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FiB
Bioenergy research

The EU commits itself to renewable energy

Energy research is given higher priority in the EU. The Parliament has just recommended that 2.4 billion euros be allocated to energy research two thirds of which will be earmarked for research in energy efficiency and renewable energy.

By Torben Skøtt

The good news was presented by Lise Nielson from Energinet.dk at the conference Forsk2006 which was held on 15 June in the DGI-byen in Copenhagen.

At the conference, Britta Thomsen (Socialist Group), Vice-Chairwoman of the European Parliament's Committee on Industry, Research and Energy was meant to give a speech on the EU's seventh framework programme, but she was prevented from coming as the programme had its first reading in the parliament that day. At the end of the day, Lise Nielsen could instead announce that the parliament had supported the proposal for the new programme which covers the period from 2007 to 2013.

Besides, Denmark has performed very well in the EU's sixth framework programme where we have received more than DKK 100 million equal to a total share of the funding amount of more than 10 per cent. Except for Holland, which has received more than DKK 150 million, Denmark is the country which has received the largest funding amount in absolute figures. However, Denmark's contribution amounts to approx. two per cent of the budget, whereas Holland's contribution is almost two and a half times larger.

The EU's sixth framework programme for the period 2003-2006, has a total budget of EUR 857 million equal to DKK 6.4 billion.

The latest round within energy is directed towards integrated demonstration plants for renewable energy and energy efficiency where Danish companies and research institutions have positions of strength. When the received project proposals are assessed, every second Danish proposal is given a positive assessment. In comparison, only every eighth project proposal from Italy is given a positive assessment.

photo: torben skøtt/biopress

Insufficient knowledge of gas from manure

The Vegger plant south of Aalborg where a series of interesting tests were carried out in 1988 regarding digestion of cattle manure.

Our knowledge of the practically achievable gas yield from manure is too poor. This is embarrassing and has to be improved. Livestock manure is by far the largest resource for the production of biogas in Denmark.

By Søren Tafdrup

How much biogas can be reclaimed from manure? The available literature on this subject usually says: 22 m^3 biogas/m^3 manure - without further details. Although the details are incredibly important. A fluctuation of plus or minus 10 per cent of the gas yield from the manure is very important as regards the financial situation in a biogas project.

Why are we short on details? After all, we have done research and developed for more than 20 years. The answer is that for financial reasons, practically all biogas plants use a mixture of manure and organic waste. This means that even though we have a lot of figures for the production of the plants, we are not able to specify the amount of gas which actually comes from manure.

But should the research and development work not have compensated for that? Well, it should actually. Unfortunately, it has not. We have to admit it. So far, the efforts have been used for other topics and projects.

But better late than never. In the years to come, we have to obtain a much better overview of how high a gas yield it is possible to achieve in practice from a given herd and from a give number of herds in the large projects. When a new project is initiated, it must be possible to obtain knowledge from the publicly financed research and development work in order to be able to safely predict the gas yield.

The following example may be used for illustration: Back in 1988, full-scale tests were carried out with thermophilic digestion of cattle manure at the common plant in Vegger. The tests lasted several months and were carried out in parallel in two of the plant's 200 m^3 reactors. In one of the reactors, the manure was digested with a retention time of 13-14 days. This gave a yield of 17.8 m3 biogas/m^3 manure. In the other reactor, the manure was digested with a retention time of 18 days. This gave a gas yield of 20.3 m^3/m^3 manure, a 14 per cent higher yield. A two-step digestion would have increased the yield from both reactors by approx. 10 per cent.

photo: torben skøtt/biopress

And how much gas are you able to make?

What is going to happen?

First of all, we have to know the exact energy potential from a given herd. In addition, we need the composition of the herd. This includes the annual yield of the cows, sows with piglets and the number of pigs for slaughtering produced a year. In the more advanced version, the feeding may also be included. As regards the cows, this means that the gas potential may be related to the milk yield from a given herd.

Secondly, dilution with water should be minimised and the manure should be as fresh as possible.

Afterwards, we must be able to evaluate the ability of a specific biogas plant to use the gas potential in the manure. In particular, this depends on the temperature, the retention time and whether or not the plant is equipped with serially connected reactors.

In total, all of this must give precise knowledge to a new biogas project of how high a gas yield can be obtained with a given number of livestock.

The largest resource

Table 1 shows why it is important to focus on livestock manure. Denmark has qualified resources for a tenfold increase of the biogas production from the present 4 PJ/year to a little less than 40 PJ/year. 70 per cent or 26 PJ is livestock manure but so far only a very limited amount is used.

As mentioned, the biogas plants add organic industrial waste in order to increase the gas production and improve the financial situation. However, the organic industrial waste is an unreliable resource. It is not possible to enter into long-term agreements with the industry, and the uncertainty is strengthened by the fact that the resources of suitable domestic industrial waste are "consumed" faster than the livestock manure. As a result, the further expansion of liquid manure-based biogas plants will be accompanied by an increased competition for the industrial waste.

This issue with advantages and risks in connection with the adding of organic waste has been important in the discussions of the research and development programmes during the past 10 years. The report "Biogasfællesanlæg fra idé til realitet" (Biogas common plant from idea to reality) from 1995 concluded that the main purpose of the further development is *"... to improve the plants to make them operate financially satisfactorily either on the basis of livestock manure alone or by supplying less attractive types of waste where the supply is much more stable in the long run."* This conclusion still applies.

Consequently, the purpose of the research and development efforts is to achieve further improvements of the technical-financial capabilities of the biogas plants in order for the section to perform well in the future even though the basis of raw materials gradually becomes less financially attractive as the resources of organic waste are being used.

