

Biomass Statistics: Firewood

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Prepared for Danish Energy Agency by Ea Energy Analyses

Objective

Figures for consumption of firewood for heating in the national Danish Energy Statistics has developed over the years based on various 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 2016.

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Definitions

Firewood

Traditional firewood produced from branches, smaller whole trees etc. in forestry, from whole trees and wood waste from gardens, parks and other recreational areas, areas along railways etc., from industrial surplus products and numerous other sources. Firewood is manually loaded into the furnaces and the single fuel particle is usually more than 20 cm long.

The national energy statistics do not include a separate fuel category for briquettes manufactured from sawdust and used in wood stoves and wood boilers. Thus, briquettes are included in the figures for firewood in the statistical data as well as in this document.

Unit of measurement: 1 m³ of firewood

Forestry products are often measured in m³, referring to 1 m³ of solid wood volume. This is the unit used in national forestry statistics and in this document.

In firewood trade the term "rummeter" is most often used, referring to 1 m³ of wood including the air between the wood pieces (m³ loose volume). This unit is imprecise due to the fact that the air/wood ratio in a pile of wood is very dependent on the size of the wood pieces and the different methods for stacking/piling.

In the recent 2005, 2007, 2009, 2011, 2013 and 2015 surveys of consumer habits in firewood consumption, the term "rummeter" was used along with a strict definition of the type of unit used.

Individual gathering of wood ("Sankning")

Individual gathering of wood not only includes wood gathered from the forest bottom, but also trees, that the forest owner points out for the consumer to cut himself. The price of the wood then depends on which kind of trees is cut, how difficult it is to cut the trees and which alternatives the forest owner must sell the wood.

Dry matter (DM)

Dry matter is solid wood with zero water content.

Heating values

Presently used heating values

The figures in Statistics Denmark's "Hugsten i skove og plantager" (Logging in forests and plantations) are measured in m³ solid volume. In table 1 is shown lower heating values used in the firewood statistics for 1 m³ (solid) wood, based on standard assumptions for wood density, water content and heating value of wood dry matter.

	Density kg DM/m ³	Water content percent	Heating value GJ/ton DM	Lower heating value GJ/m ³	LHV (rounded) GJ/m ³
Deciduous	570	15	18.7	10.41	10.4
Coniferous	400	15	19.4	7.59	7.6

Table 1: Assumptions for heating values for firewood used in Danish Energy Statistics.

The figures are best estimates. Density are standard values for beech and fir respectively, water content is the median of the estimated range for water in firewood and the DM heating values are best estimate for an average for the two types of wood.

Earlier used heating values

Before 2001 the figures for lower heating value used were based on a water content of 53 % (total weight base), which is a fairly accurate figure for freshly cut wood. However, when the wood is used for heating in private houses, the water content is reduced to 10-20% due to natural drying from wind and sun, thus a revision of heating values was necessary. The basic parameters used to determine these previous heating values are shown in table 2.

	Density kg DM/m ³	Water content percent	Heating value GJ/ton DM	Lower heating value GJ/m ³
Deciduous	531	53	18,1	8.15
Conifer	400	53	19,1	6.52

Table 2: Assumptions earlier used for heating values for firewood in Danish Energy Statistics.

When the presently used revised heating values were introduced around 2001, time series for the previous years back to 1972 were recalculated using the new figures.

Consumption categories

Single family houses

In the national energy statistics, the total consumption of firewood is placed in one consumption category: "Space heating" in "Single family houses". In practice, boilers, stoves or open fireplaces exist also in other buildings than villas, e.g. in apartments, farmhouses under the "Agriculture and forestry" consumption category. However, the consumption in other consumer categories is small compared to individual consumers, and no specific information is available. Firewood consumption in holiday houses is also included.

Import versus domestic production

As part of the 2006-survey registrations were made on private individuals use of stacked firewood sold on imported pre-packed pallets. This information was combined with business interviews to an estimate of the import fraction of the **2005** consumption of 10 %. To reflect the import in historical data, a correction was introduced for the years **2001** to **2004**, where a linear increase in the import fraction from 2 % to 8 % was assumed.

