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The ultra-flexible power plant of the future

Energinet.dk, the owner of the overall energy infrastructure in Denmark, has allocated almost DKK 29 million for a consortium that is to develop the power plant of the future. It should be ultra-flexible in order to make room for far more renewable energy in the energy system; it should be able to run on many different types of fuels and produce gas and liquid fuels for the transport sector.

By Torben Skøtt

The researchers behind a new development project called REnescience have found nothing less than a brilliant solution. By combining the newest technology within pre-treatment of biomass with a gasification system, they are going to develop an ultra-flexible power plant that can run on a vast number of different fuels and produce electricity, heat, gas or liquid fuels, depending on what is needed the most.

Energinet.dk sees a lot of potential in the concept, and has therefore allocated almost DKK 29 million out of a pool of DKK 130 million for a consortium that is to continue developing the ideas during the next four years. For the time being, they have a budget of DKK 55 million, but that is not enough to establish a complete pilot plant in Denmark. The reason for this is that the project is so extensive that several of the processes must be tested in foreign facilities, while the pre-treatment of the fuels and the conversion of gas to liquid fuels will be tested in facilities built in Denmark.

– The concept is brilliant, and therefore, we have chosen to grant it a large sum of funds, says Steen Vestervang, who is a research coordinator at Energinet.dk.

– In order to get more renewable energy into the electricity system, it is extremely necessary to develop a new generation of power plants that can quickly increase or decrease the production of electricity. This will make room for more wind mills, wave power and solar energy, says the research coordinator, who also sees a lot of potential in the development of methods for production of liquid fuels.

DONG Energy will be managing the new project. The other participants are Haldor Topsøe, Novozymes, the refuse conversion plant Amagerforbrænding, Faculty of Life Sciences at University of Copenhagen and ▶

- Institute of Environment & Resources at Technical University of Denmark.

User experiences from IBUS

The reason that DONG Energy has chosen to be in charge of project management is not least their expertise within power plant technology, but also that they have had a lot of positive experience with pre-treatment of biomass through the so-called IBUS project.

In the IBUS process, the biomass is used for production of ethanol, fuel and feed. In the new REnescience project, the biomass will first the converted into gas, after which the gas can be used for production of heat and power or for production of synthetic petrol.

The two systems have the pre-treatment in common, but other than that, there are not many similarities. The reason for this is that REnescience is not just supposed to be able to run on biomass and waste. A large part of the fuel will be coal, because the facilities will be so large that it will be difficult to get hold of enough biomass and waste within a reasonable radius.

In the REnescience facility, different fuels will be divided into fine particles, heated up and mixed with enzymes to create a "mash" that can be pumped into a high-pressure gasification system. Initially, the process will be tested at DONG Energy in Skærbæk, Denmark, where a pilot plant is to be established in 2009, which will be moved to the refuse conversion plant Amagerforbrænding afterwards. Here, tests will be carried out with different types of waste, as well as tests to figure out the best way to sort out the various metal and plastic parts that cannot be gasified.

Collects CO_2

Today, high-pressure gasification systems are a well-known technology that is used in many places for gasification of coal. For example, the Germans got through World War II by gasifying coal and then converting the gas into liquid fuels through the so-called Fischer-Tropsch process. Later, the process was developed further in South Africa, among other places, during the years where the country was subject to an extensive oil embargo, and today, South Africa is the country in the world with the most expertise within coal gasification.

photo: torben skøtt/biopress

The experiences from the IBUS project with pre-treatment of biomass will be used for the new project, which has been named REnescience.

One of the strategies behind the REnescience project is that the researchers will initially focus on the areas were Denmark is strong. Those areas are pre-treatment of fuels and conversion of gas to synthetic petrol, where especially Haldor Topsøe has significant experience.

– With regard to the actual gasification process, we are going to use some of the facilities that exist in Germany and Spain, among others, explains chemical engineer Martin Møller from DONG Energy. He has previously been with Haldor Topsøe, and is one of the ideas men behind the project, which he will now be focusing on in the years to come.

According to Martin Møller, using high-pressure gasification comes with many advantages. With a pressure of about 40 bar and a temperature of almost 1,700 degrees, the organic material will be converted into gas within a few seconds, which means that even small facilities can produce a significant output.

Facts

With a power plant based on the principles of the REnescience project, it will be possible to:

- incorporate large quantities of renewable energy in the power supply
- produce power when the price of electricity is high and petrol when the price of electricity is low
- use many different types of fuel, including household waste
- collect CO_2 from the gasification process.

Compared with biological gasification, the process is not particularly critical with regard to the fuels used, and it is rather simple to collect the content of carbon dioxide, which can then be stored in for example salt domes or pumped into oil fields. In this way, coal can become a more environmentally friendly fuel and the biomass will not just be CO_2-neutral, but CO_2-negative.

