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Czech Hydrometeorological Institute

Harvested Wood Products

Approaches, Methodology, Application

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Beginning is easy, continuous is hard.

Christiana Figueres, Executive Secretary UN FCCC, at IGES (2011)

Angle of view

This report is result of my work for Czech Hydrometeorological Institute and as intern for IGES, IPCC Technical Support Unit (TSU) for Task Force on National Greenhouse Gas Inventories (TFI). The report represents my personal opinion and so does not represent the formal opinion of IPCC, TSU or IGES.

My personal perspective on emissions and removals from Harvested Wood Products (HWP) is inventory relevant, neither political (e.g. maximalize benefits from removals) nor nature protective (e.g. biodiversity conservation or landscape protection). There is only one intention of my work and that it is to estimate emissions and removals of GHG on the national level as simple, precise and accurate as possible. For this purpose I propose some changes in the calculation of emissions and removals from HWP and describe one potential approach for HWP calculation as well as some additional methodological guidance whose purpose is to prevent double counting on the national level (Czech Republic) in current version of inventory and also for general methodological approach.

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I highly benefited from close cooperation with many Czech experts, who are involved in national statistics for wood harvest, use and waste generation. In particular, thanks go to Dr. Emil Cienciala, who provided extensive methodology guidance and information about wood timber, Mr. Ales Bufka who provided data about biomass use for energy purposes and Mr. Miroslav Havránek who provided input and advice on CO_2 and CH_4 emissions from waste management. I am also very grateful for explanatory comments; data provided for paper production and recycled paper use from Mr. Josef Zbořil.

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1 Introduction

Wood is an important renewable material. From the point of GHG emissions there is two important kinds of influences: direct (wood use for energy production) and indirect (wood replacing more energy or GHG emissions intensive materials and extending wood product life). In the first case CO2 emissions from fossil fuel combustion are avoided in the second one, energy used for and emissions from material production are saved or carbon embodied in wooden products is not released into the atmosphere. **It is very important to realize, that wood products do not remove GHGs from the atmosphere. The default assumption refers only to the timing of emissions (Ford-Robertson, 2003).**

What does it mean Harvested Wood Product? Slightly different definitions were provided by UN FCCC, IPCC and in scientific literature. There is neither clear concept on the level of the UN FCCC nor IPCC. The term of the Harvested Wood Product is often used as general concept without exact definition of parameters. Set up of all necessary parameters (e.g. minimum life time, origin of wood - domestic/abroad/eco certification, accounting of landfilled carbon[1]) have to be finished by international negotiation under the UN FCCC.

Emissions reported from wood harvest represent last important issue, where logic and natural laws are not strictly followed in national GHG emissions inventories. The basic presumption (e.g. Tier 1 of 2003 GPG for LULUCF) that carbon removed in wood and other biomass from forests is oxidized in the year of removal is widely used by countries. This assumption oversimplifies the reality, do neither reflect socio-economics not material and emissions flow and should be used only in cases when appropriate data are not available. Instant oxidation approach is also not in line with the UNFCCC definitions of:

- a sink is any process, activity or mechanism that removes a GHG, an aerosol or a precursor to a GHG from the atmosphere.
- a source is any process, activity or mechanism that releases a GHG, an aerosol or a precursor to a GHG into the atmosphere.
- a reservoir means a component or components of the climate system where a greenhouse gas is stored.

Under these definitions at least part of the wood removed from forest cannot be considered as a source of emissions. If the wood is not used for energy production (and combusted), wood and wood products can be seen as special type of reservoir (or a special part of dead wood reservoir). HWP cannot be described as sink although this is often the way of thinking and description in reports and articles (e.g. Suadicani, 2010). This is probably a question of terminology and translation rather than the result of different views on the HWP issue.

Since 2003 GPG for LULUCF and the 2006 IPCC GI. was published, methodology for CO_2 emissions and removals estimation from HWP is available. 2006 IPCC GI. mentioned instant oxidation as “zero” tier estimate and for Tier 1 methodology application is HWP calculation sheet provided. In UN FCCC (2009d) the SBSTA agreed that the process for Parties included in Annex I to the Convention (Annex I Parties) to use the 2006 IPCC Guidelines should be through a revision of the “Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UN FCCC reporting

[1]This should be issue for some countries, e.g. Norway (Flugsrud et al, 2001) estimates its HWP storage in buildings (50 %) and landfills (43 %).

guidelines on annual inventories” (UN FCCC Annex I reporting guidelines) and also agreed to launch a work program in 2010 for the revision of the UN FCCC Annex I reporting guidelines, including the CRF tables, with a view to recommending revised UN FCCC reporting guidelines for adoption by the COP, for regular use starting in 2015. Since this decision was agreed 3 workshops was organized by UN FCCC.
The 2006 IPCC GI. are used by some Annex I Parties for preparation their national GHG inventories without problems during review. All cases of 2006 IPCC GI. use are assessed individually with great emphasis on assessment of national conditions. There were only few countries, which reported HWP in 2010 submission to UN FCCC. This is probably result that:

- the HWP reporting is voluntary (UN FCCC, 2007) and countries do not want risk some problems under UN FCCC and KP reporting,
- Parties want to avoid potential great uncertainties (UN FCCC, 2003a),
- many countries are waiting for final conclusion by UN FCCC, which will provide rules for emissions and removals accounting from forests, wood products and landfills.

