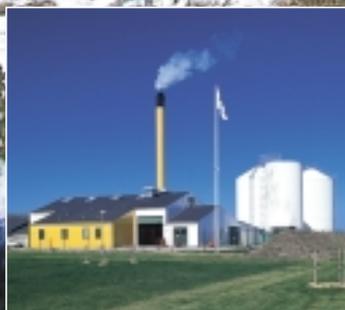


Danish Bioenergy Solutions

- reliable & efficient



Centre for Biomass Technology - 2000



Danish Biomass Solutions - reliable and efficient

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Centre for Biomass Technology

- a professional network co-operation for biomass information and dissemination.

Centre for Biomass Technology is a co-operation between four independent R&D institutions in Denmark. The Danish Energy Agency finances CBT. Based on the extensive professional network of the four institutions, Centre for Biomass Technology covers all subjects from agriculture or forestry to heat and power as well as all fields of problems within technology, economics and environment.

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Foreword

Energy production based on biomass is an important pillar for Denmark and others to lean on in order to secure a more sustainable energy sector in the future.

A more sustainable energy sector implies reduced emissions of CO₂ and reduced dependency on fossil fuels. In the Kyoto Protocol developed countries committed themselves to reduce their emissions of greenhouse gases by more than 5 percent in 2008-2012 compared to the 1990 level. The EU has agreed to reduce its emissions by 8 percent.

In Denmark biomass has become an increasingly important energy source over the last twenty years and biomass has thereby made a significant contribution to reduce Danish CO₂ emissions. Consequent energy planning,

including taxes on fossil fuels, in combination with technological development has made this development possible.

The long term perspective for the use of renewable energy in Denmark is, according to the Government energy action plan, Energy 21, to cover 35 percent of total energy consumption in 2030. The Danish strongholds in the field of biomass based combined heat and power generation and district heating supply will be important means to reach this goal.

As well small as large scale Danish bioenergy technologies are mostly being developed in co-operation between Danish industry, R&D institutions and public authorities on the municipal and national levels. This model has proven valuable to produce reliable and thus competitive technologies. The qualities of Danish technology are well known throughout the world, as the Danish export of bioenergy technology in the year 2000 rounds 130 million Euro.

This catalogue provides an overview of the Danish bioenergy sector. It describes a variety of Danish solutions to the challenge of utilising wood, straw and animal waste for an environmentally desirable and CO₂ neutral energy production in small as well as large scale systems. It furthermore describes the recent development within some promising technologies for biomass based combined heat and power generation.

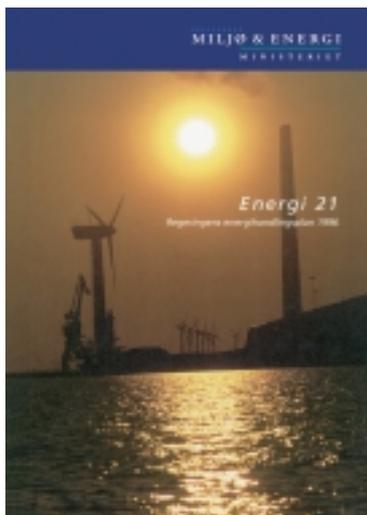
It is my wish that you, dear reader, may find this catalogue a valuable piece in your own efforts to develop a more sustainable energy future. I hope that the catalogue will help to promote international co-operation and thus accelerate the development and deployment of bioenergy.



Svend Auken, Danish Minister for Environment and Energy.

A handwritten signature in black ink, appearing to read 'Svend Auken'.

*Svend Auken
Danish Minister for Environment and Energy*



25 years of Danish energy policy

Since the mid-1980's changing governments and parliamentary majorities in Denmark have persisted in the importance of an active energy policy with increased emphasis on the resource-based and environmentally responsible policy. Consequently, Denmark has now taken a leading position within several fields of renewable energy, including various forms of bioenergy.

Denmark's latest energy plan, Energy 21, is expected to contribute to the sustainable development of the Danish society.

By Torben Skøtt

The main objective of the first Danish energy plan, Danish Energy Policy 1976 (Dansk Energipolitik 1976), was to safeguard Denmark against supply crises like the one that occurred in connection with the oil crisis in 1973/74.

The next plan, Energy Plan 81 (Energiplan 81), continued to focus on limiting fuel imports, and high priority was given to socio-economic and environmental considerations. The plan boosted the development of the oil and gas fields in the North Sea considerably, and the nation-wide natural gas network was established.

