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FiB
Bioenergy research

Biofuel research speeds up

Financial support of research into liquid biofuels is now on the rise. The Danish Globalisation Foundation will be spending DKK 200 million within the next four years for this purpose, and recently the Danish National Advanced Technology Foundation, the Strategic Research Council and Energinet.dk decided to grant close to DKK 90 million to this area.

By Torben Skøtt

In an attempt to deal with recent critics claiming that Denmark does not want to meet the EU biofuels directive, the government is now notably increasing the support of research into and development of environmentally friendly biofuels. At the same time, however, the government points out that tax reductions, strongly campaigned for by various players in the market, including the agricultural industry, are not the way forward.

The government is primarily going to focus on developing the so-called second-generation bioethanol production. Denmark is one of the leading players in this area, which is becoming very important worldwide and particularly in Europe, USA and China.

If everything works out well, this could become quite a prosperous business. The International Energy Agency expects to invest 17,000 billion US$ in the energy sector on a global basis until 2030, and we have already proven that we are able to boost the export of our energy technology immensely. This year, we are expecting the export of energy and environmental technology to reach a level of around DKK 50 billion and we have even higher expectations of the years to come.

The Globalisation Foundation

Most of the finances used to strengthen this type of research will be sponsored by the Danish Globalisation Foundation. All in all, DKK 200 million will be earmarked for research into biofuels during the next four years, along with contributions from various other foun- ▶

The Maxifuel plant at the Danish University of Technology, which produces ethanol, hydrogen, biogas and fuel pellets. Straw and other agricultural by-products are used as raw material, and the process is expected to produce a large amount of ethanol from a relatively small amount of biomass. The photo shows one of the researchers pouring straw pellets into the machine.

photo: Iar bertelsen/ingeniøren

dations and systems of subsidiaries. In September 2006, the Danish National Advanced Technology Foundation granted DKK 10 million for research into biodiesel, and in November 2006, DKK 22 million were allocated to research into bioethanol. Furthermore, the Strategic Research Council has granted around DKK 27 million to projects on biofuels and Energinet.dk have provided DKK 30 million to a consortium that focuses on research into biomass gasification and conversion into synthetic petrol (see table 1).

Ethanol

Today, biofuels only make up a few percent of the world's total fuel consumption, however, the market expands 20-25 % per year, and the worldwide ethanol production is expected to reach a level of 40 billion litres in 2006. Compared to these numbers, the biodiesel market is extremely small, reporting a turnover of just 4 million tons in 2006.

For many years, Brazil was the biggest ethanol producer, however, this year USA has headed almost half of the production worldwide, thereby entering first place. The productions in Europe and China only make up a few percent of the world market but on both continents, these figures are expected to increase within the next couple of years.

Nowadays, ethanol production takes place in so-called first-generation plants, where starch and sugar products are converted into ethanol by use of yeast. Traditional agricultural produce such as sugar cane, maize and grain constitute the raw materials.

It is easy to imagine that a yearly growth of 20-25 % will lead to a shortage of these traditional agricultural crops within no time. Space requirements are extensive, particularly for maize and grain but less for sugar cane.

Therefore, it is of utmost importance to develop technologies that apply biomass types other than traditional agricultural crop. In Denmark, we mainly use straw as raw material but in principle, almost any type of biomass could be used for ethanol production, including organic household waste.

We have previously published information on various techniques that carry

Subsidiaries from	Project participants	Amount	Project
Danish National Advanced Technology Foundation	SCF Technologies A/S, Universities of Århus and Aalborg	DKK 10 million	2nd generation biodiesel
Danish National Advanced Technology Foundation	DONG Energy, Danish University of Technology, Statoil, Topsøe Fuel Cell, Novozymes, Danish Veterinary and Agricultural College and RISØ.	DKK 22 million	2nd generation ethanol
Strategic Research Council	Danish University of Technology, RISØ, Danish Veterinary and Agricultural College, DIAS-Bygholm, Syddansk University, Novozymes and Emmelev Mølle	DKK 12 million	New methods for 2nd generation biofuels
Strategic Research Council	National Environmental Research Institute of Denmark, RISØ, Danish University of Technology, Transport Research Institute of Denmark and Danish Technological Institute	DKK 15 million	Effects of biofuels on environment and heath
Energinet.dk (PSO-funds)	Dong Energy, Novozymes, Amagerforbrænding, Haldor Topsøe, Danish Veterinary and Agricultural College and Danish University of Technology	DKK 30 million	Biogasification, CHP and synthetic petrol
Globalisation Fond	Not yet decided	DKK 200 million	Not yet decided

Table 1. List of funding allocations for biofuels, autumn 2006.

the generic term second-generation plants. The underlying principle of such plants is to pre-treat the biomass to be able to firstly break down cellulose to glucose by means of enzymes and secondly ferment it to ethanol. Turning theory into practice can be done in several ways, and discussions on whether the by-products are to be used as fuel, feed or biogas production are still going on.

Well-known players

A major part of the new financial allocations have been given to well-known industry players such as the IBUS project, headed by DONG Energy, and the Maxifuel concept, developed at the Danish University of Technology.