This approach leads to a lack of quality data on the HWP, because the Tier 1 methodology is applied for basic estimates (mainly carried out by research institutions for international comparisons and not by national institutions responsible for preparing national inventories).
This last point shows that UN FCCC Parties were not able to reach common position for more than 10 years. It shows that forest position under climate change issues are special one and that the forest issue is situated on the border of negotiation process and that it is multidisciplinary issue, because forests can be considered:

- as a sink and a reservoir of carbon (or CO_2),
- as source of renewable materials, fuels and food (important part of national industry and source on national wealth),
- important element of biodiversity,
- as producer of environmental, social, cultural, science services (e.g. clean air, water, climate, floods, erosion protection, tourism, relaxation, education, medicaments), so

The HWP accounting should accommodate all above mentioned points and much more (e.g. sustainable forest management, recycling practice, international trade with wood and much more). It is complex issue and different countries prefer different views. Decision which will prioritize one function of forest and/or wood will influence all others. Countries differently use wood and wooden products (e.g. in North America 90% of building in housing sector are built from wood compared to the 8-10 % in Europe (Beyer et al, 2006)). This situation determines the position of negotiators and “reduction” potential.
HWP issue compared to the other UN FCCC issues (e.g. set up reduction targets) is minor one. There is also unofficial rule of UN negotiators: "Nothing is agreed until everything is agreed." Next one is, that despite the fact, that HWP issue is mainly discussed by LULUCF experts, preparation of the more precise HWP emissions estimates[2] than Tier 1 application is complex issue, which needs broader cooperation among statisticians, environmental economist, emissions (inventory) and LULUCF experts.
This report is focused on the expert part of the HWP issue and specially on methods and data availability for HWP emissions and removals estimation and their applicability and accuracy on the national level. The political assessment is completely out of view of this report.

[2]Higher ties application, development of national parameters.

2 IPCC Methodology

HWP methodology development is long term process which started more than 20 years ago. All methodological guidance related to the preparation of GHG emissions and removals inventories are prepared by the IPCC, namely the IPCC National Greenhouse Gas Inventories Programme. This program was managed from 1991 by the IPCC WG I in close collaboration with other institution (e.g. Organisation for Economic Co-operation and Development - OECD and the International Energy Agency - IEA). The IPCC National Greenhouse Gas Inventories Programme was transferred to the IPCC's Task Force on National Greenhouse Gas Inventories (TFI) in 1999. Work of the TFI is supported by the Technical Support Unit (TSU). The TSU is based at the Institute for Global Environmental Strategies (IGES) in Hayama, Japan. The Government of Japan provides funds for TSU activities, which are guided by the Task Force Bureau (TFB) as the managing authority of the TFI.
Since the beginning of its work the IPCC has published the following methodological guidelines:

- 1994 - IPCC Guidelines for National Greenhouse Gas Inventories (replaced by 1996 Revised Guidelines)
- 1996 - Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories;
- 2000 - Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories;
- 2003 - Definitions and Methodological Options to Inventory Emissions from Direct Human-induced Degradation of Forests and Devegetation of Other Vegetation Types;
- 2003 - Good Practice Guidance for Land Use, Land-Use Change and Forestry;
- 2006 - 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Years indicate, when methodologies was approved by the IPCC plenary meeting, not when were published.
Next chapters describes general concept of HWP and main related information to the HWP methodology development as published in IPCC inventory guidelines[3] and IPCC meeting reports.

2.1 Concept of Harvested Wood Products

Definition of HWP is provided in (UN FCCC, 2003d) as well as basic wood and wood product flow description, data availability in FAO statistics (see BOX 1). You can observe slight move in definition (UN FCCC, 2003d) defines wood products (instead of HWP). The definition used by 2003 GPG for LULUCF is more general and explain that “Wood and paper products are referred to as harvested wood products (HWP)”. 2006 IPCC GI. (Volume 4 - Chapter 2.3.1.1) mentions “Furthermore, the wood harvest from forests becomes an input to HWP (Chapter 12).” and “***HWP includes all wood material (including bark) that leaves harvest sites***.” (Volume 4 - Chapter 12.1). Another “definition” is provided in UN ECE, 2008 which describe the HWP “as a pool of carbon that delays its release to the atmosphere”. It should be

[3]It means Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories; Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories; Good Practice Guidance for Land Use, Land-Use Change and Forestry and 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

emphasized that this is a temporary rather than permanent pool and that the “storage” is for short and medium period (UN ECE, 2008). In a long term perspective, HWP stocks will reach a steady state. The HWP could be sink of CO2 only in the case that CCS technology is used and CO2 emissions are stored. In that case CO2 sinks will be reported under the category Energy and not the HWP[4].

