Ea Energy Analyses

Danish Energy Agency

Biomass Statistics: Wood chips

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Prepared for Danish Energy Agency by Ea Energy Analyses

Objective

During the last 30 years the methods and assumptions for estimating the consumption of wood chips for energy in Denmark have changed several times. The purpose of this paper is to document the methods used in the period 1986 to 2016.

The document was prepared for Danish Energy Agency (DEA) by FORCE Technology, Mr. Anders Evald in 2013 and updated in 2017 by Mr. Morten Tony Hansen, Ea Energy Analyses.

Definitions

Wood chips

Wood chips refer to a product produced from wood residues from thinnings and logging operations in forestry, usually referred to as forest wood chips. It is a forest product, not contaminated with any other materials.

In the total consumption of wood chips some industrial wood chips are included, however the amount of chips used from such other origin is not known. Industrial chips are a natural uncontaminated product without foreign elements such as paint, glue, nails etc. Key figures for the different types of chips are comparable thus the calculation of consumption follows the same line.

The consumption of other types of wood waste from industry is handled in the paper about wood waste statistics.

1 m^3 wood

1 m^3 of wood is defined as 1 m^3 of solid wood i.e. wooden material without the air volume usually present in a pile of wood. This definition follows normal forestry practice.

1 m^3 loose volume (lv) wood chips

A cubic meter loose volume refers to the content of a cubicle of 1 m^3 containing wood chips. In contrast to solid volume, loose volume accounts for solid wood as well as the air between the wood particles.

Heating value

Up to **1992** the figure 2.8 GJ/m^3 (lv) was used to determine the energy content in wood chips on a volume basis.

This was changed to 9.3 GJ/ton in **1993**, when at the same time the basic unit for statistical data on wood chip consumption for the most important consumption categories, district heating and CHP, was changed from m^3 (lv) to ton.

9.3 GJ/tons is based on 45% water content in the wood chips and an energy content (lower heating value) of 19.0 MJ/kg dry matter based on the calculation:

19.0 GJ/ton • 0.55 – 2.45 GJ/ton • 0.45 = 9.3 GJ/ton

Discussion about heating value

Studies indicate that the average water content in forest wood chips is lower than 45%, e.g. the report “Facts on installation ….” suggests an average of 42.3%.

An evaluation of dry matter heating value suggests that the figure 19.0 GJ/ton DM presently used could be slightly higher. For example, with the publication of EN 14961-1 in 2010, a figure of 19.1 GJ/ton dry matter was suggested as a typical value for conifer wood chips, which dominates the Danish market. Further, the average for conifer wood chip quality usually produced in Danish forestry is rather 19.2 GJ/ton dry matter (Videnblad 125.2). The figure in Videnblad 125.2 is based on evaluation of many laboratory analyses, and also agreed between major traders (the District Heating Association and the major suppliers of forest wood chips) in meetings in 1998.

Thus, it could be considered to change the current 9.3 GJ/ton to 10.0 GJ/ton as key figure for heating value for wood chips, based on a water content of 42.3 % and calculated as follows:

19.2 GJ/ton • 0.577 – 2.45 GJ/ton • 0.423 = 10.0 GJ/ton

However, we do not recommend such a change now for the following reasons:

- 19.0, 19.1 or 19.2 are all close to the median or average values found (e.g. an interval of 18.5 to 19.8 is stated as typical in the EN 14961-1)
- Moisture content varies significantly from season to season, and the figure 45 % represents just as well as 42.3 % what is found in the market
- An important fraction of the consumption statistics figures is taken directly from power plants and heating plants, where each figure is given with a corresponding heating value, thus an accurate overall conversion factor is less important.

Figures for consumption

Sectors

District heating

Data for the consumption of wood chips in district heating plants was collected in the period 1986 to 1995 by Skovteknisk Institut or dk-TEKNIK (now FORCE Technology) in Centre for Biomass Technology based on knowledge on the individual plants in operation and their annual fuel consumption. These figures are used in national statistics from **1986** to **1990**.

From **1991** to **1993** similar data were collected by Danish Energy Agency in the "Fjernvarmetællingen", and from **1994** to **2016** in the more comprehensive "Energiproducenttællingen", also made by the Danish Energy Agency.

The introduction of Fjernvarmetællingen improved the reliability of the figures, however also the figures for the previous years can be regarded as reliable.

