas field, and a considerable amount of experience is available at both farm biogas plants and common plants, which will hopefully benefit the entire industry. Considering the amount of current research and work done by a number of companies, there is a real potential for Denmark to be at the forefront of manure treatment technologies.

A number of the companies are competitors, which obviously has to be respected. The solutions required are so diverse, however, that there is scope for a number of companies with different competencies to cooperate. The separation of the manure into fractions is a complex task with more than one solution. It is important to further develop some of the technologies that are already available, to develop new ones and to find new combinations of processes and products.

The new centre in Foulum is well underway. We hope for and look forward to productive cooperation with the entire industry. By early October, several companies in the industry had already decided to move to the Agro Business Park, including DDH-Contractors, BioPartners, Lugt-Tek and APSA. The centre aims at strengthening business opportunities as well as research and development in the field. In the long run, the aim is to create an international power centre that can contribute to business development, create job opportunities and promote the export of Danish knowledge and equipment.

Michael Støckler is employed at the Agro Business Park and project manager of the manure technology development project for the county of Viborg.

Agro Business Park

Anybody interested in cooperating with the centre about manure treatment technologies is welcome to contact:

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Europe's largest test plant for biogas and manure separation

A new biogas and manure separation plant at the Danish Institute of Agricultural Sciences is set to make Danish manure technology a world leader and to help solve the environmental problems that domestic animal producers have been facing for many years. The test plant can be used by companies and researchers for the development and full-scale testing of their ideas.

By Sven G. Sommer

In a few years, the Foulum research centre near Viborg will be self-sufficient with energy from a large biogas and manure plant. The construction of the new plant will start at the beginning of 2005. The many stables at the research centre and a test stable at the Danish Cattle Research Station will supply the biomass for the plant.

The main purpose of the plant is to create a framework for researchers and companies that need to develop new ideas and test them on a large scale. The plant, which will be the largest test plant in Europe, will be extremely flexible and will accommodate research and development in processes and products relevant to biogas production and manure separation.

Need for long-term approach

In order to maintain a large and perhaps even increasing animal production in Denmark, it is necessary to find new ways to ensure suitable use of the nutrients in domestic animal manure. There is also a need to increase the production of green energy so that Denmark can meet its obligations under the Kyoto protocol. The agricultural sector must therefore find ways to utilise animal manure optimally while at the same time contributing to the production of energy by gasification of manure and other types of biomass. This requires a systematic long-term approach to manure technology.

The combination of the large animal production at the Foulum Research Centre and the professional expertise at the Danish Institute of Agricultural Services makes Foulum the obvious place to locate the test plant and the many related activities.

The Danish Institute of Agricultural Sciences and the Danish Cattle Research Station produce an amount of domestic animal manure corresponding to 850 animal units and are able to supply all biomass needed for the plant.

To this should be added that Viborg is the Danish county with the largest amount of domestic animals per square metre. The county has therefore contributed to a centre for manure technology in Foulum that will assist small and medium-sized companies with the development and sale of their products (see page 2). Together with the Knowledge Centre for Domestic Animal Manure Technology (see page 6), the centre will contribute to developing the biogas and separation plant.

The biogas plant

The amount of energy in the manure that can be utilised in a biogas plant depends on the composition of the manure or biomass. Oil, fat, sugar and starch are easy to decompose, whereas the cellulose and wood pulp content in straw is very difficult to gasify. It is a well-known fact that the biogas yield from manure is relatively low and that most Danish biogas plants therefore add industrial waste, which produces a much higher gas yield.

During the separation of the manure, it is separated into a fibre fraction and a liquid fraction. The advantage of manure separation is that the fibre fractions can be enriched with nutrients. This makes it easier and cheaper to transport the nutrients to the areas where they can be put to optimum use.

photo: torben skøtt/biopress

The Danish Institute of Agricultural Sciences and the Danish Cattle Research Station produce an amount of domestic animal manure corresponding to 850 animal units and are able to supply all the biomass needed for the plant.