Both players are part of a consortium that has been given DKK 22 million by the Danish National Advanced Technology Foundation. The projects share certain characteristics; however, they do have differing ways of handling several issues as well. This will be a cooperation, allowing each project to gain from the experiences of the other, as well as a competition on developing the best solutions.

The IBUS project focuses on developing a process, whereby waste heat from a power plant is being put to use and the by-products are used as fuel within the plant. For the beginning, total crop, worked up to ethanol and feed, will be used as raw material.

The Maxifuel plant produces ethanol but also hydrogen, biogas and fuel pellets. Straw and other agricultural by-products are used as raw material, and the process is expected to produce a large amount of ethanol from a relatively small amount of biomass.

Apart from DONG Energy and the Danish University of Technology, the companies Statoil, already now using ethanol in one of their products, and Topsøe Fuel Cell, a producer of fuel cells running on ethanol, are also involved. Novozymes, a company producing enzymes used within the process, is also taking part in the project, as well as the Danish Veterinary and Agricultural College and the research centre RISØ.

Biofuels, environment and health

photo: torben skøtt/biopress

Having been given almost DKK 15 million by the Strategic Research Council, the National Environmental Research Institute of Denmark is now going to investigate the effect of biofuels on health, environment and landscape.

– This is a cross-disciplinary project that involves research into everything but biofuel production, says project manager Jytte Boel Illerup from the National Environmental Research Institute of Denmark.

– We want to identify the consequences of an extended use of biofuels on our environment and on public health. Furthermore, we are going to investigate landscape impacts, the influence on security of supply as well as the economic impacts of replacing a large amount of fossil fuels with biofuels, says the project manager.

Apart from the National Environmental Research Institute of Denmark, the project also involves RISØ, the Danish University of Technology, the Transport Research Institute of Denmark and the Danish Technological Institute. Amongst other tasks, the latter will be charged with carrying out a number of measurements on vehicles running on biofuels.

The project will last for four years and ends in 2011. *TS*

DKK 30 million for consortium

In the beginning of December, the board of directors of Energinet.dk granted DKK 30 million to a consortium dedicated to biofuel research.

In 2007, Energinet.dk will be providing financial support to a large consortium for the first time. The funds, to be drawn from the so-called PSO-scheme, will support a project called REnescience.

The consortium consists of DONG Energy, Novozymes, Amagerforbrænding (incineration plant), Haldor Topsøe, Danish Veterinary and Agricultural College and Danish University of Technology, and the goal is to establish a pilot plant for the gasification of waste and biomasses. The gas will then be used for CHP or made into synthetic petrol.

Synthetic fuels can be produced by means of native gas or gas made by means of biomass. By using high temperatures, pressure and various catalytic agents, the gas is converted into petrol or diesel for use within the transport sector.

Using biomass in the production of synthetic biofuels is still at a developmental stage, whereby several of the processes applied must be further optimised - particularly the biomass gasification process - in order to make it financially feasible to produce synthetic petrol and diesel. *TS*

DKK 12 million for a new bio-refinery

Backed by DKK 12 million from the Strategic Research Council, a group of researchers and companies have been given the opportunity to set up a so-called bio-refinery.

As of 2007, the two large Danish projects on bioethanol, namely IBUS and Maxifuels, will be joined by yet another cross-disciplinary project when the Institute of Environment & Resources at the Danish University of Technology embarks on the investigation into new ways of converting biomass into other products. Apart from biofuels such as biodiesel, bioethanol, biohydrogen and biogas, the researchers are also going to look at the possibilities of producing various types of fertilisers and natural pesticides, which would cause less damage to the environment than the pesticides used throughout the agricultural industry today.

Professor Irini Angelidaki from the Institute of Environment & Resources is heading the project, which also involves researchers from RISØ, Danish Veterinary and Agricultural College, DIAS-Bygholm and Syddansk University. Participating companies include Novozymes, in charge of delivering the necessary enzymes, and Emmelev Mølle, a milling company producing around 80,000 tons of biodiesel per year.

