IEA Bioenergy task 40

Country report 2011 for Denmark

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IEA Bioenergy

Task 40: Sustainable International Bio-Energy Trade

Content

Preface

This report is a part of the work of IEA Bioenergy Task 40 working group – "Sustainable International Bioenergy Trade: Securing Supply and Demand" and gives a picture of the situation regarding bioenergy in Denmark for the year 2010.

Large outdoor storage of straw for energy purpose in Denmark.

1 General Introduction

Denmark is the southernmost of the Nordic countries, located southwest of Sweden and south of Norway, and bordered to the south by Germany. The country consists of a large peninsula, Jutland and many islands, most notably Zealand, Funen, Vendsyssel-Thy, Lolland, Falster and Bornholm, as well as hundreds of minor islands often referred to as the Danish Archipelago. Two autonomous constituent countries belongs to Denmark, the Faroe Islands in the North Atlantic and Greenland.

Denmark became a member of the European Union in 1973 but remains outside the Eurozone. A founding member of NATO and the OECD, Denmark is also a member of the Organisation for Security and Co-operation in Europe (OSCE). With a mixed market economy and a large welfare state, Denmark ranks as having the world's highest level of income equality. The country has the world's seventh highest per capita income.

Denmark’s area is 43,000 km^2 and there are 5,5 million inhabitants (without the Faroe Islands and Greenland). The estimated nominal GDP in 2011 is $ 310.7 billion (equal to Euro 230 billion) (*Source: Wikipeida.org*).

International binding goals by the use of RE and reduction of GHG emission are:

• 30 % renewable energy in the total energy consumption by 2020

• 10 % renewable energy in the transportation sector by 2020

• 20 % reduction by 2020 in greenhouse gas emissions (compared to 2005)

• 21 % reduction in greenhouse gas emissions as an average through the period 2008-2012 as compared to 1990 (Kyoto).

Main industries relevant for biomass use:

There are several large food producing companies in DK, like Danisco, Danish Crown, ARLA as well as numerous smaller companies. Carlsberg is the dominant actor in the brewery sector, but there are several others (smaller) like Bryggerigruppen and numerous micro-breweries with no real significance in amount. In the farmaceutical industry there are important companies like NOVO Nordisk and Lundbeck. There is one producer of cement in Denmark: Aalborg Portland. The total energy consumption in the Danish industrial sector including agriculture is 137 PJ in 2010, exclusive transport which counts for 200 PJ.

The use of biomass in the industry sector was around 10 PJ in 2010, mainly for heating purposes in farms and minor industries (wood processing industries with own wood waste). Aalborg Portland is the only large industry with a certain amount of biomass use in the production.

Aalborg Portland has as one of very few industries set up goals for energy and environmental management:

- 40% of the fuel energy for “grey production” shall be substituted by alternative fuels which reduces the CO_2 emission (long-term goal).

- Use of biofuels in order to reduce CO_2 emissions by 110,000 tons. In 2007, 30,000 tons bone meal has been used as fuel, reducing CO_2 emissions by 47,000 tons.

- 3% reduction in specific electricity consumption in 2010 compared to 131.4 kWh/ton TCE in 2005 (this has been reached already with a specific electricity consumption of 127,3 kWh/ton TCE).

Total energy production and consumption by source and sector:

Fig. 1: Total energy production by source, climate adjusted.
(Source: Danish Energy Agency statistics 2010)

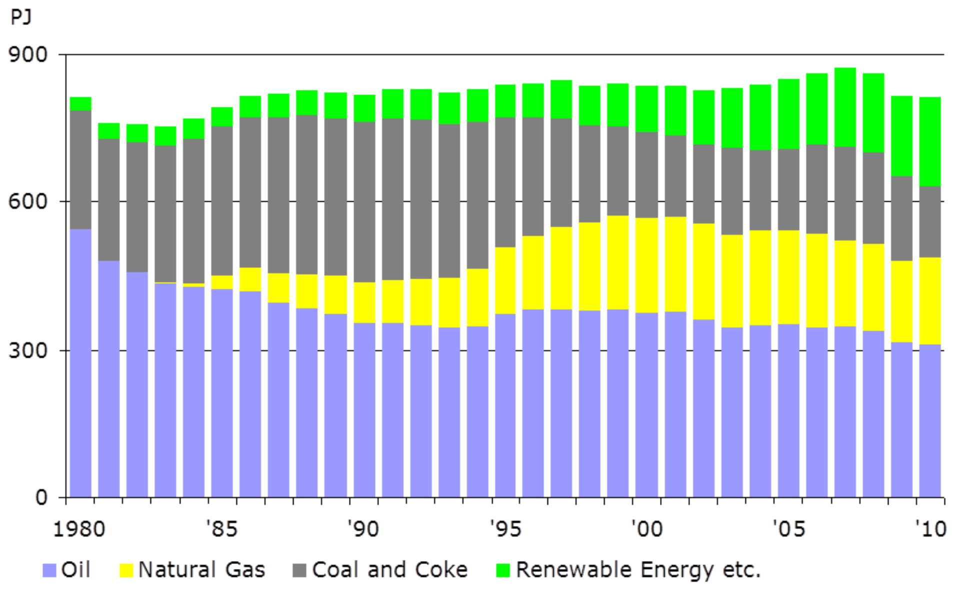


Fig. 2: Total domestic electricity production for other fuels than coal.
(Source: Danish Energy Agency statistics 2010)