Today, almost all research in biogas and manure separation is carried out in laboratories or at small pilot plants. Existing biogas plants are not very suitable for research due to a lack of storage tanks, piping systems and measuring points, and because the composition of the manure and the industrial waste varies too much.

The new biogas plant in Foulum will be designed to accommodate experimental facilities and post-processing plants in addition to the normal operation. As an example, it will comprise four reactors, each complete with storage tank for manure and the corresponding biomass and post-processing plants.

Consequently, one or two reactors will always operate under standard conditions while the other reactors can be used for research and development. This will make it possible to carry out tests with a newly developed technique in which you compare the gas production with the production from the plant operating under standard conditions. Any production stoppage in the experimental reactors will not be a major problem, as the process can easily be restarted using inoculum from the standard reactors.

Different storage facilities will be made available for tests so that manure from different pre-treatment processes can be stored with a view to performing analyses of the gasification that takes place during the subsequent storage or the need for stirring or optimisation of the separation process.

The fixed separators will probably be basic plants, but piping, valves and control will be put in place to allow advanced separation equipment to be connected to the fixed plants. It will therefore be possible to carry out tests with the removal of dissolved ammonium or potassium where the liquid fraction is discharged in an environmentally responsible manner on a limited area without causing any damage to crops. The plant will also include facilities for further processing of the solid fraction with the purpose of extracting the remaining energy from the biomass and produce fertiliser similar to commercial fertiliser.

Research

What kind of experiments will be carried out on the plant? Fortunately, the possibilities are endless, but initially the focus will be on the factors that are most critical for the reliable and effective operation of the plant. We subsequently intend to run two serially connected reactors in order to examine whether it is possible to speed up the gasification of the biomass and reduce the time the biomass spends in the reactor. Finally, we have plans to examine the effect of pulverisation of the biomass before gasification as well as the gas production during subsequent storage.

The intention is to design one of the reactors so that it requires minimum stirring. This will prevent discharge of the methane-producing microorganisms from the reactors in connection with the discharge and addition of biomass, but requires that a new technique be developed for the removal of supernatant and sediment.

The biogas plant will therefore include storage facilities, piping and a control system that are much more complex than those of a commercial plant. Sensors will be installed to record the variation in the composition of the biomass fed to the reactors. The reactors will also contain sensors for ongoing registration of biomass composition as well as analytical equipment measuring the composition and amount of biogas. Finally, they will incorporate sensors that accurately measure the amount of biomass added to and discharged from the plant.

The separation plant and post-processing plant will accommodate a composting unit to treat the fibre fractions, which can capture released ammonium. There will be room for plants to combust the treated fibre fraction using either normal combustion or pyrolysis. The nitrogen oxide, dinitrogen oxide and ammonium content in the waste gases from these plants will be measured. Finally, the plant will comprise equipment for decomposition of the fibre fraction in which the remainder of the biogas can be extracted.

photo: torben skøtt/biopress

Tests will be performed at the new plant in Foulum to reduce stirring to a minimum. This requires that a technique be developed to remove the large amounts of sediment in the reactor. The picture was taken at Thorsø and shows sediment being emptied from one of the three reactors.

photo: torben skøtt/biopress

Effective utilisation of the fibre fraction is one of the future research areas at the new plant in Foulum.

Sven G. Sommer has a master's degree and a PhD from the Royal Veterinary and Agricultural University with agricultural environment as his main subject. For the past five years, he has been involved in the research of separation and biogas production, and he has recently been appointed manager of the Knowledge Centre for Manure Technology.

New knowledge centre for domestic animal manure

The Danish Institute of Agricultural Sciences has taken the initiative to establish a knowledge centre for manure technology. The purpose of the centre is to strengthen research, development, communication and training in the area by means of a dynamic network comprising private sector researchers, universities and other research institutions.

photo: forskningscenter foulum

Foulum Research Centre where the new centre for domestic animal manure will be located.