To be able to evaluate the financial situation of the specific projects and use the country's large energy potential in livestock manure, it is important to pool and improve our knowledge of biogas from the livestock manure.

Søren Tafdrup is Head of Section in the Danish Energy Agency, e-mail: st@ens.dk.

Applications for PSO and EFP

It is now time to make a cross in the calendar if you wish to send an application to the Energy Research Programme (EFP) or the PSO scheme.

According to the traditional practice, a common information meeting will also be held this year for the applicants for the PSO scheme under Energinet.dk and the Energy Research Programme (EFP), which is administered by the Danish Energy Agency.

For many years, the two support schemes have cooperated with common information days and common deadline for applications. This year, the information day will be held on 15 August and the applications must be sent no later than 15 September. All applicants receive a preliminary status prior to 15 December and before the end of the first quarter of 2007, all applications have been considered.

– The programmes are so similar that we frequently exchange applications, explains Lise Nielson from Energinet.dk. This means that it is not important whether the application is sent to Energi.dk or to the Danish Energy Agency.

The Energy Research Programme has DKK 72 million to spend on development of new technologies within the energy area. Grants are made for research, development and demonstration regarding production, supply and efficient use of energy. In addition, grants are made for international cooperation.

The PSO scheme has funds of DKK 25 million for efficient energy use and DKK 130 million for research, development and demonstration of environmentally friendly electricity production technologies.

Further information:
www.energiforskning.dk
www.energinet.dk
www.ens.dk/sw11648.asp

Unit: PJ	Potential	Production Year 2001	Production Year 2002	Produkction Year 2003	Production Year 2004
Livestock manure	26.0	0.61	0.70	0.85	0.91
Sewage	4.0	0.86	0.87	0.87	0.83
Industrial waste, Danish	2.5	0.59	0.67	0.80	0.86
Industrial waste, imported		0.40	0.45	0.55	0.65
Meat and bone meal material	2.0	0.00	0.00	0.00	0.00
Household waste	2.5	0.03	0.05	0.07	0.03
Garden and park waste	1.0	0.00	0.00	0.00	0.00
Refuse dump gas	1.0	0.56	0.62	0.44	0.46
Total	**39.0**	**3.05**	**3.36**	**3.58**	**3.74**

Table 1. Potential and registered production of biogas during the years 2001-2004.

Straw and energy crops in biogas plants

Adding straw to biogas plants may reduce or at best completely remove the biogas plants' dependency on organic waste. However, the yield from different straw types varies significantly and it seems as if it is possible to obtain a synergy effect in certain cases which makes it extra attractive to add straw to livestock manure.

By Henrik B. Møller and Anders M. Nielsen

Straw represents a considerable energy resource and is already today widely used in the Danish energy supply sector. Furthermore, an increasing amount of straw is used as bedding in the animal husbandry, partly due to increased requirements for animal welfare, and partly due to legislative requirements for bedding materials for pigs.

The use of straw in biogas plants by means of direct supply or by indirect supply as bedding including the manure may help reduce or at best completely remove the biogas plants' dependency on organic waste. In addition, the use of straw in biogas plants may be a good supplement to direct incineration at the large power plants where it is often difficult to reuse the nutrients in the straw.

Different types of straw

During the past year, the possibilities of using straw in biogas plants have been studied at the Danish Institute of Agricultural Sciences supported by the Danish Energy Agency. A number of methods to increase the gas yield have been clarified and the gas yield from a number of straw types and energy crops have been examined. These are:

- Straw from wheat, barley, grass seed, peas and rape.
- Energy crops in the form of maize, grass and grains.

As expected, the gas yield is generally higher in grains and coarse feed compared to straw (see figure 1). However, there are large individual differences between the various straw types when the straw is used for the production of biogas. Straw from wheat and spring barley contains a significantly lower gas yield than straw from grass seed and winter barley. Whether the result of winter barley applies to all types is however uncertain as the result is only based on one study.

As mentioned, the yield from straw is generally lower than they yield from coarse feed. However, the yield from grass seed straw and winter barley straw is becoming increasingly similar to the yield from coarse feed if the contribution from after-gasification is included - meaning a long retention time in the reactor tank and/or after-gasification in a storage tank with gas reception.

Straw and manure

A number of tests have been carried out at the Danish Institute of Agricultural Sciences where the supply of pig manure and wheat straw to a biogas reactor was compared to a reference reactor where only pig manure was added.

Figure 2 shows how large a share of the dry matter content the straw represents of the total amount of dry matter, and the organic load of the straw reactor is compared to the reference reactor.

The straw was added separately at dry feeding below the level of liquid three times a week. As expected, handling problems occurred in the form of a heavy stratification and at an early stage the original propeller agitation was replaced by agitation by means of gas. However, the gas agitation was also not capable of ensuring sufficient agitation which resulted in the piling of a large amount of unconverted material at the top of the reactor tank. This may have contributed to an improved decomposition due to the long retention time.

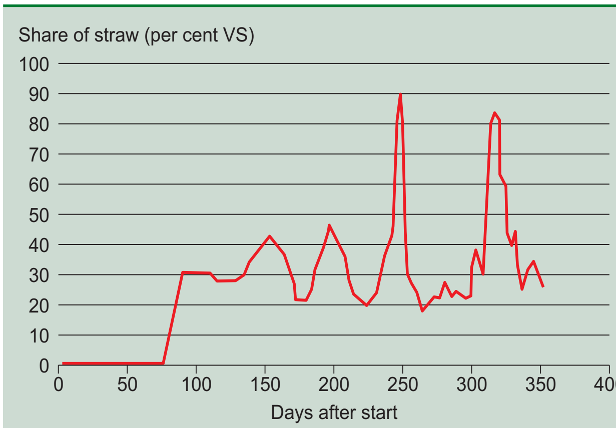

Figure 2: The share of added organic matter, which consisted of straw during the test.