In the annual questionnaire the energy producers may mark their wood fuel as wood chips even if it in some instances should be classified as waste wood, e.g. bark. This introduces uncertainty, however as the consumption is accounted for only once, only the distribution between the different classifications of wood fuels is affected, not the consumption of wood fuels as such.

District heating, private autoproducers

In the statistics a figure of 30-40 TJ occurs in the years **1994** to **1997** as private district heating. The figure originates from one industrial heat producer, which was shut down in 1997. Again in **2009** to **2016** a small industrial district heating production occur based on wood chips. In both periods, data originates from the Energiproducenttællingen.

Small-scale and large-scale CHP

Since **1992** wood chips have been used for combined heat and power production (CHP). The figures in the statistics originate from the Fjernvarmetællingen up to **1993** and from **1994** from Energiproducenttællingen. Consumption is divided into large scale plants (central CHP stations in the larger cities) and small-scale plants.

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

Private CHP

Since **2007** a consumption of wood chips is observed in privately owned CHP plants. Origin of this data is explained in the following section on manufacturing.

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

Manufacturing

A small consumption of wood chips in industry was registered in the 1999-version of the energy statistics for the years 1994 and 1996. However due to uncertainties, these figures have been removed in more recent versions of the time series.

Starting in **2007** a couple of relatively large industries replaced earlier fossil fuel consumption with wood chips. Thus, this sector rapidly gained importance in the national biomass energy supply. Data on industrial consumption is from direct communication with the industries involved and in more recent years submissions through the ETS, and from the Energiproducenttællingen.

The wood chip consumption in industries is divided between use for industrial purposes (industry internal use of steam and heat), and for combined heat and power. The latter is accounted for in the time series for private CHP, where it is divided again into use for power production and use for heat production.

Individual consumers, agriculture and forestry

There are very limited primary sources available regarding the amount of wood chips consumed in private households, farms and forestry estates. From **1986** to **1990** it was stated by Skovteknisk Institut that 14 800 m^3 (lv) of wood chips was consumed in large farms and estates.

The figure 14 800 was based on a list of wood chip fired estate size boilers. The list was established in Skovteknisk Institut in the mid 1980'ies. No small farms or other individual consumers were included in this list.

75 % (11 100 m^3 (lv)) of this was allocated to private consumption and 25% (3 700 m^3 (lv)) was allocated to process purposes (heating of outhouses, drying of grain etc.) at the farm/estate.

In 1992 the figure was evaluated and the consumption on farms and estates was determined to 38 400 m^3 (lv) (Evald, 1992) based on a revised list of boilers in use. This figure was corrected two years back in the statistics for the years **1989** and **1990**. The allocation figure between private consumption and process heating at the farm was still 75 % / 25 %.

The same figure, 38 400 m^3 (lv) has been used as basis since then (**1991** to **2016**) merely as an indication, that a certain consumption takes place in this sector.

This allocation factor between private consumption and farm processes could be reconsidered, as the similar allocation in farms using straw for energy has been 60 % / 40 % since 1997, and as there is no obvious reason for a difference between straw fired and wood chip fired boilers.

In the national energy statistics, the consumption allocated to heating (75 %) is categorised as heating of single family houses. The wood chip fired boilers are mainly installed in larger estates such as country manors, large farms and forest estates.

Today the consumption in small scale consumption categories (individual consumers, agriculture, forestry, public and private service) is insignificant (total less than 1 % of the total consumption).

Public service (institutions)

The consumption of wood chips in public institutions (schools, public buildings etc.) was also estimated in lists established in Skovteknisk Institut in the mid 1980'ies. The figure for **1986** to **1990** was a wood chip consumption of 58 100 m^3 (lv) annually.

In 1992 the lists were revised, and the figure for consumption in public institutions was determined to 52 200 m^3 (lv) (Evald, 1992). This figure was corrected two years back in the statistics for the years **1989** and **1990**.

This figure, 52 200 m^3 (lv) has been used as basis since then (**1991** to **2016**) due to lack of more recent detailed data.

In the time series in the national energy statistics this consumption is categorised as heating in public service buildings. A considerable fraction of this consumption takes place in privately owned buildings. However, no data has been elaborated to quantify this distinction.

Private service

A small consumption appears in the statistics for 1999, 2002, 2004, 2007, 2008 and 2010 to 2016.

Annual production and import

Wood chip production

Danish wood chips are mainly produced in forestry from thinnings and logging operations. A smaller amount of wood chips is produced in public and private parks, from hedges and from chipping of other trees from other clearing procedures.