Following Energy Plan 81, the first subsidy schemes aimed at the exploitation of straw and chips were introduced, and biomass became a competitive fuel

through increasing taxation of fossil fuels. The first chip-fired combined heat and power plants (CHP) were built, the number of chip-fired district heating plants and farm-based plants increased heavily, and the consumption of firewood in individual dwellings rose markedly.

The third energy plan in the series is the action plan, Energy 2000 (Energi 2000), from 1990. This plan is an ambitious attempt to increase the use of environmentally desirable fuels. At the same time, the aim of a sustainable development of the energy sector was introduced.

The fourth and latest energy plan, Energy 21 (Energi 21), was introduced in 1996. A long-term objective in this plan requires that CO₂ emissions must be halved in 2030 compared with 1998. In addition, international climate change negotiators will advocate

that by 2030 the industrialised countries halve their CO₂ emissions compared to the 1990 level.

Denmark's CO₂ objective shall be achieved through energy savings, better exploitation of the energy resources and contributions from renewable energy sources amounting to 35 per cent of the gross energy consumption in 2030.

Energy 21 assumes that renewable energy covers 12-14 per cent of the country's total energy consumption in 2005. The vast majority of this contribution is to come from biomass.

Legislation

In order to implement the activities suggested in Energy 2000 the Danish parliament "Folketinget" passed the so-called Heat Supply Act in 1990. This act gave the Minister of Energy wide powers to control the choice of fuel at district heating plants and decentralised CHP plants.

On the basis of this act a number of coal- and natural gas-fired district heating plants have been converted to natural gas-fired, decentralised CHP generation. In addition, many small district heating plants not connected to the large district heating networks have been converted to use biofuels.

The Heat Supply Act was followed by three acts offering the prospective of subsidising the process of conversion to environmentally more desirable fuels.

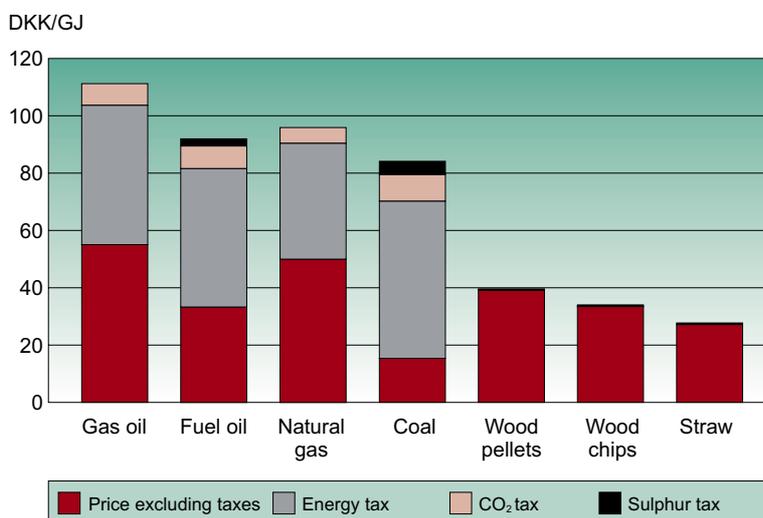


Figure 1: Fuel prices at the beginning of 2000 for district heating purposes including taxes but excluding VAT.

The purpose was to protect the consumers from higher heating prices due to the conversion.

The three acts in question are:

- “State-Subsidised Promotion of Decentralised Combined Heat and Power and Utilisation of Biomass Fuels Act”. Under this act, it is possible to grant subsidies of up to 50 per cent of the construction costs. In practice, subsidies have typically been in the range of 20-30 per cent of the construction costs.
- “State-Subsidised Electrical Power Generation Act”, under which a subsidy of DKK 0.17 per kWh is granted for electrical power generation based on straw and chips. In addition, the CO₂ tax of DKK 0.10 per kWh is refunded in the case of renewable energy, so actually private producers of renewable energy receive a total subsidy of DKK 0.27 per kWh.
- “State-Subsidised Completion of District Heating Nets Act”, under which up to 50 per cent of the construction costs can be subsidised. The scheme expired at the end of 1997.

The Biomass Agreement

On 14 June 1993 a number of parties in the Danish parliament made an agreement concerning increased use of biomass in the energy supply sector. Four years later a supplementary agreement was made with the intention of further improving conditions for bioenergy.