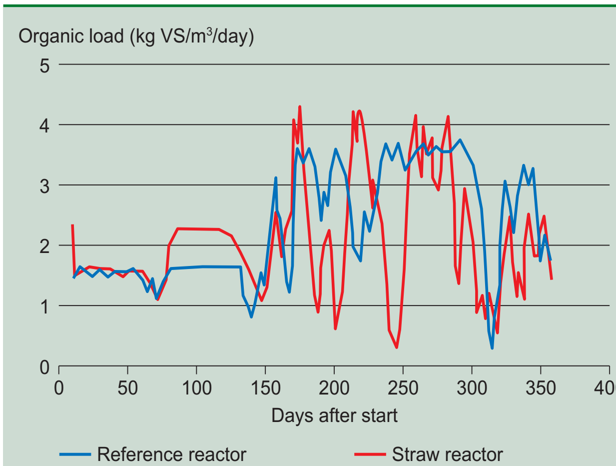

Figure 3: Organic load of the reference reactor and the straw reactor.

Process balance

During the test, the amount and composition of volatile fatty acids (VFA) was measured. The level turned out to be relatively low and stable until 230 days after start-up when a new procedure, including removal of the supernatant, shredding and subsequent redigestion was introduced (see figure 3). When this procedure was implemented, the VFA level in the straw reactor increased which can be explained by a lengthy accumulation of unconverted organic material which was activated at the shredding. After an additional 100 days, there was a minor decrease in the VFA level, however, it never reached the level of the reference reactor.

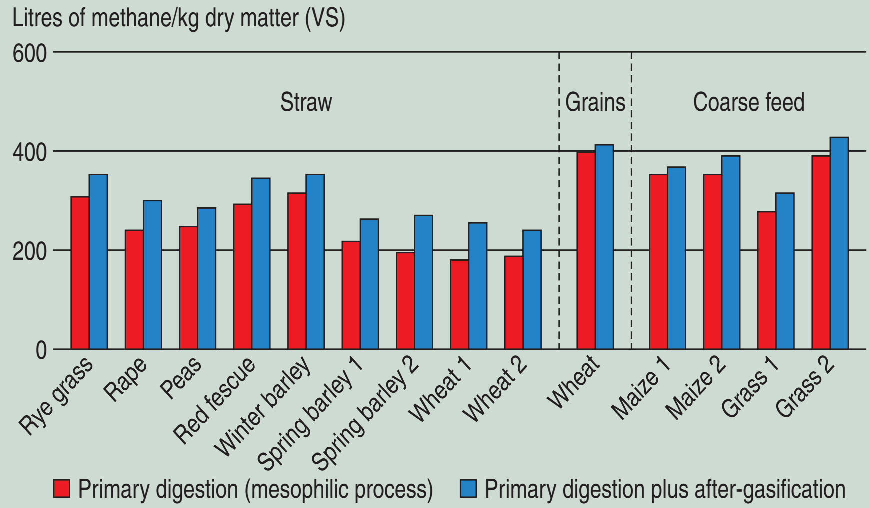

Figure 1: Methane yield from various types of biomass. Mesophilic digestion is listed as the gas yield at 35°C at a retention time of 48 days and after-gasification is listed as the yield from 48-105 days of digestion at 35°C.

Gas production

The gas production per kg organic dry matter (VS) in the two reactors is illustrated in figure 4. In general, a considerably better yield per kg VS in the reactor is achieved when adding straw compared to the reactor with pure manure. On average, the straw reactor thus gave a yield of 377 litres CH_4/kg VS compared to a yield of only 278 litres HH_4/kg VS in the reference reactor. This is surprising as pig manure in most studies has shown a yield of 300 litres CH_4/kg VS while wheat straw has given a maximum yield of 220 litres CH_4/kg VS. This indicates that there has been a synergy effect when straw was added - probably due to a considerable stratification in the straw reactor which has ensured a very long retention time of hardly convertible material.

In addition, the production in the straw reactor has varied considerably when periods with very high gas production have coincided with the supernatant being "activated" by manual agitation. Furthermore, there has been a remarkably higher gas yield during the period after start-up with regular removal of the supernatant, shredding and redigestion. A yield of 451 litres CH_4/kg VS was thus measured during the period after start-up using this procedure, while the production was "only" 333 litres CH_4/kg VS during the period without shredding. The high yield during the last period is probably due to the fact that it has been possible to transform a lot of piled up material from the first period and it is thus not just obtained due to the effect of shredding.

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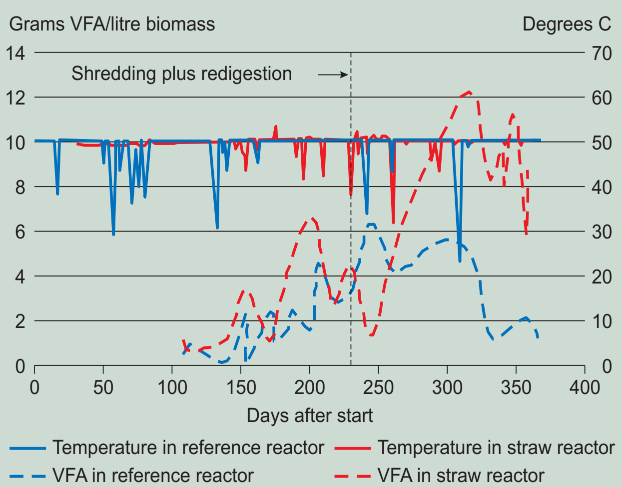

Figure 4: Total fatty acid content (VFA) and temperature in the straw and reference reactor.