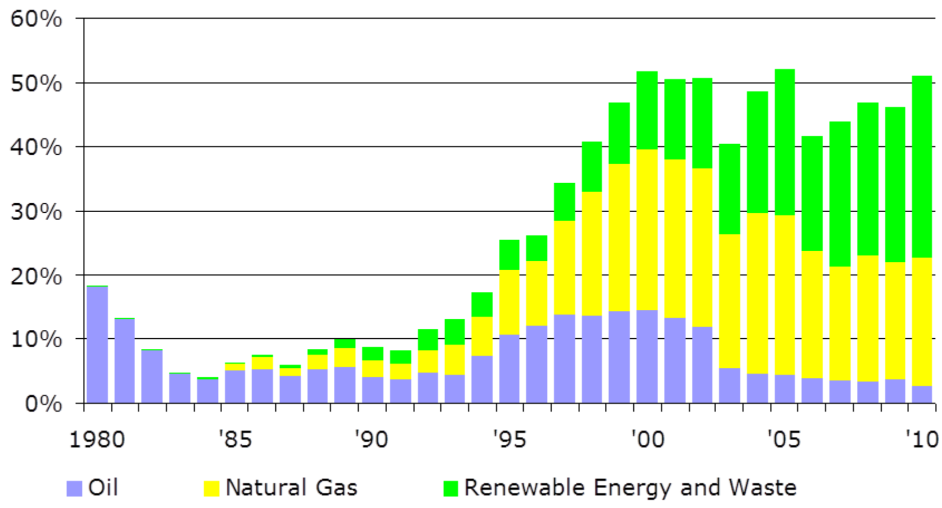
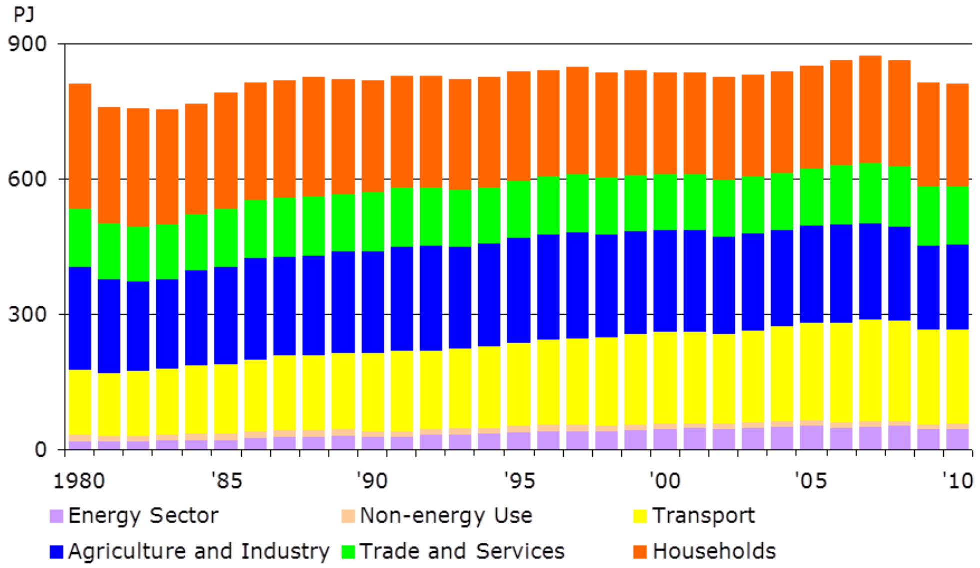


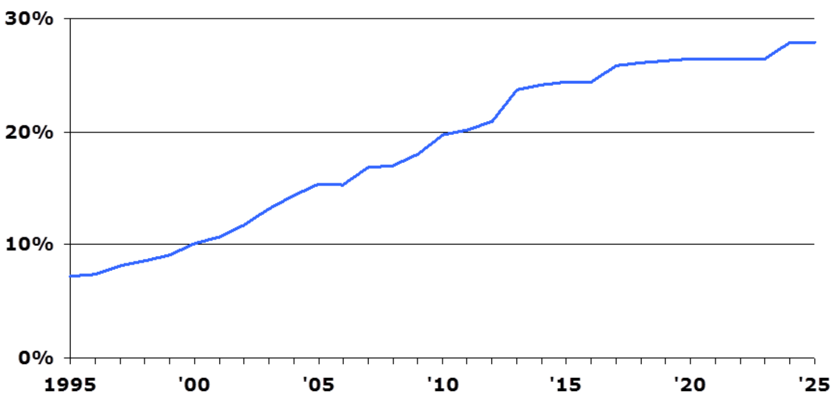
Fig. 3: Total energy consumption by sector. Climate adjusted. (Source: Danish Energy Agency statistics 2010)



