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|----------------------------------|----------------------|----------------------|---------------------|---------------------|--|
| • Danish Energy Agency | 44 Amaliegade | DK-1256 Copenhagen K | Tel +45 33 92 67 00 | Fax +45 33 11 47 43 | www.ens.dk |
| • Danish Technological Institute | Teknologiparken | DK-8000 Aarhus C | Tel +45 89 43 89 43 | Fax +45 89 43 85 43 | www.dti.dk |
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| • Research Centre Bygholm | 17 Schüttesvej | DK-8700 Horsens | Tel +45 75 60 22 11 | Fax +45 75 62 48 80 | www.agrsci.dk |

Authors: Lars Nikolaisen (Editor)
Carsten Nielsen
Mogens G. Larsen
Villy Nielsen
Uwe Zielke
Jens Kristian Kristensen
Birgitte Holm-Christensen

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Straw for Energy Production
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Foreword

This publication illustrates how Denmark has succeeded in utilising straw, a former surplus product, for an environmentally desirable and CO₂ neutral energy production. It further illustrates the recent Danish advances in the field of using straw as an energy option with respect to both technology, environment, and economy.

At the United Nations Climate Change Conference in Kyoto, Japan, in December 1997, the emission of greenhouse gases was an issue of great concern. For the first time ever, legally binding emission reduction target levels of greenhouse gas emissions by developed nations were established. Total emissions must be reduced by 5.2% by 2012, and the European Union has undertaken the major reduction of 8% compared to the 1990 level.

One of the tools for a reduction of the emission of greenhouse gases is to increase the renewable energy share of total energy production. Today, only 6% of the European Union's energy consumption is covered by renewable energy, but that will change over the next years. The EU Commission Renewable Energy White Paper that was published in December 1997, prescribes a doubling of the share of renewable energy by 2010. Biomass is the sector that is to be developed most and most rapidly. By 2010, it should contribute by 74% of the total EU consumption of renewable energy.

Energy 21, the governmental plan for a sustainable energy development in Denmark, also gives renewable energy high priority. In a long-term perspective, it is the intention to develop an energy system in which a steadily growing part of the energy consumption is covered by renewable energy. This presupposes that a constant and gradual adaptation takes place concurrently with the technological and financial potentialities.

The Danish government is aiming towards an enlargement of 1% per annum on average. This means that the renewable energy share increases to 35% in 2030. The enlargement will primarily be in the form of an increased use of energy based on biomass and wind energy, and biomass will therefore contribute considerable to Denmark's energy production in the next decades.

There are great potentialities for the use of biomass - both in Denmark and internationally, and the experience gained in Denmark so far is already extensive. We have made great achievements both in respect of individual energy supply and collective energy supply systems. Denmark's strongholds are particularly in the fields of collective energy supply and decentralised combined heat and power (CHP) supplies, areas of great potentialities for the Danish energy industry - also in the export market.



Svend Auken
Minister for the Environment and Energy

1. Danish Energy Policy

Danish energy policy is in a constant process of change. The government's Energy Action Plan of 1996, Energi 21, is the forth in a series of plans that all have or have had as their objective to optimise the Danish energy sector to the present national and international conditions in the field of energy.

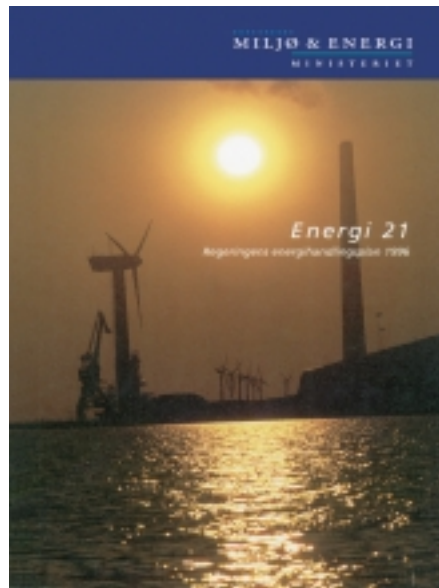
The Four Energy Plans

The objective of the first energy plan, Danish Energy Policy 1976 (Dansk Energipolitik 1976), was to safeguard Denmark against supply crises like the energy crisis of 1973 /74.