A vital element of the agreement stipulates that the centralised electrical power plants are obliged to buy 1.4 million tonnes of biomass per year, including at least 1 million tonnes of straw. Originally, the aim should have been met in 2000, but under a new supplementary agreement from 22 March 2000 the time limit is extended to the year 2005.

Furthermore, the biomass agreement means that bio-

mass-based CHP generation has a higher priority in a number of local areas, including areas with natural gas. In addition, the local authorities are instructed to promote CHP generation from biogas, landfill gas and other sorts of gasified biomass.

The electrical power reform

On 3 March 1999, a broadly based majority among the political parties in the Danish parliament made a framework agreement concerning an overall law reform for the electrical power sector. This reform ensures that the market for sale of electrical power will be opened completely by the end of 2002.

In order to ensure the competitiveness of renewable energy sources, a special market for “eco-friendly” electrical power will be opened at the same time in Denmark. The idea of the system is that a number of “eco-friendly” certificates corresponding to the electrical power generation for a certain period is awarded to e.g. biogas plants. The individual biogas plants can then sell the power on the free market for electrical power while selling the certificates on a special market for “eco-friendly electrical power”.

The eco-friendly power is so-called “high priority power”. This means that operators generating it have a guarantee that they can sell their product, even if

there is a surplus production of electrical power.

Consumers will be obliged to buy a certain amount of eco-friendly electrical power each year, but in practice the demand for the eco-friendly certificates will be found among the electrical power companies and parts of industry.

Thus, the certificates will replace the current system with grants for the generation of electrical power and fixed prices for electrical power generated at renewable energy plants.

The purpose is to increase competition between the individual producers and renewable energy technologies. Wind turbines will be able to compete in this market, but it may be hard for new technologies such as gasification of biomass, Stirling engines and the like.

In order to ensure appropriate development of these technologies, it will still be possible to award subsidies for research, development and construction. In addition, the authorities are considering the possibility of paying a supplementary price per kWh generated to less competitive biomass technologies - at least for a certain period of time.

The final layout of the market for eco-friendly electrical power will be decided upon in the near future.

Torben Skøtt is a journalist and editor of the magazine Dansk BioEnergi.

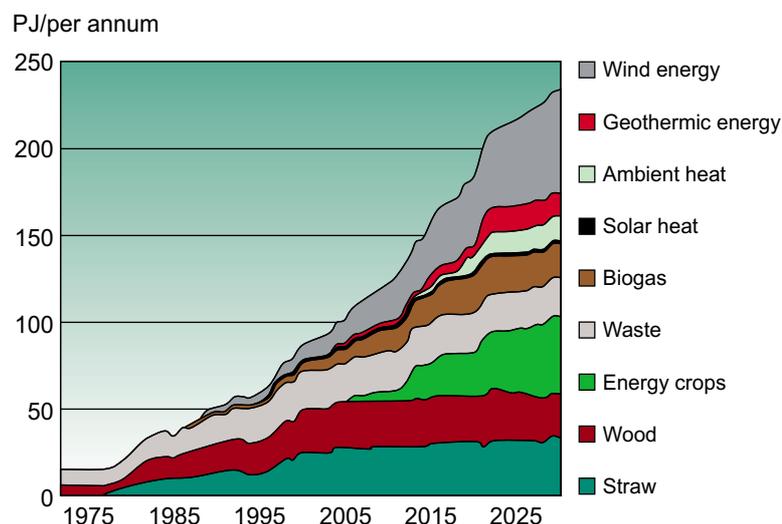


Figure 2: Energy 21 proposal for the use of renewable energy sources up to the year 2030.

Danish biomass for energy purposes

By far, the largest share of energy generated from renewable energy sources in Denmark comes from biomass. There is a large fuel market as well as well-developed technologies for the production, handling and exploitation of biomass.

By Torben Skøtt

Biomass consists of many different sorts of plant and animal materials suitable for energy purposes.

Biomass is the most widely used energy source in the world, and wood was probably the first energy source exploited by man. For thousands of years, biomass has been the dominating energy source, and apart from a relatively short period of time it has been the main element of the energy supply.

When fossil fuels entered the market in the post-war era, they soon displaced biofuels, partly because of the price, and partly because it is easy to use them for many different energy purposes.

After the oil crises, the 1970s saw a new era for the exploitation of biomass. The scarcity of fossil fuels and environmental considerations made it attractive again to exploit the vast amounts of biomass in nature. In Denmark the biomass used mainly consists of residual products from forestry, agriculture and the food industry, but later on a considerable contribution is expected from crops grown specifically for energy purposes.