For **2006** the import fraction was estimated equal to that of 2005, while the later study for **2007** indicated a maintained import in absolute figures but reduced to 8 % of the total consumption. The next survey from 2010, for the year 2009, also indicates an 8 % import fraction, which were then used for the years **2008** to **2009**, and

initially also for **2010**. The survey for **2011** (performed in 2012) showed an import fraction of 14 %, which led to a correction of the previous year, **2010**, to 11 % based on linear interpolation. For **2012**, the import fraction for 2011 was used. A survey covering **2013** was carried out in 2014, which indicated an import fraction of 15 % of which 8 %-points were covered imported firewood, 2 %-points were imported logs that were split in Denmark and 5 %-points were the consumption of wood briquettes which are all assumed to be imported. For **2014** the import figure for 2013 was used. In 2016 a newly designed survey covering 2015 was carried out, showing a reduced import fraction of just over 10 % due to a reduced import of firewood and logs. For **2016** the figure from 2015 was used. The **2017** figure remains to be estimated.

Publication of statistics and time series

Time series for firewood consumption in energy units year by year from **1972/1975**) are available from DEA's web site.

- Danish version: [Årlig energistatistik](#)
- English version: [Annual Energy Statistics](#)

Data is published in Excel spreadsheet files. Firewood data can be extracted by filtering column D for data on "bra". Conversion into other units can be made using the conversion factors stated above.

Figures for production and consumption

General remarks on methodology

Firewood *production* in forestry is determined in the annual national forestry statistics from Statistics Denmark. The registered production of firewood can be used as an indicator of the consumption of firewood; however, this only includes the official figures on logged firewood in forests and plantations. Firewood originates from many other sources than forestry (gardens, parks and other recreational areas, railway areas, from industrial surplus products, replacement of old hedges, road trees, urban and open country single trees and small groups of trees and numerous other sources).

For the first many years, the basic principles were to estimate the national consumption of firewood as the recorded production of firewood from forestry with an estimated correction for firewood used from all other sources than recorded in forestry. Firewood *consumption* were then calculated using the forestry production as an indicator and multiplying with a certain factor to reflect consumption of wood from other sources than forestry.

The agricultural statistics divides the forest production in several wood species. In the energy statistics, figures were calculated based on total harvest for deciduous species and coniferous species respectively. Using the above average figures for heating value pr. m³ of wood for deciduous and coniferous respectively the consumption in m³ were converted into TJ.

The methodology is shown in detail in the time series, where production, multiplication factor as well as heating values for all years are shown.

In 2005 a new approach for estimating the firewood consumption was successfully introduced, further details are given below in the section on data from 2005 and onwards.

Further, from the statistics covering 2015 a new and more precise method was introduced. Details are given below.

Annual production of firewood in forestry

The annual production of firewood in forestry in Denmark is determined in an annual survey on forests products logged, "Hugsten i skove og plantager" (Logging in forests and plantations), produced by Statistics Denmark.

From 2012, Statistics Denmark has applied a new method for surveying logging based on a questionnaire to Danish forests with an area more than 0.5 ha. However, the statistics still has the same standard and same target population as previously where the questionnaire was sent to all forest owners of 100 ha and above (up till and including 2004 the lower limit was 50 ha), and to a sample of properties smaller than 100 ha.

The forest owners are asked to provide information on wood logged, divided into beech, oak, other deciduous species and conifers. The figures must include individual gathering of firewood (sankning). The figures must include wood for the forest owners' private use.

Figures should be given in m³ *solid volume*. However, figures could also be given *including* air in the woodpile, referred to as m³ *stacked volume*, which is then calculated to m³ *solid volume* by the forest owner using an individual correction factor, or by the statistical office using a standard solid mass percentage of 60%.

For properties above 100 ha (earlier 50 ha) information is also requested information on *sold* beech and *sold* conifer. Any difference between the *sold* beech and the *logged* beech should represent the properties own consumption, and wood which may not be *sold* in the referred year.