From gas to petrol

One of the other main elements of REnescience is the conversion of gas into synthetic petrol. This will be done with a catalytic converter that was developed by Haldor Topsøe in the beginning of the 1980s. At that time, the project was a technological success and a pilot plant was for example built in Houston, USA, but subsequently, when the oil price went down, the technology was put away.

– The concept was based on natural gas, but there is not a lot of difference between natural gas and the synthesis gas that the high-pressure gasification system can deliver, explains Finn Joensen from Haldor Topsøe. It is his estimate that one of the new challenges will be to be able to vary the load depending on the electricity market and to demonstrate that the process can also work on a large scale.

Haldor Topsøe's process, which is called Tigas, is in many ways simpler and easier to handle than the well-known Fischer-Tropsch process, where you basically produce crude oil, which then has to be refined. The company is now going to start building a pilot plant, which will be moved to Spain afterwards, where it will be tested with gas from a large commercial gasification plant. ■

photo: torben skøtt/biopress

Denmark should have a showroom ready for the climate summit in 2009 in order to show the rest of the world how a major city can become sustainable with regard to energy, environment and waste management.

In the opinion of Ulla Röttger, manager of the refuse disposal plant Amagerforbrænding, Amager should be a showroom - a World Energy Showroom - that can show the participants of the climate summit in 2009 what Denmark has to offer within energy technology and environmental technology.

– And when they go home from the summit, we will not leave them alone, says Ulla Röttger. She finds that it is much too random today how foreigners become aware of the competences that we have in Denmark.

– We need joint and professional marketing, and in that connection, Amager would be an obvious choice as a showroom for the climate summit in 2009. We have a biomass-powered CHP station, energy-efficient waste management and sewage works, extraction of geothermal energy, wind mills on land and at sea, soil decontamination and much more, explains Ulla Röttger.

However, the launch of Amager as a kind of energy Mecca will not be at the expense of other energy attractions in Denmark. The intention is that the World Energy Showroom is supposed to work as a showroom as well as an entry point to a number of other projects, whether it is hydrogen-powered vehicles in Ringkøbing, wave power in Sdr. Nissum, fuel cells in Svendborg or green energy islands such as Samsø and Ærø.

Ulla Röttger is perfectly aware that there is a lot of work ahead before all agreements fall into place, but she has engaged in positive dialogue with several of the large companies within the energy sector, and she hopes that the government will support the initiative. The first task will be to establish a secretariat, which must be in place during the fall, after which the various companies have until the summit to get their facilities in place. *TS*

1,000 operating hours with newly developed gasification facility

On the night up to the 14th of March, a newly developed gasification facility built by BioSynergi Proces reached the first 1,000 operating hours. The actual event took place in silence as the facility was continuing its unmanned operation.

The successful development means that biomass-powered CHP stations for companies and district heating plants with up to 500 consumers are within reach. This will result in less expensive and more environmentally friendly electricity and heat, says Henrik Houmann, who is the manager of BioSynergi Proces.

The gasification facility is located in Græsted, North Zealand, and is connected to Græsted district heating plant, which uses the heat produced, while the power is sold to the public supply network. The next phase will be to build a facility with an electricity output of 300 kW or approximately four times as much as the facility in Græsted can produce.

– We have been granted DKK 3 million by Energinet.dk for development of the new facility, and we are in contact with a district heating company that is interested in being the facility host. Now, we have to start finding investors who will contribute with capital for the new facility, and we have to work out a plan for sale and marketing of the technology, says Henrik Houmann. *TS*

Biofuels battling a headwind

The criticism of biofuels is increasing. NGOs from most of the world fear that the green oil will undermine food security, and here in Denmark, new calculations show that biofuels provide very little environmental benefit for the money. You deceive the population by presenting this as a solution, says a well-known scientist within environmental accounts.

By Torben Skøtt

The discussions about the use of renewable energy usually follow a specific pattern: On the one side, we have the environmentalists arguing that we should focus 100 per cent on renewable energy. On the other side, we have right-wing parties and large parts of the industrial sector, who are more reluctant and would prefer to let the market determine to which extent renewable energy should take over the role of fossil fuels.

But when the debate is about biofuels, the picture becomes fuzzier. In that connection, the industrial sector is pushing for allocation of the necessary funds for research and development, and not least for creation of the framework conditions necessary to bring the green oil out on the market. By contrast, NGOs and environmental experts are becoming more and more worried about the problems that could occur if large amounts of biomass are to be converted into liquid fuels. Recently, more than 200 environmental and developmental organisations have appealed to European leaders not to establish binding goals about biofuels. They fear that millions of hectares of rain forest, nature resorts and farming areas will be converted into monocultures for the sole purpose of delivering raw materials for ethanol factories. This could have catastrophic consequences for the climate, local communities and not least food security.