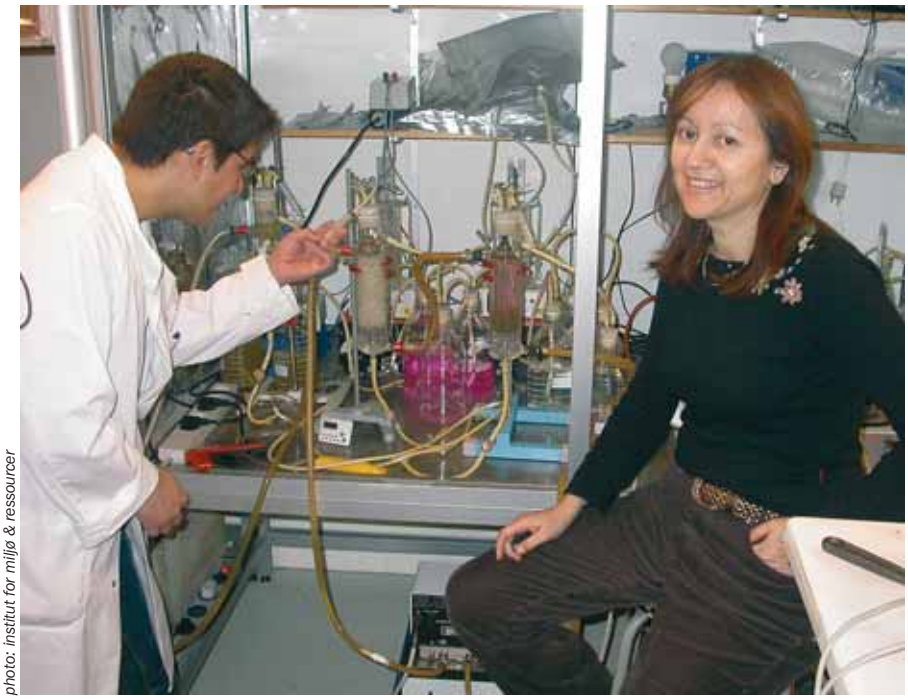


photo: institut for miljø & ressourcer

Researchers from the Danish University of Technology are going to investigate new methods of converting biomass. On the right professor Irini Angelidaki, who is in charge of the project.

According to Irini Angelidaki, the idea behind the bio-refinery is still so new that all options are to be kept open, and she considers this new project mainly a good supplement to the two existing projects, IBUS and Maxifuels.

– When you work with a concrete concept, you often get stuck in certain lines of thought that prevent you from seeing new possibilities. Therefore, we want to avoid getting associated with existing concepts and instead look at the challenge from a completely new angle, says Irini Angelidaki.

Biodiesel and ethanol

One of the tasks of this project is to find out how to make biodiesel production cheaper and more energy-economic, e.g. by using enzymes and by utilising by-products in the production of ethanol or natural pesticides. Whereas the latter will be investigated by the Danish Veterinary and Agricultural College, the Danish University of Technology and the research centre RISØ will be in charge of ethanol production.

Additionally, the researchers are going to focus on ways to efficiently handle those large amounts of biomasses that will be treated in a bio-refinery, both in terms of raw materials needed for the plant and in terms of products that are to be returned to the farmers.

The project will last for four years, starting in 2007. *TS*

Controversy about bio-oil patents

In the last issue of FIB - Bioenergy Research, we presented a new type of technology used for bio-oil production developed by SCF Technologies. In short, this process, called CatLiq, involves heating up organic material, pumping it into a container using high pressure and then treating it by means of a catalyst process similar to the one that once created the oil reserves of the Earth.

It may be, however, that SCF Technologies does not own the rights pertaining to this new technique. Following our publication about the CatLiq-process in the last issue of FIB, we were contacted by the chemist Kjeld Andersen, who claims to own both the European and Chinese patent for this technique.

This claim was immediately rejected by the general manager of SCF Technologies, Karsten Felsvang.

– That is not true. We have developed this technique ourselves, and furthermore, the patents of Kjeld Andersen are going to expire in March 2009. By that time, anyone is allowed to use the process that Kjeld Andersen claims to hold a patent for, says the general manager. *TS*

Bioenergy came in first place at Energinet.dk

Bioenergy was the true winner at the distribution of PSO-funds for research and development for 2007. Almost half of a total budget of DKK 130 million was given to projects on bioenergy and waste.

In the beginning of December, the board of directors at Energinet.dk distributed the 2007 budget of DKK 130 million for research and development within the so-called PSO-scheme.

Around half of the funds were allocated to projects on bioenergy and waste, whereby

27 % of the DKK130 million will be used for research into fuel cells and the rest for projects on sun, wind and energy systems as well as management and regulation.

By the closing date for applications for subsidiaries 2007, Energinet.dk had received applications amounting to a total of around DKK 600 million. Many projects had an extremely high professional level, and projects amounting to a total of DKK 265 million were awarded top marks, however, as the budget was limited to DKK 130 million, several good projects had to be turned down.

Within its 2007-programme, Energinet.dk has taken the opportunity to support a large consortium for the first time by granting DKK 30 million to REnescience, headed by DONG Energy. This project focuses on biomass gasification and ways of using it in CHP or converting it to synthetic petrol.

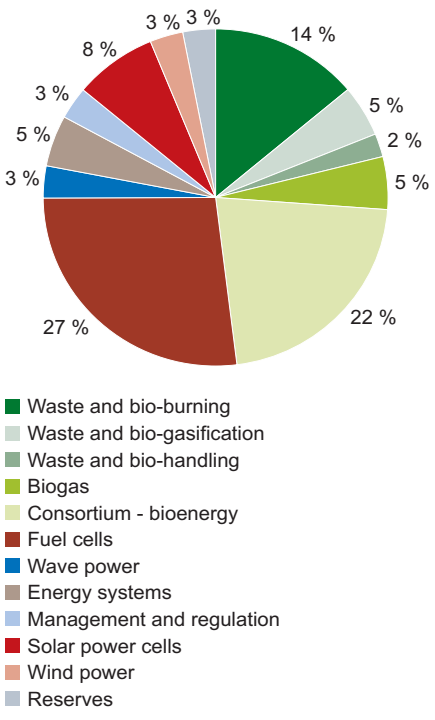
– Out of the total amount of DKK 130 million, 34 million will be spent on demonstration projects, says Niels Fog, chairman of the board at Energinet.dk.

