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Suadiciani, Manne Kjell

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# Carbon sequestrations and emissions from harvested wood products - Different approaches and consequences

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By Kjell Suadicani



**Title**

Carbon sequestrations and emissions from Harvested Wood Products -  
Different approaches and consequences

**Author**

Kjell Suadicani

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Forest & Landscape Denmark  
University of Copenhagen  
Hørsholm Kongevej 11  
DK-2970 Hørsholm  
Tel. +45 3533 1500  
Email: SL@life.ku.dk

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# Foreword

International climate policy provides the opportunity to account for carbon sinks in forests through the Kyoto Protocol. The role of carbon sinks in Harvested Wood Products (HWP) is generally accepted, and one of the themes discussed in the negotiations of a post 2012 agreement is the possible inclusion of HWP in accounting of CO<sub>2</sub>-emission after 2012 (Hetsch 2008).

The Danish Ministry for Climate and Energy, and Forest and Landscape therefore agreed on a project that should highlight the carbon sinks in HWP as well as effect of different accounting methods.

The purpose of the project is to describe and analyze the methods and how Denmark could report on HWP as described in the IPCC 2006 guidelines. Especially the Danish Ministry for Climate and Energy wants to focus on the annual harvest in Danish forests and if possible to distinguish the amount used domestically or exported. This affects how Denmark can report on HWP according to the IPCC guidelines.

The production and consumption of HWP can be described in a flow diagram - a so-called wood-chain. The chain needs to be detailed to a certain degree, because different products have different time of decomposition. The globalization has meant that the Danish wood chain is more and more integrated in the European and the global wood chain. Raw material, semi-manufactures and end products are imported and exported to a large degree, and the proportion of export and import differs a lot between the different product types.

A master thesis (Beck 2008) provides an excellent basis of the work. Anyhow it is necessary to validate and discuss the inclusion of HWP in a broader view.

# Abstract

Harvested wood products (HWP) are defined as wood-based materials harvested from forests, which are used for products such as construction timber, furniture, plywood and paper and paper-like products or for bioenergy. HWP exclude logging residues that are left at harvest sites.

Accounting for carbon sinks in HWP would encourage silvicultural measures and provide incentives for the use of HWP. Negotiations on the second commitment period of the Kyoto protocol open the way for possible inclusion of carbon sinks in HWP.

A number of different calculation and reporting methods have been suggested and the different calculation methods are called approaches. The IPCC default approach, instant oxidation is a very simple approach assuming that inflow equals outflow. All other approaches try to capture the changes of stock of HWP over the years. When countries can account for carbon sequestration in HWP, it provides an incentive to increase the use of HWP and thereby increase the sequestration of carbon especially in long lived wood products.

There is an increased consumption of HWP in Denmark. This is a result of (1) a decreasing production of HWP in Denmark, (2) a rapidly increasing import of HWP, and (3) an increase in the export of Domestically produced HWP. The decreasing production of HWP is mainly caused by poor competitive condition in the Danish wood industry, which has resulted in largely reduced production capacity.

All approaches except of the stock change approach (SCA) result in negative sequestration from around 1995 and onward, when looking at the currently available data for Denmark and with the current guidelines. The trend in the data is expected to continue for a long period of time. The reason is that an increasing proportion of the domestically produced wood is used for energy and at the same time is an increasing proportion of the domestically produced wood exported as round wood or in form of wood products. The proportion of imported HWP used in Denmark is also increasing rapidly. The so-called globalization is known for many different products in many different countries.

It is suggested that Statistics Denmark should deliver relevant data to Eurostat instead of the Danish Forest Association as it is now. If the sector should be included in validating the data the most relevant organization is Danish Industry.

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## Introduction

The Kyoto Protocol is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC), aimed at combating global warming. The UNFCCC is an international environmental treaty with the goal of achieving »stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system«.

Under the Protocol, 37 industrialized countries (including Denmark) commit themselves to a reduction of four greenhouse gases (GHG) (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride) and two groups of gases (hydro fluorocarbons and per fluorocarbons) produced by them. The Protocol allows for several »flexible mechanisms«, such as emissions trading, the clean development mechanism (CDM) and joint implementation to allow the countries to meet their GHG emission limitations by purchasing GHG emission reductions credits from elsewhere, through financial exchanges or projects that reduce emissions in other countries.

The EU produces around 22% of global greenhouse gas emissions, and has agreed to a reduction of 8% on average from 1990 emission levels. Denmark has committed itself to reducing its emissions by 21%. On 10 January 2007, the European Commission announced plans for a European Union energy policy that included a unilateral 20% reduction in GHG emissions by 2020.

There is an overall agreement that harvested wood products can be seen as a storage pool of wood based carbon and that harvested wood products can substitute more energy intensive materials and fossil fuels (Grêt-Regamey *et al.* 2008).

Harvested wood products (HWP) are defined as wood-based materials harvested from forests, which are used for products such as construction timber, furniture, plywood and paper and paper-like products or for bioenergy. HWP exclude logging residues that are left at harvest sites.

The Kyoto protocol accounting for emissions and removals from Land Use, Land Use Change and Forestry (LULUCF) include emissions from HWP using IPCC's default approach. This approach assumes instant oxidation of HWP which consequently means that annual inflow to the pool is equal to annual outflow from this pool – meaning the pool is in balance. The IPCC default approach provides no incentive to increase the carbon stock in HWP by utilizing the resources in the forests. On the contrary the IPCC default approach provides an incentive to increase the carbon stock of forests and it also provides incentives for the use of wood for energy instead of for industrial purposes. This is unwanted side effects because high carbon stocks in the forests increase the risk of forest instability, and because it is intended that HWP should contribute to carbon storage and reduced carbon emission by substituting more energy intensive materials and products based on petrochemicals.