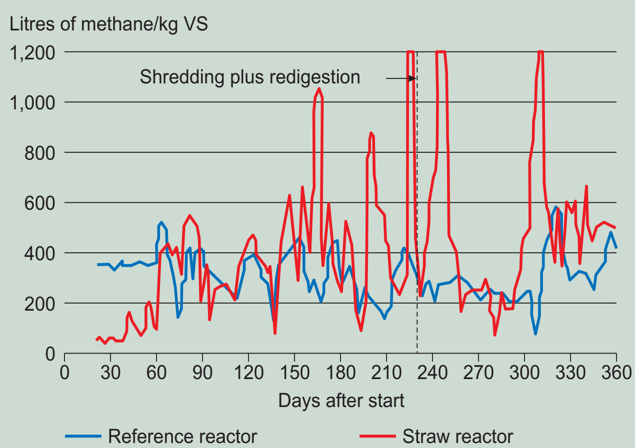

Figure 5: The gas production for the reference reactor and the reactor where straw and manure were added.

Test plant for the entire industry

After years of work, the Danish Institute of Agricultural Sciences can now start building a full-scale biogas test plant which will fulfil the ambition of new increased research and testing within biogas and manure separation.

By Flemming Nielsen

photo: flemming nielsen/cbmi

We already have a couple of manure tanks and in six months we have a biogas test plant.

The agreement has been signed a long time ago, the neighbours in Foulum have been calmed and the money is in an available account. It is now absolutely certain: The Danish Institute of Agricultural Sciences (DJF) will get its biogas test plant.

– The excavation starts at the beginning of June and after New Year the plant will start producing gas. Afterwards, Xergi which supplies the plant has a 3-month period to run in the plant, says Gunnar Hald Mikkelsen, Operations Manager at the Danish Institute of Agricultural Sciences.

With this plant, the research institution is looking forward to strengthen the efforts in this area.

– With the biogas plant, we obtain a platform we can use when introducing the agricultural section to an energy production. We integrate the agricultural production and the production of energy, explains Gunnar Hald Mikkelsen, who believes that the Danish Institute of Agricultural Sciences has all the qualifications required to make a difference in the entire biogas industry.

New energy possibilities

– The Danish Institute of Agricultural Sciences is good at optimising the production within animal production and farming, and I am convinced that we will also be good at optimising "the mixed feeding" for the biogas plant, assesses Gunnar Hald Mikkelsen.

He emphasises that the Danish Institute of Agricultural Sciences constantly optimises the loss of nutrients in connection with a minimum release to air, soil and water. He expects that this knowledge, systematics and experience will constitute a motive force in the operation and use of the test plant.

– A research area, which uses the strategies as regards the optimisation of the nitrogen, is another possibility. We might design the crop for a later production of biogas. Maybe we develop, optimise or gene splice strains which are suitable for direct energy production, he suggests.

Another focus area is storage and handling of the products.

– Today, we ensile with cutting and plastic covering. It is not certain that we will continue doing so. We may need to develop cheaper storage facilities and handling of crops, says Gunnar Hald Mikkelsen.

Test station for companies

The fact that the Danish Institute of Agricultural Sciences will be responsible for the plant means that it will be a plant with test facilities open to everybody who is interested in processes and technologies in relation to biogas.

– With this plant, it is possible for companies to have their equipment tested on the basis of genuine research workmanship, stresses Gunnar Hald Mikkelsen.

One of the advantages obtained by having the equipment tested at Foulum in the future, is that they are able to offer statistical scientific evidence that the equipment functions.

– Our own research projects, students and training will be attached to the plant and this promises to give a Danish bioenergy adventure a head start, predicts Gunnar Hald Mikkelsen.

photo: torben skøtt/biopress

Today, the farmer ensiles with cutting and plastic covering, but this is probably not how we will do it in the future.

The multi-purpose plant

The biogas plant at the Danish Institute of Agricultural Sciences is a multi-purpose plant with four test reactors and a test hall.

By Flemming Nielsen

photo: flemming nielsen/cbmi

– With the biogas test plant, is it now possible to explore many process optimisations and hardware, estimates Anders Peter Jensen, Process Developer in Xergi.

It is a versatile package which the Danish Institute of Agricultural Sciences has ordered from Xergi. It hides nothing less than a fully operational production plant and four test plants with numerous adjustment possibilities.

The creativity and the opportunities hide in the test plants.

– The test plant consists of four reactors two of which measure 30 cubic metres and two measure 10 cubic metres. All of them are able to run thermophilic and mesophilic processes and processes in between, tells Anders Peter Jensen from Xergi's development department. With four pretanks each containing 30 cubic metres, it is possible to control precisely what is added to the plant. In addition, there is also input from nutrient medium tanks containing, for example, vegetable or animal fat products.

Matrix structure

From the pretanks, the mixture is led into two heating and dosage plants each with a capacity to cover the need in all four test reactors.

– The dosage plant has been designed to allow the feeding of solid products with, for example, a front-end loader. The material is of course weighed in accordance with the mixture, says Anders Peter Jensen.

In the heating tank, the heating time and temperature is optional. There is a permanent connection to each of the four reactors with feeding at three levels in the reactor. This means that both heating and dosage plants are capable of feeding at three levels in each of the four reactors.

The reactors may be connected in series or in parallel, it is possible to remove biomass from five levels and hygienisation is possible.

