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Focus on biofuels

On 14 to 15 June, the Danish Energy Authority's (formerly the Danish Energy Agency) Follow-up Programme for Decentralised CHP in Solid Biofuels was officially concluded at a seminar at Middelfart Kursuscenter. In this issue of Bioenergy Research, we focus on the biofuel projects represented at the seminar.

Since the first energy crisis in the 1970s, Denmark has focused on combined heat and power production, which is an efficient way to exploit fuels to the maximum. When biofuels were introduced, it seemed natural to establish a follow-up programme that could support, coordinate and communicate the many activities in the field.

Today, Denmark is at the forefront when it comes to using biofuels in small as well as large CHP plants. Fur-

thermore, Denmark is among the very few countries in the world that are capable of building straw-fired power plants and the only country in the world using straw pellets as fuel.

The vast experience with biomass-fired CHP plants was presented at a seminar which was arranged by the Danish Energy Authority and held at Middelfart Kursuscenter from 14 to 15 June. In near future, a series of reports will be written in which the participants' experiences will be presented.

In this issue of Bioenergy Research, we focus on biofuels for CHP plants. Handling of fuels has often caused stop-downs, and fuel is very likely to constitute the most important entry on plant budgets. The Follow-up Programme has contributed to an improvement in fuel handling, a series of analysis methods has been developed throwing light on the properties of the various fuels, and finally pricing and trade with biofuels have been analysed. ■



photo: torben skott/biopress

Straw bales have gone out of fashion

Biofuels have become an international commodity with a stable price range, which is not influenced by price variations in fossil fuels. The exception is straw, which is still only traded locally, but this may change when it becomes more common to use straw pellets instead of bales.

By Henrik Flyver Christiansen

- Straw bales are outdated in many ways. They work all right when straw has to be gathered in from the fields, but excessive transportation costs prevent straw from becoming an international commodity like wood pellets, wood chip and logs. The price you pay to cross the Great Belt Bridge alone prevents free trade between the regions, said Lars Nikolaisen from the Danish Technological Institute at the Danish Energy Authority's seminar on combined heat and power from biomass in June.

Lars Nikolaisen is one of the many participants in the Danish Energy Authority's Follow-up Programme for Decentralised CHP in Solid Biofuels, and during the past few years he has concentrated on international trade with biofuels, energy crops and fuel pellets.

At the seminar, he gave an account of the extensive national and international trade with biofuels - a trade that changes continuously as countries decide to let biofuels make up smaller or larger amounts of their energy supply. Germany, for instance, has, until a few years ago, exported large amounts of wood by-products and residues, but since the price of biomass electricity has increased considerably, the export has stopped. Similarly, because of the Danish duties, Denmark exports large amounts of biodiesel, but this export

can end, too, if the provisions are changed.

German research from 1998 shows that the trade with biofuels inside the EU amounts to around one million tonnes of oil equivalents annually. This nearly corresponds to Denmark's total consumption of wood and straw for energy purposes.

Across continents

Especially wood based biofuels such as logs, branch bunches, wood chip and wood pellets have become international commodities. Wood chip and wood pellets are even traded across continents. Denmark for instance has imported wood chip from the US, and for many years we have also bought wood pellets in Canada.

Industrial residues like shea nuts, sunflower seed, olive stones and the like have especially been exported from Russia and the countries surrounding the Mediterranean Sea. The market is very sensitive - not only to the prices of the different raw materials but also to the world market price of soy and to whether there is vacant ship capacity or not.

As already mentioned, straw is only traded locally, but this picture can easily change when the use of straw pellets becomes more widespread.

- It is possible to ship wood pellets from Canada to Denmark, so I am sure it will also be possible to ship straw



photo: torben skott/biopress

Today, wood chip is traded in large amounts across borders. Here wood chip imported from the US arrives at the port of Grenå.