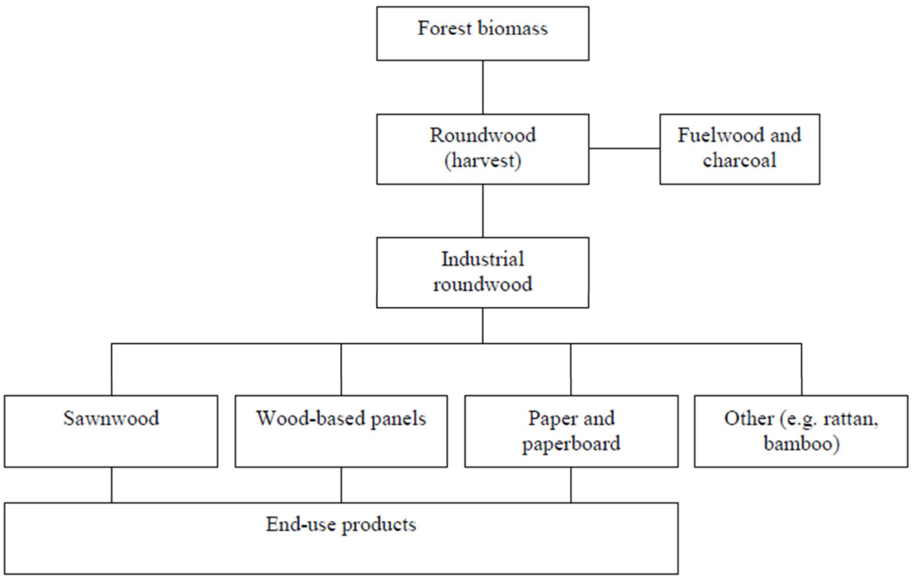
BOX 1. UN (UN FCCC, 2003d)

II. TECHNICAL BACKGROUND

A. Concepts and definitions

8. **Wood products** are wood-based materials harvested from forests, which are used for the production of commodities such as furniture, plywood, and paper and paper-like products, or for energy. In principle, other fibre products from non-timber sources, such as rattan or bamboo, could also be considered wood products. Figure 1 introduces the classification of wood products used in this document.

Figure 1: Classification of wood products



Source: Based on FAO (2000).

The UN FCCC view and also the definition as provided in 2006 IPCC gl. are different. In 2006 IPCC gl.[5] the Stock-Change Approach estimates changes ***in wood carbon stocks in the forest pool*** (and other wood producing lands) and ***wood-products pool*** in the reporting country. Changes in carbon stock in forests and other wood producing land categories are

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[4]2006 IPCC Gl. CCS chapter - Negative emissions may arise from the capture and compression system if CO2 generated by biomass combustion is captured. This is a correct procedure and negative emissions should be reported as such.

[5]Annex 12.A.1 of 2006 IPCC gl. is introduced by “This annex provides descriptions of some approaches for HWP.” This introduction sentence is confusing, better wording should be “This annex provides description of some approaches for HWP accounting as subsystem of overall biomass (carbon) storage and/or GHG emissions flows.”

reported by the country in which the wood is grown, referred to as the producing country. Changes in the products pool are reported by the country where the products are used, referred to as the consuming country. Because the stock changes actually occur in the reporting country the report indicates when and where the stock changes occur.
The definition used in the 2006 IPCC GI for approach description is much broader and takes into account whole LULUCF (A/FOLU) sector than simple definition of HWP. IPCC methodology as described in the chapter 12 of 2006 GI. (and HWP calculation sheet) is focused only on wood and paper product use and decay. LULUCF (A/FOLU) methodology is described in other chapters of IPCC gl. Difference is illustrated on the Figure 1 (only for Stock-Change Approach).