The population is being deceived

Here in Denmark, one of the sternest critics of biofuels is Henrik Wenzel, who is an expert in environmental accounts and works as a senior lecturer at University of Southern Denmark in Odense. He believes that it would practically be idiocy to focus extensively on producing biomass for liquid fuels when we are using valuable fuels such as oil and gas for heat and power at the same time. Thus, he is questioning the reasonableness of the public sector using large sums on developing a technology that may very well turn out to be superfluous.

– You deceive the population by presenting this as a solution. There is not enough environmental benefit, economy or adequate volume for it to solve the energy problems of the transport sector, and it is a house of cards that is bound to come down eventually, says the senior lecturer, who is currently finding support from more and more environmental organisations.

A quick look at the latest reports on the green oil also shows that Henrik Wenzel's criticism is not unfounded. Thus, the report "Tomorrow's Fuels for the Transport Sector" from the Danish Board of Technology estimates that the CO_2 reduction costs of using biofuels from 1st-generation technologies are 900-1,100 DKK/ton of CO_2, while the corresponding figure for 2nd-generation technologies is all the way up to 1,900 DKK/ton. That is far more expensive than using biomass for heat and power, where the costs are about 300 DKK/ton of CO_2, not to mention biogas for power and heat, where the costs are as low as 40 DKK/ton of CO_2.

Large business potential

Based on this information, it may seem strange that the government as well as the opposition are so thrilled with the new technology, considering that they have

photo: torben skøtt/biopress

Among other things, the NGOs fear that large nature resorts will be transformed into monocultures for the sole purpose of delivering raw materials for the ethanol factories.

rejected the 1st-generation facilities for years, because the do not provide enough environmental benefit for the money.

– But there is much more business potential in developing 2nd-generation technology, says the spokesperson for energy policy from the Danish Liberal Party, Lars Christian Lilleholt. He believes that it is absolutely necessary to do something about the dependency of the transport sector on fossil fuels, and that it is not good enough just to produce power and heat, but Henrik Wenzel does not find that reasoning particularly persuasive:

– The basic problem is that biomass is a limited resource, and we get 3-4 times as much environmental benefit for our money by focusing on power and heat instead of biofuels. If we want to turn the transport sector "light green" using biomass, we will need a "black" power and heat sector. The sectors are like communicating vessels, says Henrik Wenzel, who also believes that the entire debate should be viewed from a larger perspective:

– Bioethanol produced on the basis of waste can cover a very small part of the energy needs of the transport sector. Considering the fact that the transport consumption goes up by 10 per cent over a period of three years, it is like a snowball in hell. In 50 years, there will be 50 per cent more people on the planet, and on average, each person will be using 3.5 times as many resources as today. Seen in that perspective, there is not nearly enough biomass, which means that we have to use it prudently. We simply cannot afford to make a blunder like the one in the USA, where they are focusing massively on using bioethanol for transport, says Henrik Wenzel.

He is of the opinion that there is no justification for using biofuels as long as we use oil and gas to produce power and heat. Quite simply, we can exchange the biomass at a far higher rate of exchange within the power and heat sector than within the transport area, and we probably have gas and oil for another 30-40 years.

Use gas and pig fat

Today, there is general agreement that the area of heat and power provides higher CO_2 reduction than biofuels, but this does not make the advocates of ethanol and bio-diesel waver. They believe that the area has significant business potential, and that we have to keep up with developments in order not to fall behind compared with the countries around us.

photo: torben skøtt/biopress

Expert in environmental accounts Henrik Wenzel believes that the population is being deceived when biofuels are presented as a solution to the problems of the transport sector.

– In a narrow sense, it may be a good enough idea to do research within alternative fuels, but my claim is that when we do not have oil and gas any more, we will have developed the fuel cells and electric cars. This is far more efficient than using ethanol in combustion engines with a total efficiency rate of 10-20 per cent, explains Henrik Wenzel.

If we really must find alternatives to petrol and diesel right now, the scientist refers to a combination of natural gas and biogas - a model that Sweden and Germany, among others, focus on. In that case, the environmental accounts look reasonable, and as gas produces clean exhaust, it is a model that could become very popular in large cities.

Finally, there is the production of bio-diesel on the basis of animal fat that Daka is going to start up sometime during the fall. With this method, a waste product is used that has formerly been used for heating, but which can relatively easily be converted into bio-diesel. According to Henrik Wenzel, this is a far better solution than using biomass for diesel and ethanol. One of the reasons for this is that the conversion loss is only about 10 per cent. ■

Energy researcher:

Critics of bioethanol are fools

A researcher of bioethanol believes that the critics of biofuels are obdurate and influenced by the opinion of the Danish Energy Authority, which wants to convert all energy into electricity.