By Sven G. Sommer

Over the years, research institutions, private companies, the agricultural sector and legislation have all contributed to making Danish agriculture more efficient and environmentally friendly. Competition is increasing, however, and today's society makes increasing demands on the agricultural sector. The farmer must produce more efficiently, reduce the environmental load further, reduce the energy consumption and preferably even contribute to the energy production.

Research institutions and private companies have supported the agricultural sector by developing new techniques and operating systems. The sector has now reached a stage where it would be an advantage to combine the many scattered initiatives and focus on research and development through cooperation. The new knowledge centre for manure technology will contribute by bringing together the different parties, thereby creating the necessary synergy to accomplish more than the parties would be able to accomplish independently.

Meeting place for many

The centre has two target groups. One group consists of universities and institutions conducting research in manure technology. This group is interested in promoting its own research through cooperation on common projects or coordinated activities.

The other target group consists of private companies and the agricultural sector as well as public authorities that wish to work more closely with the research institutions. The researchers and companies, agricultural sector and public authorities share the goal of using research results for new product development and general advisory services.

The centre also wishes to promote cooperation between the various institutions/companies involved and associations like DANIDA. Such contact would stimulate the dissemination of new knowledge and therefore contribute to the development of more sustainable, environmentally friendly and hygienic ways of handling domestic animal manure globally. Extended European cooperation on EU-based research projects is also an obvious task for the knowledge centre.

Dynamic and open organisation

The purpose of the knowledge centre is to disseminate knowledge, be a portal for and coordinate professional activities. Private sector researchers, universities and other research institutions will therefore participate in the network. The knowledge centre also has the job of organising research, development and professional training. The participants can benefit from combining different project activities and carrying them out at the institution that offers the best facilities. The centre participants can also jointly prepare compendiums and study material, organise study tours in Denmark and abroad, organise courses for the advisory services and authorities or cooperate with the universities on PhD and master's degree programmes.

Good ideas are welcome

The Danish Institute of Agricultural Sciences would like to ensure mutually profitable cooperation and strong relationships between important players in the industry.

The centre will regularly invite relevant institutions and universities to join and from time to time centre participants whose research focus changes to other areas will leave the centre. It is a prerequisite for participation in the centre that the institution in question works on a project that falls within the scope of the centre activities and that can form part of the centre's project database. A project may consist of research, education or advisory services.

The centre will be based at the Foulum Research Centre and the staff will consists of a centre manager, centre researchers and a network engineer. ■

Straw incorporation has limited effect

photo: torben skøtt/biopress

Tests performed at the Danish Institute of Agricultural Sciences over the last 36 years have shown that ploughing crop residue into the soil instead of using it as fuel has limited effect on soil fertility.

Since 1986, the Danish Institute of Agricultural Sciences has carried out a number of tests with straw incorporation on fields with uniform cropping. The last tests were completed in 2002, and the test period thus covered an impressive 36 years. The tests involved growing spring barley on various soil types using only NPK-fertiliser in scenarios where the residue was removed, burnt or ploughed in, respectively.

The use of straw for fuel has often been severely criticised, especially by organic farmers. Many have been of the opinion that it is inexcusable to use straw for energy production, because it reduces the soil's carbon content.

The results of the many years of tests at the Danish Institute of Agricultural Sciences show, however, that straw incorporation has limited effect. Uniform cropping generally poses problems because it impoverishes the soil, and although straw incorporation may help alleviate the situation, it does not prevent it.

The use of the straw has limited effect on the yield for the first many years. Generally speaking, straw incorporation tends to increase yields on sandy soils, has little or no effect on clay soil and causes a slight decrease in yield on intermediate soils containing 5-15% clay.

After 15-20 years of tests, the clay soil showed a remarkable tendency to produce increased yields where the straw had been burned rather than ploughed in. A possible explanation is that the conditions for decomposition of the straw deteriorate as the soil becomes increasingly impoverished.

Source: www.agrsci.d ■

CO2 taxes can be used for the development of manure technologies

Over the next four years, the Danish business sector will receive DKK 144 million for environmental purposes, which includes funds that can be used to develop new technologies for manure treatment and the reduction of odour nuisances.