– We have noticed a special need for demonstration project funding and are very pleased that the Globalisation Foundation has earmarked DKK 277 million during the next four years for the demonstration of environmentally friendly technologies within the area of electricity generation.

– We are actively going to make an attempt to ensure that these funds will result in a synergy process involving existing energy research programmes, says Niels Fog. *TS*

photo: jørgen schytte

Just over a quarter of the PSO-funds for 2007 were allocated to demonstration projects. The photo shows a demonstration plant for gasification of straw and waste, and the company Danish Fluid Bed Technology was given funding to develop this project further.



Distribution of PSO-funds for 2007. Almost half of the funds were allocated to projects on bioenergy and waste, including DKK 30 million for a consortium headed by DONG Energy.

Environmental award

The two researchers, professor Birgitte K. Ahring from the Danish University of Technology and development manager Charles Nielsen from DONG Energy, who spent several years developing a method of producing bioethanol by means of straw, won the Environmental Award 2006 of DKK 250,000 from the Aase and Ejnar Danielsen Foundation.

Birgitte Ahring is heading the Maxifuel project on converting straw to ethanol, biogas, hydrogen and fuel pellets, and Charles Nielsen has been heading the IBUS plant, today located by the Skærbæk plant, for many years. This plant produces ethanol, feed and fuel by means of total crop but in principle, any type of biomass could be used. ■

Bioenergiportalen.se

In Sweden, bioenergy now has its own internet site: www.bioenergiportalen.se. This initiative was implemented by Jordbruksverket, an organisation that advices the Swedish government on agricultural issues.

The site is mainly set up for producers and users of biomasses but also advisors, public authorities and others, who take an interest in bioenergy, will find this platform useful. Apart from various articles on how to utilise biomasses for energy purposes, the site also includes a news section, which is updated several times a day, a list of relevant meetings and conferences, a photo archive, a discussion forum and an extensive list of links to other relevant internet sites. ■

New research has shown that the Danes' consumption of firewood is about 60 % higher than presumed. This means that firewood meets 13 % of our yearly need for space heating.

photo: torben skøtt/biopress

Firewood is a neglected resource

– and a neglected area of research

Today, 13 % of the Danes' need for space heating is being met by firewood but from a technological point of view, our wood stoves are at a similar stage to an old-fashioned wooden mill. Nevertheless, it has proven almost impossible to obtain funding for research into wood firing, a well-known researcher from the department of Forestry & Landscape within the Danish Veterinary and Agricultural College claims.

By Torben Skøtt

photo: torben skøtt/biopress

Modern wood stoves are still using technologies from the 19th century. This photo shows stove builder Knud Schmidt from Christiansfeld next to an old cast iron stove.

– I know that I might sound like a constant complainer, however, it is about time that we focus on the possibilities we have of making wood firing more efficient. Such developments would benefit our environment, security of supply and export status.

This statement was made by Niels Heding, a respected researcher from the department of Forestry & Landscape, currently belonging to the Danish Veterinary and Agricultural College but as of January 2007 to be known as "The Life Science Faculty of Food Items, Veterinary Medicine and Natural Resources", in short "Faculty of Life Science".

Niels Heding has a PhD in agronomy and he has been doing research into the use of wood for energy purposes for decades. During a recently held symposium on bioenergy, hosted by the Danish Veterinary and Agricultural College, he spoke about the immense potential that lies within a more efficient utilisation of wood in the production of energy.

60 percent more firewood

Recently, the Danish Energy Agency published findings indicating that our consumption of firewood is about 60 % higher than previously assumed. This means that firewood meets 13 % of our yearly need for space heating, substituting a yearly consumption of 480,000 tons of oil equivalent to 1.5 million tons of carbon dioxide emission.

– That is a lot. In order to meet the goals entailed in the Kyoto protocol, we need to reduce our carbon dioxide emission levels with 12 million tons per year. Wood firing actually accounts

for more than 10 % of those reduction goals already, explains Niels Heding and continues,

– We would be able to utilise our resources much better if we managed to develop a new generation of wood stoves with a high degree of efficiency. The stoves we use today are based on a technology that was developed during the 19th century. If we run a comparison with the wind mil industry, we are looking at old-fashioned wooden mills or Dutch wind mills. In reality, they are only able to utilise around half of the energy content contained in wood because it is almost impossible to reach the temperature level needed for the gasses to burn, and they contain 50 % of the energy content.

photo: torben skøtt/biopress

The last half of the 18th century saw a lot of research on efficient wood firing, especially in Sweden as a reaction to wood shortages. The result was this heating stove, named "Cronspisen", which still counts as one of the most efficient stoves on the market. A well-isolated fire chamber ensures that the temperature reaches the level needed to burn the gasses, and an ingenious system of long flue ducts transfers the heat to the heavy stones. This is why starting a new fire is only required twice a day in a heating stove.