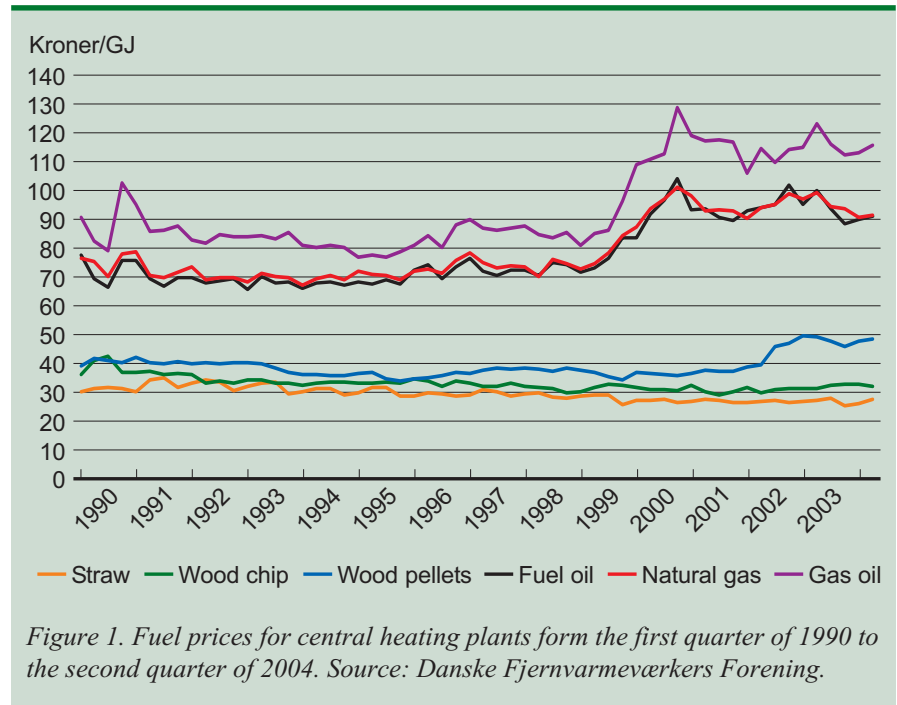
pellets from Ukraine to Denmark. I am sure it will come - it is only a question of time, said Lars Nikolaisen with a hint to the Danish straw suppliers, who may soon experience keen competition from abroad.

Stable prices

Danske Fjernvarmeværkeres Forening (an association of Danish district heating plants) has for many years kept statistics on how much district heating plants pay for the various fuels. These statistics clearly show that while the prices of fossil fuels vary considerably, the prices of biofuels are practically constant. Especially the straw pellet and wood chip prices have been stable lately, whereas the price of wood pellets rose a bit in the autumn of 2002.

The rise in the wood pellet price was closely connected with the considerable rise in raw material prices from 1995 to 2002. The price of sawdust and chips from the Danish furniture factories thus rose from DKK 30 to 550 per tonne in only seven years. The raw material price as well as the price of wood pellets have fallen a little again, but there are no indications that they will end at the same level as straw and wood chip.

The rising prices of raw materials for wood chip have led to a series of attempts to produce cheaper fuel pellets consisting of different forms of biomass. The tests have shown that if the right additives and binding agents are added, it is possible to produce pellets from almost all sorts of biomass at



a price and of a quality which can compete with wood pellets.

Increasing demand

Much seems to indicate that the demand for biofuels will continue to rise in future. International agreements to limit the emission of greenhouse gasses make it necessary to use biofuels, and in Europe, the great dependence on oil and gas from unstable areas like Russia and the Middle East will also push the trade with biofuels. Today, the EU imports half its consumption of oil and gas, and if nothing is done the import will rise to around 75 per cent in 2030. This might very well be a more important threat than the threat of climate changes.

According to Lars Nikolaisen, there are no immediate signs that we will come to lack biofuels. The world resources are enormous, not to mention the possibility of growing energy crops and optimising the use of industrial residues. In Northern Europe, the growing of energy crops would produce a yield of 10-15 tonnes of dry matter per hectare, but in the countries surrounding the Mediterranean Sea, the expected yield would be around 40 tonnes of dry matter per hectare.

The EU whitepaper from 1997 suggests tripling the use of biofuels from 35 to 135 million tonnes of oil equivalents in 2010, which corresponds to using the entire farming area set aside in the EU for energy production. If you think that sounds like a lot, remember that in 1943, 23 per cent of Denmark's farming area was used for the production of energy crops. Back then, however, it was not about producing electricity and heat or biodiesel for the tractor - what was grown was oats for the horses.