Accounting for carbon sinks in HWP would encourage silvicultural measures and provide incentives for the use of HWP. Negotiations on the second commitment period of the Kyoto protocol open the way for possible inclusion of carbon sinks in HWP. Regardless as to which approach is used, accounting for HWP but not accounting for forest management could create an incentive to pool carbon in HWP rather than the forest, thus possibly rewarding unsustainable forest management or possibly deforestation. Therefore, one prerequisite of HWP accounting is that the country should have elected forest management under Article 3.4.

The flow chain of products based on harvested wood is illustrated in figure 1. It can be seen that the inflow to the stock of wood products in use (the red box) is based on a domestic production chain from the forest until the consumer, and import and export different places in the chain. Import and export has become more and more important in the flow chain of products based on harvested wood. As time goes some of the wood products is taken out of use, which is the so-called outflow.

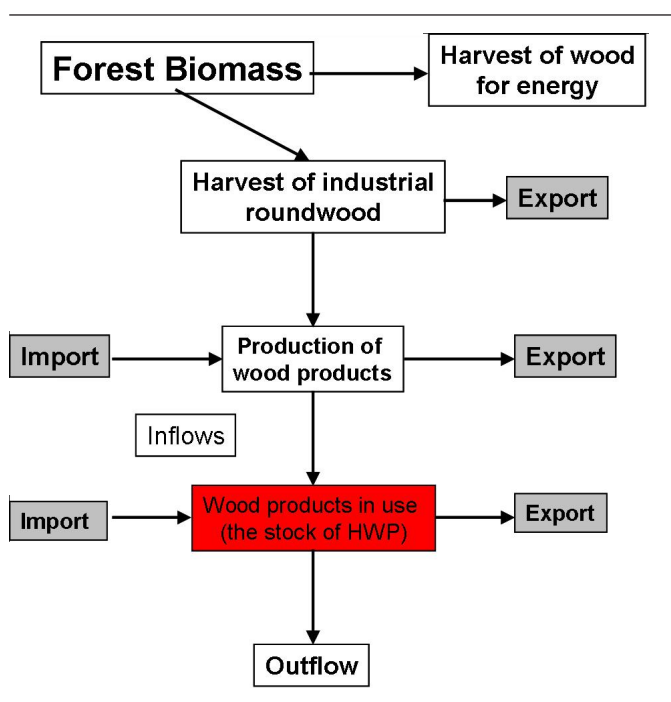


Figure 1. The flow chain of products based on harvested wood. The red box mark the stock of harvested wood products and the grey boxes mark the import and export that has increased importance in the flow chain.

While this report does not attempt to provide estimates of possible accounting results using the different approaches it should be noted that carbon sequestration in HWP are the result of inflow being larger than outflow, and carbon emissions from HWP are the result of outflow being larger than inflow. Therefore carbon sequestration or emission does not only have to do with the annual inflow of products but it also includes emissions from the existing HWP pool (outflow).

Statistical data used in this report comes from FAO STAT calculations of carbon sequestrations and emissions based on FAO STAT are the default tier 1 method (which is explained later).

## The decay functions and half lives

The outflow from the HWP pool is the emissions from the pool. Emissions are estimated using a decay function for the different wood products. It is possible to use different decay functions for different type of products but often calculations are done only using two different decay functions; one for solid wood products and one for paper and paper products. The decay factor is also used for the inflow calculating half a year's reduction assuming that the HWP on average is produced in the middle of the year. The decay factor used for the stock calculates the reduction in one year.

Decay functions are most often based on estimates of half lives. Half lives are the period of time when half of the material in a pool has been decayed. Half lives have been discussed a lot, and it is quite difficult to give qualified estimates of half lives. In the IPCC guidelines half lives of 30 years for solid wood products and 2 years for paper and paper products is suggested. Shorter half lives e.g. 15 years for solid wood and 1 year for paper and paper products reduce the size of the carbon sequestration/emission, but it will not change the trends.

The calculation of the stock of carbon in woody material is based on the annual inflows from 1900 until 1990. Inflows before 1900 are excluded from the calculation. FAOSTAT starts in 1961, and the annual inflows in 1900 to 1960 in tier 1 are therefore based on a regression of the annual inflows in 1961.

The decay function used on historical inflows is the same as the decay function used on present inflow. It means that the importance of the decay rate (half lives) are smaller than one should expect because a low decay factor gives a high stock and a high decay factor gives a low stock. The consequence is that the inflow is compared to a weighted average of the inflows in the period from 1961 to the year before the present year. If the lifetime is expected to be long (as it is the case with solid wood products) the weight of older inflows is significant. If the lifetime is short (as it is the case with paper and paper products) the weight of older inflows is small.

The relative importance of the inflows from different years on the present stock is shown in figure 2. For solid wood it can be seen that the last 10 years inflow accounts for 22%. For paper and paper products the last 10 years inflow accounts for 97% of the stock, and the last 5 years inflow accounts for 85% of the stock. The consequence is that an increase in the inflow of paper and paper products within few years will result in an increased outflow. It is difficult to increase the stock of paper and paper products because they leave the stock quickly. On the contrary an increase in the inflow of solid wood products will have long term effects on the sequestration of carbon.

It can be seen that the year of 1961 has a large effect on the stock of solid wood. This is because the inflow in 1900-1960 is calculated on basis of 1961. In general long half-lives will be beneficial for all, because an increase in the

level of the inflow will have a longer effect of the carbon sequestration.