Figures for the annual production of wood chips in Danish forests are also recorded in forestry statistics, which is based on an annual questionnaire on forestry logging.

From 2012, Statistics Denmark has applied a new method for surveying forest logging based on a questionnaire to Danish forests with an area more than 0.5 ha.

Previously, the questionnaire was sent to all forest owners of 100 ha and above, and to randomly selected properties smaller than 100 ha. The latter was aggregated to cover all forest in this size category in Denmark.

In the annual statistics, the forest owners were asked to provide information on forest logged in m^3, divided into beech, oak, other broad-leaved and conifers. The figure should include wood for own uses. The questionnaire included wood energy as firewood, wood chips and round wood for energy purposes.

On several occasions, e.g. in 1990, it has been suggested to use these figures in the Danish energy statistics. But production figures for wood chips in forestry was found to be significantly lower - in 1990 a factor of two - than what was reported to be used for energy purposes.

In 2010, if round wood for energy purposes is counted solely as wood chips, forestry statistics reported a production of wood chips of around 7 PJ, still significantly lower than the Danish production as determined based on consumption (see below). There are several possible reasons for this difference. Part of the difference is related to the figures given by the forest owner himself. The forest owner often hires an entrepreneur to cut the forest and sell the products and he may not know what is sold as firewood or other wood products and what is chipped. Further the definition of wood chips of forestry origin as reported in forestry statistics, is not the same as for biomass energy plants (who also include industrial wood chips, bark and other types of wood fuel in the open fuel category wood chips). Finally, additional wood chips may be produced in parks, other public areas, from fences or private gardens and used for energy purposes.

Thus, the national production of wood chips is stated in the statistics as the total national consumption minus the estimated import.

Import

Wood chips for energy have only been imported to Denmark within the past approx. 15 years. Until **1998** no attempt was made to estimate the size of the import. For **1999** an import share of 10 % of the total wood chip consumption in Denmark was estimated by CBT to reflect a development in the market. The figure, which is very uncertain, has been maintained from up to **2004**. The following years up to **2007** an increasing import fraction of 20 %, in **2008** to **2010** 30%, and in **2011** and **2012** 34% is used based on market estimation from CBT. Generally, it is assumed, that domestic production no longer increases significantly, and that most of the strong growth in consumption is covered by import.

The import fraction is however very uncertain.

Recent updates on estimation of consumption and import

In recent years the DEA has requested estimates of the development in the consumption and import of wood chips for energy purposes in sectors outside the supply sector, i.e. outside Energiproducenttællingen. FORCE Technology and subsequently Ea Energy Analyses has assisted the DEA in assessing the development. In practice the assessment is based on a small survey where key market players within fuel supply, consultancy, large consumers in industry, plant manufacturers, boiler suppliers and authorities (subsidy schemes for conversion to biomass) are interviewed by telephone about the recent development. Results are gathered in a short report for the DEA.

The development in consumption data is then based on the consumption in the previous year adjusted with the new developments and adjusted for climatic variations in the relevant sectors.

For a period, the wood chip industry has disagreed with the estimate of the wood chip import stating that the import has been varying more than is shown in the statistics. Recently the import has been estimated by Ea Energy Analyses to around 300,000 tons per year which is around half of the previous estimates. The estimate is based on interviews with market actors.

Time series

Time series for wood chips consumption in energy units year by year from **1972/1975** are available from DEA web site:

- Danish version: Årlig energistatistik
- English version: Annual Energy Statistics

Data is published in Excel spreadsheet files. Wood chip data can be extracted by filtering column D in the Danish version for data on "fli". Conversion into metric tonne or m^3(lv) can be made using the conversion factors stated above.

The time series only includes data after 1986, when the first statistical data on wood chips consumption appears. A minor consumption has taken places before this year; however, this has been very small and with no significance to the national energy balance.

Recommendations

1. Data on import of chips could be improved e.g. by collecting data from a larger number of relevant stakeholders, possibly identified via Energiproducenttællingen or possibly by including questions on import in the questionnaire in Energiproducenttællingen if this is assessed feasible.

2. New data on wood chip consumption in schools, institutions, estates etc. could be estimated, e.g. by collection from boiler owners
3. The allocation factor between private consumption and farm production may be changed to 60 % / 40 % as it is assumed for farms using straw for energy.

References and sources

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Fjernvarmetællingen (Survey of district heat producing units)

An annual survey performed by Danish Energy Agency 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 (Survey of electricity and district heat producing units)

An annual survey performed by Danish Energy Agency 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.