The debate concerning biofuels can sometimes be harsh and irreconcilable, and now, Professor Birgitte Ahring from Technical University of Denmark is accusing several energy researchers of being obdurate, hating biofuels and having a life-long crush on Danish coal- and straw- fired power stations. Thus, she says to Altinget.dk about the many critics of bioethanol: “I do not want to waste my life on fools”.

The professor, who does research within bioethanol and is behind the Maxifuels facility at Technical University of Denmark, among other things, is particularly fed up with senior lecturer Henrik Wenzel, whom she accuses of being on an actual crusade against biofuels.

But other energy researchers are not spared either. According to Birgitte Ahring, critics of biofuels are influenced by the opinion of the Danish Energy Authority, which has been managed by electricity people with a special affection for small decentralised CHP-stations.

– It is their sacred cow. In their world, everything must be converted into electricity to be useful. But wake up! With regard to the transport sector, the electric car will not be ready until in 20 years, says the professor with a despondent attitude to Altinget.dk.

Henrik Wenzel takes the harsh words quite calmly. He thinks that you should keep their different interests in mind.

– I can make a living making accurate environmental analyses of energy technologies. That is what my career depends on. I guess you can call that my crusade. But Birgitte Ahring's crusade is to strengthen research within bioethanol, and on top of that, she also has commercial interests. I hope people realise that when they see what we are each quoted for, says Henrik Wenzel to Altinget.dk.

TS

Pig fat and waste become diesel

Daka, which receives 800,000 tons of slaughterhouse waste and fallen stock each year, is now almost ready with a new type of bio-diesel that is more environmentally friendly than the current types of biofuels. Before the end of the year, the company will be able to deliver 50,000 tons of bio-diesel per year, but the production can easily be doubled in order to cover almost five per cent of Denmark's consumption of diesel.

photo: torben skøtt/biopress

Four of the project participants from Waste to Value are looking at Kjær Andreasen's Citroen C5, which has been running on bio-diesel for more than a year. From the right, the persons on the picture are Kjær Andreasen from Daka, Svend Lykkemark from OK, Hans Ove Hansen from Danish Technological Institute and Ken Friis Hansen from Dinex.

By Torben Skøtt

Diesel is the fuel of the future, and therefore, it is important to develop environmentally friendly alternatives to the traditional diesel oil. That is the philosophy behind a new consortium called "Waste to Value", which has been granted more than DKK 10 million by the Danish Council for Technology and Innovation to develop a new type of bio-diesel based on slaughterhouse waste and sewage sludge, among other things. The companies behind the consortium are Daka, Grundfos, OK and Dinex, together with researchers from Technical University of Denmark and Danish Technological Institute.

At Daka, south of Horsens, they are already in the process of establishing a factory for production of bio-diesel that is to be ready before the end of the year. The raw materials will be fatty waste from slaughterhouses and fallen stock, and initially, the capacity will be 50,000 tons per year. However, the company has enough fat to be able to expand the production to 100,000 tons per year, which means that the new type of bio-diesel would be able to cover almost five per cent of the diesel oil consumption of the Danes.

That is the good news. The bad news is that Daka will probably have to send the entire production out of the country because of the Danish duty system. At a press conference on the 27th of February, the Danish minister of transportation and energy Flemming Hansen had a lot of praise for the new consortium, but did not say a single word about duty cuts or forced intervention, which would be necessary to get the product onto the Danish market.

At Daka, technical manager Kjær Andreasen wonders why the minister is still hesitant with concrete initiatives in the area:

– The government has been saying that it would not support traditional production of ethanol and bio-diesel, but wait until the fuels could be produced from waste. Now, we have shown that it is possible, so it would seem strange if we have to sell production to other countries, says Kjær Andreasen.

photo: torben skøtt/biopress

Daka's test facility for production of bio-diesel in Hedensted, south of Horsens.

Higher CO_2 displacement

Diesel cars run much further per litre than petrol cars, so for that reason alone, it is possible to achieve a nice reduction of the release of CO_2 by using diesel instead of petrol, explains head of centre Frank Elefsen from Danish Technological Institute. He is frustrated that bio-diesel has been overlooked in the debate in Denmark, which has been focused almost exclusively on the development of 2nd-generation technologies for production of ethanol.

In that connection, he is supported by senior lecturer Henrik Wenzel, who does research on environmental accounts at University of Southern Denmark. He estimates that the CO_2 displacement from Daka's bio-diesel is about twice as large as from 2nd-generation bioethanol. Add to this that the release of particles and nitric oxides is a bit lower for bio-diesel produced from slaughterhouse waste than for bio-diesel produced from crops such as rape and soya.