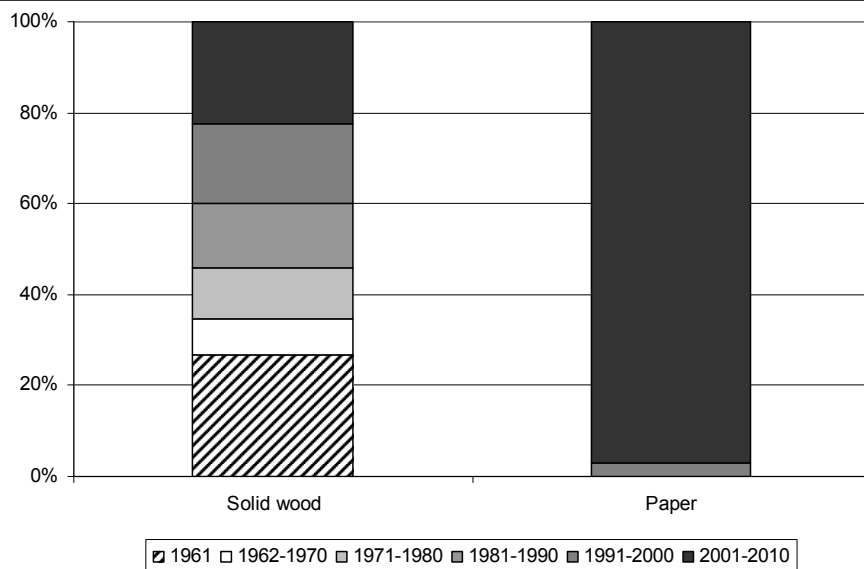


Figure 2. The relative importance of inflows 1960-2010 on the stock of solid wood and paper and paper products. The calculation is based on 30 year half lives for solid wood and 2 years for paper and paper products.

## Tiers

The countries can choose between different tiers, in order to calculate the estimated inflows. In the different tiers different data sources can be used in the calculations and different calculation methods can be used.

### Tier 1

Tier 1 is the default simply using data from FAOSTAT. Calculations based on FAOSTAT have been performed by IPCC for most industrialized countries. It is tier 1 data that has been used in this report.

The FAO-STAT data on harvested wood products are delivered by Eurostat, which is the statistical office of the European Union situated in Luxembourg. Its task is to provide the European Union with statistics at European level that enable comparisons between countries and regions. EURO-STAT has built up ESS, the European Statistical System, which is the partnership between the Community statistical authority and the national statistical institutes (NSIs) and other national authorities responsible in each Member State for the development, production and dissemination of European statistics. Member States collect data and compile statistics for national and EU purposes. The ESS functions as a network in which Eurostat's role is to lead the way in the harmonization of statistics in close cooperation with the national statistical authorities. ESS work concentrates mainly on EU policy areas - but, with the extension of EU policies, harmonization has been extended to nearly all statistical fields.

Statistics Denmark is the National Danish statistical Institute, and among other Danish institutions The Danish Energy Agency and The Danish Forest and Nature Agency could be mentioned.

The formal responsibility for delivering data on production, import and export of HWP to EUROSTAT is held by The Danish Forest and Nature Agency, and they have outsourced the task to the Danish Forest Association. The Forest Association bases their submission on Statistics Denmark, and other available sources. If no data is available or the data seems unrealistic the Danish Forest Association gives a qualified estimate.

It is not quite clear whether there is some validation process of the data submitted to EUROSTAT, but It seem to be the case, because The Danish Forest Association has found out, that the submitted data in some cases are changed during the process. The quality of the Danish data in the FAO-stat is acceptable but they are probably not very precise.

### ***Tier 2***

Tier 2 improves the estimates by using country data, which means statistics of production, import and export of product types and wood species. In tier 2 the countries can also change the conversion factors and the decay rate. Beck (2008) has compared tier 1 and tier 2 using data from Statistics Denmark, but unfortunately the data was not delivered directly from Statistics Denmark. Instead they were collected from Statistics Denmark's web-page. The difference is important because Statistics Denmark could have validated the data if they were asked to deliver the data.

In an international context statistical data from Statistics Denmark must be considered as very reliable. Of course some unregistered import and export of different wood products takes place, and some production of firewood etc. are not registered in the sale statistics. Statistics Denmark is aware of this and corrects the statistics in order to produce the best possible data. Some errors can be found if one focus on production, import and export of single products, but it is expected that such errors are equalized when many products are summed.

A validation process could improve the data in Statistics Denmark. Use of statistics data automatically means that the data are validated, because errors and discrepancies are often found when you are working with the data, but validation can also be initiated on its own.

It would be relevant to ask Statistics Denmark to deliver the relevant data from 1960 to 2010 and also to deliver the data in the future.

Anyway this will probably not change the trends as compared to tier 1.

### ***Tier 3***

In Tier 3 each country can use alternative methods for the calculations. Different countries have tried to calculate the stock based on other statistical sources, but so far no country seems to go for a tier 3 approach.

## Description of the different approaches

Although it by the first sight looks a little tricky the HWP calculation methods are quite logic and straight ahead. A number of different calculation methods have been suggested and the different calculation methods are called approaches.

Tabel 1. Overview of the different approaches. Details and explanations can be found in the text.

Approach	Abbr. or nick name	Basic data	Characteristics	Advantages	Disadvantages	In favour of countries with:
IPCC default Approach	Instant Oxidation	None	Assumes no change in carbon stock or flows in HWP	Easy to use	Makes no incentive to increase the use of HWP	
Stock Change Approach	SCA	Stock Change	Based on domestic consumption of HWP	Easy to calculate from available statistics. Gives an incentive to increase the domestic consumption of HWP	Does not make incentive to increase the domestic production of HWP	Increasing consumption of HWP
Production Approach	PROD	Stock Change	Based on domestic production of HWP	Gives an incentive to increase the domestic production of HWP	Does not make incentive to increase the consumption of HWP	Increasing production of HWP
Stock Change Approach of Domestic origin	SCAD	Stock Change	Includes only HWP produced and consumed domestically		Makes only an incentive to increase the production of HWP consumed domestically and an incentive to increase the consumption of HWP produced domestically	Increasing production of HWP consumed domestically
Athmospheric Flow Approach	AFA	Flows	Somehow parallel to SCA			
Simple Decay Approach	SDA	Flows	Somehow parallel to PROD			

In all approaches the inflow of carbon is held up against the outflow. The differences between the approaches are caused by different system boundaries and calculation methods mainly the calculation of the outflow. The main difference in system boundaries is whether it is the producing country or the consuming country that accounts for the sequestration of carbon in HWP. The difference in calculation method is whether the calculation is based on stock changes or the carbon sequestration is calculated as gross fluxes.