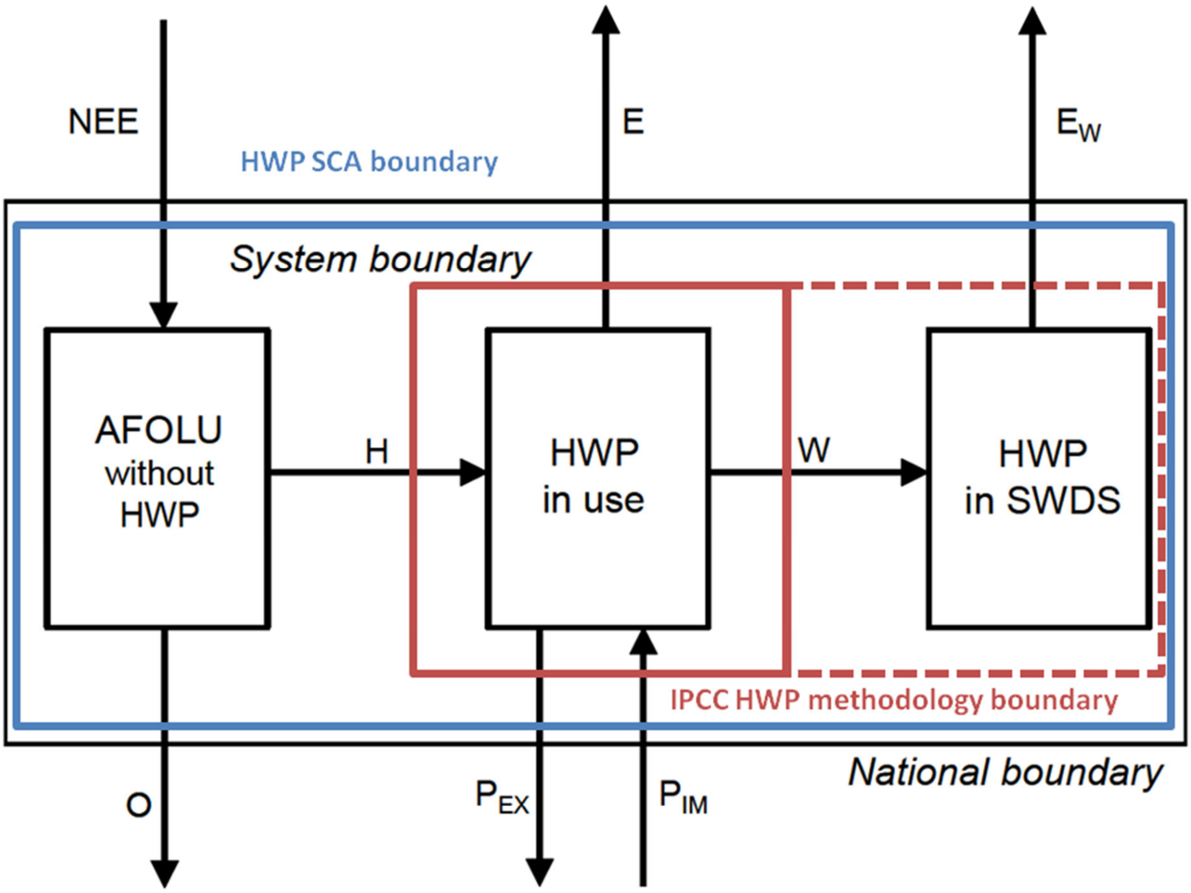

Figure 1. Difference between narrower and broader definitions of the HWP for Stock-Change Approach.

Source: 2006 IPCC GI. (Annex 12.A.1.)

The basic flows, carbon pools and concept of HWP is shown on the Figure 2 (adapted from UN FCCC, 2003d and Pingoud, 2003). In this report narrower definition is followed and HWP approaches are understood as higher level of emissions / removals accounting from LULUCF/AFOLU category. The LULUCF/AFOLU part is same for all HWP approaches and so could be omitted when differences between approaches are described. Also LULUCF/AFOLU accounting is driven by another (part) UN FCCC/IPCC methodology. Flows of carbon-containing compounds (e.g. biomass, wood, CO_2, CH_4) are relatively complicated process. Not all processes, which produce CO_2 and CH_4 emissions are fully understood and described in the IPCC methodologies (see Figure 2). As will be described later on IPCC methodology on the HWP estimates is focused on wood as total mass and emissions from wood decay. Another parts of IPCC methodology provide precise description of processes and all parameters needed for emissions estimates from biomass (wood) combustion (CO_2 and CH_4), biomass (wood) wastes incineration (CO_2 and CH_4) and from biomass (wood) wastes decay on landfills (only CH_4, but CO_2 emissions can be easily estimated).

Emissions from wood and wood products, which are not combusted and/or landfilled, are not individually described and estimated, but they are part of the overall decay process. This could be illustrated on an example the decomposition of bark. Wood (carbon) removed from the forest are calculated with bark. Sometimes bark is removed from trunk on the site of logging (e.g. this is common practice in Australia), sometimes just before wood processing (e.g. this is common practice in the Czech Republic), depends on the national circumstances. In Czech Republic is bark used for energy generation and partly also for garden purposes. In the first case CO_2 and small amount of CH_4 emissions occur forthwith. The second one is slow decay process, which emits only CO_2.

To avoid double counting of CO_2 emissions, CO_2 emissions from wood and wood use are reported and accounted only in the LULUCF (AFOLU) sector. In the Energy sector emissions are estimated and reported only for control purposes. Slightly different situation is with CH_4 emissions. If the amount of carbon emitted, estimated, reported and accounted as CH_4 is not subtracted from emissions reported in the LULUCF (AFOLU) sector, in that case it is double-counting. More information about this potential problem of double-counting is provided in chapter 8.2.