2 Policy

Denmark has pursued an active energy policy since the 1970s, with energy saving and renewable energy as high priorities. There is still a need for on-going efforts in these areas in order to deal with the many challenges faced by society today, whether it is in relation to the climate or environment, economic considerations, or ensuring a high degree of supply reliability. It is the Danish government's policy that by 2020, Denmark will be a green, sustainable society and will be among the three most energy-efficient countries in the OECD. Denmark must also be among the three countries in the world that fulfils its renewable energy share up to 2020. In the RE (Renewable Energy) Directive, Denmark has already committed itself to an ambitious target of 30% renewable energy by 2020, which the government initially hopes to fulfil via national initiatives. The Danish Renewable Energy Action Plan describes the measures that will ensure energy savings and expansion with renewable energy up to 2020.

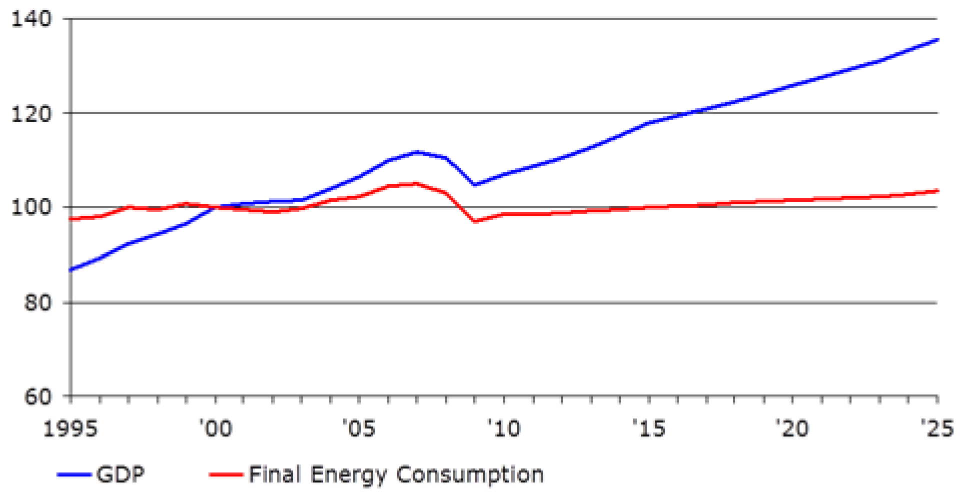
Fig. 4: Actual and planned consumption of renewable energy 1995-2025: Share of Gross Energy Consumption in %. (Source: Danish Energy Agency statistics 2010)



Measures for the promotion of renewable energy within the EU – including support schemes – are nationally based and like other EU countries, Denmark has developed its own national support system. It is, however, the Danish government's opinion that EU countries should also work together to avoid any inappropriate 'support competition' between Member States.

Since the 1980's, a decentralisation of Danish energy generation has taken place. Whereas generation of electricity and heat was previously dominated by a number of central power stations situated in the larger towns and cities, it now takes place in many different locations throughout the country. There is also a significant increase in co-generation and district heating based on excess heat, which has contributed significantly to the fact that Denmark is currently one of the most energy-efficient countries in the world. Since 1980, it has been possible to keep energy consumption more or less stable whilst achieving an economic growth of about 80 %.The plan is to keep this elation in the future. See Fig 5

Fig. 5: Actual and expected development of GDP and final energy consumption 1995 – 2025. Climate adjusted. Index for 2000 = 100
(Source: Danish Energy Agency statistics 2010)