The IPCC default approach, Instant Oxidation is a very simple approach assuming that inflow equals outflow. Therefore, the change in carbon sequestration is zero, and there is no need for further calculations. The three stock change approaches (the stock change approach, the production approach and the stock change approach of domestic origin) calculate the total carbon stock in harvested wood products every year and the difference between the total carbon stock one year and the next determine the carbon sequestration or emission. The two last approaches (the atmospheric flow approach and the simple decay approach) do not focus on carbon stock in

harvested wood products. Instead they calculate the carbon sequestration and the emissions directly.

All but the IPCC default approach capture the changes of stock of HWP over the years. When countries can account for carbon sequestration in HWP, it provides an incentive to increase the use of HWP and thereby increase the sequestration of carbon especially in long lived wood products. The approaches are shortly described in the following.

### ***IPCC default approach (Instant Oxidation)***

In the 1st commitment period of the Kyoto protocol HWP is included using the IPCC default approach which assumes that inflow of HWP equals outflow. Consequently the assumption is that the carbon stock in HWP does not change. For simplicity the carbon biomass in all HWP are assumed oxidized in the harvest year because the inflow of HWP is equaled by outflow of older HWP. This is the reason why this approach has the misleading name Instant Oxidation.

Instant Oxidation does not capture the changes of stock of HWP over the years, which is in contrast to all other accounting methods.

### ***The Stock Change Approach (SCA)***

It is a little confusing that the stock change approach is the common name for the three approaches that calculate carbon sequestration as difference in carbon stocks and at the same time the name for one approach. Anyway the name is so widely used that it cannot be changed.

The carbon stock in each year is calculated on basis of the consumption of HWP in the years before. The consumption of HWP each year is calculated as the domestic production plus the import of HWP minus the export of HWP. Thus, SCA accounts for carbon sequestration based on stock changes within national boundaries, where and when they occur.

The stock change approach is the most simple of the approaches because it can use national statistics directly. You only need to know the production, import and export of HWP in the period from 1960 until to day to calculate the carbon sequestration according to the stock change approach. The consumption of solid wood products and paper and paper products respectively in each year is calculated as the production plus the import minus the export.

As shown in figure 3 the consumption in Denmark of solid wood products has been increasing in the period from 1960 to 2006. The consumption has increased from 1,5 mio. m<sup>3</sup> in 1960 to 4,0 mio. m<sup>3</sup> in 2007. When the statistical data is used in the approaches, the unit must be changed from m<sup>3</sup> solid to tons carbon. A set of conversion factors based on standard density and standard carbon content in the dry matter has been developed.

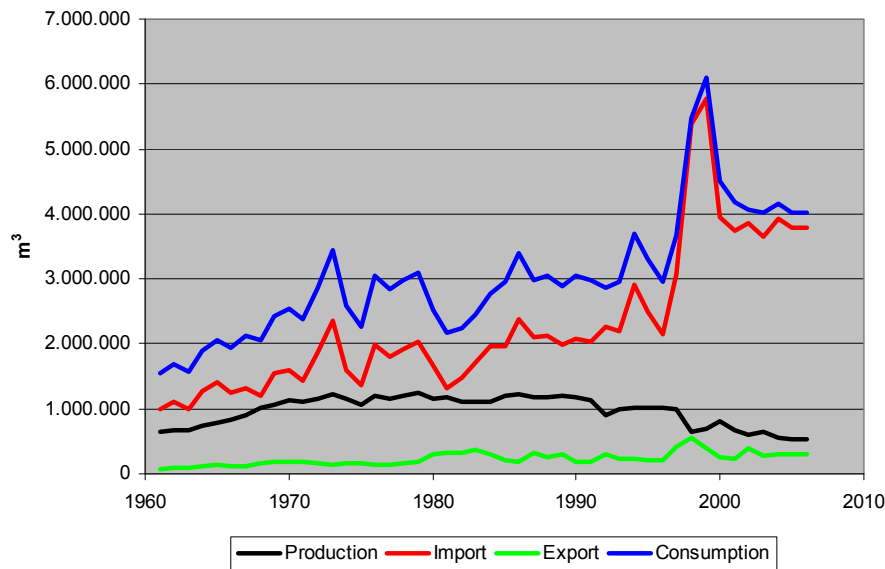


Figure 3. Production import, export and consumption of solid wood products in 1960-2006 (Pingoud 2006 rev. 2008).

It is quite clear that an increasing proportion of the consumption of solid wood products comes from import, and at the same time the proportion of solid wood products domestically produced is decreasing. The production of solid wood products in Denmark increased until 1970, was constant until 1990, and has decreased since 1990. The production in 2006 was only 540.000 m<sup>3</sup>, which is half of the production in 1970-1990. In spite of the decreasing production the export of solid wood products has slightly increased. The globalization is clear. Solid wood products are traded more and more internationally, which is an important point to discuss especially when international trade is excluded from the calculations (as it is in SCAD).

In figure 4 you can see the same graph for the production, import export and consumption of paper and paper products. The development in production, import, export and consumption of paper and paper products shows almost the same picture as solid wood products. The consumption has increased from 500.000 tons in 1960 to 1.300.000 tons in 2006. The increase is almost entirely based on the increased import of paper and paper products. There is an increase in the production of paper and paper products from 200.000 to 400.000 tons, but at the same time the export has increased from zero to almost 300.000 tons. The tendency forward globalization is also clear when it comes to paper and paper products. When the inflow (in this approach the consumption) increases over the years the outflow from the stock is smaller than the inflow and additional carbon will be sequestered. When the statistical data is used in the approaches, the unit must be changed from tons paper and paper products to tons carbon. A set of conversion factors based on standard density and standard carbon content has been developed.

