IEA Bioenergy TASK 40

Sustainable International Bioenergy Trade - Securing Supply and Demand

Country report 2014 for Denmark

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Content

Preface

Danish know-how within bioenergy technology is much in demand and the country serves as an industry hub and testing ground for modern energy technology i.e. liquid/solid biofuels and biogas. Denmark is a leader in the development of combined heat and power plants (CHP) and Danish technology is among the best when it comes to turning waste and biomass into energy in CHPs.

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 2013.

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 area is 43,000 km^2 and there are 5,5 million inhabitants (without Faroe Islands and Greenland). The estimated nominal GDP in 2013 is $ 330.6 billion (equal to Euro 289,3 billion). (*Source: World Bank*)

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 127 PJ in 2013, exclusive transport which counts for 202 PJ.

The use of biomass in the industry sector was around 10 PJ in 2013, mainly for heating purpose 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 reduce 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.

Total energy production and consumption by source and sector:

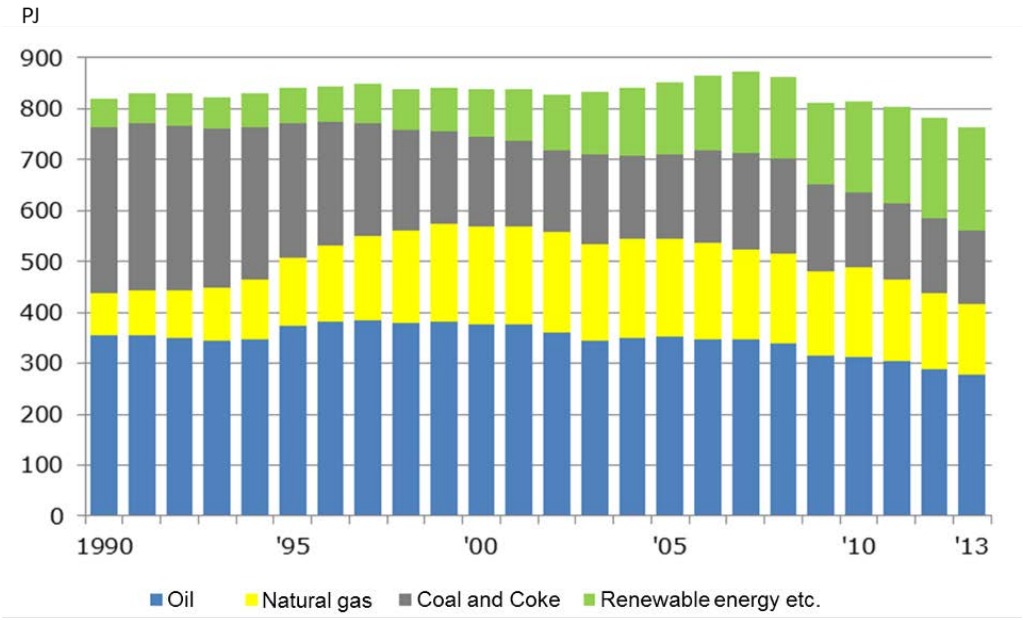

Fig 1: Total energy production by source, climate adjusted.: (Source: DAE 2014c).