No subsidiaries

According to Niels Heding, it is nevertheless very difficult, not to mention impossible, to obtain funding for research into efficient wood firing.

– Research funds tend to be exclusively allocated to more advanced types of bioenergy. Amongst other things, this used to be gasification plants but nowadays the so-called 2nd generation plant for bioethanol win the large funding sums. Simpler solutions that really have an impact on environmental issues and supply security are not the focus of attention at the moment, says Niels Heding.

He does not understand this kind of prioritising because in reality, research into efficient wood firing meets all the requirements listed by the Danish Council of Energy Research in their latest strategy from April 2006:

- security of supply
- goals entailed in the Kyoto protocol
- growth and business development

– Research into efficient wood firing meets all three criteria, says Niels Heding and continues,

– I am old enough to remember World War II, during which time most living quarters were heated with wood. If a similar crisis would arise now, wood firing would once again be able to contribute to the security of supplies. The Swedes, amongst others, are very aware of this fact and they have introduced a new rule requiring chimney access in all new residential buildings.

– Wood stoves produce CO_2-neutral energy, and increasing the average degree of efficiency from 50 to 80 would have a notable impact on the problem of CO_2-emission.

– Finally, efficient wood firing would also support growth and business developments. Already at this stage, Denmark exports wood stoves at a value of around

DKK 500 million to a very large market. Do not forget that in many countries, district heating is still unknown, and space heating involves individual oil burners and electric heating.

Niels Heding on the idea of putting the producers in charge of the necessary research and development processes:

– I do not agree with that idea. The industry is made up of a lot of small and medium-sized companies that would not be capable of handling such a task. The public needs to take on that responsibility. Saying that, the producers do back attempts to extend research into wood firing and they are ready to convert the results of such research into practice. ■

Danish Energy Agency: Wood firing is not a top priority

The Danish Energy Agency would be able to allocate funds to wood firing research but this is not a top priority.

– The energy research programme is fully capable of giving funds to research on efficient wood firing. In principle, nothing impedes such support, says civil engineer Jan Bünger from the Danish Energy Agency, who has been involved in the administration of funding within the energy research programme for several years and is fully aware that wood firing is not a winner when it comes to obtaining financial backing for research. He claims that this situation is second nature:

– We have limited resources and need to set priorities. We have chosen to focus on more advanced ways of exploiting biomasses that result in a high degree of efficiency in terms of electricity, heating and transport. Amongst other things, we support the development of the so-called 2nd generation technology for the use in production of liquid biofuels along with the production of CHP, says Jan Bünger.

He believes that the reason for ethanol receiving so much support at the moment is that Denmark is at the forefront in that area and needs to remain involved now, as a range of countries are developing plants running on waste and various agricultural by-products. *TS*

Consumption of firewood much higher than presumed

photo: torben skøtt/biopress

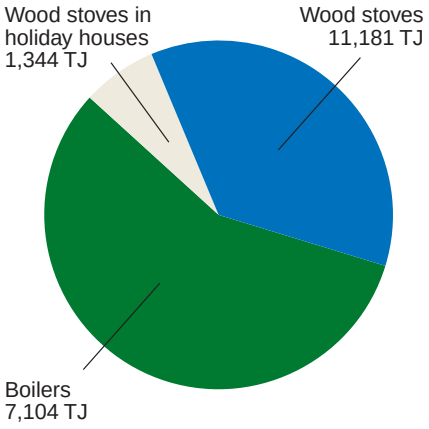
Recent research has shown that the Danes' consumption of firewood has been extremely underestimated and might in fact be around 60 % higher than presumed.

For many years, firewood consumption levels were calculated based on the assumption that a third of it would stem from forestry cutting and the rest from other sources such as import, private land and gardens as well as industrial residues.

In 2005, new research indicated that the total firewood consumption level could be significantly higher than previously assumed, and based on that investigation, Force Technology and the Danish Technological Institute were asked by the Danish Energy Agency to draw up a more in-depth account with regards to this topic.

The latest account is based on an extensive interview study carried out during the summer of 2006. 1,000 consumers were questioned about their actual consumption of firewood, and the researchers found out that the Danes used 19,630 terajoule last year. This amounts to some 60 % more than what previous studies have concluded, indicating that 13 % of the Danish energy consumption for space heating purposes is covered by wood firing.

On the other hand, it seems that the number of wood stoves in use has been overestimated for years. Whereas the Danish Guild of Chimney Sweeps expected some 600,000 to be in use throughout the country, other organisations spoke of numbers as high as 800,000. According to the study performed by Force Technology and the Danish Technological Institute, the correct number, including fireplaces and masonry stoves is 525,000. Around 90,000 wood stoves serve as the main heat source in Danish holiday houses.



Wood consumption of stoves and boilers.

Boilers

The above mentioned wood stoves, fireplaces and masonry stoves are joined by around 48,000 boilers. Whereas the average wood stove uses 4 stacked cubic metres of wood per year, a typical boiler consumes 25, making boilers account for around one third of the total yearly wood consumption.