Henrik Flyver Christiansen, MSc engineering, functions as a project coordinator at the Danish Energy Authority's Follow-up Programme for Decentralised CHP in Solid Biofuels. ■



Logs for energy production are imported especially from the Baltic countries.

Pellets are the future way to handle biofuels. Biopellets contain almost as much energy as coal, which makes it feasible to exploit the enormous biomass resources around the world. In Denmark, the energy production and trading company Energi E2 has chosen to use 450,000 tonnes of biopellets in existing power plants instead of building new plans that can use the biomass directly.

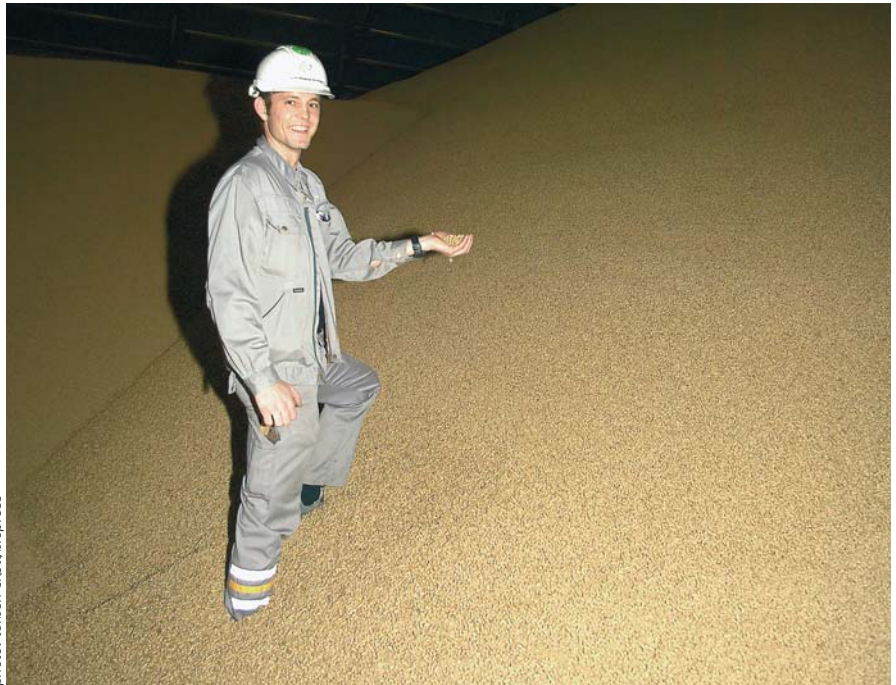


photo: torben skott/biopress

Straw and wood pellets have become fashionable

By Henrik Flyver Christiansen

It sounds like a joke: You take a stack of wood chip and a bunch of straw bales and comminute it in a hammer mill, and then you press it into fuel pellets. After that, the pellets are transported to the Avedøre or the Amager plant, where they are crushed. The pellets cannot be used directly at these two plants - they need to be comminuted into a pile of dust, which can be fired in the same way as coal.

But there is a purpose to all this. The energy production and trading company Energi E2 that owns the power plants and the new pellet factory has discovered that it is cheaper and more flexible to produce biopellets to be used in existing plants than to build new power plants, which can use the biomass directly from the farms and forests. So said Per Ottesen from Energi E2 at the Danish Energy Authority's seminar on combined heat and power from biomass from 14 to 15 June in Middelfart.

The largest surprise is perhaps that in total Energi E2 can obtain a slightly

improved energy economy by using fuel pellets. This does not sound logical because naturally energy is consumed when the pellets are pressed and handled, but to make up for this the power plants that use the pills are far more efficient than the smaller plants, where straw bales and wood chip are fired directly. The electricity efficiency of the Avedøre plant for instance is just about 50 per cent, whereas the smaller plants that burn the fuels directly typically have an electricity efficiency of less than 40 per cent.

When producing straw pellets, only 1.5 per cent of the energy content of the straw is used for the production, while the corresponding figure for wood pellets is 6.7 per cent. This has to

do with the fact that almost 5 per cent of the energy content is used to dry the wood chip before it can be pressed into pellets.

Low-cost solution

The new pellet factory in Køge, which is to produce 130,000 tonnes of straw pellets annually and 180,000 tonnes of wood pellets, has cost DKK 375 million. That may sound like a lot, but Energi E2 has estimated that it would have cost three times as much to build new power plants that could burn the biomass directly.