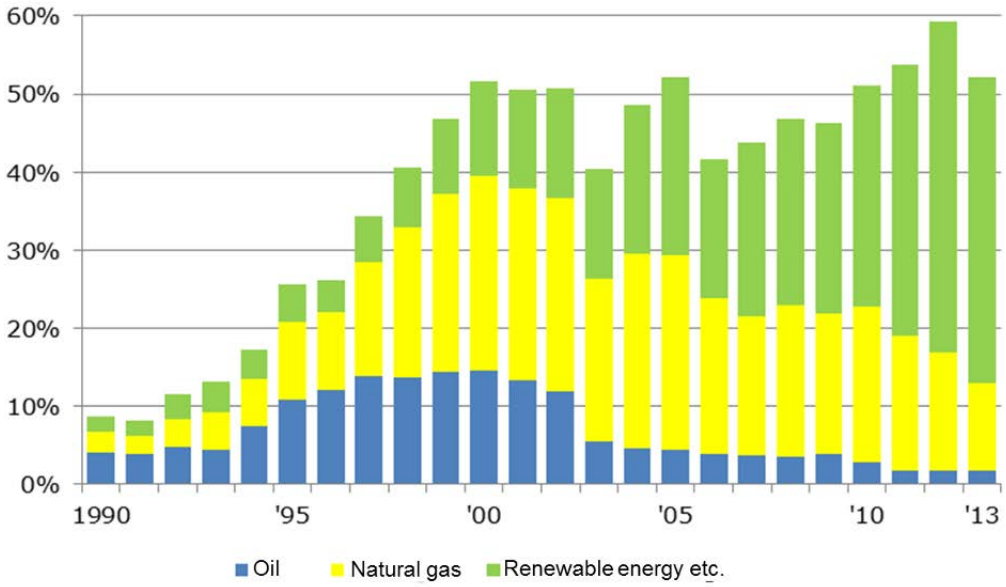

Fig 2:Total domestic electricity production for other fuels than coal. (Source: DAE 2014c).

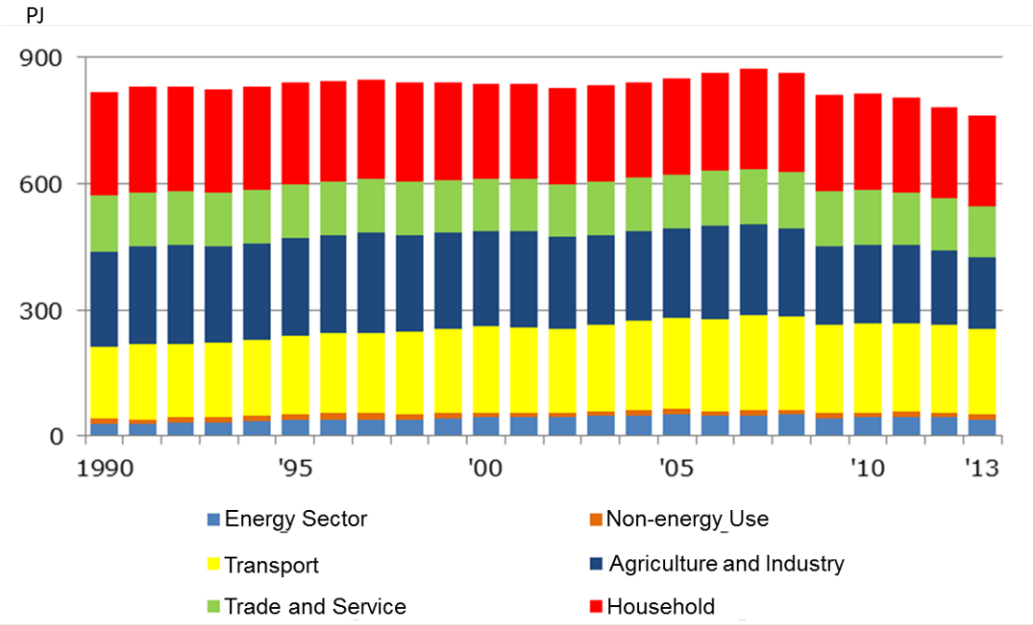

Fig 3: Total energy consumption by sector. Climate adjusted. (Source: DAE 2014c).

2 Domestic biomass resources, current use, trends, and main users

Resources and production of bioenergy

Production of bioenergy in Denmark has increased steadily since 1990. In figure 4, it can be seen that especially energy production from wood and waste has increased.

