Biomass Statistics: Straw

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Prepared for the Danish Energy Agency by FORCE Technology

Objective

Figures for consumption of straw for energy in the national Danish energy statistics are based on many different sources and calculated based on several not easily available assumptions. The purpose of this document is to make publicly available the background for the figures used in the period 1972 to 2010.

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Definitions

Straw

Agricultural residue collected in a naturally dried state from agricultural land.

Pellets made from straw are in recent years in use in a significant amount (in the order of 5 % of the total national consumption). Consumption takes place in one power plant, Amagerværket Unit 1, located near Copenhagen. All consumption figures for straw pellets are included in the data for straw. Even though the moisture content in straw pellets may be slightly lower (in the order of 10 % versus straw in bales 15%), the two products are accounted for equally ton for ton in the statistics.

Heating value

Lower heating value per metric ton of straw in the form the fuel is available to the market.

Calorific value

The calorific value used for straw in energy statistics is a net calorific value of 14.5 GJ/ton. This figure is used today for the whole period discussed **1972-2010**. However originally a figure of 15.0 GJ/ton was used for the period **1972-1990**; this was changed to 14.5 in 1991 also for the previous years.

The figure 14.5 is determined from a dry matter calorific value of 17.5 GJ/ton based on numerous laboratory analyses. Two detailed studies in the mid 1990'ies have established the water content of straw as a large-scale market average to be 15%.

The calculation from dry matter heating value follows the formula:

$$17.5 \text{ GJ/ton} \cdot 0.85 - 2.45 \text{ GJ/ton} \cdot 0.15 = 14.5 \text{ GJ/ton}$$

Figures for consumption

Agriculture and Forestry

The annual consumption of straw in farms is determined from the number of farms with a straw boiler unit multiplied with the average consumption per unit.

Straw used for heating in farms is divided into straw used for heating in the private house (which in the national energy statistics is categorized as heating of single family houses) and heating used for process purposes (heating of farm outhouses, grain drying etc.) on the farms. This is done using an allocation factor.

In the following the methods for determination of the number of units is described and evaluated, followed by details on the method used for determination of the average consumption of straw per unit.

Number of installations in farms

From **1972** to **1979** the total amount of straw used for energy in farms is a best estimate, made by the Danish Energy Agency. By dividing with the average consumption per farm the number of installations can be determined (Dal, 2000). These are shown in the time series table.

From **1980** to **2010** figures for number of installations has been determined from Statistics Denmark data presented in their annual LG surveys. In some years these data were missing; interpolated value is used. In the latter years up to 2010 a constant figure corresponding to the number used for 2001 has been used as verified more recent data is not available.

Year	Method, sources, assumptions
1972 – 1979	DEA Total consumption divided by consumption per unit
1980 - 1982	Statistics Denmark, Nygaard, 1993
1983	Interpolated between 1982 and 1984
1984 - 1985	Statistics Denmark, Nygaard, 1993
1986 - 1987	Interpolated between 1985 and 1988
1988	Statistics Denmark, Nygaard, 1993
1989	Interpolated between 1988 and 1990
1990	Statistics Denmark, Nygaard, 1993
1991 - 1992	DEA: estimated = 1990
1993 - 1994	Interpolated between 1992 and 1995
1995 - 1998	Statistics Denmark
1999	Interpolated between 1998 and 2000
2000 - 2001	Statistics Denmark
2002 - 2010	DEA: assumed = 2001

Table 1: Origin of and assumptions behind annual figure for number of farm scale boilers, 1972 to 2010

In earlier versions of the national energy statistics other methods has been used. Originally the 1972 to 1979-type of rough estimate were also used for the period **1980** to **1987.** In 1987 it was decided to use the number of installations determined by Statistics Denmark in their annual LG surveys. The statistics was then changed back in time, using the number of units determined in the LG surveys 1980 to 1987.

Also in earlier versions of the statistics data from another Statistics Denmark survey, the HFT Survey has been used assuming this could add precision of the data. However in 2001 it was recognized, that

the use of different sources (LG survey in some years and HFT survey in others) introduced unexpected increase/decrease in straw consumption. Thus it was decided to use only figures from the LG surveys, and use interpolated figures for years with missing data. Previous figures for the years **1992** to **2000** were then changed.