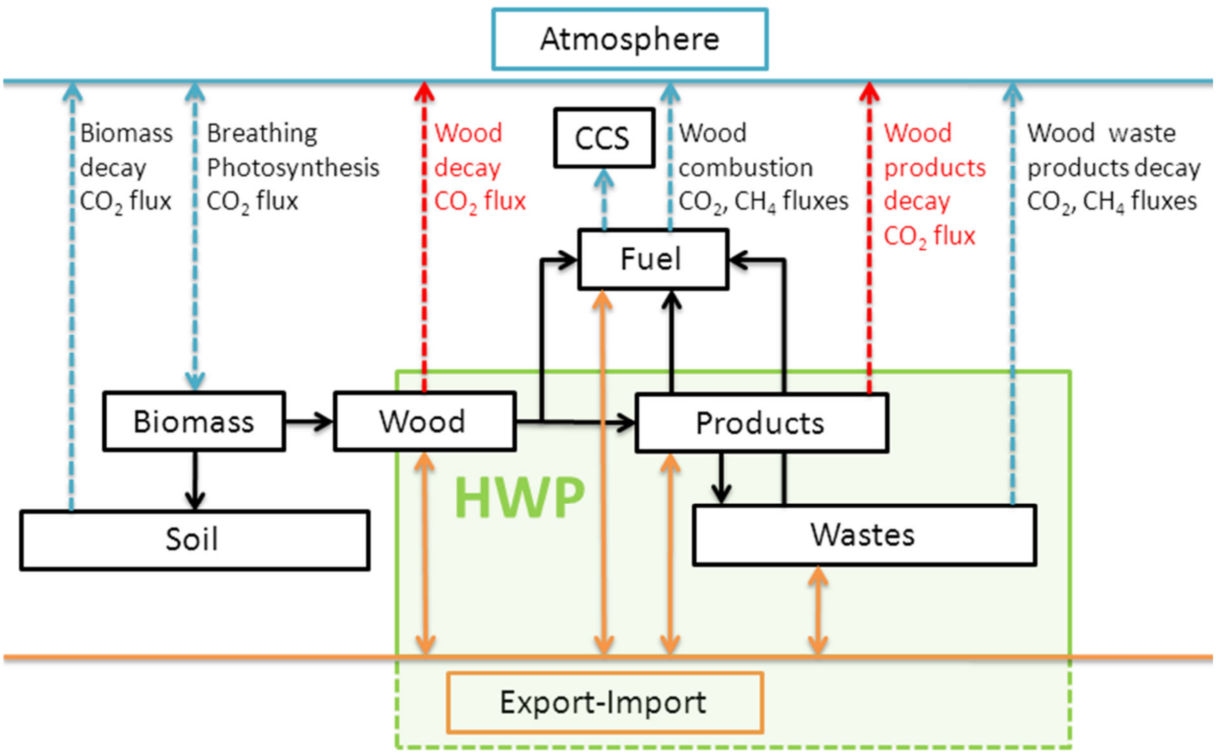

Figure 2. Flows of carbon-containing compounds (adapted from UN FCCC, 2003d and Pingoud, 2003)

Issues related to the HWP accounting is relatively intensively addressed by the UN FCCC negotiation and also by negotiating parties. In UN FCCC negotiation HWP issues was discussed as standalone (e.g. UN FCCC, 2001 and UN FCCC 2003a) but in latest years was allocated into separate issues (e.g. UN FCCC 2009a, UN FCCC, 2009c and UN FCCC, 2010a):

- LULUCF/AFOLU accounting,
- 2006 IPCC Gl. use,
- review of Reporting Guidelines for Annex I parties.

Relevant documents with the views of Parties addressing the HWP issues can be found in UN FCCC documents on the www.unfccc.int. Important sources of information about positions of the Parties are documents which are marked as "Submissions from Parties" (MISC document series), Technical paper (TP document series) or "Note by the secretariat" (INF document series):

- FCCC/SBSTA/2001/MISC.1 - Issues Related to Emissions from Forest Harvesting and Wood Products
- FCCC/SBSTA/2003/MISC.1 - Methodological Issues Good practice Guidance and Other Information on Land Use, Land-Use Change and Forestry, Implications of harvested wood products
- FCCC/SBSTA/2003/MISC.1/Add.1 - Methodological Issues Good practice Guidance and Other Information on Land Use, Land-Use Change and Forestry, Implications of harvested wood products accounting - Addendum
- FCCC/SBSTA/2003/MISC.1/Add.2 - Methodological Issues Good practice Guidance and Other Information on Land Use, Land-Use Change and Forestry, Implications of harvested wood products accounting - Addendum
- FCCC/TP/2003/7 - Estimation, Reporting and Accounting of Harvested Wood Products
- FCCC/TP/2003/7/Corr.1 - Estimation, Reporting and Accounting of Harvested Wood Products - Corrigendum
- FCCC/SBSTA/2004/MISC.9- Issues relating to harvested wood products
- FCCC/SBSTA/2004/MISC.9/Add.1 - Issues relating to harvested wood products - Addendum
- FCCC/SBSTA/2004/INF.11 - Report on the workshop on harvested wood products
- FCCC/SBSTA/2005/INF.7 - Information on harvested wood products contained in previous submissions from Parties and in national greenhouse gas inventory reports
- FCCC/SBSTA/2005/MISC.9 - Data and information on changes in carbon stocks and emissions of greenhouse gases from harvested wood products and experiences with the use of relevant guidelines and guidance of the Intergovernmental Panel on Climate Change
- FCCC/SBSTA/2005/MISC.9/Add.1 - Data and information on changes in carbon stocks and emissions of greenhouse gases from harvested wood products and experiences with the use of relevant guidelines and guidance of the Intergovernmental Panel on Climate Change - Addendum
- FCCC/SBSTA/2005/MISC.9/Add.2 - Data and information on changes in carbon stocks and emissions of greenhouse gases from harvested wood products and experiences with the use of relevant guidelines and guidance of the Intergovernmental Panel on Climate Change - Addendum
- FCCC/KP/AWG/2009/MISC.11 - Views on options and proposals for addressing definitions, modalities, rules and guidelines for the treatment of land use, land-use change and forestry

- FCCC/KP/AWG/2009/MISC.11/Add.1 - Views on options and proposals for addressing definitions, modalities, rules and guidelines for the treatment of land use, land-use change and forestry
- FCCC/SBSTA/2009/MISC.3 - Experience with and considerations relating to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and further considerations relating to the future revision of the UNFCCC reporting guidelines for Annex I Parties
- FCCC/SBSTA/2010/MISC.1 - Views on issues relating to the 2006 IPCC Guidelines and the revision of the UNFCCC Annex I reporting guideline
- FCCC/SBSTA/2010/MISC.7 - Views on the revision of the UNFCCC Annex I reporting guideline
- FCCC/SBSTA/2010/MISC.7/Add.2 - Views on the revision of the UNFCCC Annex I reporting guideline

Parties' positions described in the above listed documents has political background, rarely they include information about technical problems and propose solution. Important point is the requirement of a uniform methodology for choosing one approach, which will be mandatory for all (UN FCCC, 2009c).