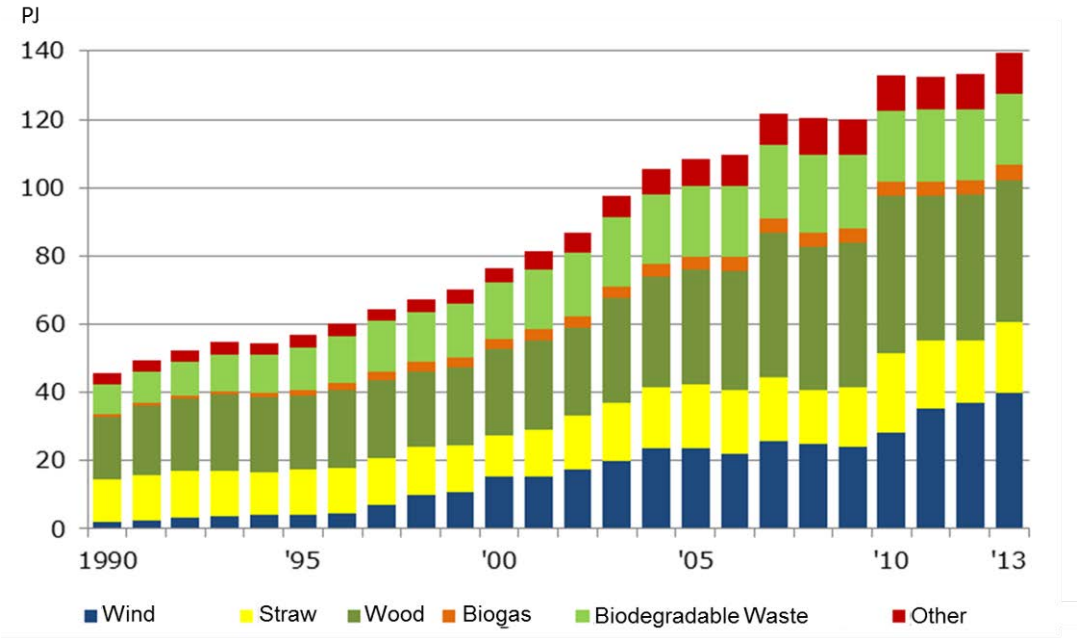

Fig 4: Production of renewable energy by energy product, 1990-2013. (source: DAE 2014c)

Use of biomass for bioenergy

Renewable energy accounts for some 27% of the total energy consumption in Denmark in 2013. The biomass account for some app. 140 PJ. The use of different biomass sources for bioenergy in Denmark in 2013 is listed in Table 1.

Table 1: Use of biomass in Denmark 2013 (Source: DAE 2014c)

Type of Biomass	Use 2013 (PJ)
Straw	21
Wood	40
Wood pellets	34
Wood residues	9
Organic waste	21
Biofuels	10
Biogas	5
Total biomass	**140**

Main users of biomass for bioenergy

In Denmark, use of biomass for energy production is widespread, both in the private and public sector.

Straw and domestic wood resources are used in private boilers as well as for district heating, CHP and power plant. However, In recent years, there is a trend of several plants switching to imported wood pellets.Wood pellets are also used in private boilers for heating.Organic waste is incinerated and used for district heating.

At present, there is a production of biodiesel from animal waste, DAKA. A pilot scale plant for ethanol production from straw exist in Kalundborg, INBICON. Other than that, biofuels are imported.

Aquatic biomass

In the Danish country report from 2010, the potential for bioenergy production from aquatic biomass was discussed. Since then, further economic assessments have been carried out.

At present, the general understanding in Denmark is that cultivation/harvesting of aquatic biomass with production of bioenergy as the main end product is not feasible with the prevailing conditions. So, in order to produce substantial amounts of bioenergy from this source, the aquatic biomass has to be processed in biorefineries with production of higher value products as main target.

3 Policy support and expected biomass use in 2020 (and beyond)

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 ongoing 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 Danish government 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 countries that fulfils its renewable energy share up to 2020. In the RE (Renewable Energy) Directive, Denmark has committed itself to an ambitious target of 30% renewable energy by 2020.

The Danish Renewable Energy Action Plan describes the measures that will ensure energy savings and expansion with renewable energy up to 2020.

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 %. In fact, the plan is to keep this trend in the future (See Fig 5) by further focus on energy effeciency in the whole system.

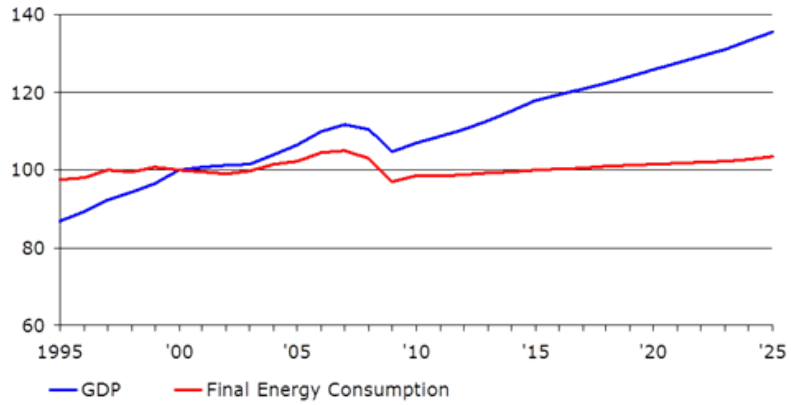

Fig 5: Actual and expected development of GDP and final energy consumption 1995 – 2025. Final energy consumption is climate adjusted, i.e. adjusting energy during e.g. a harsh winter to an average winter. Index for 2000 = 100. (Source: DAE 2010)

The government's Green Growth plan contains a number of initiatives for achieving its vision of a society which is 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 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.