- Furthermore, the fuel pellet solution has the advantage of being very flexible. A ship with biopellets can contain nearly as much energy as if it

Biomass	Energy content	Density	Ash	Price in Denmark
Straw	14.5 GJ/tonne	130 kg/m ³	5.0 %	DKK 37/GJ
Straw pellets	15.0 GJ/tonne	600 kg/m ³	5.0 %	DKK 56/GJ
Wood chip	10.5 GJ/tonne	250 kg/m ³	0.5 %	DKK 30/GJ
Wood pellets	17.5 GJ/tonne	650 kg/m ³	0.5 %	DKK 44/GJ

Data for straw, straw pellets, wood chip and wood pellets. The energy content per tonne is almost the same as for coal.

was loaded with coal, and pellets can be transported from anywhere in the world to any power plant, so we are not bound by local suppliers, says Per Ottesen.

- For the time being, straw pellets are produced only in Køge, but in the long run the production will spread to other areas with large amounts of cheap straw. The world has enormous biomass resources. In many places, wood is just lying around rotting or it is burned on enormous fires, because people do not know what to do with it.

Energi E2 plans to use 300,000 tonnes of wood pellets at the Avedøre plant and 150,000 tonnes of straw pellets at the Amager plant. The total production of the new pellet factory in Køge will only be 310,000 tonnes a year, so Energi E2 has to buy 140,000 tonnes of biopellets in the open market.

According to the Biomass plan, Energi E2 must burn 500,000 tonnes of biomass annually, but when the new pellet factory has been run in, the total consumption will amount to 850,000 tonnes a year. The total amount of energy will, however, be even higher as especially wood pellets have a higher calorific value than wood chip.

Because of environmental considerations, the pellets are sailed to the Avedøre or Amager plant. Economically it would have been better to use trucks, but that model would have caused considerable nuisance to the neighbours of the two power plants.

Commissioning problems

The construction of the new pellet factory was begun in the summer of 2002, and a year later the production of straw pellets was initiated. Today, the production is only half of the expected production, and there are still commissioning problems to be solved.

- One of the difficult things is to choose the right size for the dies in the pellet presses. There are practically no suppliers who know anything about straw pellets, and there is very little knowledge of the relation between different types of wood and the choice of dies and roll pressure. It is a long and complicated process because it takes a couple of months to make a new dies, explained Per Ottesen.

Despite the fact that Energi E2 has practically had to start from scratch with their production of straw pellets, it has proved easier than to produce wood pellets. The advantage is that the straw does not need drying, and moreover the dies can produce up to 6,000 pellets before they need sharpening. The most important problems have been with the straw shredder, which has now been replaced with a more robust model.

The production of wood pellets is a little more complicated because the water content in the wood chip has to be reduced from approx. 45 to 10 per cent. The first step in the drying process takes place in a pressurized drying installation with steam form



Køge Biopillefabrik, which is to produce 310,000 tonnes of biopellets annually.

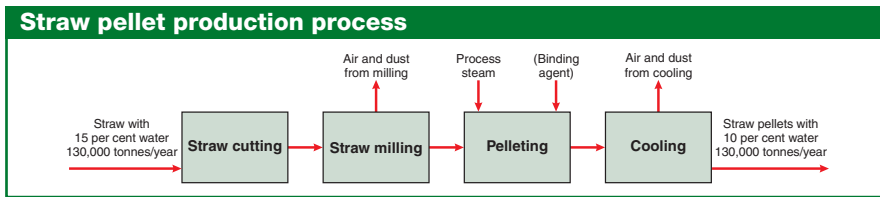


The coaster "Grethe" unloading straw pellets for the Amager plant.