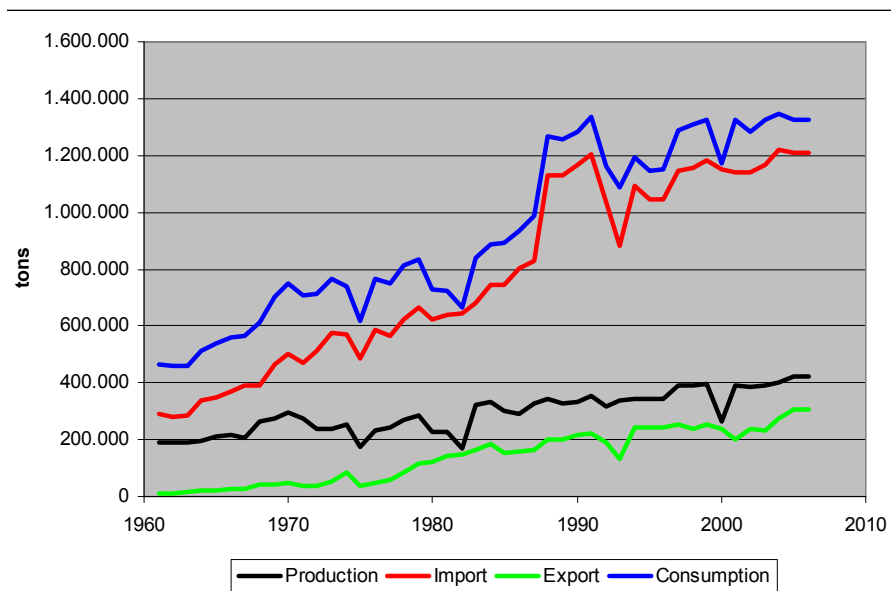


Figure 4. Production import, export and consumption of paper and paper products in 1960-2006 (Pingoud 2006 rev. 2008).

Figure 3 and 4 is based on FAOSTAT (Tier 1). National statistics (Tier 2) is often considered more precise than data from FAOSTAT, and the accuracy of the Danish data in FAOSTAT has been questioned by Beck 2008. Anyway when it comes to the Danish data the overall trends in figure 3 and 4 are in line with the general assumption of the trends in the period.

#### Production approach (PROD)

The production approach is also a stock change approach, meaning that this approach also calculate carbon sequestration as the difference in the total carbon stocks between one year and the next. In this approach the carbon stock is calculated on basis of the production of HWP from domestically produced roundwood.

The basis of the calculation of the annual inflow is the production of HWP (figure 3 and 4). Import and export of HWP is not included in the calculation. Anyway the production must be adjusted to exclude production based on imported roundwood and include production in other countries based on exported roundwood. This is done by a correction factor. The correction factor is:

$$\frac{\text{Production of industrial roundwood}}{\text{Production of industrial roundwood} + \text{net import of industrial roundwood}}$$

If the net import of roundwood is positive the correction factor becomes smaller than 1 meaning that the production based on imported roundwood is larger than the production in other countries based on the exported roundwood. If the net import is negative, the correction factor becomes larger than one meaning that the production based on imported roundwood is smaller than the production in other countries based on the exported roundwood.

The correction factor is used on both solid wood products and paper and paper products.



Therefore in order to calculate the inflow in PROD the production of HWP must be known as well as the harvest of industrial roundwood and the export and import of industrial roundwood.

The calculation includes import and export of (1) industrial roundwood, (2) chips and particles and (3) wood residues. It can therefore be noted that chips and particles and wood residues is assumed to be used for industrial purposes, which might be the case in most countries, but not in Denmark, where the import of chips and particles is assumed to be used for energy. The import of industrial roundwood is shown in figure 5. In spite of the large variation the import shows some trends. It can be seen that the import of industrial roundwood has been increasing since 1990. The import of chips and particles and residues has increased from a very low level in 1995.

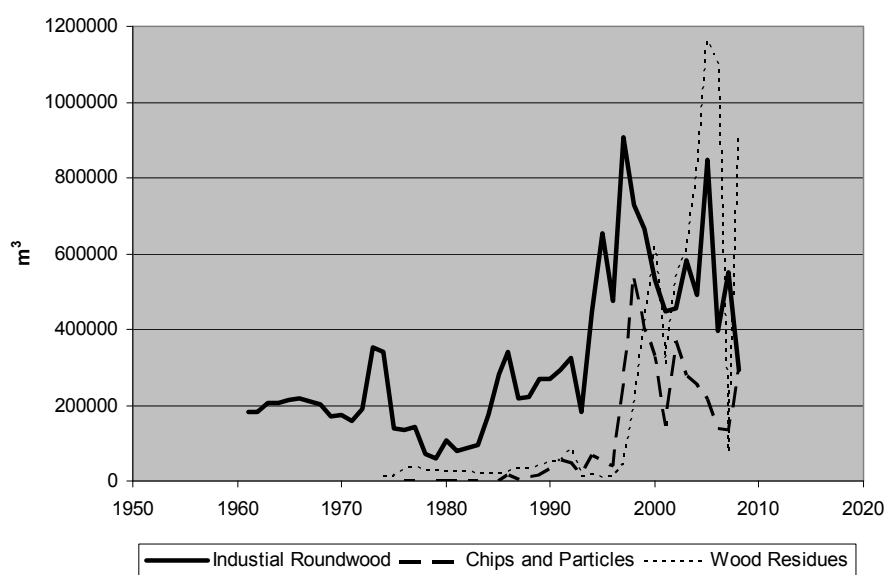


Figure 5. The import of industrial roundwood, chips and particles and wood residues (Statistics Denmark 2010).