The second energy plan, Energiplan 81, attached increased importance to socio-economic and environmental considerations, thereby continuing the efforts of reducing the dependence on the importation of fuels. Through the 1980s, the oil and gas fields in the North Sea were heavily extended, and also the nation-wide natural gas net was established. The first subsidy schemes for the utilisation of straw and wood chips were implemented via increasing taxes on fossil fuels (oil and coal), thereby making it possible to make biomass competitive as a fuel. See Figure 1. The first CHP plants based on straw were constructed, and the number of straw-fired district heating plants and farm plants gathered momentum.

The third energy plan in the series is the action plan Energi 2000 of 1990. This plan is an ambitious attempt to increase the use of environmentally desirable fuels. At the same time, the objective of a sustainable development of the energy sector is introduced. In Energi 2000, the environmentally desirable fuels are defined as natural gas, solar heat, wind, biomass (straw, wood, liquid manure, and household waste). The use of biomass is based on the fact that it is CO₂ neutral, that it saves foreign currency, that it creates Danish jobs, and that it utilises waste products from agriculture, forestry, households, and trade and industry. The ambitious objective of Energi 2000 is that compared to the year 1988, Denmark shall achieve the following aims by 2005:

- Reduce energy consumption by 15%
- Increase the consumption of natural gas by 170%



Energy 21 shall contribute to a sustainable development of the Danish society. The energy sector shall continue being a financially, vigorously, and technologically efficient sector that forms part of a dynamic development of society.

- Increase the consumption of renewable energy by 100%
- Reduce the consumption of coal by 45%
- Reduce the consumption of oil by 40%
- Reduce the CO₂ emission by not less than 20%
- Reduce the SO₂ emission by 60%
- Reduce the NO_x emission by 50%

The objectives are achieved by means of a wide range of activities: Energy savings, tax on CO₂ emissions, conversion to the use of environmentally desirable fuels by CHP generation, subsidised schemes for the construction and operation of district heating systems, financial support for the establishing of biofuel boilers in rural districts etc.

The forth and last energy plan is Energi 21/ref.1/ that was introduced in 1996. According to Energi 21, it is planned that the "household" with its resources shall have a central role. The energy sector is still dominated by our consumption of depletable, fossil energy sources, and the emissions resulting from the consumption and energy production burden the atmosphere and the environment. The important clue of Energi 21 is to main-

tain the existing objective of Energi 2000 to the effect that Denmark must reduce its CO₂ emission by 20% by the end of 2005 compared to the 1988 level, and that the emission by the end of 2000 shall be stabilised under the 1990 level. In addition, international climate change negotiators will advocate that the industrialised countries by 2030 halve their emissions of CO₂ compared to the 1990 level. At the UN Climate Change Conference in Kyoto in 1997, the EU reduction was fixed at 8% by the end of 2012 compared to the 1990 level.

Energi 21 estimates that renewable energy covers 10% of the country's total energy consumption in 2000. This is equal to 75 peta joule (PJ) and the increase is primarily a consequence of the centralised power plants' increased use of straw and wood chips (see the section on the Biomass Agreement). An increased use of biomass and landfill gas also contributes to achieving the objective of 75 PJ.

Thus the initiatives in the field of biomass are directed towards the following subsidiary targets of Energi 21:

- Increased use of straw and wood chips at centralised power plants.
- Increased enlargement of decentralised CHP generation based on straw, wood chips, biogas and landfill gas.
- Conversion, to the greatest possible extent, of 350 block heating units above 250 kW in rural districts from fossil fuels to biofuels.
- Right to establish biofuel plants that were former reserved for natural gas.
- Accomplishing of a demonstration and development scheme that can illustrate future use of energy crops (including cereal grain, rape etc.) in the energy supply.
- Accomplishing of a minor pilot project for the purpose of demonstrating the basis of the production and the use of liquid biofuels.