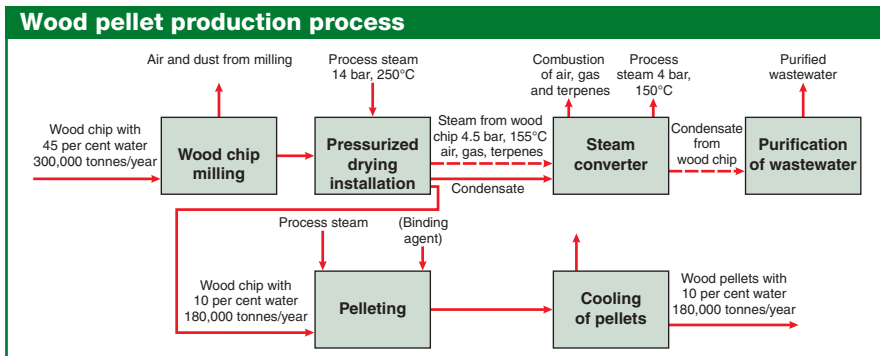


The Avedøre plant, which is to use 300,000 tonnes of wood pellets annually.

The principle behind the production of straw pellets. As it is not necessary to dry the straw, the production is fairly simple.



The principle behind the production of wood pellets. It is necessary to reduce the water content from 45 to 10 per cent before the wood chip can be pressed into pellets.



Juncker's CHP plant, which was taken over by Energi E2 in 2001. After the drying installation, a so-called steam converter has been installed which makes it possible to reuse 85 per cent of the steam and send the impurities that have been released in the drying process to a sewage treatment plant. - The drying installation has caused some trouble. It has not been an easy task to fill wet wood chip into a vessel with a pressure of four bar and then afterwards take it out again in a controlled manner, but it works now, said Per Ottesen.

Coal is best for biofuels

This year, the Amager plant has burnt coal as well as straw pellets, but next year, only straw will be used. The environmental permit of the plant to burn coal runs out at the end of this year, and so the straw pellets will prolong the life of the plant, which began operating in 1971.

The combustion of straw pellets has worked well. There is less than 3,5 per cent carbon in the fly ash, which indicates very good combustion. The straw has caused some coating of the heating surfaces, but the problem is expected to be solved when soot blowers are installed in the boiler.

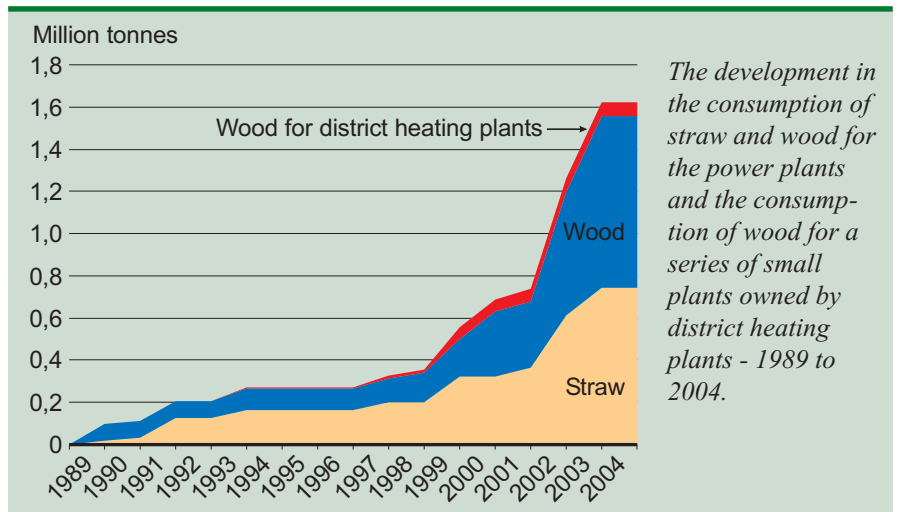
At the Avedøre plant, the wood pellets have caused a bit more trouble because they are burned together with natural gas or heavy fuel oil. It would be much easier to burn them with coal, but politicians have decided that this plant should not burn coal. Energi E2 will now try to add fly ash from coal to stabilise the boiler and avoid unnecessary wear, but as Per Ottesen puts it: - It is extremely stupid that we cannot choose where to burn the coal ourselves. We do not wish to burn more coal, but we would like to burn it where it works best. It is like spanking - doing it in the most difficult way. Economically it is extremely unwise, and from an environmental point of view even more so, but that seems to be the way the authorities want it!

Henrik Flyver Christiansen, MSc engineering, The Danish Energy Agency, Biomass Division. ■

Less straw - more wood

While the amounts of straw agreed in the Biomass plan from 1993 are not quite used yet, the use of wood has become more widespread than expected. According to the original agreement, the power plants were to use 1.2 million tonnes of straw and 200,000 tonnes of wood before the end of 2000. Later on the agreement was changed, so the power plants could cut their use of straw to one million tonnes and use more wood instead.