There is a step in number of installations from 1979 to 1980, which is explained by the different methods applied before and from 1980. This indicates that the number of installations estimated in the end of the 1970'ies might be too low. However changes in the market, such as the oil crisis and the subsidy scheme to farms for installing straw combusting units, can also explain part of the big difference. In any case it is difficult to re-evaluate the number of installations from 1972 to 1979 without new data.

A steep increase took place from 1980 to 1985, which may also be explained by the oil crisis and a subsidy scheme valid at that time. From 1985 the number of units has been stable until 1990, where the number of units started to decrease.

Consumption per installation

In the end of the 1980'ies average consumption per unit was estimated to 35 tons annually. In the HFT 1992/93 it was determined that the average unit consumption was around 50 tons (Nygaard, 1993). As the basic data in the 1970'ies was an estimation of the total amount of straw used, this meant the estimated number of installations was reduced accordingly. Nygaard, 1993, argues that per unit consumption actually have been decreasing from 46.4 tons per unit in 1982 to 39.1 tons per unit in 1992. In these calculations it is included that 22.7% of the farms included in the survey did not use their straw combusting unit. There is, however, a group of farms, who sell straw to other private consumers, who are not included in the survey. This might outweigh the decrease from 46.4 tons per unit in 1982 to 39.1 tons per unit in 1992. Summing up Nygaard, 1993 argues that the unit consumption should be changed from 35 to 50 tons per unit; this was done in 1993 back in history **1972** to **1992**.

Allocation between private use and agricultural processes

The straw consumption in farms is divided into two consumption categories in the energy statistics by allocating a fraction to the household sector and the remainder to the agricultural sector.

The allocation was historically 75% to private farmhouse heating and 25% to production buildings and process purposes such as grain drying. In the HFT survey in 1992/93 the farms were asked about their straw consumption in more detail and it was determined that the fraction used for heating the private houses is 67% and 33% is used for production purposes. And in a similar survey, HFT 1996/97 the allocation was determined to 58% for private houses and 42% for production buildings. Based on this information it was decided in 1997 to change the allocation factor to 60% for private houses and 40% to production buildings and agricultural processes, back in time for the period **1972** to **1996**. The same allocation has been used in all following years, **1997** to **2010**.

From **1997** to **2010** (except 2006 to 2009) one or a few farms supplying district heating from farm scale boilers and using 400 tons to 3000 tons of straw annually has been subtracted from the total consumption in farms before the above mentioned allocation.

District heating plants

No use of straw in district heating plants has been recorded before **1979**.

The figures from **1979** to **1992** was collected and evaluated by the Centre for Biomass Technology (CBT). It was established in annual surveys on how many new plants had been established in the year and how much straw they were using.

From **1989** to **1993** the information was collected through and the annual heat survey "Fjernvarmetællingen". During the transition period 1989 to 1993, Centre for Biomass Technology in cooperation with DEA established the data based on a combination of CBT market knowledge "Fjernvarmetællingen".

From **1994** the annual electricity and heat survey "Energiproducenttælling" (EPT) gave the amount of straw used in district heating plants. In several years market knowledge in CBT was used to validate the data from EPT.

Autoproducers, heat only and CHP

A minor fraction of straw used in the district heating sector is consumed by autoproducers of heat (companies such as industries, who sell heat as district heating from biomass fuels, but to whom energy production is only a side business). These figures are also based on "Fjernvarmetællingen" and "Energiproducenttællingen".

A consumption of straw of 400 tons/year to 3000 tons/year is recorded in "Energiproducenttællingen" in **1997** to **2010** (except 2006 to 2009). This consumption takes place at a few farms supplying district heating, and the figure is thus subtracted from the total consumption in farms.

From **1995** to **2001** a small consumption (less than 200 tons) of straw is recorded as consumed for electricity production in private CHP plants. The origin of this information has not been investigated in detail.

Small scale and large scale CHP

Straw use in combined heat and power production (CHP) started on an experimental basis in **1985**.

Up to **1994** data were collected by Centre for Biomass Technology based on consumption data from each plant.

From **1994** the Danish Energy Agency collected the data in the Energiproducenttælling.