The export of industrial roundwood is shown in figure 6. Again the variation is quite large, but the trends are similar to the import. The export of industrial roundwood has increased as well as the export of chips and particles and wood residues.

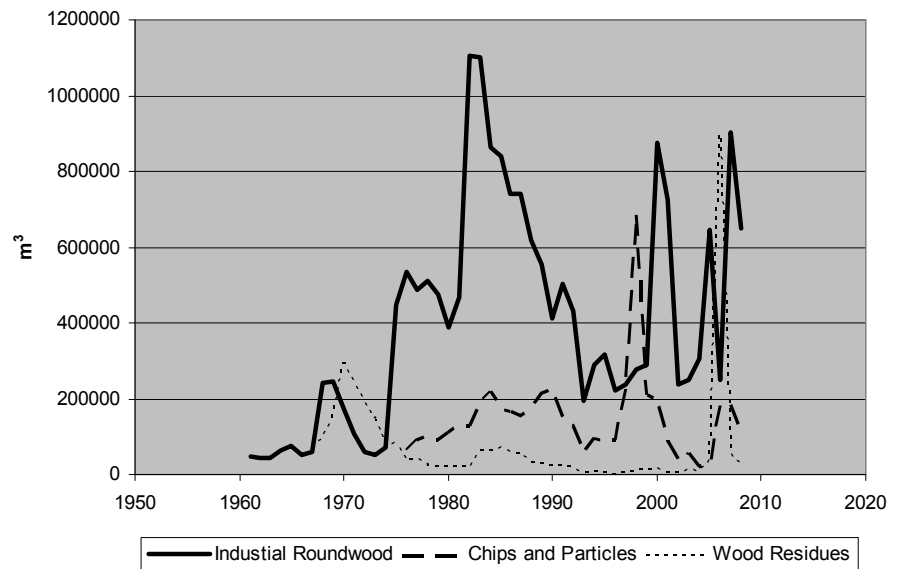


Figure 6. The export of industrial roundwood, chips and particles and wood residues (Statistics Denmark 2010).

In figure 7 the net import of industrial roundwood is shown. There is no trend in net import of industrial roundwood, but it seems as if the net import of chips and particles and wood residues is increasing. These resources should probably have been removed from the correction factor because they are most probably used for energy purposes.

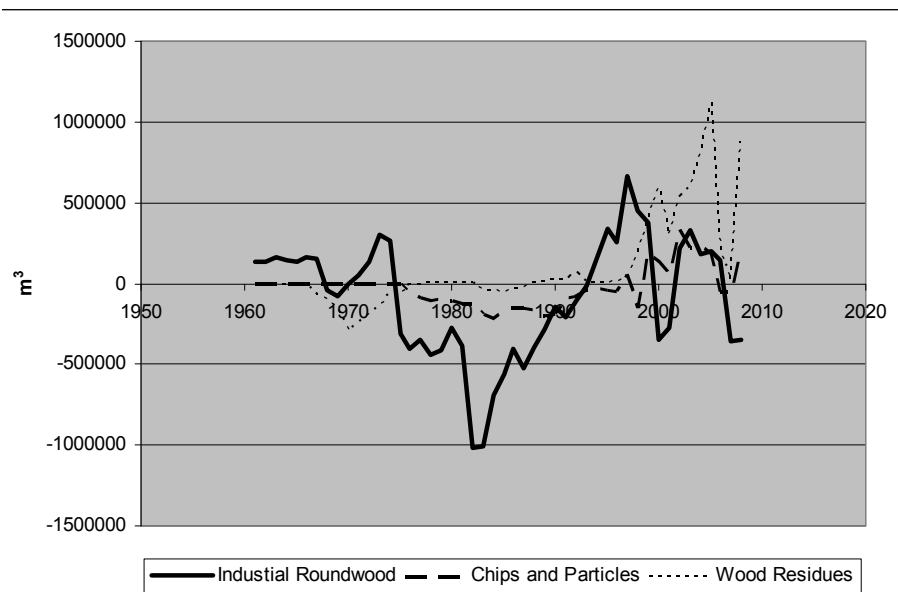


Figure 7. Net import of industrial roundwood, chips and particles and wood residues (Statistics Denmark 2010).

### *Stock change approach of domestic origin (SCAD)*

This stock change approach also calculates carbon sequestration as difference in carbon stocks. In this approach the carbon stock is calculated on basis of HWP that are domestically produced and consumed. The annual inflow is calculated as the production of HWP minus the export of HWP. Internationally traded HWP is accounted as instant oxidation in the country

of origin. This is a principally important difference from SCA and PROD. Again the basis of the calculation of the annual inflow is the production of HWP (figure 3 and 4). Import of HWP is not included in the calculation, and the export reduces the domestic production. The domestic production must be adjusted to exclude production based on imported roundwood. As with PROD this is done by a correction factor. The correction factor is:

$$\frac{\text{Production of industrial roundwood}}{\text{Production of industrial roundwood + import of industrial roundwood}}$$

The correction factor is always smaller than 1.

The inflow of HWP based on SCAD is a subset part of PROD and also a subset of SCA. The difference between SCA and SCAD is the consumption based on imported HWP and HWP produced of imported roundwood. The difference between PROD and SCAD is the production of HWP for export and HWP produced in other countries of the exported roundwood. The correction factor is used on both solid wood products and paper and paper products.

### ***Atmospheric flow approach (AFA)***

The AFA regards emissions and removals as flows between the atmosphere, the forest and the HWP pool and accounts for net emissions/removals of carbon to/from the atmosphere within national boundaries. Removals of carbon from the atmosphere due to forest growth are accounted for in the producing country, and emissions of carbon to the atmosphere from oxidation of HWP are accounted for in the consuming country. In this context AFA is similar to SCA.