The only disadvantage is the properties in cold weather, which are a bit poorer for diesel produced from animal fat than for diesel produced from rape. However, it is probably not going to be a big problem in practice, as bio-diesel will usually be mixed with regular diesel oil. During the winter months, you can therefore choose to add a bit less bio-diesel than during the summer months, where the properties in cold weather are not of any importance.

Sewage sludge as a raw material

However, slaughterhouse waste and fallen stock are not the only types of raw materials that the new consortium is going to use. Within a foreseeable number of years, they expect to be able to produce bio-diesel from wet biomass such as sewage sludge and household waste. This will be done through a so-called supercritical process, where high temperatures and high pressure are used to imitate the process that has created the oil reserves on earth.

On the face of it, this sounds like a very energy-consuming process, but according to Thorbjørn Machholm from Grundfos New Business, the energy calculations look reasonable. The advantage is that a large part of the energy consumption for the process can be recuperated, and because you are dealing with waste in liquid state, it is relatively easy to achieve the very high pressure that the process requires.

At Grundfos, they are now going to start building a pilot plant to demonstrate the process in practice, and at Technical University of Denmark, the researchers are working on developing a new type of catalytic converter, which is going to be an important component in the new facility.

Initially, the plan is to use relatively non-hazardous sludge from food industries, among others, but later, the process will also be tested on the more problematic types of waste. If everything goes according to plan, it will already be possible to produce bio-diesel from sewage sludge in 2010.

The consortium behind Waste to Value estimates that sewage sludge can cover almost five per cent of the diesel oil consumption of the Danes. Together with bio-diesel from Daka, it will therefore be possible to replace approximately ten per cent of the diesel consumption with oil produced from various types of waste. ■

Facility for bioethanol on Bornholm

photo: biogasol

The MaxiFuels facility at Technical University of Denmark.

BioGasol, which does research on production of ethanol from residual products, is ready to build the first facility on the island of Bornholm. The facility is going to cost DKK 275 million and produce 10 million litres of bioethanol per year.

As far as BioGasol is concerned, the people on Bornholm can drive around on bioethanol produced from waste and residual products from the island's farmers in a few years. The reason for this is that the company, which is behind the MaxiFuels facility at Technical University of Denmark, among other things, has chosen the sunny island as the place where the 2nd-generation technology for production of ethanol is to be scaled up to a demonstration facility.

The plan is that the facility is to treat almost 100,000 tons of wet biomass per year, which corresponds to a bit more than 40,000 tons of dry matter. The end product will be approximately 10 million litres of bioethanol and 10,000 tons of fuel pellets. Furthermore, the facility will produce 4 million cubic metres of biogas, but the main part of this will be used to run the facility.

The regulatory processing has already been started, but the financing still has to fall into place. BioGasol expects to get half of the DKK 275 million that it is going to cost to build the facility from the globalisation pool, where the Danish government has earmarked DKK 200 million for development of bioethanol over the next four years. The rest is expected to be financed by Bankinvest, which is a co-owner of BioGasol.

– But it is important to make a decision soon. There is a lot of international competition about developing 2nd-generation technology for bioethanol, so it will be the last chance soon, says Professor Birgitte Ahring, who is the managing director of BioGasol.

She informs of the fact that the American energy agency has recently made public that they are going to invest up to USD 385 million in six bio-refineries over the next four years to help the industry and bring the 2nd-generation technology out on the market.

Furthermore, projects have been started in Canada, Spain and the Netherlands, among other places. In Spain, the company Abengoa is going to have a facility ready during the summer of 2007, and in the Netherlands, the British company TMO is planning to build a facility that is supposed to be ready for operation in 2008. *TS*

If you would like to know more

– about research on the use of biomass for energy purposes, you can take out a free subscription for Bioenergy Research. The magazine, which appears six times a year, is published with support from the Energy Research Programme, and you can have the following sent directly to you:

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New types of "feed" for energy purposes

photo: flemming nielsen

Rye, maize, wheat and hemp are among the crops that are now being tested for their ability to boost production of biofuels and biogas.

The Danish Faculty of Agricultural Sciences is working with Innovation Centre for Bioenergy and Environmental Technology on finding out how to ensure supply of biomass for production of biofuels and biogas all year. This spring, 30 small lots will be planted with different crops in order for the researchers to be able to test how to make the best "feed mixture" for energy purposes.

By Flemming Nielsen

Biogas facilities run the best on a good "feed mixture" that is supplied continuously all year round. This also applies for continuous production of bioethanol, bio-diesel and hydrogen. The main challenge is to find crops that are available all year round and that have the highest total yield.

This challenge has been taken up by the Danish Faculty of Agricultural Sciences (DJF) in co-operation with Innovation Centre for Bioenergy and Environmental Technology (CBMI), and they are now in the process of finding suitable crops.