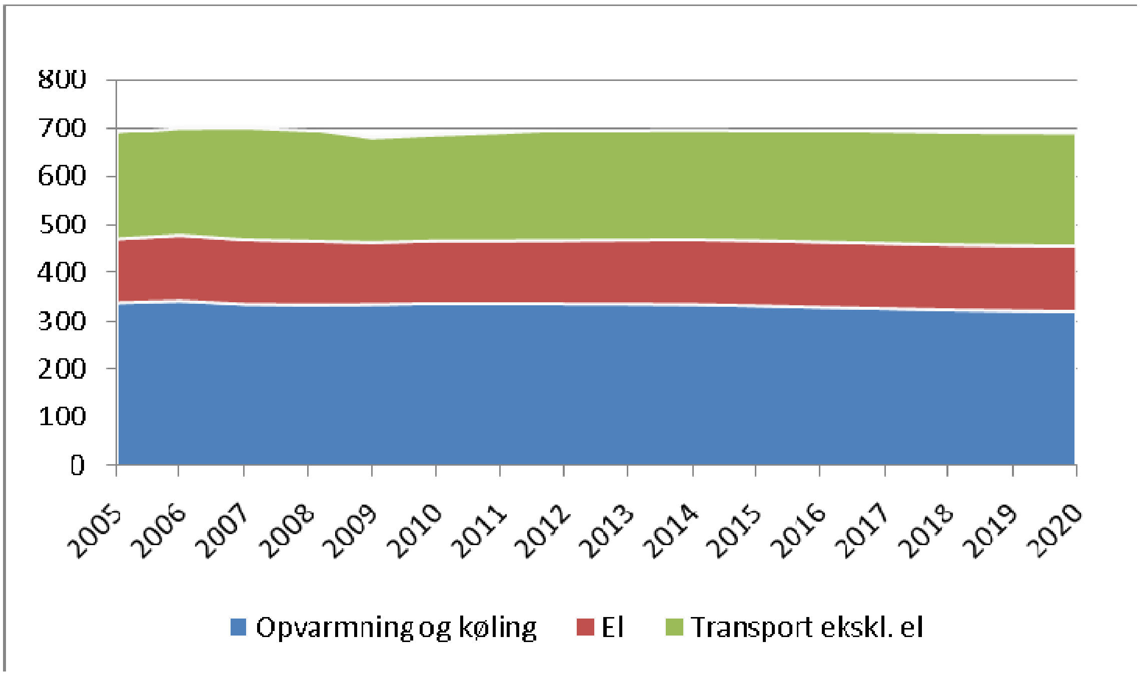
In February 2010, the government presented a report on security of energy supply, which illustrated some of the challenges facing the Danish energy system. In a few years, Denmark will be a net importer of fossil fuels. An active effort to achieve an effective and climate-friendly energy supply is necessary, not only to ensure a high security of supply and a robust economy, but also to achieve this in relation to climate policy targets. The report also indicates that in the long term the further inclusion of renewable energy itself may present a challenge to stability of supply. To achieve a more reliable inclusion of renewable energy, adjustments to the present electricity grid will be necessary, as well as achieving a greater degree of balance between electricity consumption and generation.

The government's Green Growth plan contains a number of initiatives for achieving its vision of a society committed to green behaviour and green technology in order to tackle the challenges of the environment, the climate and nature while at the same time creating a green growth economy. The plan includes the expansion of the agriculture's role as supplier of green energy such as energy crops and biogas. A Green Development and Demonstration programme has been established in connection with the agreement, which is intended to create a better connection between the research, development and demonstration of knowledge in the food, agricultural, fisheries and aquaculture sectors. The "Green Growth 2.0" agreement from April 2010 contains further initiatives intended to support the use of biomass from agriculture.

EXPECTED FINAL ENERGY CONSUMPTION 2010-2020

As a result of the Energy Policy Agreement of 21 February 2008, which states that there must be an annual energy saving corresponding to 1.5 % of the energy consumption, the energy saving initiative up to 2020 will be considerably greater than the initiative in the previous period. It should, however, be emphasised that there is great uncertainty about the development in energy consumption up to 2020 which is partly related to the current conditions for economic growth and developments in energy prices and partly to uncertainty about the sensitivity of energy consumption to changes in energy costs in the long term and uncertainty about the accumulated effect of the current energy saving initiatives up to 2020.

Fig. 6: The expected additional final energy consumption by use in PJ in accordance with the additional scenario, as also shown in Table 1. (Source NREAP 2010)



Legend:

Blue square: Heating and cooling

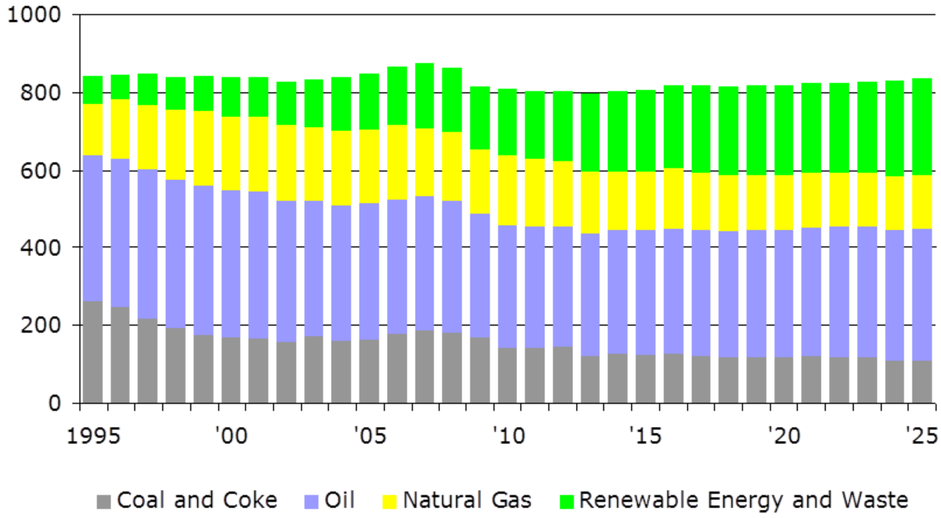
Red square: Electricity

Green square: Transport, excl. electricity

Table 1: National overall targets for the share of energy from renewable sources in gross final consumption of energy in 2005 and 2020 (Source: NREAP 2010).