According to Lars Nikolaisen from the Danish Technological Institute, the boilers pollute the most. In many places, old cast iron boilers, designed for use with carbonised coal, are used for wood firing, causing nuisance to the neighbours. Thus, the new scrap scheme, which the Danish Environmental Protection Agency wants to introduce in 2007, will probably only involve boilers. *TS*

Shortage of engineers

The Danish Academy of Technical Sciences has mapped out the current challenges within the energy sector and concludes that a shortage of highly educated staff members is the main problem. The entire energy sector is beset with a lack of engineers and should this situation persist, an increasing number of research and development tasks will be given to countries that have better access to the human resources needed, claim Peter Assam and Claus Thomsen from the Danish Academy of Technical Sciences.

Source: www.atv.dk

Ethanol production record

In September, the American ethanol production hit another record by reaching a daily production of 53,000 cubic metres. This achievement was, however, not sufficient to meet current demands of an estimated 60,400 cubic meters a day. Today, some 109 ethanol factories exist in the USA and another 53 are under construction.

Source: Lantbrukets Affärstidning

RISØ plays for high stakes

RISØ is on the lookout for people with PhD degrees and postdocs specialising in wind power, biofuels and energy systems. Currently, 26 positions are available within the areas of environment and energy, the news magazine "Ingeniøren" writes.

– The truth is that our energy consumption is going to increase around 50 % during the next 25 years so we really need to get going. We cannot just sit back and relax because changing the energy system takes a long time, says Hans Larsen, manager of the department for system analysis at RISØ.

RISØ is looking for a total of 33 new researchers, of which 26 will be working in the area of energy and the rest in the area of health research.

According to general manager Jørgen Kjems, RISØ has been able to free up the necessary financial means to hire more new researchers by saving DKK 10 million on what he calls the technical-administrative area. ■

How far can we drive on a hectare?

This question related to energy crop does not have just one single answer. Crop rich in lignocelluloses, such as willow, which is converted into methanol or synthetic diesel, take us the furthest.

photo: torben skott/biopress

Willow is one of the most environmentally friendly crops and at the same time, it contains one of the highest levels of excess energy. Yet, Denmark only has around 1,000 hectares of energy willow at the moment.

– If Denmark is to grow crop for energy production on a larger scale, it is important that we identify what type of crop and technology convert into the best yield per hectare, says senior researcher Uffe Jørgensen from the Danish Institute of Agricultural Sciences. He is going to speak about this topic at "Plantekongres 2007", a congress held on January 9th and 10th in Herning, Denmark.

– We are unable to replace the entire current oil consumption with self-produced biomasses, however, we need to exploit the possibilities provided as effectively as possible, says Uffe Jørgensen.

No comprehensive Danish analyses of the entire chain from biomass production to vehicle use exist, however, the level of excess energy in certain plants and technologies can be estimated based on available research. The excess energy level equals the relation between the amount of energy used in growing and converting crop for energy purposes and the end product value.

Danish analyses have shown large differences in excess energy levels depending on the type of plant and treatment method used, and studies performed in the transport industry have come to the same conclusion - how far we can "drive on the hectare" really depends. Crop rich in lignocelluloses, such as willow, which is converted into methanol or synthetic diesel, take us the furthest.

Six times the production

In Denmark, biomasses are almost exclusively used for heating and CHP, primarily utilising by-products such as wood chips, straw and liquid manure. Danish farmers use a significant size of farming land to grow rape for biodiesel but this is all exported. Additionally, around 1,000 hectares are used for growing perennial energy crop, mainly willow.

Last year, biomasses accounted for 11 % of the total energy supply in Denmark. Currently, waste makes up around half of those biomasses but using it more extensively is definitely possible. An analysis carried out by the Danish Institute of Agricultural Sciences shows that agriculturally based biomass production could be six times the current size without compromising the primary role of the farming industry as food manufacturer. *TS*

Researcher: Ethanol might turn into an economic catastrophe

Danish bioethanol production is going to become an economic catastrophe.

Short and sweet - this is how Alex Dubgaard, research manager at the Institute of Food and Resource Economics, expressed himself at a conference held on December 11th by the Royal Danish Agricultural Society, the Innovation Centre for Bioenergy and Environmental Technology as well as the Danish Agricultural Advisory Service.

– In Brazil, bioethanol is produced by means of sugar cane at a lower price than that of oil pumped up in the Middle East, and the only thing preventing this ethanol from entering the EU are the customs barriers, Alex Dubgaard concluded.

This conclusion provoked the other participants at the conference "Bioenergy in farming".

– Bioenergy in the form of ethanol results in bad operating economics in the short term, however, in the long term, it is bound to be a good investment, said Uffe Jørgensen, senior researcher at the Danish Institute of Agricultural Sciences.

He pointed out that Denmark is going to play an important role and thus gain from bioenergy by becoming the producer of technologies needed in biomass handling plants, and continued,

– But we need to compare the different types of bioenergy; not only in terms of economical issues but also with respect to related topics such as environmental gains, lower greenhouse gas emission levels and job creation.