The equipment used for the production of wood chips has been improved significantly in recent years.

Biomass is a CO₂-neutral energy source, because the amount of CO₂ absorbed during photosynthesis corresponds to the amount emitted when the biomass is subsequently converted. This is very important at a time when CO₂ is considered to be one of the major causes of the greenhouse effect.

Wood

For hundreds of years, the forestry industry has been a major supplier of fuel, and actually the vast majority of the trees can only be used for energy purposes.

Today, the forests cover 12 per cent of Denmark - approximately three times more than 200 years ago. However, over the next 80-100 years the area covered by forests is expected to double, as forests will be planted on a considerable part of the marginal land.

Forestry is a long-term production process with a span of 50 to 150 years from the afforestation of an area until the trees are felled. Approx. 40 per cent of the wood produced is processed at sawmills and wood processing plants. The remaining 60 per cent can practically only be used for energy purposes and paper production.

Out of the 40 per cent processed, 50-60 per cent will end up as residual products in the form of dust, cross-cut ends, shavings, etc. In total, only 20-30 per cent of the wood produced (the solid part) is used as commercial timber. The remains are mainly used for energy purposes and, to a smaller extent, for chipboard and paper production.

Firewood is mainly produced in connection with the thinning of hardwood forests. In Denmark an estimated 700,000 m³ of solid content firewood is produced each year, approx. 400,000 m³ of which comes from forestry. The rest comes from gardens, parks and the like.

Wood chips mainly come from the thinning of softwood forests. In Denmark the importance of chips as a fuel has continued to increase over the past 20 years, and today approx. 200,000 m³ of solid content fuelwood is produced each year. Chip production equipment has been improved considerably in recent years, and this has helped to keep fuel prices at a reasonable level.

Wood pellets and briquettes are made on the basis of wood

waste from industry. Production levels have reached 200,000 and 20,000 tonnes per year, respectively, but the market is growing rapidly, in particular for wood pellets. Today we have a wide wood pellet distribution network, which has grown after several large oil companies have entered the market. Today, a considerable part of the wood waste used for the pellets is imported.

Straw

Only a minor share of the straw produced in Denmark is used for energy purposes. A large part of it is used as forage and litter in agricultural production, and the agricultural sector uses a large amount for heating.

Furthermore, the sector sells straw to a number of district heating plants and combined heat and power (CHP) plants. The use of straw at CHP plants is expected to increase particularly much in the years to come, as the electrical power companies are obliged

to buy at least 1 million tonnes of straw per year as from 2005.

Straw is pressed into small bales, medium-sized bales, round bales and big bales - also known as Hesston bales. Nowadays, district heating plants and CHP plants only use Hesston bales.

Straw is more difficult to process than wood, i.a. because there is a higher risk of corrosion and slagging problems. On the other hand, the price is normally lower than the price for chips and wood pellets.

Energy crops

So far, the growing of special crops for energy generation purposes has been unattractive due to the large excess amount of straw and chips. Unless these residual products are exploited fully, it is difficult to make energy crops economically viable. However, in the latest Danish energy plan it is expected that energy crops will make a significant contribution as from 2005. At

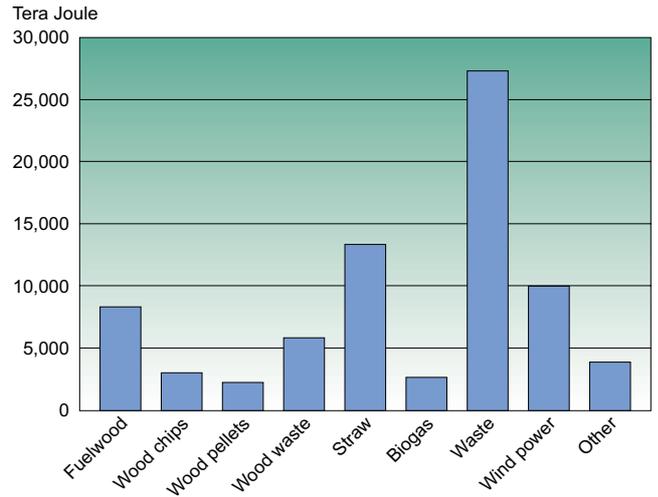


Figure 3: The share of energy production among renewable energy sources in 1998. Note that waste is also considered a source of renewable energy in Denmark.

this time the electrical power companies will have expanded the CHP production capacity and be able to convert 1.4 million tonnes of biomass per year.

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