Share of energy from renewable sources in the gross final energy consumption in 2005 in %	17
Target of energy from renewable sources in the gross final energy consumption in 2020 in %	30
Expected total adjusted energy consumption in 2020 in PJ	684
Expected amount of energy from renewable energy sources, corresponding to the 2020 target in PJ	205

Fig. 7. The expected gross energy consumption by fuel stated in PJ. There is a difference in this graph compared to Fig. 6, as Fig. 7 is climate-adjusted. (Source: Danish Energy Agency statistics 2010)



Price subsidies for biomass

With electricity produced by the burning of biomass, there is a price subsidy of 2 Euro cent per kWh, irrespectively of whether the electricity is produced by installations that solely use biomass, or installations that use a combination of biomass and other types of fuel. The scheme is optional and is administrated by the network companies that measure electricity generation, and Energinet.dk pays out the subsidy.

The support scheme is based on broad energy policy agreements and can be adjusted in accordance with new agreements. The subsidy was most recently amended by the RE Act which came into force in January 2009. The expected impact of the support scheme will be an increased use of biomass for electricity generation. There is no fixed end date for the scheme.

There are no requirements for compliance with energy efficiency criteria, and there is no set of minimum or maximum size for the systems that are eligible for support. A project may not take of advantage of more than one scheme.

3 Biomass Resources

An assessment of all the significant renewable resources in Denmark compared with the current consumption of renewable energy is included in the Danish National Renewable Energy Action Plan (NREAP 2010).

Table 2: Biomass potential calculated on the basis of a number assumptions on area use and based on recognised technology. There is no differentiation between annual and perennial crops. (Source: NREAP 2010).

Type of Biomass	Use 2008 in PJ	Unexploited potential in PJ	Conditions for potential evaluation
Straw	15	40	Current area use
Wood	41	10	Current use and forest areas
Energy crops	4	65	10% of the land area
Biodiesel/ethanol	5	20	Non-used straw, 40PJ. η = 50%
Biogas	4	35	Current generation of manure
Marine biomass	0	?	No data available
Total biomass	**64**	**125**	
Waste etc.	24	5	Estimated amount of waste 2020

The first row shows Danish biomass generation for energy in 2008. The second row shows further possible biomass generation from, for example, a more intensive utilisation of agricultural waste products etc., from the cultivation of energy crops, increased tree planting and the establishment of solar installations on ground areas that would otherwise be used for foodstuffs production. Resource calculations thus overlap. For example, straw resources of 40 PJ are assumed to produce bioethanol for the potential evaluation of bioethanol and therefore they cannot be used in co-generation.

It can be seen that significant un-utilized biomass potential exists in all areas (straw, wood, energy crops, biodiesel/bioethanol and biogas). With the right market conditions, the biogas potential of these can be harnessed. The development potential of biomass production for energy is discussed later in this section, which indicates that there is a good argument for the generation of 'energy wood' increasing over the coming years as a result of market forces and the price relationship between timber and energy wood. For the other types of biomass such as waste, straw and manure, it expected that changes in consumption and generation will run parallel. It is estimated that the share of manure in biogas generation is 50 %, as the remainder comes from organic waste such as abattoir by-products.

The estimated assumption is that 20 % of the un-utilized wood potential of 10 PJ will be exploited by 2020.

4 Current and Expected Future Use of Biomass

Current use of biomass

In Denmark, the use of solid biomass – especially wood and straw – for energy purposes is widespread, both in private dwellings, district heating plants and CHP and power plants as well as (although to a much smaller extend) in the industry. The use has increased rapidly and steady since 1980.

Fig. 8: Production of renewable energy by energy product 2010.
(Source: Danish Energy Agency statistics 2010)