In Table 3 an example of results of this survey is shown for the year 1998. Firewood figures are given in m³ solid volume, and include wood of secondary quality, which is logged together with logging of industrial wood, wood produced in thinning operations, and sankning.

	Firewood 1000 m ³	GJ/m ³	Firewood TJ
Beech	153.3	10.4	1 594.32
Oak	21.4	10.4	222.56
Other deciduous	80.7	10.4	839.28
Total deciduous	255.4	10.4	2 656.16
Coniferous	107.1	7.6	813.86
Total	362.5		3 470.02

Table 3: Example for 1998 of registered firewood production in Danish forestry.

The figures for logging of firewood from "Hugsten i skove og plantager" have been used continuously in the period **1972** to **2004** as basic figures for firewood energy statistics.

Recent figures for "Hugsten i skove og plantager" can be found at Statistics Denmark's Statistikbanken: <http://www.statistikbanken.dk/skov55>.

Estimated consumption of firewood (1972 - 1994)

In the period 1972 to 1994 the multiplication factor was estimated at 1.82 based on the ratio between a 1989 Skovteknisk Institut rough estimate and the forestry statistics figure for that year.

When a better estimate for the multiplication factor, 3.0, was introduced in 1995, the annual consumption in the previous years **1972** to **1994** was corrected to the new factor.

Estimated consumption of firewood (1995 - 2004)

A multiplication factor of 3.0 was introduced in **1995**. The factor 3.0 was used also for the following years **1996** to **2004**, and a correction was made backwards for the years 1972-1994. The following section summarizes the methodology behind this factor.

In 1992 to 1995 three surveys were carried out, which assisted in determination of the firewood consumption in Denmark. Based on these three surveys it is possible to estimate how much firewood is used that is not bought from the forestry. In two of the three the poll covered all relevant household categories in Denmark, while the third only covered households in "energy planning zone 4", i.e. households located outside public supply systems for district heating or natural gas (Houmøller, 1995).

In Houmøller, 1995 the three surveys were evaluated. The use of different stoves, fireplaces and wood boilers and the consumer habits in Danish households are evaluated with the aim of determining the actual final firewood consumption in Denmark.

The total number of firewood installations in Denmark was then estimated to:

- app. 400 000 stoves in private home,
- additional app. 100 000 stoves in holiday homes,
- app. 75 000 boilers for firewood and,
- app. 100 000 open fireplaces for firewood.

A method to determine firewood consumption from a unit consumption and number of units were considered. If the average wood consumption were known, it would be possible to determine the total firewood consumption in Denmark. But no reliable data for unit consumption existed. And as only a limited number of consumers use their firewood burner as their basic heat supply, average consumption could not either be estimated from heat demand in the houses.

Instead the surveys focussed at determining to which extent "bought" firewood covered the actual firewood consumption - the approach were to determine the fraction of the total consumed firewood bought from forestry and compare this figure with the forestry logging statistics.

The three studies gave different results.

In the survey "Omnibus 1992", the "bought in forest" fraction of the total firewood consumption were 26%. In this case the final firewood consumption thus would be 3.9 times forestry firewood in Statistics Denmark, assuming that firewood "bought in forest" corresponds to the official forestry statistics. When the figure included the amount of firewood bought at "firewood sales outlets", which to an unknown extent is also supplied from forestry, the fraction from forestry increased to 35% and the multiplication factor were reduced to 2.7.

In the survey "Omnibus 1994", the interview questions were formulated so that the results should be easily comparable with the logging statistics. Unfortunately, there were no reply category for "own supply", which made the figures less reliable than the figures from "Omnibus 1992". As a result, the multiplication factor were lower, approximately 1.7.

In the survey "Det åbne land" the population interviewed were not representative for the whole country. However, if one assumes that firewood consumption in this area is the same as in the rest of the country, an overall multiplication factor of 1.7 could be estimated.