Figure 2 illustrates the distribution of the individual renewable energy sources. It shows, e.g., that the full utilisation of straw and wood chips is planned to be achieved already in 2000, and the use of energy crops (annual or perennial) begins in 2005 and increases until the year 2030 when the energy crops are planned to be approx. 45 PJ that is equal to approx. 3,000,000 tonnes of straw.

EU Influence

EU Commission Renewable Energy White Paper 1997/ref. 28/ fixes an increase in the EU use of renewable energy from 6% to 12% up to the year 2010. It is estimated that the biomass sector will be the fastest growing sector within the renewable energy technologies. The use of agricultural land is closely connected to the EU agricultural policy. In the most recent EU proposal in respect of future agricultural policies, it is estimated that the legal obligation to fallow land will be abolished, and there will be one rate for subsidies no matter the choice of crop. That will affect the farmers' management also with regard to growing energy crops on land voluntarily left fallow.

The Heat Supply Act

For the purposes of implementing the activities suggested in Energi 2000/ref. 5/, the Heat Supply Act of June 13, 1990, was passed by the Danish parliament "Folketinget". This Act gave the Minister of Energy wide powers to control the choice of fuel in block heating units, district heating plants and decentralised CHP plants. This was carried into effect by means of the so-called "Letters of Specific and General Preconditions" that were circulated to municipalities and owners of plants in three staggered phases. The "Letters of Specific Preconditions" describe in details the con-

version to environmentally desirable fuels to selected municipalities and owners of plants. In addition, "Letters of General Preconditions" that describe the prospect of voluntary converting from coal and oil to more environmentally desirable fuels were circulated to all Danish municipalities.

The conversion was immediately implemented. Phase 1 was during the period from 1990-1994 and included the conversion of a number of coal- and natural gas-fired district heating plants that should be converted from natural gas to decentralised CHP plants. Phase 2 was during the period from 1994-1996 and included the remaining coal- and natural gas-fired district heating plants that are converted to natural gas-fired, decentralised CHP plants. In addition, minor district heating plants outside of the large district heating nets are converted to biofuels.

Phase 3 began in 1996 and is not yet accomplished. It was estimated that small, gas-fired district heating plants be converted to natural gas-fired, decentralised CHP plants and that the remaining district heating plants be converted to biofuels. See also the section on the Biomass Agreement and the adaptation of progress of the phase.

The CO₂ Acts

The Heat Supply Act was followed by three new acts offering the prospective of receiving grants for the process

of conversion to more environmentally desirable fuels. The target was that the Minister of Energy could then counteract the consumers being charged higher heating prices due to the conversion.

The three acts are Act Nos. 2, 3 and 4/1992 and the titles are:

- "State-Subsidised Promotion of Decentralised Combined Heat and Power and Utilisation of Biomass Fuels Act". Under this act, it is possible to receive subsidies up to 50% for the construction works. In practice, the subsidies given have been in the range of 20-30% of the cost of construction. In 1997, the scheme was prolonged until 2000.
- "State-Subsidised Electrical Power Generation Act". A subsidy of DKK 0.10/kWh is given for electrical power generation based on natural gas and DKK 0.27/kWh for electrical power generation based on straw and wood chips. The scheme has no time limit. However, on January 1, 1997, an Executive Order was put into force which, e.g., requires an 80% overall efficiency of the biomass plant in order for it to receive the maximum subsidy.
- "State-Subsidised Completion of District Heating Nets". Under this act, up to 50% of the cost of construction could be subsidised. The scheme expired at the end of 1997.