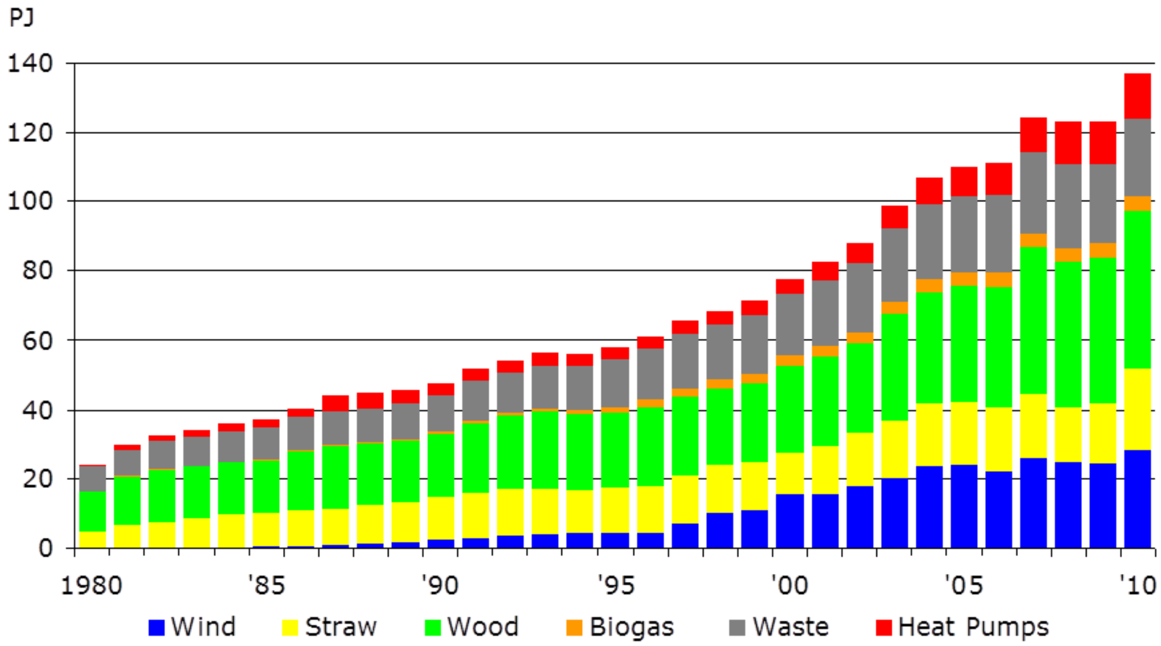


Table 3: The production and import in year 2010 in PJ of different RE sources (Source: Danish Energy Agency statistics 2010). Waste is household waste and industrial waste.

Source, PJ in 2010	Straw	Wood chips	Fire wood	Wood pellets	Wood waste	Biogas	Waste	Bio-diesel
Production	23.6	11.2	24.6	2.4	7.6	4.3	38.1	4.8
Import	0	4.8	2.1	27.7	0	0	0	1.1
Total	**23.6**	**16.0**	**26.7**	**30.1**	**7.6**	**4.3**	**38.1**	**5.9**

Expected future use of biomass up to 2020

According to the Danish NREAP the calculated development of renewable energy consumption in the electricity, heating and transport sectors measured in growth in RE in the gross final energy consumption in the period up to 2020 is:

The renewable energy in the **electricity sector** comes almost exclusively from wind power (estimated at 70.3 % of the total consumption of renewable energy in 2010) and biomass, i.e. straw, wood, biodegradable waste and biogas (estimated at 30.3 % in 2010). Consumption of renewable energy in the electricity sector was estimated to increase by 65%, from 12.4 TWh (44.6 PJ) in 2010 to 20.6 TWh (72.2 PJ) in 2020.

Renewable energy in the **heating sector** comes primarily from biomass, i.e. straw, wood, bio-oil and biodegradable waste (estimated at 90.5% in 2010). The contribution of renewable energy in the district heating sector in 2010 was estimated at 40.4 % of the total consumption of renewable energy for heating. Consumption of renewable energy in the heating sector was estimated to increase from 103 PJ in 2010 to 127 PJ in 2020, in other words by 20%.

The consumption of renewable energy in the **transport sector** was calculated as being 1.7 PJ in 2010, rising to 10.8 PJ in 2012 and 12.2 in 2020. Biofuels are thought to constitute the largest part of this, with 1.3 PJ in 2010, 10.2 in 2012 and 10.9 in 2020. Consumption of renewable energy by electric trains and vehicles makes up the rest with 0.5 PJ in 2010 and 2012 (only electric trains) and 1.2 in 2020 (electric vehicles and trains). The consumption of renewable energy in the transport sector is thus estimated to increase from 1.7 PJ in 2010 to 12.2 PJ in 2020, which is more than seven times higher. See Fig. 6.

Biomass from the sea

A number of algae types occur naturally in Danish waters. It is quite possible to utilize this biomass production for energy generation. For example, experiments with sea lettuce in tanks have shown that with the addition of nutrients etc., it is possible to achieve a dry material yield per area unit that can be 3-4 times higher than traditional land-based biomass. It would seem that algae can be used as raw material, not only for the generation of ethanol or biogas, but also for fodder and other pharmaceutical products. However, it is currently impossible to present an assessment of the combined potential for the use of sea algae biomass.

5 Current Biomass Users

In Denmark, the use of biomass for energy purposes is widespread, both in private households, district heating plants, CHP plants and large power plants. Industries use minor amount of biomass for heating purposes, and farmers use quite a lot of straw for heating and grain drying purposes.

Table 4 below for biomass end use in Denmark can be compared with Table 3 where the different biomass sources are listed.

Table 4: List of end users of biomass for energy purposes. Waste is household waste and industrial waste (Source: Danish Energy Agency statistics 2010).