– All possible options are available. Of course with a state-of-the-art control and documentation, says Anders Peter Jensen.

Test hall becomes test station

The test hall which is part of the plant will be divided into six areas where it will be possible to carry out independent activities. The test hall will be so large that a lorry can enter it.

The companies will have their products evaluated in the test hall. We also have a showroom with room for 30 persons and a landscape window which gives a good overview of the hall.

– If we look a little further into the future, it may be possible for the companies to obtain a kind of type approval through testing at the test plant. As to Xergi, we will be able to optimise our own products, estimates Anders Peter Jensen.

Production plant with potential

In connection with the test plant, a full-scale production plant will be built.

– The plant will be constructed as other plants we produce, but here it is possible to implement the technologies from the test plant in the production plant, Anders Peter Jensen informs us.

The production plant will include a primary reactor of 1,200 cubic metres which is able to work within the thermophilous and mesophilous temperature area and the area in between. It is possible to add another reactor if required at a later time. The gas from the production is used in a biogas engine in connection with the power plant at the Danish Institute of Agricultural Sciences as well as in a biogas boiler in connection with the biogas plant. In addition, a torch may be used in emergency situations for the burning of excess gas.

Furthermore, a separation plant based on a decanter centrifuge is mounted as part of the plant.

In total, the demonstration plant will process approx. 29,000 tonnes of livestock manure and approx. 2,000 tonnes of other biomass a year. With the added biomass, the plant has a capacity to produce 850,000 m^3 methane gas a year.

Energy output from biomass may be doubled

Until year 2020, we may double the energy output from biomass and at the same time maintain our present agricultural production. This is the conclusion of a group of researchers in a new report that compares different technologies for the exploita-

By Flemming Nielsen

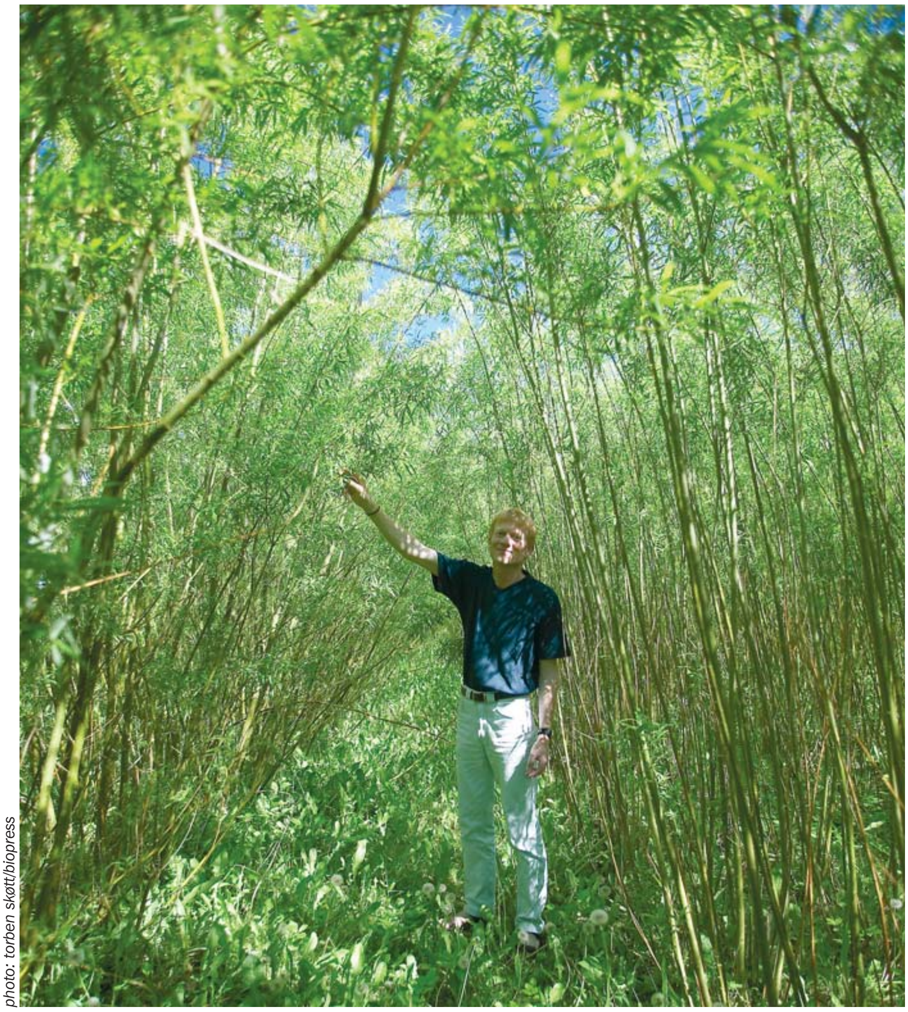
photo: torben skøtt/biopress

Uffe Jørgensen in one of Foulum's willow plantations. Willow is one of the most efficient crops when it comes to getting as much energy as possible out of the farm land. A hectare of willow gives an energy output of 150 GJ or fifteen times more than if rape was cultivated for the production of biodiesel.

Bioenergy research has been allowed to see the working paper for a new report on biomass for energy. The persons responsible for the report, which is expected to be completed during the summer of 2006, are Uffe Jørgensen, senior research associate and Peter Sørensen both from the Danish Institute of Agricultural Sciences as well as Anders Peter Adamsen, APSA Environment.

- At the present moment, it is not possible to conclude that one technology is superior to the other. It depends on which parameters you consider to be the most significant, says Uffe Jørgensen who is the key author of the report.

He points out that three different standards exist by which to assess the various technologies.