The Danish Energy Agency (DEA) has defined different scenarios for a fossil free energy supply by 2050 and with fossil free production of heat and electricity by 2035. The main conclusions are:

Bioenergy is a limited resource. Since Denmark is a small country, there is an option whether to regulate in order to create a fuel-based system with large import of biomass or an electricity-based system with limited use of biomass corresponding to domestic resources. If the target of fossil free energy supply by 2050 is to be met, that choice probably has to be taken shortly after 2020 as important transitions necessary to achieve these changes, for example expansion of wind energy production, takes time. The choice essentially addresses the wish for independency of foreign resources.

Expected future biomass use until 2025

Based on current regulations and implemented initiatives in the energy and transport sector, the share of renewable energy in Denmark is expected to amount to approximately 35 % by 2020, and thereby exceed the targeted obligation of 30 %. More than half of this renewable energy will be produced based on biomass. Overall, the use of all types of biomass is expected to increase from 132 PJ in 2012 to 166 PJ in 2020 and is also expected to be the most widely used renewable energy source in 2025 (Figure 6). In the fossil free vision of 2050, there could be a number of scenarios for consumption of biomass varying between about 200 and 700 PJ.

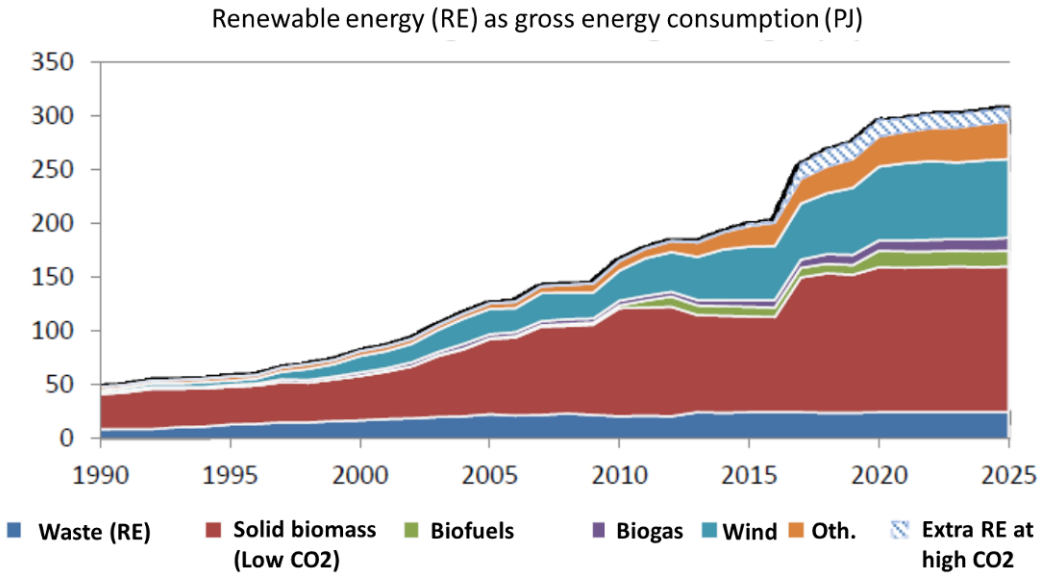

Fig 6: Renewable energy in gross energy consumption at a low share price, adjusted for climate and energy trading, where the shaded area shows the expected additional volume VE at high allowance price, primarily an increased amount of solid biomass (PJ) – (Source: "Danmarks energi og klimafremsskrivning 2014", DAE 2014)

Taxes supporting biomass for bioenergy

Consumption of energy in Denmark is regulated by energy and environmental taxes, particularly through environmental taxes on methane, SO_2, NOx and CO_2, and energy taxes on coal, waste fuels, gas, oil and electricity. Biomass is supported as there is no energy or CO_2-tax on renewable fuels

While the energy taxes vary depending on whether the energy consumption is used for transport, production processes, heating and other household purposes, or power production, the environmental taxes do not differentiate between application and are applied on all fuels based on their agreed content of S, N and calorific value.