The consumption is divided into fuel used for heat and fuel used for power based on DEA procedures for allocation.

Large power plants

In the period **1995** to **1997** a separate consumption category "Large power plants" exists, which reflects consumption at Studstrupværket power plant, where experimental straw fuel operation was performed these years. Later use of straw in power plants is accounted for in the above mentioned categories for large scale CHP.

Annual production and imports

CBT states, that no imports or exports of straw fuel of any significance has taken place during the period in question. Thus all straw consumption is assumed produced domestically in the year when consumption takes place.

In reality straw is stored from one harvest to the next, and sometimes longer, leading to a small difference between annual production and annual consumption. This is not reflected in the figures in the statistics.

Statistics Denmark's annual survey HT can be used to verify the total use of straw, but not divided into consumption categories. In 2010, the HT states a production of 1.60 million tons of straw for energy purposes, which matches quite well the 1.63 million tons found in the energy statistics.

Publication of statistics and time series

Time series for straw consumption in energy units year by year for the period **1972** to **2010** are available from DEA's web site.

Danish version Årlig energistatistik

English version Annual Energy Statistics.

Recommendations

1. A new survey should be made to establish more precise figures on the current situation in farms scale systems (number of systems, fuels used in boiler, average straw consumption, re-evaluation of the allocation factor for private heating and agricultural use)
2. Evaluation of the unit consumption: Should it be considered as a function of efficiency, farm size and consumption of other biomass resources, and should it be evaluated differently every year?
3. Minor adjustments should be made to refine the statistics in years 1995, and 1998-2001, where the appearance of a statistical difference of up to 3 TJ apparently is caused by consumption in autoproducers of CHP not being included in the total consumption.
4. Deletion of 1994 unlikely consumption of 400 tons / 5.8 TJ in the category autoproducers, heat only. The figure was stated as 0 in the 2001 version of the statistics; and deletion will neutralize the statistical difference found in 1994.

References and sources

Dal, 2000

Personal information from Peter Dal, Danish Energy Agency, 2000

Nygaard, 1993

Internal note from Ivan Nygaard, Danish Energy Agency, 1993

Landbrugs- og gartneritællingen (the LG survey)

This survey updates the basic database for Statistics Denmark with regard to Danish agriculture. This survey includes number of installed straw combusting units. The database is updated every year, but does not include straw fired boilers in the latter years.

Høsttællingen (the HT survey)

This is a sample survey on approx. 3 000 Danish farms, which is carried out every year. The survey uses the updated LG database for basic data. The main aim of HT is to determine the grain yield, which is elaborated with a question on straw utilization patterns (feed, fodder, energy and others). The farmers are asked how much of their straw is used for the various purposes. The grain yields and the information on straw use are then used to determine the annual straw production and straw consumption for the various purposes.

Halmfyringstælling (the HFT survey)

This is a specific straw boiler survey, which were carried out some years, e.g. in 1992/93, 1994/95 and in 1996/97. The Danish Energy Agency (DEA) provided funds for this survey. This survey is based on the number of farms in the LG-database, which has a straw fired unit installed. This part included in 1997 approximately 17 800 farms. The figure is summed up with farms having an installation and farms, which during the last 5-10 years had a straw-firing unit. This means for instance that the 1996 LG-database survey includes farms, which had an installation in 1989. The final HFT survey normally involved 400 farms selected among the 17 800 farms.

Fjernvarmetællingen (the annual heat survey)

An annual survey performed by DEA based on a questionnaire, where all commercial heat producers gives energy related information and data, most important data on fuel consumption and heat production. Fjernvarmetællingen was initiated in 1989 and in 1994 followed by Energiproducenttællingen.

Energiproducenttællingen (the annual electricity and heat survey)

An annual survey performed by DEA based on a questionnaire, where all commercial energy producers deliver energy related data, most important data on fuel consumption, production of heat and electricity. Energiproducenttællingen was initiated in 1994.

Danmarks Statistik (Statistics Denmark)

Den samlede halmanvendelse i Danmark 1996/97 (Total consumption of straw in Denmark 1995/97). *Nyt fra Danmarks Statistik, no. 442, 16.12.1997.*

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