End use, PJ in 2010	Straw	Wood chips	Fire wood	Wood pellets	Wood waste	Biogas	Waste	Bio-diesel
Large power plants	10.3	5.1	0	15.2	1.0	0.03	0	0
CHP plants	3.6	2.7	0	0.15	0.45	1.9	9.8	0
District heating plant	4.9	6.4	0	2.9	0.6	0.1	0.56	1.9
Small CHP	0	0.58	0	0	0.42	1.15	22.8	0
Small scale	0.04	0.01	0	0	0.49	0.08	2.8	0
Road transport	0	0	0	0	0	0	0	1.1
Farms	1.9	0.03	0	0	0.01	0.45	0	0
Industries	0	1.0	0	0.95	4.6	0.13	1.7	0
Public, private service	0	0.15	0	0.8	0.01	0.44	0.42	0
Private households	2.9	0.08	26.7	10.1	0	0	0	0.02
Export	0	0	0	0	0	0	0	2.9
Total in PJ	**23.6**	**16.0**	**26.7**	**30.1**	**7.6**	**4.3**	**38.1**	**5.9**

6 Biomass Prices

Prices on **straw** and **wood chips** to district heating plants are quite stable, with a tendency for slight increase in both prices. The price for straw is calculated at 15% humidity, and the price for wood chips is calculated at 45% humidity. There are no price statistics from the utility companies (power plants).

Table 5: Prices for straw and wood chips delivered to district heating plants. (Source: Danish District Heating Association).

End user excl. VAT	2010
Straw in bales	73 Euro/t
Wood chips	5.8 Euro/GJ

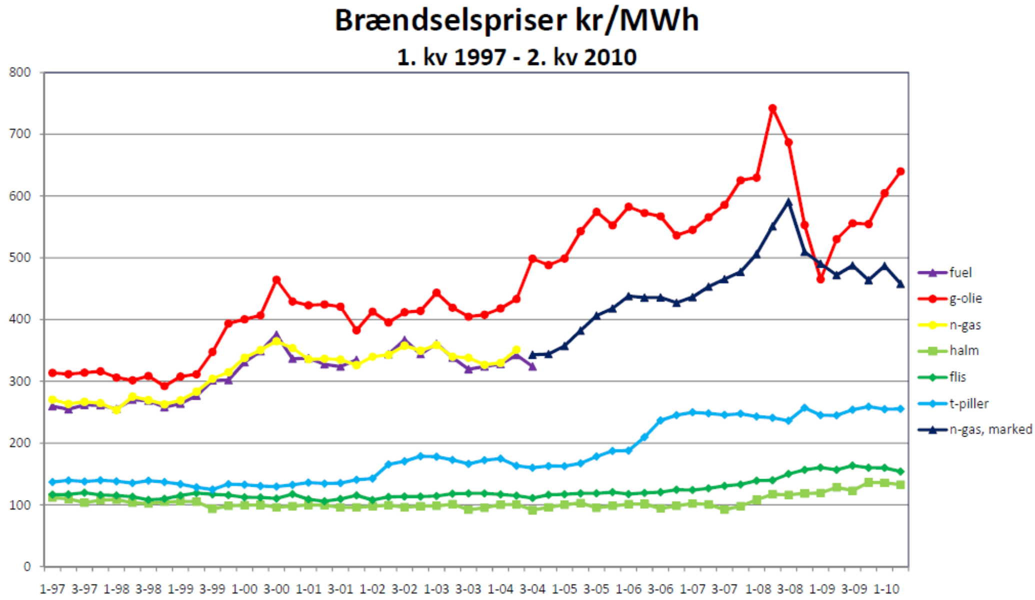
The price on **wood pellets** has been quite stable in the last years for district heating plants and for private consumers. The price for truck delivery to private consumers in a quantity of 5-6 tons is 216 Euro/tons excl. VAT, which in Denmark is 25%. For district heating plants the price is lower due to purchase of large amounts and due to the often lower quality compared to what private consumers purchase. There are no price statistics from the utility companies (power plants).

Table 6: Wood pellets delivered by truck to end user in quantity over 5 tons. Prices are without VAT. In Denmark VAT is 25%. (Source: PelletAtlas, Danish District Heating Association and private information).

End user excl. VAT	2008	2009	2010
Private households	214 Euro/t	214 Euro/t	216 Euro/t
District heating plants	161 Euro/t	165 Euro/t	166 Euro/t

The price on **fire wood** for private households varies a lot depending on the user's ability to produce the fire wood himself, or it is bought from grocer's market. It is possible to buy dry fire wood (often imported from the Baltic area) to a price of 100 Euro/M^3 excl. VAT.

Fig. 9: Development in fuel prices for Danish district heating plants for the period 1997-2010. Currency: DKK. Exchange rate: 750 DKK = 100 Euro (Source: Danish District Heating Association).



Legend:

Heavy fuel oil: Magenta

Light oil: Red

Natural gas: Yellow

Straw: Green (lowest graph)

Wood chips: Green

Wood pellets: Blue

Natural gas, market price: Black

7 Biomass Import and Export

In Denmark biomass is imported in (relatively) considerable amounts compared to the Danish production and consumption of biomass. The figures in Table 3 and 4 show that 22.7% of the biomass used is imported. This is 34.6 PJ of wood chips, fire wood, wood pellets and biodiesel. In addition, 2.9 PJ biodiesel is exported due to the high taxation of transportation fuels in Denmark.

Table 7: Biomass import to Denmark, 2010. (Source: Danish Energy Agency statistics 2010 and private information).