– Basically, we are in the process of finding the crops that give the highest net yield over the year. It is important that there is biomass available all year to provide a stable supply for a biogas facility, for example, explains Margrethe Askegaard, senior researcher at the department of agroecology and environment of DJF.

The end objective of the project is to select the energy crops that are most suitable for production of biofuels and biogas with a large energy potential. Important elements of that decision are growing, harvesting and storage technique.

At the moment, work has started in the fields, where the focus is on elephant grass, energy willow and a number of annual crops. On a small hectare of land, almost 30 small lots will be planted with rye, wheat, beets, triticale, maize, perennial ryegrass, Jerusalem Artichokes and hemp.

photo: flemming nielsen

The trials include a number of perennial crops such as sorrel, elephant grass and willow. The picture shows elephant grass.

Crops all year

With the somewhat special field plan put together at DJF, there will be harvesting activities all year. For example, there is early rye, which is harvested in the middle of May, followed by maize, which is harvested approximately eight months later.

– We have tried leaving the maize until January before harvesting, but that has only been a partial success. In Foulum, an early autumn storm knocked down the crops already in November, but we have had a really good yield in Jyndevad until the end of January, says Margrethe Askegaard.

Next season, the researchers are going to attempt harvesting the maize at other times.

At the more curious end of the scale, the researchers are going to plant hemp, if DJF can get the necessary permits. The reason that these permits are necessary is that hemp is subject to special regulations due to the plant's special properties as a euphoriant.

The field plan also includes the three winter crops winter wheat, winter rye and winter triticale, with perennial ryegrass as catch crop.

Back to the beets

Several years ago, beets became too difficult to handle as animal feed, but now,

they are given an opportunity to show their worth as biofuel.

– So far, beets have been difficult to handle, but with new technology, we will probably be able to collect the beets with roots and tops, brush off the dirt and crush them. That makes it easy to put the beets directly into a silo, explains Margrethe Askegaard.

She finds beets particularly interesting, because it is easy to convert the sugar in the plants into bioenergy, and because beets are among the annual crops with the highest yield.

– But the main challenge in this connection will be whether the technology for handling the beets is ready, she says.

Jerusalem Artichokes and grass

The Swedes are particularly fond of Jerusalem Artichokes as a "biobooster" in biogas facilities, and there is a good reason for this, explains Margrethe Askegaard:

– Jerusalem Artichokes produce significant growth. They become two to three metres in height and you can harvest the tops in October. The actual tubers can be left in the ground until spring, where they can be taken out when the biogas facility needs additional "feed".

The organic agriculture has also included testing of clover for production of biogas.

– Grass fields grown organically may be a good addition to the energy chain in a biogas facility, where nutrients can lead back to the organic fields. This could result in significant environmental advantages, is the estimate of Margrethe Askegaard. She expects to be able to harvest the organic fields with clover 3-4 times a year.

photo: flemming nielsen

Senior researcher from the Danish Faculty of Agricultural Sciences, Margrethe Askegaard, is going to participate in finding a number of energy crops that are suitable for production of biogas.

Only just started

For the time being, the test is going to run for a year, where the combination of different crops and catch crops will be put together in one complete plan.

– As the individual crops are harvested, a chemical and biological characterisation of the plants will be carried out, for example through digestion in a biogas facility and production of ethanol. The dry solids content of the crops will be analysed along with a number of other parameters, and there will be focus on the consistency of the harvesting times with the need for biomass, explains Margrete Askegaard.

After the initial screening, the researchers will compare the dry solids content against the energy input needed to produce the crop. This will result in a proposal for a concept of continuous harvesting of suitable crops that can be used by producers that grow crops for energy purposes within a few years.

Flemming Nielsen is a journalist and works at CBMI.

Trial plan

Annual crops:

- Early rye + maize
- Hemp
- Green-cut winter wheat + perennial ryegrass
- Green-cut winter rye + perennial ryegrass
- Green-cut winter triticale + perennial ryegrass
- Jerusalem Artichokes
- Green-cut spring triticale + perennial ryegrass
- Fodder beets

Perennial crops:

- Elephant grass
- Energy willow
- Sorrel

We need an organic biogas movement

Organic farming is facing difficult challenges with regard to meeting the rising demand for organic products and becoming independent of fertilizer from conventional farming. These challenges can be addressed by growing green manure and gasifying the crops in biogas facilities.

At one time, organic farmers did not like biogas. When the first biogas facilities were established in the late 80s, organic farmers often expressed their opinion that biogas could not be reconciled with the ideas behind organic farming. Instead, they pointed at a fertilising system based on composting plants with heat recuperation and nitrogen precipitation.

Now, that is a thing of the past. As we know, composting plants never became a success, and today, more and more organic farmers are planning to establish biogas facilities.