The Scheme for Renewable Energy and the Biomass Committee

In 1991, the Minister of Energy set up the "Committee for Biomass for Energy Purposes" as an advisory body. The committee has, e.g., drafted two 3-year development programmes. The "Bioenergy development programme" (Bioenergi Udviklingsprogram (BUP-95))/ref.35/ is a 3-year development programme for the period of 1995-97 describing activities for the promotion of the technological development of biomass-based plants. In the programme, e.g., the following activities are recommended:

- The development of CHP technologies on the basis of straw and wood chips as fuels. The technologies are steam, gasification, and Stirling engine.
- District heating plants should focus on fuels flexibility and an environmentally desirable handling of fuels.
- Environmentally desirable boiler plants should be developed for private houses.

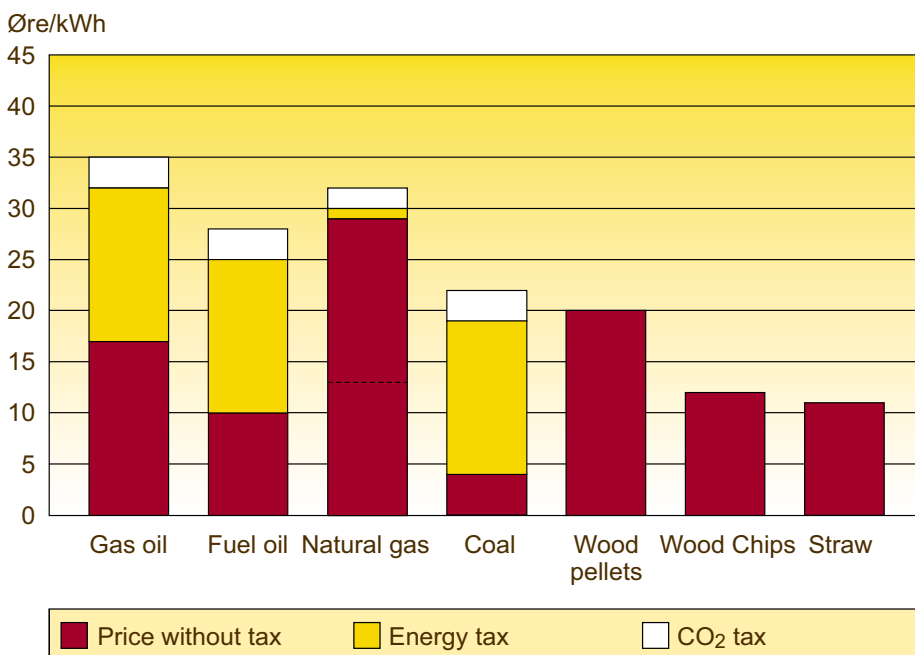


Figure 1: Fuel prices at the beginning of 1998 for heating purposes including taxes but exclusive of VAT. Coal and oil for electrical power generation are not taxed. The natural gas price for electrical power generation is 13 øre/kWh. The consumers are billed for the tax imposed on electrical power.

- Energy crops should be investigated with a view to the growing, handling and use of them.

The Danish Energy Agency's scheme titled "Development Scheme for Renewable Energy" supports projects for the promotion of biomass in the energy supply and uses, e.g., "BUP-95" as background material when considering applications.

The Biomass Agreement

In order to safeguard the achievement of the targets laid down in Energi 2000, the government, the Conservative Party, the Liberal Party, and the Socialist People's Party entered into an agreement on June 14, 1993 on an increased use of biomass in the energy supply with a special view to use at the centralised power plants. The main points of the agreement are as follows:

1. A gradual increase in the use of biomass at power plants should take place resulting in a consumption by 2000 amounting to 1.2 million tonnes of straw and 0.2 million tonnes of wood chips annually equal to 19.5 PJ.
2. Eleven towns in natural gas districts that have not converted to natural gas-fired CHP within Phase 1 or Phase 2 may make a choice between biofuels and natural gas as fuels. It is possible to wait until 2000 in order to, e.g., await the development and commercialisation of technologies in the field of biomass.
3. Phase-2 towns outside the natural gas area may postpone converting until 1998 if they choose biomass-based CHP.
4. Six towns in Phase 3 may postpone converting to biomass-based CHP until 2000.
5. Approx. 60 small towns in Phase 3 should be converted to biomass-based district heating by the end of 1998.