2.2 (Pre)History of HWP

The history of HWP was started under the UN FCCC negotiations, where the first versions of approaches were developed. This suggests that the development of the HWP is largely determined by political negotiations (HWP is mainly problem of accounting and not of emissions or sink estimation preparation or reporting) and not technical discussions under the IPCC. The HWP history is table tennis game[6] between UN FCCC and IPCC.

In 1995, an approach for estimating the net carbon (CO2) emissions from forest harvesting and wood products was developed by the IPCC Expert Group on Land Use Change and Forestry. After reviewing draft approach, a second expert meeting on the HWP was held in Brazil 1996. Results were forwarded later to the IPCC-Plenary (IPCC12, Mexico City) as part of the 1996 revision to the Guidelines for National Greenhouse Gas Inventories. However, the IPCC deferred a decision on a greenhouse gas inventory module related to the HWP. It requested that the SBSTA be consulted on the matter because of the broader policy implications. The SBSTA welcomed this decision and asked IPCC for an evaluation of the importance of the HWP as carbon sinks (Poker J., Dieter M., Thoroe C., 2002, Brown S., Lim D., Schlamadinger B., 1998)

2.3 1994 IPCC GI.

IPCC Guidelines for National Greenhouse Gas Inventories have been approved by the IPCC at its 10th session in Nairobi (November 1994). The same methodology description, instant oxidation, (see BOX 2) was published also in Revised 1996 IPCC GI.

[6] The table tennis game means that UN FCCC asked IPCC for methodology preparation. But the object of interest (the HWP) was not (and still is not) clearly defined (by UN FCCC/SBSTA), so IPCC provides general methodology, which is by Parties (SBSTA) recognized as insufficient and (UN FCCC/SBSTA) asked for more development and more detailed methodology.

2.4 Revised 1996 IPCC Gl.

The official IPCC HWP history started in previous version of IPCC methodology. The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Revised 1996 IPCC Gl.; http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html) provides the same information as 1994 IPCC Gl. (see BOX 2). As the name of guidelines suggests, the methodology was approved by the IPCC in1996 and was published one year later. The Revised 1996 IPCC Guidelines consists of three volumes.

Revised 1996 IPCC Gl.: Reference Manual provides general guidance on the HWP, but does not specify any methodology and does not describe any approach for emissions and removals from HWP estimates. The part of Revised 1996 Gl., which is involved to the HWP is shown in the BOX 2.

The basic idea, so called default assumption (or also instant oxidation or "zero" tier), for emissions estimate from HWP in Revised 1996 IPCC Gl. is "For the purposes of the basic calculations, the recommended default assumption is that all carbon removed in wood and other biomass from forests is oxidized in the year of removal." This default assumption is not valid from the short term time horizon and in the case of change of wood based carbon pools. But when we take into account limitation (e.g. availability of wood as material for paper production or for construction or wood product lifetime), we can consider that from the long-term time horizon all wood will be oxidized (if new technologies and wood use methods will not be developed and used, e.g. analogy with Carbon Capture and Storage[7] technology).

The terminology was not fixed and still is not, so 1994 a 1996 IPCC Gl. talks about Harvested Wood, the term Harvested Wood Product (HWP) appeared first in the report from IPCC/OECD/IEA meeting, which was held in Dakar, 1998.

2.5 1998 Dakar Meeting

Full name of meeting, which was organized by IPCC/OECD/IEA Programme on National Greenhouse Gas Inventories was "Evaluating Approaches for Estimating Net Emissions of Carbon Dioxide From Forest Harvesting and Wood Products". The meeting was held from 5 to 7 May 1998 in Dakar, Senegal. Report (Brown S., Lim D., Schlamadinger B., 1998) from this meeting is available on http://www.ipcc-nggip.iges.or.jp/meeting/meeting_others.html as well as 3 Annexes, which covers this topics:

- Implications of the Approaches on the Management of Forest Resources,
- Working Group Reports and
- List of Participants.

The report (Brown S., Lim D., Schlamadinger B., 1998) discusses 3 different approaches (Stock Change approach, Atmospheric Flow approach, Production approach). The meeting report describes all these approaches and discusses its strong and weak points from the inventory (feasibility, accuracy) and political (relevance to the reporting needs of the UN FCCC and the Kyoto Protocol, relevance to national policies) point of view.

Short description of all approaches, which was identified by this meeting, is shown in BOX 3. More detailed information is provided in the subsequent chapters.

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[7]Combustion of biomass and CCS technology application can be considered as a very specific way of HWP. However, the emissions and removals estimates have to be prepared in line with CCS (Energy) chapter and not HWP (LULUCF / AFOLU) chapter and methodology.

BOX 2. Chapter about HWP in Revised 1996 IPCC GI.

LAND-USE CHANGE & FORESTRY

Changes in forest and other woody biomass stocks may be either a source or a sink for carbon dioxide for a given year and country or region. The simplest way to determine which, is by comparing the annual biomass growth versus annual harvest, including the decay of forest products and slash left during harvest. Decay of biomass damaged or killed during logging results in short-term release of CO_2. For the purposes of the basic calculations, the recommended default assumption is that all carbon removed in wood and other biomass from forests is oxidised in the year of removal. This is clearly not strictly accurate in the case of some forest products, but is considered a legitimate, conservative assumption for initial calculations. Box 5 provides some further discussion of this issue.