The producing country will have to report only emissions resulting directly from harvesting, such as decay of slash. In contrast to the stock-change approach, the consuming country will not increase its pool of carbon in HWP but will have to report the emissions as imported wood products decay. Where the producing country is also the consuming country, this is translated into a direct delay of emissions from HWP.

The atmospheric-flow approach does not account for depletion of forest carbon stocks to the extent that losses in carbon stocks are exported. In this case, sustainable management of forest carbon stocks is not encouraged. Furthermore, it could promote deforestation: If wood from deforestation is exported, the emission is accounted for in the importing but not the exporting country.

The Atmospheric flow approach can be calculated on basis of the available statistics. The calculation is most easily done by using the carbon sequestration from SCA corrected with carbon sequestrations or emissions from import and export of HWP.

## Simple decay approach (SDA)

Another approach is the simple decay approach or accounting for “harvesting emissions”, which also sees emissions/removals as gross fluxes between the atmosphere, the forests (and other land uses) and HWP. This approach assumes that emissions from wood products are estimated over time as products decay. Rather than allocating emissions where they occur, as in the atmospheric-flow or stock-change approaches, the simple decay approach suggests that these emissions be allocated to the producer. In this context SDA is similar to PROD. It does not estimate emissions from existing HWP pools, but simply delays emissions from harvesting by a factor that reflects the decomposition rates of carbon in HWP.

This approach is only a suggestion, and when calculated on basis of available statistics the calculation is similar to PROD.

## Comparisons between the approaches

In the stock change approaches the total carbon stock in harvested wood products is calculated every year and the change in carbon sequestration is calculated as the difference between the total carbon stock one year and the next. The difference between the three stock change approaches is the system boundaries. SCA calculates the stock change of HWP that has been consumed in the country; PROD includes the stock change of HWP from roundwood produced in the country and SCAD includes only HWP that has been produced of domestic roundwood and consumed in the country. As it can be seen in figure 8 the total stock of HWP in Denmark is increasing if SCA is used (the red line). If PROD is used, the total stock of HWP has increased until 1993, and thereafter decreased. If SCAD is used, the total stock has increased until 1997 and thereafter decreased. It is also worth noting that the total stock is much larger when using SCA as compared to the other two approaches. SCAD has the smallest stock because it only include HWP produced and consumed domestically.

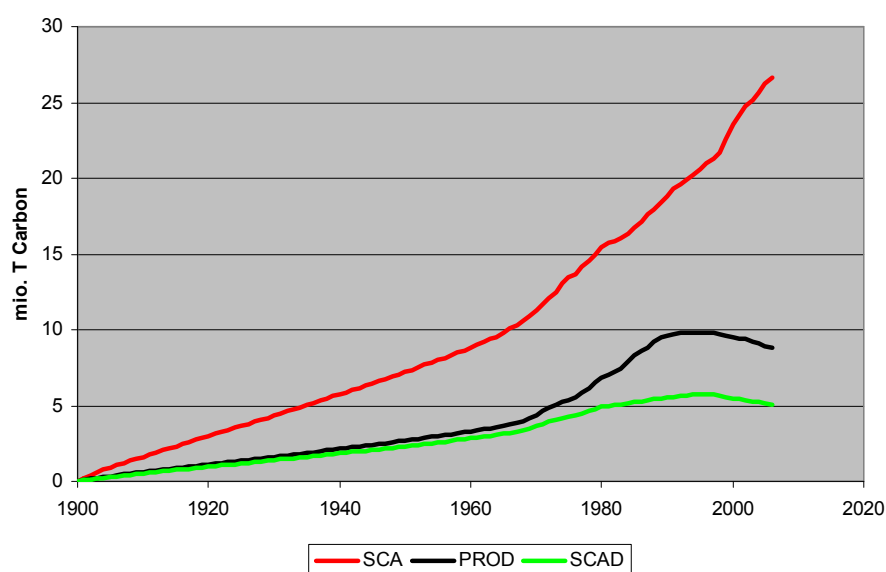


Figure 8. The total stock of the three stock change approaches (Pingoud 2006 rev. 2008).

The difference between the red line (SCA) and the green line (SCAD) is the total stock based on imported HWP and HWP produced of imported roundwood. In other words, the total stock of SCA consists of one part of HWP produced and consumed domestically (below the green line) and another part of imported HWP and HWP produced of imported wood (between the red and the green line). The proportion of the total stock of HWP based on imported HWP and imported roundwood has increased steeply since 1984. Until 1984 the stock of imported HWP was 68% of the total stock, but after 1985 the proportion increased and in 2006 the stock of imported HWP was 81% of the total stock of HWP. In the same period the proportion of the stock of domestically produced and consumed HWP based on domestically harvested wood has decreased from 32% to 19%.

The difference between the black line (PROD) and the green line (SCAD) is the stock of HWP produced in Denmark and exported. Until 1970 the proportion was only round 15%, but the proportion has increased steadily and in 2006 the proportion was 43% meaning that 43% of HWP produced in Denmark are exported.

Looking at the carbon sequestration (the stock changes of the stock change approaches) (figure 9) one can see larger variations than seen in figure 8. Anyway the trends are clear, and basically the two figures show the same. The stock change of SCA is positive and increasing. The stock change of PROD increased until the mid 1980's and was positive until the mid 1990's thereafter became negative meaning that the total stock is decreasing. The stock change of SCAD has been positive until the mid 1990's and negative thereafter. The (negative) sequestration from the AFA approach is also added to figure 9. It is clear that especially AFA results in high emissions of carbon from HWP because the large net import of HWP is added to the emission in the year they are imported.