Today, four years after the Biomass plan should have been carried through, Jutland and Funen are still 100,000 tonnes of straw short of fulfilling the obligation of the Plan, but to make up for that the use of wood has increased so the power plants' total use of biomass is about 1.5 million tonnes. Furthermore, approx. 60,000 tonnes of wood are used at a series of smaller CHP plants owned by the district heating plants in Assens, Hjordkær and Harboøre respectively. ■



The Follow-up Programme

The Follow-up Programme for Decentralised CHP in Solid Biofuels was started by the Danish Energy Authority (then the Danish Energy Agency) in 1994/95 with the purpose of collecting and communicating experiences from pilot and demonstration plants and research and development projects. The programme thus played a central role in the development of new technologies and in that way it helped solve problems in the best and cheapest way.

Throughout the 1990s, the Development Programme for Renewable Energy (UVE), the Energy Research Programme (EFP), the CO₂ support programmes, the electricity sector and the industry have supported initiatives in biomass-based CHP. The activities of the Follow-up Programme are thus also financed by these programmes, though primarily by UVE.

11 different GTS-institutes (approved technological service institutes), universities and other institutions have been involved in the programme. The various participants have been responsible for areas such as fuel and ash analyses, economic analyses, wastewater analyses, general energy and environment analyses, process analysis and tar and chemical analyses. Furthermore, every month, operation and production data from 14 different biomass-fired CHP plants have been collected.

Biomass-based CHP projects which have been supported by the Danish Energy Authority have automatically become part of the Follow-up Programme. For projects that have not been supported by the Danish Energy Authority the Follow-up Programme has been an offer - an opportunity to exchange results and experiences with other projects.

The price difference decreases

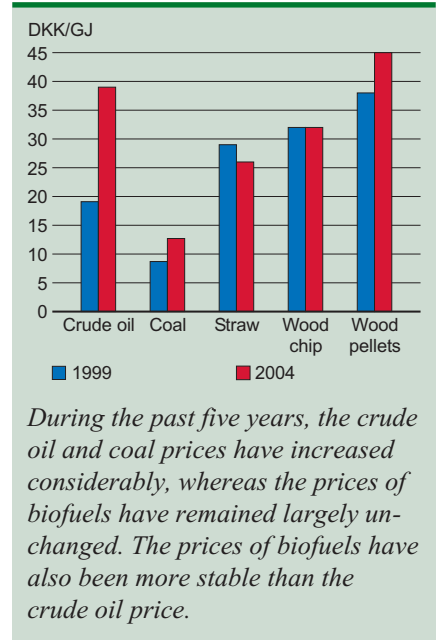
The oil price has increased dramatically during the past few years, and unlike earlier the coal price has followed suit this time. The massive growth in China and other Asian countries has caused the coal price to rise to DKK 13 per GJ, where the normal level is approx. DKK 9 per GJ.

The price increases, however, are not only due to the fact that the coal price has increased. Another contributory factor is the high transportation costs, which are yet another consequence of the economic growth in China.

For many years, the coal price has contributed to ensuring the stability on the market for fossil fuels, but those times seem to have passed. The market

for biofuels, on the other hand, is still very stable and completely uninfluenced by the price increases in fossil fuels. The straw price has actually fallen a bit during the past five years, while there has been a slight price increase in the market for wood pellets. The wood pellet price, however, is on its way down again, though it is probably not going to become as low as in the 1990s.

The price difference between fossil fuels and biofuels is thus decreasing right now, and the trend seems likely to continue. The demand for fossil fuels will continue to increase, while the resources will decrease, which will no doubt lead to price increases. ■



Large savings on heavier straw bales



photo: torben skott/biopress

Using heavier straw bales would mean saving almost DKK 100 million annually on the million tonnes of straw that the power plants are to use according to the Biomass plan.