An exemption is in place for the CO_2 emitted from processes and power generation included in the EU CO_2 Emission Trading System (EU-ETS).

Price subsidies supporting bioenergy produced from biomass

Financial support by feed-in premium tariffs for renewable power produced from biomass has been existing in Denmark since the Biomass Agreement of 2000, but has been modified several times since then. The support is now extended to all renewables and collected via the public service obligation (PSO) tariff paid for by the electricity consumers. The support is administered by the grid operator Energinet.dk. Historically, the support has been mainly given to power produced from the combustion of solid biomass (0,15 DKK/kWh = 0,02 €/kWh) but with the Energy Agreement of 2012, new schemes for supporting the use of biogas and gasification gas for CHP were implemented, too. These price premiums are significantly higher than for power from

solid biomass, but are adjusted annually based on the price of natural gas, and can also vary from plant to plant.

In addition to these subsidies on power production, the energy agreement of 2012 has also given new contractual freedom to the central CHP and the district heating systems they supply to utilise tax advantage for biomass on the distribution of the heat. Certain conditions must be met: there must be a supply of biomass for hot water or steam, pricing must then be based on an agreement between the central power plants and its heat distributer (district heating company) and the parties can only be free to allocate the tax advantage when the heat purchaser is a municipal or consumer-owned collective heat supply. The change has given incentive to increase biomass conversion at the central CHP plants.

4 Biomass prices

Price on **straw** and **wood chips** to District Heating plants are quite stable, with a tendency for slight increase in both prices (see fig 7). The price for straw is calculated at 15% water content, and the price for wood chips is calculated at 45% water content. There are no price statistics from the utility companies (power plants).

Table 3: Prices for straw and wood chips delivered to district heating plants. Source: Danish District Heating Association and private information.

End user excl VAT	**2013**
Straw in bales	76 Euro/t
Wood chips	22 Euro/MWh

Price on **wood pellets** has been stable in recent 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 approximately 220 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 consumer purchase. The price given in table 6 is an average that covers quite a large span between the most expensive and the cheapest prices. There are no price statistics from the utility companies (power plants).

Table 4: Wood pellets delivered by truck to end user in quantity over 5 tons. Price without VAT. In Denmark VAT is 25%. (Source: PelletAtlas, Danish District Heating Association and personal information)

End user excl VAT	**2010**	**2013**
Private households	216 Euro/t	220 Euro/t
District Heating plant	166 Euro/t	165 Euro/ton

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

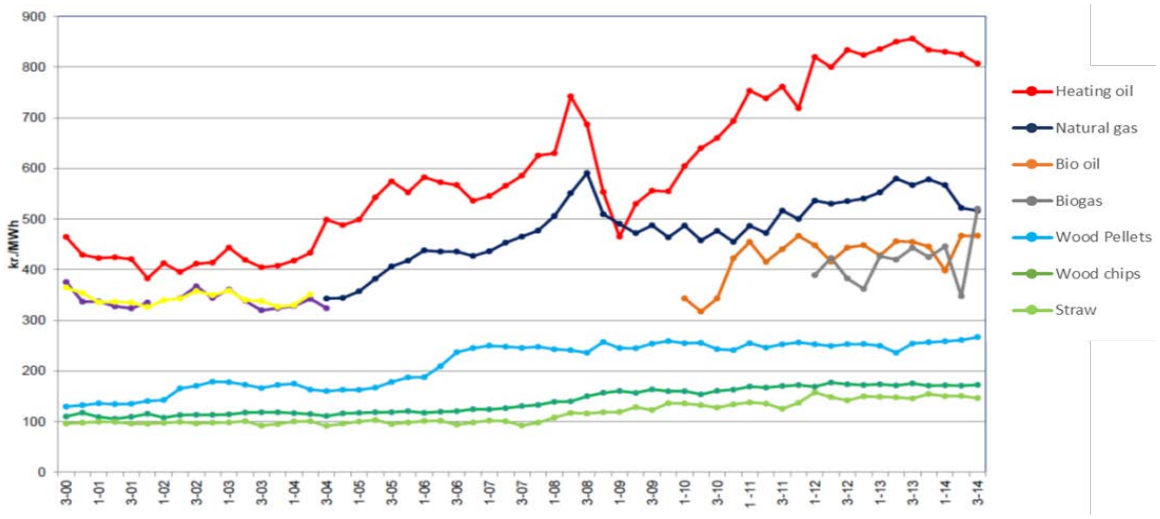

Fig 7: Development in fuel prices for Danish District Heating plants for the period 1997-2014. Currency: DKK. Exchange rate: 750 DKK = 100 Euro (Source: Danish District Heating Association)