Box 5
THE FATE OF HARVESTED WOOD

Harvested wood releases its carbon at rates dependent upon its method of processing and its end-use: waste wood is usually burned immediately or within a couple of years, paper usually decays in up to 5 years (although landfilling of paper can result in longer-term storage of the carbon and eventual release as methane or CO), and lumber decays in up to 100 or more years. Because of this latter fact, forest harvest (with other forms of forest management) could result in a net uptake of carbon if the wood that is harvested is used for long-term products such as building lumber, and the regrowth is relatively rapid. This may in fact become a response strategy.

For the initial calculations of CO_2 emissions from changes in forest and other woody biomass stocks, however, the recommended default assumption is that all carbon in biomass harvested is oxidised in the removal year. This is based on the perception that stocks of forest products in most countries are not increasing significantly on an annual basis. It is the net change in stocks of forest products which should be the best indicator of a net removal of carbon from the atmosphere, rather than the gross amount of forest products produced in a given year. New products with long lifetimes from current harvests frequently replace existing product stocks, which are in turn discarded and oxidised. The proposed method recommends that storage of carbon in forest products be included in a national inventory only in the case where a country can document that existing stocks of long term forest products are in fact increasing.

If data permit, one could add a pool to Equation 1 (1) in the changes in forest and other woody biomass stocks calculation to account for increases in the pool of forest products. This information would, of course, require careful documentation, including accounting for imports and exports of forest products during the inventory period.

BOX 3. The basic description of different approaches as provided in Meeting report - summary.

Stock-change approach - This estimates net changes in carbon stocks in the forest and wood-products pool. Changes in carbon stock in forests are accounted for in the country in which the wood is grown, referred to as the producing country. Changes in the products pool are accounted for in the country where the products are used, referred to as the consuming country. These stock changes are counted within national boundaries, *where* and *when* they occur.

Production approach - This also estimates the net changes in carbon stocks in the forests and the wood-products pool, but attributes both to the producing country. This approach inventories domestically produced stocks only and does not provide a complete inventory of national stocks. Stock changes are counted *when*, but not *where* they occur if wood products are traded

Atmospheric-flow approach - This accounts for net emissions or removals of carbon to/from the atmosphere within national boundaries, *where* and *when* emissions and removals occur. Removals of carbon from the atmosphere due to forest growth is accounted for in the producing country, while emissions of carbon to the atmosphere from oxidation of harvested wood products are accounted for in the consuming country.

2.6 GPG

Good Practice Guidance consists of two parts, which were published in 2000 and 2003

- 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories; public available at http://www.ipcc-nggip.iges.or.jp/public/gp/english/ and
- 2003 Good Practice Guidance for Land Use, Land-Use Change and Forestry, public available at: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html).

The first part of the GPG, which was published in 2000, is focused on the other sector than LULUCF. The second part, 2003 GPG for LULUCF contains many references to the issue of the HWP, but do not provide binding and a clear solution, because SBSTA is still considering this issue.

2003 GPG for LULUCF provides methodology for HWP estimates preparation in an appendix rather than part of the main text, because the political decision on all necessary rules was not done. The appendix makes no judgment about possible future decisions on reporting or accounting.

The default assumption in IPCC Guidelines that carbon removed in wood and other biomass from forests is oxidized in the year of removal is still valid (as Tier 1). **Main and important change is that 2003 GPG for LULUCF gives to the Parties possibility to report on the HWP pools if they can document that existing stocks of forest products are in fact increasing.** Appendix 3a.1 provides guidance and all necessary information to Parties for the HWP estimation preparation, information that could be used in future methodological development or which should be subject to decisions by UN FCCC. In some cases provides more detailed data than 2006 IPCC Guidelines e.g. Table 3a.1.3 provides country specific information about half life for different categories of wood product use. Above mentioned table shows life time range between 1 and 10 years for paper. In other case there is missing some information, which are available in the next version methodology - 2006 IPCC Guidelines (e.g. there is no information about charcoal).

2003 GPG for LULUCF do not differentiate between approaches and methods. They are mentioned on the same level. It is not fully clear how tiers of methods match with different approaches (e.g. Tier 1 suggested that there is no HWP).
These guidelines represent the latest version of IPCC methodology which was approved by UN FCCC and KP bodies for inventory preparation for compliance with reporting requirements. As the HWP chapter is identified as Appendix and not as a “classic” chapter, its use is voluntary and is not binding under the UN FCCC and KP