Based on an overall evaluation of the three surveys, including other ways to determine firewood consumption based on the interviews, and including an estimation of the certainty in each estimate, it was decided in **1995** to use a multiplication factor of 3.0 between forestry statistics on firewood logging and actual consumption of firewood. The decision was made in a joint meeting between Danish Energy Agency (DEA) statistics responsible personnel and Centre for Biomass Technology (CBT) experts.

It was obvious already then, that the uncertainty in the factor of 3.0 is more important than the uncertainty in forestry statistics for firewood itself. Based on the above-mentioned surveys it was estimated, that the factor 3.0 was the best possible value until a more accurate method for estimating the firewood consumption could be introduced.

The multiplication method is no longer in use after the new method was introduced in 2005. The assessment in the report from the new study in 2005 is that the old method was significantly more uncertain due to the following facts:

- the method relies on forestry registration of logging, any non-registered logging in forestry is missing,
- uncertainty as to the connection between what respondents see as "originate from the forest", and the registered logging by forest owners,
- uncertainly related to firewood sales from forestry to traders, who then sell firewood to private households,
- uncertainty caused by respondents acquiring firewood from several sources, which means they cannot simply be categorized as buyers of firewood from forestry.

Estimated consumption of firewood (2000 - 2014)

In 2006 a new study was made, using a different approach to estimate the total consumption of firewood in Denmark in **2005**. The details of the study are given in the detailed report “Brændeforbrug i Danmark”. Similar subsequent studies were made in 2008 for the year 2007, in 2010 for the year 2009, in 2012 for the year 2011 and in 2014 for the year 2013.

Several private individuals were interviewed by phone about their use of wood stoves, wood boilers etc. One main result was a much better than earlier estimate of the present number of wood stoves, wood boilers, open fireplaces etc. in Denmark. But most importantly, the study introduced a new way to more accurately estimate the average annual consumption in each unit. The respondent was asked about his annual consumption in “rummeter”, and as a follow-up question was asked to specify his understanding of the term “rummeter”. This way the study was able to “translate” the individual consumers’ very different understanding of how to measure a pile of firewood. Thus, the unit consumption could be converted into energy units with some accuracy, which has never been successfully done before. The main results of the 2005-survey are given in table 4.

The new methodology was considered to be significantly more accurate than the earlier multiplication factor method. The new survey shows total firewood consumption for **2005** of 19.63 PJ. All details on methodology and data from this and the subsequent studies for 2007, 2009, 2011 and 2013 are found in the reports mentioned below (in Danish).

	Number	Unit consumption GJ	Consumption TJ
Wood stoves in homes (incl. open fireplaces and mass furnaces)	436 936	25.59	11 181
Wood stoves in uninhabited houses	25 637	-	-
Wood stoves in holiday houses	88 342	15.22	1 344
Wood boilers in homes	47 753	148.76	7 104
Total			19 630

Table 4: Number of stoves etc., unit consumption and total consumption of firewood according to the 2005-survey

Based on the new study a steep increase in the registered consumption of firewood was introduced in the statistics. From 2004 to 2005 an increase of more than 60 % was highly unlikely. A correction was then introduced for the years **2000** to **2004** stating the consumption these years on a multiplication factor of 3.20, 3.40, 3.60, 3.80 and 4.20 (up from previously 3.0 in all five years). The rationale behind this was the assumption, that the historical data was as accurate as possible under the circumstances, but that an increase in the consumption to the present level during the past five years was very likely based on the favourable price ratio between wood heating and increasing oil and gas prices in these years.

Due to the costs associated with the new method, similar future surveys are expected to be made every 2 years only. In the intermediate years the firewood consumption can be settled based on forestry harvest statistics as previously, by estimation of the recent development or as an average between the previous and the following years. The figure for **2006**, 21.13 PJ was calculated this way adding an increase corresponding to increase of 7.64 % observed in forestry logging statistics for firewood.

For **2007**, the data is based on the repetition of the 2005-study made in 2008. This study gave a surprising increase of 39 % over the 2005-study, giving cause for concern that the methodology is sufficiently accurate.