There are several reasons for this. Organic farmers definitely need fertilisation, and biogas facilities ensure better utilisation of the nitrogen and a reduced loss of nitrogen to the surroundings. Therefore, environmentally friendly fertilisation is an area that is of more and more interest to researchers as well as agricultural advisers.

In an article published on www.lr.dk, consultant Michael Tersbøl encourages organic farmers to take the word green manure a bit more literally. In the future, green manure should not just be ploughed into the ground to produce nitrogen for the next crop. In the future, it should be harvested, gasified in a biogas facility and thus be used to produce liquid manure. This will result in more nitrogen for the crops and a higher yield.

But an organic biogas facility is not something than an individual farmer can build just like that. Therefore, there is a need for an organic biogas movement – a movement that can create attention about the possibilities that lie in establishing organic biogas facilities and organise the farmers that want to participate actively in this development, writes Michael Tersbøl. *TS*

Centralised biogas facilities of the future

An analysis of new biogas concepts shows that the gas yield per cubic metre biomass can be doubled in comparison with a traditional biogas facility that only treats liquid manure. However, it is most profitable for farmers to treat the liquid manure themselves, and if they choose to be part of a centralised biogas facility anyway, the traditional solutions will still be the most profitable.

photo: torben skøtt/biopress

The expansion with biogas facilities has come to a halt even though it is still one of the least expensive ways of reducing the release of CO_2.

By Kurt Hjort-Gregersen

In 2002, the Danish Institute of Food and Resource Economics published a report with economic analyses of centralised biogas facilities. The conclusion in this report is that the technology is now functional and economically viable with very low costs for reduction of climate gases. A lot of people expected this conclusion to result in establishment of new facilities, but reality turned out to be completely different: The expansion practically stopped - mainly because of poorer framework conditions and local resistance against positioning of new facilities.

However, the report from 2002 also showed that there are still a number of areas where a further effort can improve the economy of biogas facilities. That became the background for the following project: Future biogas plants - new systems and their economic potential.

Two phases

The project, which has gained support from The Energy Research Programme, was divided into two phases: During the first phase, a number of tests were carried out with animal manure from various separation and pre-treatment facilities. After that, a number of different scenarios were set up, which were analysed with a view to being able to select the most promising facility concepts later.

The analyses include the complete system from the farmer's storage tank to utilisation of the nutrients in the field. Calculations have been carried out on mass balances, production of biogas, energy consumption for the process, availability of nutrients and utilisation, as well as calculations of revenues and costs during all parts of the chain. Furthermore, a veterinary risk assessment analysis has been carried out. This has not been included in the assessment of the individual scenarios, but should be seen as a supplement to the actual system analysis.

The analyses are based on a farming area that delivers animal manure for a biogas facility and buys the gasified products. The treatment of the liquid manure primarily takes place at the biogas facility, but several of the scenarios include pre-separation at some of the farmers to increase the dry solids content of the liquid manure.

With regard to farming, all scenarios are equal. Part of the fibre fraction is exported away from the area to achieve phosphorus balance, the animal producers pay for storage and delivery of liquid manure, and all scenarios include the same rotation of crops, fertilisation level and yield level. Thus, changes in the fertilisation values do not affect the yield levels, they only affect the amount of supplied commercial fertilizer.

Doubling of gas production

No organic waste is supplied in any of the scenarios, as the objective has been to find the best concept for treatment of liquid manure.

The gas production and economy of the various scenarios can be seen in table

Biogas facilities of the future

The project about the biogas facilities of the future has become a reality as a result of co-operation between:

- Danish Institute of Food and Resource Economics
- University of Copenhagen, BioCentrum
- Technical University of Denmark
- Faculty of Agricultural Sciences - University of Aarhus
- National Veterinary Institute – Technical University of Denmark
- National Food Institute – Technical University of Denmark
- Danish Agricultural Advisory Service — The Centre of Crop Production.

The project was completed with the publishing of report no. 188: "Future biogas plants - new systems and their economic potential", which can be obtained from Danish Institute of Food and Resource Economics, telephone no. 3528 6800, www.foi.dk.

No.	Treatment	Dry solids in per cent	m^3 methan/ ton of biomass	Farmer DKK/ton	Biogas facility DKK/ton	Total expense DKK/ton
0	No biogas facility.	–		49	0	49
1	Biogas facility with post-separation and export of fibre fraction.	5.4	12,1	39	29	68
1 a	Biogas facility with serial-digestion, post-separation and export of fibre fraction.	5.4	13,3	39	25	65
1 b	Biogas facility with post-separation and recirculation of fibres, as well as export of fibre fraction.	5.4	13,2	40	28	68
2	Pre-separation, post-separation and wet oxidation of fibre fraction and recirculation of fibres.	10.0	25,1	49	18	58
2 a	As scenario 2, but with pressure-boiling of fibre fraction instead of wet oxidation.	10.0	24,7	49	24	60
2 b	As scenario 2, but without pre-separation. The entire amount of liquid manure is fed into the biogas facility.	5.4	14,6	39	27	66
2 c	As scenario 2, but without wet oxidation and recirculation of fibres. Part of fibre fraction is exported.	10.0	20,8	50	19	59

Table 1. Dry solids content, gas production and economy of the various scenarios.