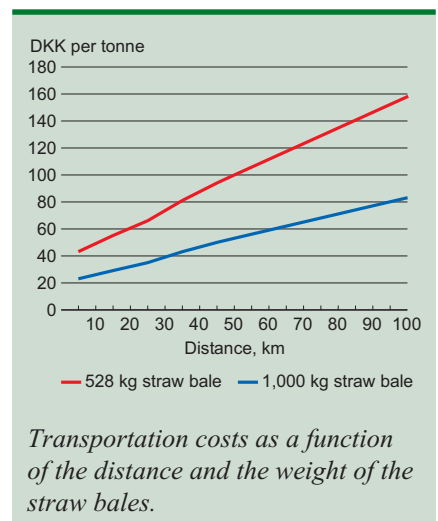
One of the most important obstacles to an increased use of straw for energy purposes is that the straw price is relatively high compared to the price of fossil energy. The straw price primarily depends on the market, though the size of the handling, storage and delivery costs influences the pricing as well.

Today, district heating plants and CHP plants primarily use big bales of 500 kg, but unfortunately that means that the capacity of the trucks transporting the bales is not utilized to the fullest since it would be no problem at all for the trucks to transport straw bales weighing the double of the ones used today. Heavier straw bales would also entail considerably lower storage costs, and the handling cost would be reduced as well.

Existing big balers would be able to press the straw so that a bale would weigh 600 kg, but for the weight to

reach a tonne, the machines would need to be altered or new big balers would have to be developed.

So far no one has taken on the task, but when the power plants reach a million tonnes a year it will be about time to develop new machines that can press straw bales weighing around a tonne. At one million tonnes of straw annually, the savings in connection with handling, transport and storage will amount to a little less than DKK 60 million, and if the savings at the power plants are included, you get little less than DKK 100 million a year. ■



FIB – Bioenergy Research is published with support from Denmark's Energy Research Programme, Elsam and Energi E2. The newsletter, which is free of charge, is published six times a year both in a Danish and an English version. Both versions can be downloaded from the Internet at the following homepage: www.biopress.dk

The Danish version of the newsletter is also available in a printed version supplied as an insert in the Danish magazine, Dansk BioEnergi. Further copies of the Danish version can be ordered from BioPress, via the following e-mail address: biopress@biopress.dk, or telephone number +45 86 17 34 07.

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Photo on the front page:

Torben Skøtt

Copies printed: 4,000

Print: CS Grafisk. The magazine has been printed on environment-friendly offset paper.

Reproduction of articles or illustrations has to be accepted by BioPress. It is allowed to quote articles if the source is clearly indicated.

Next issue:

to be published in the middle of October 2004. The deadline for articles is 15 September 2004.

Wood chip is not just wood chip



photo: torben skøtt/biopress

The Follow-up Programme for Decentralised CHP in Solid Biofuels has meant that Denmark has had considerable influence on the coming European standard for biofuels.

The handling of biofuels, especially wood chip, still causes many stop-downs at district heating plants and CHP plants, which is why it is important to create standards for trade with wood chip so the plants know what they are buying.

As a part of the Follow-up Programme for Decentralised CHP in Solid Biofuels Forest & Landscape, which is now a part of The Royal Veterinary and Agricultural University, has carried through a comprehensive project with the aim of characterising the various types of wood chip.

One of the first tasks was to develop a rotating classifier that could characterise the various types of wood chip. The chip particles are divided into five different sizes, and afterwards the quality of the wood chip can be defined.

The rotating classifier has given the researchers an overview over the types of wood chip produced by the different chippers. This has made it possible to adjust the different chippers to produce more homogeneous qualities.

Long particles - the so-called slivers - can easily block the feeding

mechanism of a wood chip plant, but it is also a problem if the particles are too small because that causes excessive amounts of ash. By building a classifier into the chipper, the small particles can be sorted out so the amount of ash is minimised, and furthermore nutrients will be added to the forest floor.

Bridging of the wood chip is another well-known phenomenon, which can cause stop-downs at district heating and CHP plants. The researchers from Forest and Landscape have therefore carried through a series of tests to become better at defining the conditions needed for wood chip to bridge. Especially large particles cause bridging, but the water content and the thickness of the layer also plays a part, just as a more homogeneous chip quality can help solve the problem.

Apart from characterising the different chip types, the researchers have tested equipment for determination of water content and the endurance of wood pellets and wood briquettes. The work has greatly influenced the coming European standard for biofuels, Bionorm, which is expected to be terminated this autumn.

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