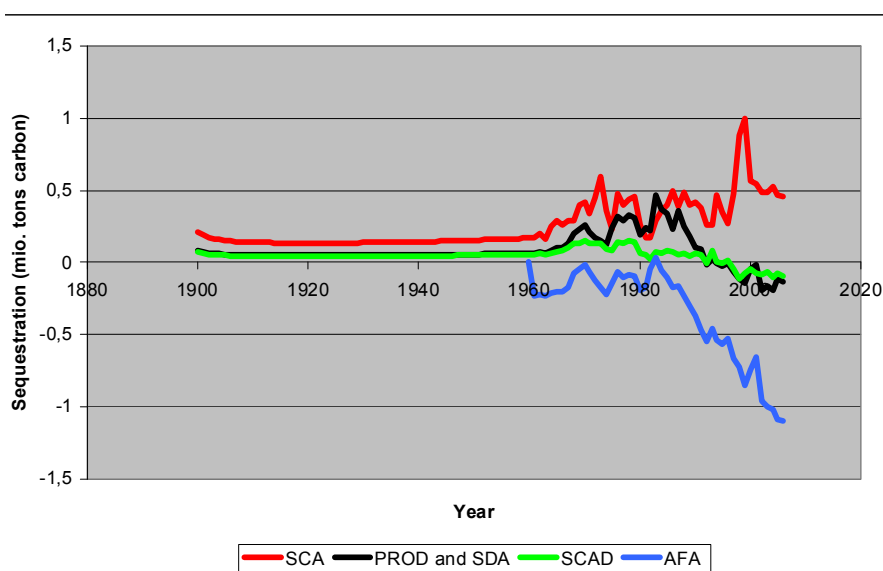


Figure 9. The annual carbon sequestration of the five approaches (Pingoud 2006 rev. 2008).

Roughly two third of the inflow comes from solid wood products and one third from paper and paper products, but because the life time for paper and paper products is so short, 94-97% of the stock consists of solid wood products.

## Conclusions

In general accounting for carbon sequestration in HWP is only relevant if the carbon stocks are changing or if gross fluxes from and to the atmosphere are different from zero. If the carbon stocks are constant or the gross fluxes are insignificant the net carbon sequestration will be zero as it is assumed using the IPCC default approach.

If the carbon stocks are increasing or the gross fluxes from the atmosphere are positive then the calculations result in carbon sequestration which will decrease the country's overall emission of CO<sub>2</sub>. On the contrary if the carbon stocks are decreasing or the gross fluxes from the atmosphere are negative then the calculations will result in net emission of CO<sub>2</sub> from HWP.

Accounting for carbon sequestration in HWP gives very different results for Denmark and also other countries depending on the approach used. The reason is that import and export of industrial roundwood and HWP is increasing, and what actually makes the difference between the approaches is who will include the inflow and outflow of carbon from HWP traded between countries. SCA and AFA include internationally traded HWP into the calculations of the consuming country, while PROD and SDA include internationally traded HWP into the calculations of the producing country.

In SCAD all internationally traded HWP is calculated using the IPCC default approach, which is the same as saying that no country include internationally traded HWP into their calculations. As internationally traded industrial roundwood and HWP constitute an increasing proportion of the total production and consumption, the consequence is that an increasing proportion of HWP is excluded from the calculations. SCAD is suggested as a compromise between the two opposite groups of countries preferring either PROD or SCA, but the evaluation of this compromise must be negative. A large and increasing proportion of HWP is excluded from the calculations and this also means that the incentives connected to the inclusion of the HWP are not working. More precise you can say that using this approach makes no incentives for producing or consuming HWP that will be imported or exported.

Globally seen, SCA, PROD, AFA and SDA include all HWP in the calculations. What is not included in one country's calculation is included in another country's calculation, and no HWP is included more than once in a calculation. This is not the case for SCAD as described above. As the proposals are formulated in the available notes, it seems that the countries have the possibility to choose the IPCC default approach instead of an approach leading to net emission of CO<sub>2</sub>. If some countries use this solution or if it becomes possible for different countries to choose different approaches then some HWP will not be accounted for and other HWP will be included more than once globally seen.

In Denmark, SCA results in a high annual carbon sequestration in HWP mainly because the consumption of HWP in Denmark is increasing. PROD,

SCAD SDA and especially AFA results in negative carbon sequestration (net carbon emission) from HWP mainly because the production of HWP in Denmark is decreasing. This trend is expected to continue in the future. Tier 2 data is not expected to change this conclusion.

The import of chips and particles and wood residues to Denmark is used for energy purposes and should therefore not have been included in the calculations of PROD and SCAD. The consequence is that the estimates of the inflow after 2000 become smaller than they should be. Anyway this is not expected to change the conclusion that for Denmark PROD and SCAD will lead to negative carbon sequestration.

It is recommended that Statistics Denmark deliver the data relevant to accounting of HWP to Eurostat. If the sector should be included in validating the data the most relevant organization is Danish Industry. Using tier 2 data instead of tier 1 data is not expected to change the overall results of the calculations.

Different decay functions and half lives have smaller consequences than one should expect. The reason is that the same functions are used on the historic stock and on the outflow. Long half lives result in lower outflow of a larger stock and shorter half lives results in higher outflow of a smaller stock. In general shorter half lives reduce the size of the carbon sequestration or emission, but will not change the trends.

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Harvested wood products (HWP) are defined as wood-based materials harvested from forests, which are used for products such as construction timber, furniture, plywood and paper and paper-like products or for bioenergy. HWP exclude logging residues that are left at harvest sites.

Accounting for carbon sinks in HWP would encourage silvicultural measures and provide incentives for the use of HWP. Negotiations on the second commitment period of the Kyoto protocol open the way for possible inclusion of carbon sinks in HWP.

A number of different calculation and reporting methods have been suggested and the different calculation methods are called approaches. The IPCC default approach, instant oxidation is a very simple approach assuming that inflow equals outflow. All other approaches try to capture the changes of stock of HWP over the years. When countries can account for carbon sequestration in HWP, it provides an incentive to increase the use of HWP and thereby increase the sequestration of carbon especially in long lived wood products.

The report analyses and compares the different approaches and the possible effect on Danish carbon accounting.