1. From this, it can be seen that the gas yield can be increased in several ways, but that particularly the combination of several steps creates a significant effect. The highest effect is achieved through a higher dry solids content through supply of pre-separated fibre mass. When combined with pre-treatment, the methane yield can be doubled per ton of biomass in comparison with a traditional facility that only treats liquid manure. However, a positive effect has also been found in serial digestion and recirculation of fibres, but on a smaller scale.

Not appealing to the farmer

The economic analysis is divided into a farming section and a biogas section. The farming section includes costs for storage and delivery of liquid manure, separation of liquid manure at the farms, as well as purchase and delivery of commercial fertilizer. The biogas section includes transport of liquid manure and fibre, pre-treatment, post-separation and revenues and costs in connection with operation of the facility. In scenario 0, the costs for export of surplus fibre are placed in the farming section, while the biogas facility is responsible for those costs in the other scenarios.

Table 1 shows the costs of the various scenarios. The costs of DKK 49/ton for the complete system in scenario 0 are central to the analysis, as they show the costs of the farm, if the farmer has to handle the liquid manure himself and solve the problem of surplus phosphorus himself. This means that a scenario with a biogas facility has to be able to match this price to be an appealing alternative for the farmers.

As can be seen in the table, this is not the case for any of the analysed scenarios, which explains why the expansion with biogas facilities has stalled. In most cases, the existing facilities achieve a viable economy by adding organic waste, but resources are limited, and there is not enough waste to ensure the economy of new facilities. Thus, it is necessary to improve the framework conditions in order to achieve the significant expansion with biogas facilities that is proposed in the new energy strategy of the government.

Further testing

However, the project about the biogas facilities of the future also shows that it is possible to find new facility concepts that result in better finances than the traditional biogas facility in scenario 1.

Generally, farmers derive the most benefit from the more traditional facility concepts that only treat liquid manure. The reason for this is that the farming section is responsible for the costs for separation of a certain amount of liquid manure at the farms in the other scenarios. However, the biogas facility derives the most benefit from the scenarios where the liquid manure is separated at the farms. The most economic scenarios are 2, 2a and 2c, which have the lowest net costs for the system as a whole.

If the dry solids content of the liquid manure was higher from the beginning than is the case today, the advantages of pre-separation would not be as significant as appears from the analysis. A higher dry solids content would therefore place the concept with the traditional joint biogas facility in a more favourable position.

With regard to the more advanced facility concepts, there is a need for further testing and documentation of revenues and costs before it becomes advisable to establish full-scale systems. However, facilities with several serial reactors and supply of fibres can be put into operation already today.

photo: torben skøtt/biopress

Wet oxidation is one of the techniques that may be able to improve the economy of the new biogas facilities.

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Danish environment minister Connie Hedegaard:

Do not use straw for biofuels

photo: jakob dall

Danish environment minister Connie Hedegaard is now supporting the researchers that are warning against using straw and other types of biomass for production of biofuels.

This happens after the publishing of an exam project from Technical University of Denmark, where two students have analysed the environmental consequences of using green-cut crops for production of bioethanol. Thus, the environment minister says to Altinget.dk:

– I believe that this report once again documents that the use of biomass for production of power and heat makes more sense environmentally and provides less expensive CO_2 reduction than when using biomass for production of bioethanol. As long as fossil fuels can be replaced by using biomass for heat and power, it will be difficult for biofuels to compete with regard to environmental benefit regardless of further technological development, says Connie Hedegaard.

On this background, she concludes that the use of biomass for bioethanol in Denmark is not as interesting from an environmental perspective as in other countries where straw is not used for power and heat.

However, the environment minister still thinks that biofuels are the most realistic possibility of reducing CO_2 release in the short to medium term. Therefore, she points at other residual products such as animal fat from farming, liquid manure and household waste.

At the moment, Daka at Hedensted, south of Horsens, is building a factory that can convert animal fat from slaughterhouse waste and dead animals into bio-diesel. This factory, which will be placed into operation at the end of the year, can cover approximately five per cent of the Danes' need for diesel when it has been fully expanded.

The use of liquid manure and household waste lies a bit further into the future, but many researchers are working intensively at the moment on developing new techniques that can convert the more problematic types of waste into ethanol or bio-diesel.

The exam project from Technical University of Denmark has the following title: "2nd generation bioethanol for transport: the IBUS concept - boundary conditions and environmental assessment".