Biomass Import	PJ	Lower heating value GJ/t	Average humidity in %	Tons	Main country of origin
Wood chips	4.8	12	30-35	400,000	Balticum, Russia
Fire wood	2.1	15	20	140,000	Poland, Balticum
Wood pellets	27.7	17.5	8	1,580,000	Balticum, Sweden, Russia, Poland, Canada
Biodiesel	1.1	37.6	0	29,000	?

Wood pellets and wood chips are imported, especially from eastern European countries and Canada, to cover the increasing demand for private small-scale, medium-scale (district heating plants) and large-scale (CHP and power plant) consumption. Fire wood is imported (8% of the consumption) from the Baltic area by boat or truck. In 2012 a new trade route has started from Ghana to Denmark with wood chips from old plantations of rubber trees. It is the energy company Verdo that over the next 5 years imports 750,000 tons wood chips from rubber trees. Verdo runs two medium-sized CHP plants in Jutland.

Straw is exported, mainly to Germany and the Netherlands, but in some years also to Austria, Belgium and France. It should be noted that the exported straw may be used for feeding and bedding for animals and not for energy production; however, it is not possible to distinguish between exported straw for bioenergy and non-bioenergy use; and anyway the mechanisms regarding the international trade are the same, and considerations regarding barriers and opportunities are therefore relevant in this context. In the statistics from the Danish Energy Agency there is no export/import of straw listed for energy purposes. In any way, the import of straw for energy purposes is considered to be negligible at the moment, and there are no statistics so far.

In general, the potential for international straw trade is considered to be considerable, with more countries turning towards exploiting straw as an energy source. But straw has to be turned into a bulk commodity (pellets) before there will be a regional or international market for trade of straw.

8 Barriers and Opportunities

The main market drivers are that there is no tax on biomass and that the utility companies are forced by government decrees to use biomass in large amounts. As mentioned in Chapter 2 there is a price subsidy of 2 Eurocent per kWh. In the early biomass days in the 1980'es and 1990'es there was heavy investment support (up to 25%) on new biomass plants, both CHP and heat production plants. The price subsidy for electricity production was even higher at that time than today. In addition there have been heavy taxes on fossil energy since the 1970'es.

The barriers are that the supply chain for pellets needs large investments, overseas ship transport, new storage facilities under roof and modifications for in house transport systems, milling systems and burners.

Danish Act no. 638 of 03.07.1997 defines what biomass is and what waste is. Wood, straw, kernels, nuts, shells, etc. are extempted for tax (as waste) if they are listed in the Act.

A wide range of renewable sources can be used for the energetic utilization in combustion systems. In Denmark biomass is defined according to the Danish Act no. 638 of July 3 1997 on biomass waste. Any type of biomass or mix of biomass that is not mentioned in the annex to the act is defined as waste and must be handled and approved according to the EU Waste Incineration Directive in terms of temperature and retention time during combustion in an incineration plant. Furthermore, a waste tax is due. The following biomass is defined according to the Danish Act no. 638 of 1997.07.03:

- raw wood incl. bark, forest wood chips
- clean wood including shavings and saw dust
- wood waste from the production and treatment of clean laminated wood
- straw
- kernels and seeds from fruits and berries
- fruit residues
- nut and seed shells
- untreated cork, grain and seeds, cotton and flax
- lolly sticks and green pellets (dried grass, clover etc.)
- malt, thatched roofing and tobacco waste
- fuel pellets or fuel briquettes produced exclusively from wastes.

There is no tax on the listed biomass, and they can be traded free for taxation, but a small sulphur tax is imposed with effect on straw. In this context there is tax on household waste and wood contaminated with glue, and these fuels are taxed when delivered to incinerator plants for energy generation.

Fig. 10: Normal transport of straw for large scale energy use. There are 24 big bales in two layers on the truck and trailer, with a total weight of 12 tons. Unloading takes place with an automatic crane taking 12 bales in one lift. Weight of the bales and water content is measured during the unloading process.

A barrier for regional and international straw trade is that the logistic system developed in Denmark for handling up to 2 million big bales annually is based on short distance transport, in average 100-200 km, on truck. There are two main problems:

- The density of the bales are low, 120 kg/m^3 , pellets have 650 kg/m^3

- Big bales are not a bulk commodity which can be stored and transported as wood pellets, coal, wood chips and granulates.

Another barrier in the Danish Archipelago is that toll bridges and ferries prevent "free trade" in the region. A one way ticket for a truck crossing the Great Belt Bridge costs 150-200 Euros depending on the size of the truck. The value of 24 bales the truck can carry is 880-900 Euros. It is obviously not possible for the farmers to have straw contracts at the other side of a toll bridge in Denmark.

Standards, classifications etc. on biomass are made to make trade easier. On the contrary, rigid standards for product quality may in some cases be a barrier, because many biomass types have a natural variation in quality parameters depending on external factors beyond the control of the producer. This is indeed the case with straw, where the weather conditions in growth seasons and especially during harvest determines many of the most important combustion characteristics of the straw.

9 References

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