Source: www.cbmi.dk

photo: torben skøtt/biopress

Nitrogen conversion in biogas plants

When organic industrial waste turns out to be in short supply, more and more biogas plants will start adding energy crop, separated liquid manure etc. In this way, the manurial value of the degasified biomasses is increased but at the same time, the risk of inhibiting or even completely destroying the biological process rises as well.

By Henrik B. Møller

The nitrogen contained in animal manure consists of inorganic nitrogen, primarily in the form of ammonium, and organic nitrogen in the form of proteins, amongst other things.

The amounts of inorganic and organic nitrogen contained depend on the type of animal and manure system used and on whether or not the manure is treated in a biogas plant or not. When animal manure is degasified, a mineralisation process, which converts organic nitrogen to inorganic nitrogen, takes place.

In many instances, it is important to know how much organic nitrogen is converted into ammonium in a biogas plant.

Firstly, an increased amount of ammonium mirrors the extent to which the manurial value rises by degasifying the animal manure in a biogas plant.

Secondly, ammonium is one of the most important parameters when it comes to inhibition of biological processes. If the ammonium level increase can be identified, the effect of adding protein-rich biomasses to the process can be evaluated much better. In turn, this could be of great assistance to plant managers, who are considering adding protein-rich biomasses such as energy crop and separated liquid manure.

Letting biomasses with a high level of nitrogen digest normally requires the application of post-degasification in under-cover storage tanks.

Recent studies

The Danish Institute of Agricultural Research has recently carried out a

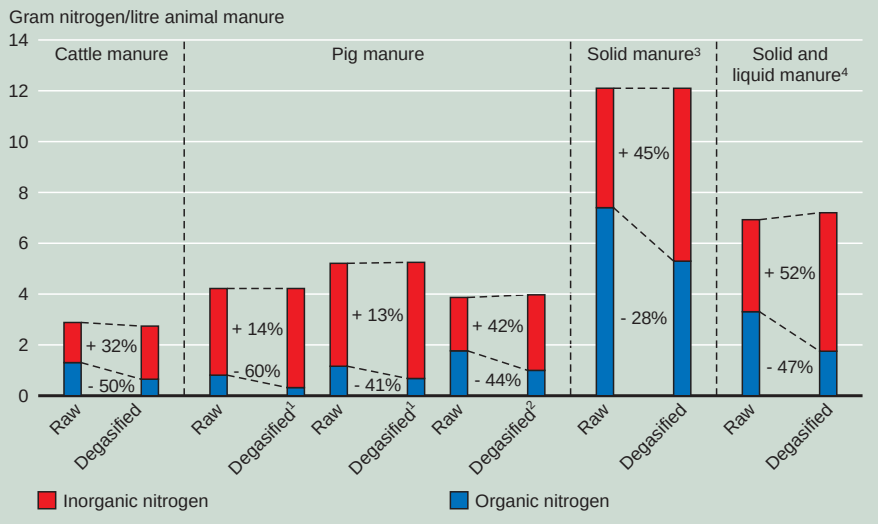


Figure 1. Nitrogen composition in different types of biomass before and after degasification in biogas plants.

1. *Thermophilic reactor*
2. *Mesophilic reactor. Results from an international study by Lanotti, E.L., Porter, J.H., Fischer, J.R. and Sievers D.M., 1979.*
3. *Solid manure from decanter centrifuge.*
4. *60 % solid manure from Kemira separation plant and 40 percent liquid manure.*

range of experiments involving different types of liquid manure being degasified separately without the addition of waste. These experiments have shown how the nitrogen make-up changes when liquid manure is digested in a biogas plant.

Figure 1 shows that the conversion of nitrogen in a biogas plant is more or less constant for both cattle manure and pig manure, however, as pig manure contains large amounts of inorganic substances anyway, the percentage increase in ammonium levels is limited.

The opposite is true for cattle manure. A relatively high level of organic nitrogen is converted into inorganic substances, which are easier for plants to absorb. Thus, treating cattle manure in a biogas plant results in a significantly larger increase in manurial value compared to pig manure.

Nevertheless, a biogas plant has a positive effect on both types of liquid manure, including a lower level of washing out of nitrate.

Inhibition of nitrogen

A high level of nitrogen in the biomasses might inhibit the biological process within the biogas plant.

Biogas plants involving digestion in a thermophilic temperature range experience the biggest problems with this issue. In most cases, it results in a small or large reduction of gas yields, however, in more extreme cases the process might break down completely.

We know from previous studies that those biogas plants, which are used to handling biomasses with high levels of ammonium contents, are able to cope with three grams of nitrogen per litre of biomass without any major problems. At higher nitrogen levels, the gas production typically decreases ten percent each time the nitrogen content increases by one gram per litre of biomass. In most cases, however, this decrease can be compensated for by letting the biomass post-digest in under-cover storage tanks.