– The political standard is especially focused on security of supplies and the energy-economic standard focuses on the energy output. Finally, there is the question which technology has the best profile from an environmental point of view, e.g. in terms of emission of greenhouse gases or loss of nutrients, explains Uffe Jørgensen, and elaborates:

– The large distinction is between biomass for power plants or biofuels which are both winners in each their area. On the basis of the above-mentioned, it is not possible to point out a clear winner, he assesses.

Various developmental phases

To obtain an overview of the area, it is, according to Uffe Jørgensen, important to examine the various technologies which have reached very different developmental phases.

- Raw plant oil and biodiesel are technologies which are easy to handle but the resources are limited.
- The outlook for ethanol may be better as a larger energy efficiency is expected in the future.
- New types of fuel such as DME and methanol offer more advantages but the technology is not yet fully developed and there will be a requirement for adjustment of the engines.
- So far, biogas is too expensive for the transport sector, but it is too early to reject the technology. For example, in Sweden they are dedicated to making biogas profitable through large-scale production advantages.

From a regional and local perspective, biogas, rapeseed oil and Stirling engines are concrete technologies with a special potential.

Be careful with winners

With the above review, the authors of the report have made an overview which assesses developmental phases and potentials for the individual technologies.

– At the moment, the societal debate is focused on ethanol compared to other

	Product: Biofuel (B) Electricity (E) Heating (H)	Technological phase	Basis of raw materials	Derived environmental gains	Energy output	Plant: Centralised (C) Decentralised (D)
Direct incineration	E – H	***	***	*	***	C – D
Thermal gasification	E – H	**	***	**	***	C
Conversion into hydrogen	B – E – H	*	***	**	?	C – D
Biogas	B – E – H	***	***	***	**	C – D
Methanol and MDE	B	*	***	**	**	C
Raw plant oil	B – E – H	***	*	**	*	C – D
Biodiesel	B – E – H	***	*	*	*	C
Ethanol from starch	B	***	**	**	*	C
Ethanol from lignocellulose	B – E – H	*	***	**	**	C

In the table, differences in developmental phases are summarised together with the basis of raw materials, environmental gains, energy output and centralised and decentralised use of a number of technologies. The marks (one to three stars) should not be understood as absolute as the technological development is an ongoing process. Source: Uffe Jørgensen.

technologies, but it is dangerous to only focus on one technology. In particular, it is important to advice the politicians who are decision makers and who do not have the insight and knowledge of what to pay special attention to.

– There are several technologies which need attention, stresses Uffe Jørgensen.

Among other things, he misses life cycle analyses which describe how the individual technology is performing in environmental and social calculations.

100% more bioenergy

In the report, the authors point out that until 2020 there is room for approx. 100% more bioenergy from the agricultural industry.

– We see a considerable potential in increasing the yield from primarily straw, livestock manure, meadow grass and energy crops.

– We expect to be able to increase the total energy output from biomass from 90 PJ in 2004 to 169 PJ in 2020. At the same time, we must maintain today's agricultural production, include new areas for infrastructure and protection of nature and take an increased population growth into consideration, says Uffe Jørgensen.

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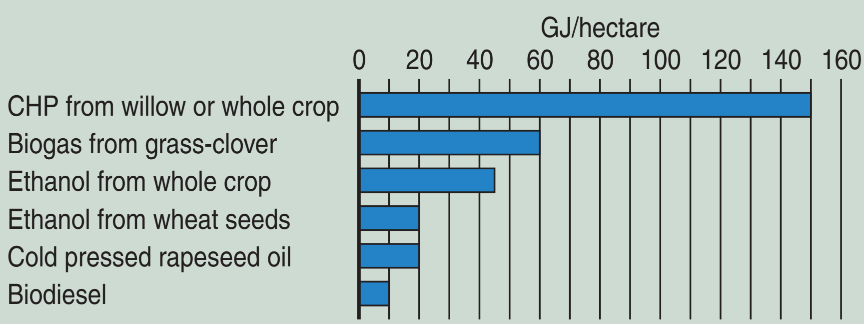
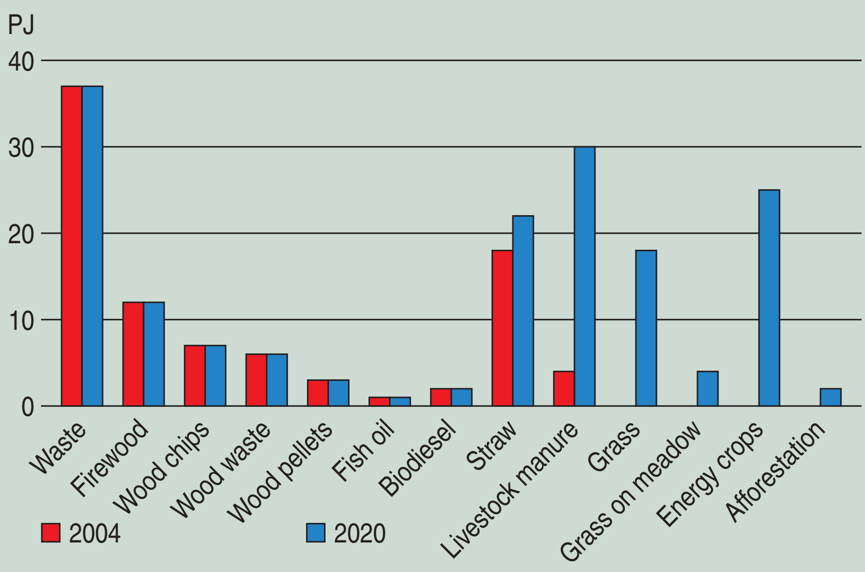


Energy output/hectare from various forms of bioenergy. The figure shows that there are obviously very large differences in the various forms of bioenergy even though the products are different and various by-products exist which are not included.