5 Biomass import and export

In Denmark, biomass is imported in considerable amounts, compared to the Danish production and consumption of biomass. In 2013, 47,8 PJ of biomass was imported to Denmark, resembling 34 % of the biomass utilised for energy. The major part is constituted by the import of wood pellets mainly for the use of replacing coal in large scale CHP plants.

Table 5: Biomass import to Denmark 2013. (Source: Danish Energy Agency statistics 2014 and Danish Oil Industry Association).

Biomass **Import**	PJ	Lower Heating value GJ/t	Average humidity in %	Tons	Main country of origin
Wood chips	6,05	12	30-35	400.000	Balticum, Russia
Fire wood	3,07	15	20	140.000	Poland, Balticum
Wood pellets	32,3	17,5	8	1.580.000	Balticum, Sweden, Germany, Russia, Poland, Canada
Biofuels (Bioethanol + Biodiesel)	6,5	26,7 BioEt 37,6 BioDi		~260.000	Main import from other EU countries

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 especially the large scale (CHP and power plant) consumption. Fire wood is imported 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 who over the next 5 years will import 750.000 tons wood chips from rubber trees. Verdo runs 2 medium size CHP plants in Jylland.

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. In any case, 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,no export/import of straw is listed for energy purpose. Anyhow, 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 substantial, with more countries turning towards exploiting straw as an energy source. But straw has to be turned into a bulk commodity (pellets or briquettes) before there will be a regional or international market for the trade of straw.

Biofuels are mainly imported, but a small amount of biodiesel (0,9 PJ) is produced from animal fat of mainly pig carcases. This fuel is exported due to the high taxation of transportation fuels in Denmark. The export is however declining as the Danish demand for biofuels, both biodiesel and bioethanol, is increasing due to laws of at least 1% biofuels blend in transport fuels.

Import of biofuels is mainly from EU-countries but a significant amount of palm-oil derived biodiesel, imported from Asia, is also part of the mix (Danish Oil Industry Association).

6 Drivers and barriers

The main market drivers are that there is no tax on biomass and that the utility companies are forced by Government decree to use biomass in large amounts. As mentioned in Chapter 5, since 2001, a price subsidy of 15 øre/kwh (2 Euro cent /kWh) is in place. In the early biomass days in the 1980's and 1990's, there was heavy investment support (up to 25%) on new biomass plants, both for CHP and pure heat production plants. The price subsidy for electricity production was even higher at that time than today. In addition, there has been heavy taxation of fossil energy since the 1970's.

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 is biomass and what is waste. Wood, straw, kernels, nuts, shells, etc are exempted for tax (as waste), but only if they are listed in the Act.

A wide range of renewable sources can be used for the energetic utilisation 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 03.07.1997:

- 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 8: 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 up to 100-200 km, on truck. 2 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 Euro depending on the size of the truck. The value of 24 bales the truck can carry is 880-900 Euro. It is obviously not possible for the farmers to have straw contracts at the other side of a toll bridge in Denmark.

Standards, classification 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 season and especially during harvest determines many of the most important combustion characteristics of the straw.

The expected increase in biomass consumption – and import – towards 2020 presents a number of challenges regarding sourcing of sustainable biomass at reasonable price.

From most of the expected exporting countries, pellets and wood chips based on different types of residues as well as some environmental optimized forestry can be purchased. In addition, there will probably be wood fuels on the market, where forests are harvested for the sole purpose of supplying energy and thereby challenging the sustainability.

At the same time as Denmark is converting its energy system from fossil fuels to renewables, the global demand for biomass for food, energy, materials, chemicals, etc. is increasing, too; in particular due to the increase in global population and increased general transition away from fossil fuels.This increased demand could lead to higher global prices of biomass, which may affect the utilization of biomass resources in country depending mainly on import of these resources.

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