The money comes from the CO2 taxes paid by companies. Since the adoption of the Energy Agreement in 1995, these funds have been channelled back into the business sector.

A new business scheme earmarks these funds for areas where the Ministry of the Environment sees a potential for Danish companies in the coming years.

The Danish Environmental Protection Agency administers the scheme, calls for tenders, evaluates the tenders and selects the winner. Depending on the contract amount involved, tenders will be called for either by inviting companies to tender directly by circular letter or following a public invitation to tender in the EU.

The part of the scheme that will consist of a subsidy awaits the hearing of a draft executive order in Denmark and the necessary EU approval. Once the legal basis is in place, the Danish Environmental Protection Agency will publish further information about the scheme.

Projects will be launched in four main areas: chemicals, waste, Water environment plan III as well as water and industry. Under Water environment plan III, funds will be available for projects that fall under the heading: "Development of new technologies for the treatment of manure and the reduction of odour nuisances". Examples of such projects are:

- Research in chemical and microbial processes
- Development of measurement techniques and spreading models
- Development of stable systems with a view to limiting odour nuisances and the loss of ammonium
- Treatment of animal bi-products in biogas and manure separation plants
- Development of biogas concepts
- Optimum design and operation of plants for the removal of the nitrogen content in biogas
- Utilisation of phosphorus fractions in domestic animal manure
- Methods for the creation and utilisation of concentrates from separation plants
- Heat treatment and other processing methods
- Side effects of biogas and manure separation

Further information is available at www.mim.dk/ Nyheder/Pressemeddelelser/270904_ virksomhedernes_miljoforhold.htm ■

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photo: thy statsskovdistrikt/per kynde

Returning the ash to the forest

By Simon Skov and Morten Ingerslev, Skov & Landskab

Whole-tree chips consist of trunks, twigs, branches, bark and needles. A large part of a tree's nutrients is found in the twigs, branches, bark and needles. Intensive whole-tree chip production removes large amounts of nutrients from the forests, which in the long term may impoverish the soil and impair tree growth. This is a relatively new situation, as traditional forestry concentrating on timber production only removes trunks and therefore leaves most of the nutrients in the forests.

Chip ash largely contains the same nutrients as the original chip. It is therefore possible to solve the problem by returning the ash to the forest. Researchers at Skov & Landskab plan to have a closer look at this option in the "Pre-processing and recirculation of chip ash" project, which has been granted subsidy under the PSO scheme (PSO = Public Service Obligation).

The ash is very reactive at the time it leaves the furnace. The nutrients are loosely bound and quickly leach out. In addition, the ash is very alkaline and can therefore potentially scorch the vegetation on the forest floor.

The purpose of the project is to develop a method for the pre-treatment and hardening of the ash. During hardening, the chemistry of the ash changes, and the substances become more strongly bound. As a result, the negative effect on the forest floor will be reduced.

Together with Karsten Frisk from the National Forest and Landscape Agency and Staring Miljø A/S in Brønderslev, Skov & Landskab aims at determining whether a normal lime spreader can spread the ash in a sufficiently even layer and in a sufficiently precise dose. If it turns out to be necessary to pellet the ash, they will have a look at that as well. They already have experience with pelleting from previous tests.

In general, the 8-10 kg nitrogen/acre supplied by the air is sufficient for the forests. However, it is not sufficient for Christmas tree and greenery plantations. Skov & Landskab has therefore entered into cooperation with Staring Miljø A/S, which has developed a manure separation plant in which manure is separated into solid matter and water. To become perfectly clean, the water has to be filtered, and the idea is to develop a filter column of ash to clean the water. This would enrich the ash with nitrogen. The result is a fertiliser that could cover some of the needs for nutrients in Christmas tree and greenery plantations.

Finally, the project comprises a number of field and laboratory tests to determine if the spreading of ash would result in an unintentional seepage of nutrients into the ground water. ■