Energy output from biomass in 2004 and a scenario for the production in 2020. During a period of 16 years, it will be possible to double the production of biomass for energy purposes without affecting today's agricultural production.

Does your neighbour raise dust?

It is a well-known fact that microorganisms from straw and wood chips may cause bronchial problems, but neighbours of biofuel plants do not have to fear for their health. A new study from the Danish Institute of Occupational Health concludes that generally the concentrations are too small to cause health problems, unless you are close to a storage room of straw or a pile of wood chips.

photo: simon skov, skov & sandskab, kvl

It is not always healthy to be close to a plant where straw and wood chips are handled.

By A. M. Madsen, M. Z. Nørgaard and K.G. Jensen

Supported by the PSO funds which today are administered by Energinet.dk, the Danish Institute of Occupational Health has carried out a study of the air quality close to biomass-fired plants. No less than 20 plants have participated in the study and the results have been compared to the air quality in, for example, an urban environment.

It is a well-know fact that everywhere where there are biofuels, microorganisms exist in the form of mould fungi and bacteria. The fungi produce spores which may cause health problems and some bacteria produce endotoxin which is toxic. Bacteria, fungus spores and endotoxin are easily spread by the air as dust and water fog - the so-called bioaerosols. Due to the inferior size of the microorganisms, they are able to penetrate the lungs and thus be a health risk.

The study of the Danish Institute of Occupational Health includes air quality at neighbours who live approx. 250 metres from the plant as well as persons who live close to a storage room of straw or wood chips.

The results show that neighbours to biofuel plants are exposed to slightly increased concentrations of bioaerosols which contain mould fungi and endotoxin. However, considerable variations exist and generally the level is far below the limit values which are expected to cause health problems.

The situation is somewhat different for people who stand outside an open gate to a storage room of straw or close to a pile of wood chips. Concentrations of endotoxin and mould fungi have been found here which may cause problems - especially if the persons in question have a weakened immune response.

250 metres from the plant

The study conducted by the Danish Institute of Occupational Health shows, among other things, that the air 250 metres from a straw-fired plant contains increased concentrations of endotoxin (see figure 1). If a person stands in the wind from a straw-fired plant, he/she will, on average, be exposed to 5.3 EU/m^3 air (EU = Endotoxin Unit). This is more than in an urban environment but far below the level allowed in a working environment where limit values of between 50 and 200 EU/m^3 air are permitted.

As figure 1 illustrates, the measurements carried out by the Danish Institute of Occupational Health vary considerably. One measurement is below the average level of an urban environment while another measurement is as high as 37 EU/m^3 air - which is close to the lowest proposed limit values for a working environment.

In the wind from woodchip-fired plants, no increased concentrations of endotoxin have been found but instead the mould fungus Aspergillus fumigatus resistance is high (see figure 2). It is a fungus which causes bronchial problems and allergy - especially if the persons in questions have a weakened immune response. The mould fungus concentration is probably related to the woodchip-fired plants having outdoor piles of wood chips. The concentration of dust in the wind from woodchip-fired plants has proved to be slightly increased, however, it is far below the limit value for dust in the working environment.

In the air from straw and woodchip-fired plants, mould fungi and

Fact

Endotoxin – comes from bacteria and high concentrations may cause bronchial problems.

Aspergillus fumigatus – is a mould fungus which may cause bronchial problems and allergy.

Mould fungi - contain allergy causing substances and may for example cause hay fever.

Actinomycetes – is a group of bacteria which contain allergy causing substances.

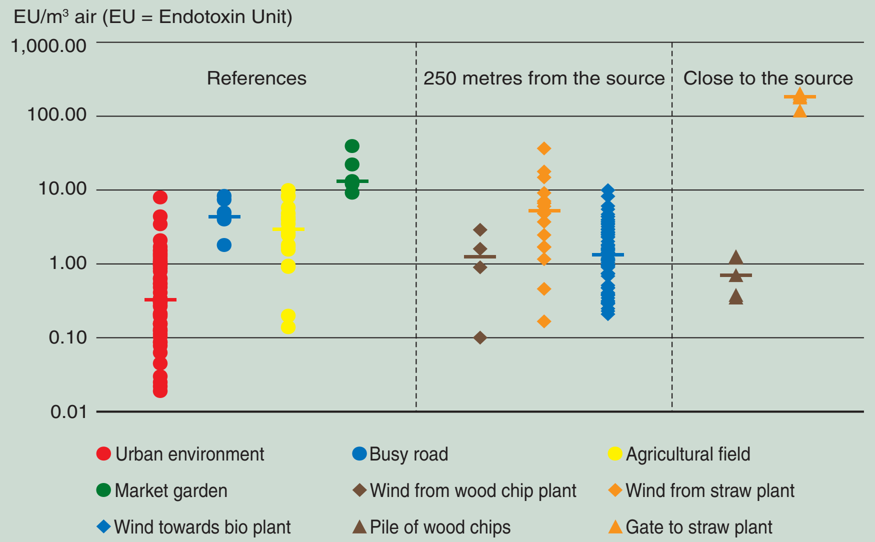


Figure 1. Concentrations of endotoxin in the air in various environments measured during the winter. Each symbol illustrates a measurement, while the horizontal lines indicate the average value. Note that the scale is logarithmic.

actinomycetes have been found (see figure 2). The latter is a group of bacteria which contain allergy causing substances. However, the concentrations are lower than the levels where people normally experience inconveniences and they are lower than the concentrations in a recent German study. The German study shows that neighbours who live 50-500 metres from a compost plant are exposed to increased concentrations of bioaerosols in their home and that several neighbours have complained about bronchial problems.