The agreement has resulted in Sønderjyllands Højspændingsværk (electricity utility) constructing a biomass-based power plant in Aabenraa with a

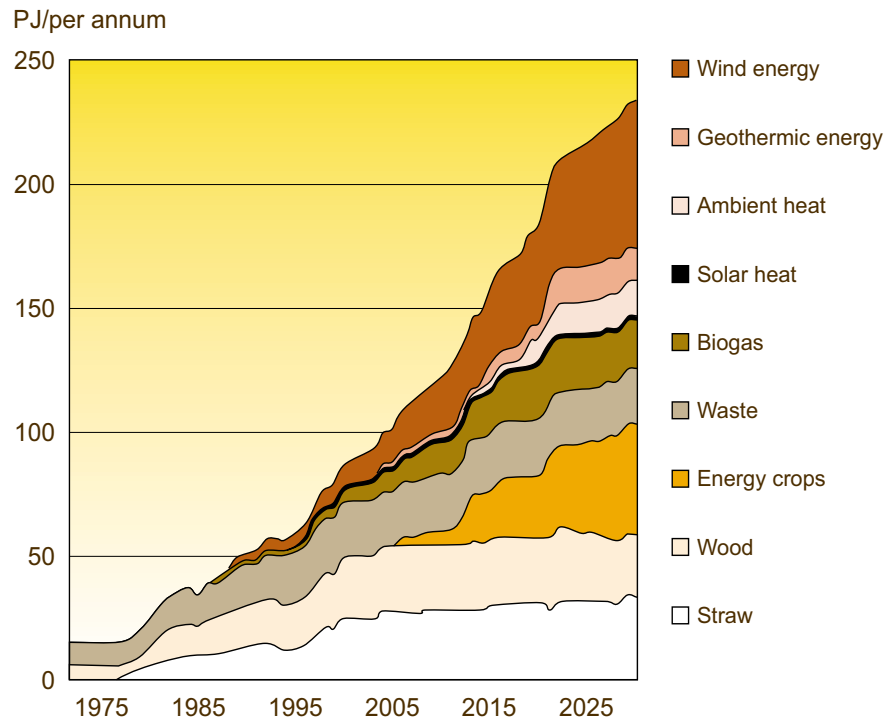


Figure 2: The Energy 21 proposal for the use of renewable energy sources up to 2030.

consumption of 120,000 tonnes of straw and 30,000 tonnes of wood chips annually. Sjællandske Kraftværker (Electricity Utility Group) has constructed a straw- and wood chips-fired CHP plant at Masnedø, and a plant at Maribo is being planned.

On July 1, 1997, the political parties to the Biomass Agreement drafted a supplementary agreement with the intention to improve the possibilities of adapting biomass to the energy supply. The supplementary agreement implies, in principle, that

- the centralised power plants are freer to choose among straw, wood chips, and willow chips, since there will be transformed 1.0 million tonnes of straw, 0.2 million tonnes of wood chips, and for the remainder, there will be freedom of choice, though, in a way so that the total amount makes out 19.5 PJ.
- biomass-based CHP plants are permitted in natural gas areas.
- the municipalities shall give priority to CHP based on biogas, landfill gas, and other gasified biomass.

- seven towns in Phase 3 may continue the present district heating supply until a conversion to biomass-based CHP is technically and financially appropriate.

Political Harmony

It is characteristic that since the middle of the 1980s, changing governments, parliamentary majority, and ministers of energy have persisted in the importance of an active energy policy thereby increasingly weighting the resource-based and environmentally acceptable line. The conversion to the use of renewable energy sources may seem very costly, but with the knowledge gained so far in the field of global circulation and the greenhouse effect, it is imperative. Denmark has a leading position in the field of several renewable energies, and it is the target of Energi 21 that this position be maintained.