The **2008**, consumption figure were preliminarily estimated equal to the 2007-data. Later when 2009-data became available, the 2008-figure was adjusted to the average of 2007 and 2009.

For **2009**, the data is based on the repetition of the 2005-study made in 2010. For **2010**, a preliminary figure is estimated at 6.62 % more than 2009 based on an evaluation of the effect of the significantly colder weather this year.

For **2011**, data is based on the repetition of the 2005-study made in 2012. The **2012** consumption figure was preliminarily estimated to equal the 2011 figure. In 2014, when the 2013 consumption was studied and known, the 2012 consumption was re-estimated to be average of 2011 and 2013 added the 2013 consumption of wood briquettes.

For **2013**, data is based on the repetition of the 2005-study made in 2014. The **2014** consumption figure was preliminarily estimated to be equal to the 2013-data, however, adjusted for climatic variations by the DEA. In 2016, when the when the 2015 consumption was studied and known, the 2014 consumption was re-estimated. The climate adjusted 2014 consumption of firewood was estimated to match the climate adjusted 2013 consumption of firewood. Subsequently, the consumption of wood briquettes - an average of the consumption in 2013 and 2015 - was added.

Estimated consumption of firewood (2015 -)

When a survey of the firewood consumption in **2015** was due in 2016, Ea Energy Analyses teamed up with Statistics Denmark and jointly designed a new method in cooperation with the Danish Energy Agency and the Danish Environment Protection Agency (EPA).

In the context of this study, the agencies wanted more detail in the geographical determination of plants and consumption and lower uncertainty about the results regarding consumption per combustion unit, number of combustion units, age determination etc. The survey for 2015 thus builds on the previous studies but took a new and improved method in use.

In the new survey, the use of firewood for heating purposes in households was examined via a questionnaire sent to households representatively selected in Denmark. Of a total of 40,000 households, 50% of the households were randomly drawn throughout Denmark among all housing types, while 50% were drawn randomly amongst specific types where the probability of wood stoves is higher. The households were contacted by Statistics Denmark via their digital mail box and asked about how their home and, if relevant, cottages in Denmark is heated and about their consumption of fire wood in stoves, burners, etc. in 2015. The response in terms of participation was impressive 38% and the number of users of firewood for heating purposes that responded to this survey was around 10 times higher than in the previous surveys.

Data about fuel consumption and firewood combustion devices etc. was subsequently cleansed and weighted with regard to region, type, number of persons in each household and living area. Then the information was extrapolated to cover all of Denmark for the total population of households. The use of digital mail box reveals who answered and who did not. This knowledge was used to adjust for bias. As a result, the uncertainty regarding fuel consumption per combustion unit, number of units, age distribution of the units etc. has been dramatically reduced in comparison with the previous surveys.

While the new method provides a more detailed and more robust result and provides for detailed studies of units, consumption, pollution etc., it also makes the result not directly comparable to the result of previous studies. For example, the number of wood stoves in Denmark in the new study was greater than the number in previous studies. This does not necessarily indicate a real growth but that the study is based on an improved approach. The same applies to the calculation of the fuel consumption, which increases with the number of combustion plants.

Figures for consumption of firewood for heating for the **2016** national Danish Energy Statistics were preliminarily estimated to be equal to the 2015-data, however, adjusted for climatic variations by the DEA.

During the 2015 survey it was considered if data collected by Danish chimney sweeps under coordination of the chimney sweep association could be used as a basis for assessment of the population of wood combustion devices. At that stage it was assessed that the quality of the data could be questioned and that the price set by the chimney sweeps was too high. Meanwhile the chimney sweeps have worked to improve coverage and data quality and the Danish EPA has decided to acquire the data and to use them as a basis for the population of combustion units in Denmark. The population is used to estimate emissions from combustion units across Denmark. The association does not cover all areas of Denmark. It has been decided by the EPA to supplement the chimney sweep data with data from the National Building Registry (BBR). This decision can be questioned since the data quality in BBR - although serious efforts are being made to improve the quality - in terms of heating devices is very low and in many cases misleading.

For **2017** a survey is pending.

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