Storage room and piles

Outside an open gate to a storage room where straw is transported, an increased concentration of endotoxin and mould fungi has been found (figures 1 and 2). The concentrations are so high that they are at the same level as the limit values which are proposed in other studies or at a level where it may cause health problems.

In addition, relative high concentrations of the fungus Aspergillus fumigatus and actinomycetes have been found in all air samples around piles of wood chips and storage rooms of straw. The average concentration of mould fungi and actinomycetes outside a storage room of straw is at the same level as what has been found in the mentioned German study approx. 200 metres from a composting plant.

Further information

If you want to know more about exposure of bioaerosols in connection with biofuel, you will find further information in: Madsen AM, Eduard W, Blomquist G, Midtgaard U. Biofuels and Occupational Health - with special focus on microbial factors. NMR publication 2003 (74 pp.).

If you want to know more about the German study on the neighbours of compost plants, you will find further information in: Herr CE, Zur NA, Jankofsky M, Stilianakis NI, Boedeker RH, Eikmann TF: Effects of bioaerosol polluted outdoor air on airways of residents: a cross sectional study. Occup Environ Med 2003, 60:336-342.

Results concerning concentrations of endotoxin in various environments, including close to biofuel plants will be published in June in: Annals of Agricultural and Environmental Medicine, website http://www.aaem.pl/. The article is called: Airborne endotoxin in different background environments and seasons, by A.M. Madsen.

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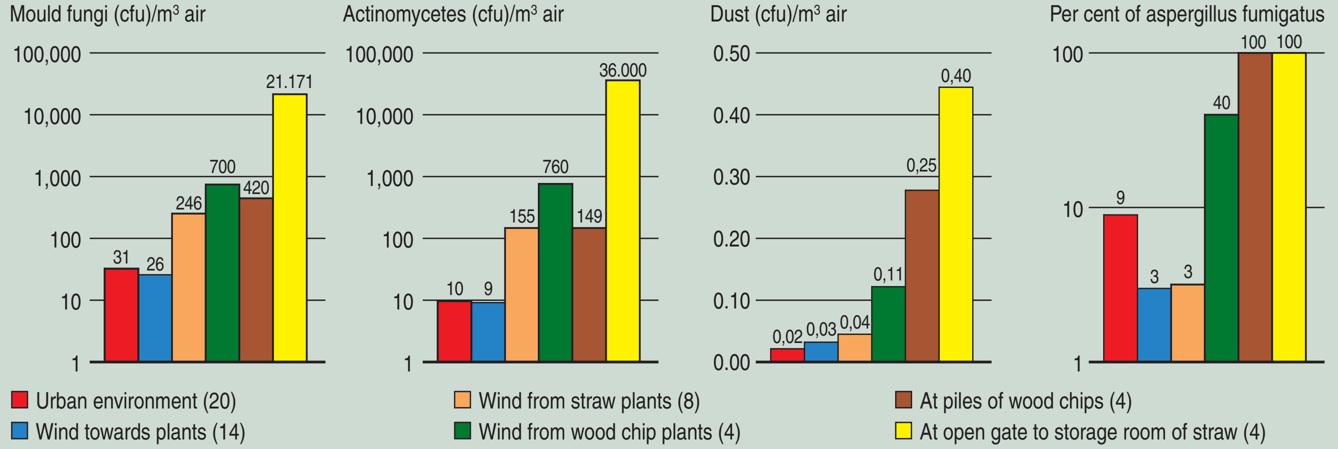

Figure 2. Concentrations of mould fungi, bacteria (actinomycetes), dust and the mould fungus Aspergillus fumigatus. The figures in parenthesis indicate the number of areas or plants where air samples have been taken.

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New record for fuel cells

photo: dtu – institut for mekanik, energi og konstruktion

The Viking gasifier at the Technical University of Denmark.

Jesper Ahrenfeldt, doctoral research student and Ulrik Henriksen, senior lecturer from the Institute for Mechanics, Energy and Construction at The Technical University of Denmark have beaten the record for the operation of fuel cells on gas.

The fuel cells were powered by gas which is produced by gasification of wood chips at the institute's so-called Viking gasifier which has been mentioned previously in this magazine.

According to the available literature, the previous record is 48 hours whereupon the yield of the fuel cell decreased drastically. The new record is 150 hours for one of the cells and 168 hours for the other.

Both cells were put out with no loss of yield but due to lack of time as the researchers from Munich and Athens, who work with these cells, had to go home. Jesper Ahrenfeldt and Ulrik Henriksen are now considering carrying out a 1,000-hour test with the fuel cells.

The success is mainly obtained due to the very clean wood gas which the Viking gasifier is able to produce. The gas is normally used in a small power plant with an electricity effect of 25 kW, but in addition a number of tests have been carried out to use the gas for the production of methanol and now also for the operation of fuel cells.

Besides, the Viking gasifier has its own world record with an electricity efficiency of 25 per cent when the gas is used for power plants - no other plants that size have been able to match this. In cooperation with the Weiss manufacturer, researchers have now started to upgrade the technology, so that it will be possible to build plants with an electric power of 250 kW.

On 16 June, another Danish research project within gasification technology reached a new record. At one o'clock in the morning, Henrik Houmann Jakobsen from BioSynergi Proces reported that his "open-core" gasifier had reached 1,000 operating hours, of which 480 hours were reached by means of electricity production. And as he writes in an e-mail for the editors: As regards optimism – it is really really high! *TS*