Figure 2 depicts a typical example of gas production reduction in a biogas reactor through an increasing nitrogen level within the biomass. Such a process will yield

25-30 % less than when using normal manure on the basis of dry substances. The decrease is probably also, in part, caused by a lower gas potential in the solid biomass. In order to take full advantage of the gas potential in biomasses containing high levels of ammonium, it is important to make sure that the reactor is works with a mesophilic temperature range or is equipped with under-cover storage tanks for post-degasification.

This study is part of the EFP-project "Precision guidance in biogas plants".

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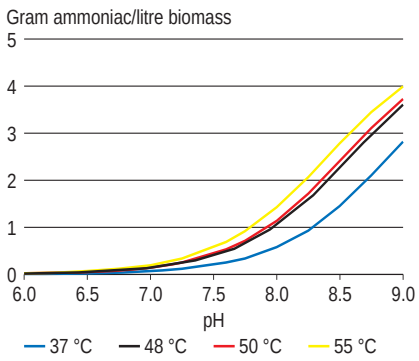
Facts on ammonium and ammonia

In principle, what might inhibit the process within a biogas plant is not the content of ammonium but rather the amount of free ammonia available within the biomass. Free ammonia is very dependent on temperature and pH, and using a lower temperature in the biogas reactor prevents process inhibition.

Such inhibitions typically arise when the level of free ammonia surpasses 1 gram/litre biomass. This figure shows an example involving a total ammonium content of

5 gram/litre biomass. In this case, the process will be inhibited at a temperature of 55 °C, whereas a temperature of 48 °C will only lead to limited inhibitions. Mesophilic operation (37 °C) will solve the problem completely.



Examples of process inhibition.

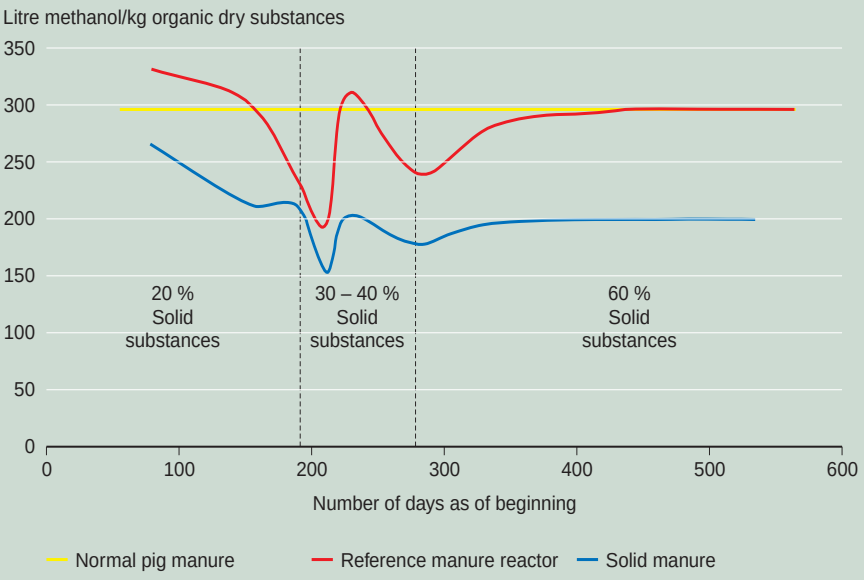


Figure 2. An example of a decreasing gas production within a thermophilic biogas reactor as a result of increasing biomass nitrogen levels. At the maximum allocation of solid substances, the ammonium content reached 5.2 gram/litre of biomass in the reactor handling solid substances (blue curve), whereas a content of 3.6 gram/litre was measured in the reference reactor using pure pig manure.

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Biodiesel from liposuctions

photo: scanpix/afp

The Norwegian company Venøy & Co wants to produce biodiesel using human fat from an American hospital group.

We all thought that the obesity epidemic was a terrible thing, however, there might be positive side effects to it – we just have to make the most of it!

The Norwegian Lauri Venøy has found out that excess human fat, particularly a problem in the USA, can be put to use. In a relatively simple process, human fat can be converted into biodiesel in order to cover parts of the increasing energy consumption evident in the transport sector, writes the Norwegian newspaper "Dagens Næringsliv".

According to the newspaper, the Norwegian company Venøy & Co is negotiating a contract with the gigantic American hospital group Jackson Memorial with a view to take delivery of fat from the numerous liposuctions carried out on overweight Americans every day by the hospital group. The contract involves a weekly delivery of 11,500 litres of human fat, which converts into 10,000 litres of biodiesel.

The Norwegian regards human fat a lasting source of energy and is considering whether or not to urge people to eat more fat in order to be able to cover a larger part of our energy consumption in this way.

In Norway, biodiesel is almost exclusively produced by means of fish oil and deep fat. Human fat is currently not used in Norway; they do so much skiing that very few people are in fact overweight.

An estimated 60 % of all Americans are overweight and around 30 % of those are regarded as heavily overweight, a recent study from Harvard University reveals. Previously, it was presumed that the number of heavily overweight people was only around 20 % but those numbers were based on telephone interviews, which the Harvard researchers consider rather useless as women tend to lie themselves a few kilos lighter and men a few centimetres taller, when asked to describe their physical characteristics. *TS*