2.7 2006 IPCC Guidelines

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories represents the latest version of IPCC methodology which was accepted by IPCC and published on http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html. There are also published all corrigenda, which was prepared (April 2007, November 2008, February 2009, June and November 2010). The 2006 IPCC Guidelines consists of 5 volumes, which covers all categories.
This version of IPCC guidelines was accepted by UN FCCC, but for regular use it is necessary wait till 2015, when new version of “Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories” (UNFCCC Annex I reporting guidelines) should be ready for use.
The 2006 IPCC Gl. represents the HWP as regular chapter of the guidelines and provides (in general way) all necessary explanation, procedures and methodologies description, parameters, tiers including QA/QC activities, uncertainty or completeness assessment. Approaches were removed into the separate Annex 12.A.1[8]. This split represented logic of emissions estimates (scientific/expert part) on the one site and emissions reporting / accounting (political part of the process) on the opposite site. IPCC guidelines shall be methodological guide for emissions estimates and not political guidance for emissions reporting and accounting. Emissions accounting have to be solved by SBSTA or another political body of UN FCCC.
The 2006 IPCC Gl. defines modular system which provides results for approaches described in the Annex 12.A.1. Gl. Because the UN FCCC does not provide exact definition of the HWP nor rules for emissions and removals accounting it is not possible to provide exact methodology (step by step description) and define all input parameters. It may happen that the UN FCCC (SBSTA) will agree conditions for the determination of emissions and removals from the HWP, that the current methodologies and procedures will be applied only partially or not at all. In that case, the missing parts will need to be developed. It is relatively clear, that approach which will be approved by UN FCCC (COP/MOP) for the HWP accounting will not be fully in line with methodologies described in the 2006 IPCC Gl. Because all approaches included in 2006 IPCC Gl. was developed in 1995 and since then, they was not approved by UN FCCC. Negotiation under the UN FCCC has identified other possible approaches (see chapter 3.1.6).
IPCC procedures for documents (methodology) preparation are time consuming (according to the complexity of the preparation it will take 2 years or more). Higner ties methodology (as described in 2006 IPCC g.) will need to be updated to accommodate new conditions negotiated under the UN FCCC.

[8]Annexes are understood as voluntary or non-binding part of the IPCC methodology.

The 2006 IPCC GI. describes 4 tiers methodology. The “Zero” Tier is “instant oxidation” or zero emissions for the case that annual change in carbon in the HWP stocks is insignificant. Other tiers 1-3 follow general IPCC methodology, default, default with country specific data and detailed country specific method. Information about results comparison of different Tiers are very limited. Basic information provides (Beck, 2008), that there could be difference between Tier 1 (FAO data) and Tier 2 (nationally provided data). The study (Beck, 2008) does not provide explanation what was the reason. It is probably problem with national statistics, because this kind of problem was not observed in the case of Czech Republic and no similar issue was described in any other article or report.
2006 IPCC GI. also provides the HWP calculation sheet (excel sheet model), which could be very easily used for HWP emissions and removals estimation for Tier 1 (and theoretically also for Tier 2). The model is based on public available data provided by FAO[9]. Because all equations are protected by password it is not possible to adapt model on national circumstance except some basic parameters (e.g. life time for paper and wood products, conversion factors and estimated growth rate of HWP consumption prior to 1961). This is barrier for adaptation of this model on national circumstances (Tier 2).
FAO definitions could be differently interpreted in different countries. In some cases chips and particles could be used for energy purpose instead of industrial purposes (paper or particleboard production) (Suadicani, 2010). This is (additional) source of uncertainty, which will be very difficult to quantify.

2.8 2010 Geneve Meeting

IPCC Expert Meeting on HWP, Wetlands and Soil N2O was organized by Task Force on National Greenhouse Gas Inventories, TFI-TSU in Geneva from 19 - 21. October 2010. Detailed information will be published soon (IPCC, 2011), meeting report will be available on http://www.ipcc-nggip.iges.or.jp/meeting/meeting.html. The meeting in general considered that the methodological advice for the HWP contained in the 2006 IPCC Guidelines still reflects the latest science.
There was also mentioned by Sebastian Rüter that the new accounting approaches (“Stock Change of Domestic Origin (SCAD) approach” and “Production Approach with Partitioning of Exports”) being proposed in the UN FCCC negotiations and the additional guidance that would be needed to report the HWP contribution using them. Because there is no only one new proposed approach and because it is not clear if one of these approaches will be approved by UN FCCC (COP/MOP) for use, there is no reason for developing guidance, except timing issue. It can happen easily that no one, from above mentioned approaches, will be adopted and the methodical work will be wasted.
Another presentation by Gregg Marland (USA) discussed possibilities for more accurate description of the rate of oxidization of the products and proposed the use of a gamma distribution decay function. He expressed that this function better represent the probabilistic nature of the decay of products. But as presented in the subsequent chapter 7.6, the decay function has limited influence on the emissions ant their timing, much more important is parameterization of the function.
The meeting confirmed that the existing guidance is correct and complete, but emphasized that it needs to be implemented in its entirety to ensure that complete estimates are made

[9] http://faostat.fao.org/site/630/default.aspx

without any double counting or omissions. However the group did note there were some editorial issues with the text which should be corrected (IPCC, 2011).
The meeting report (IPCC, 2011) also list recommendations for 2006 IPCC gl. refinement, some of them are relevant and helpful (e.g. How to derive country specific service life data) other of them will have only limited benefits (e.g. Using information on housing stocks as this type of information is limited to some countries[10] or Examples of the use of tier 3 methodologies[11]).

2.9 HWP consistency with inventory principles

HWP is partly political issue and do not respect all UN FCCC and inventory principles. Especially convention definition of "Emissions", which means the release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time (UN FCCC, 1992). In UN FCCC (2009b) Australia described two cases for principle of national boundaries and time (see BOX 4) and provided arguments for that.

BOX 4. UN FCCC definition of time frame and national boundaries
Under the UNFCCC, **Parties report emissions and removals that occur within their national boundaries, in the year in which they occur**. With coal, for example, emissions that occur during the mining of coal are reported in the country in which the coal is mined and in the year in which it is mined, while emissions that occur when the coal is burned are reported in the country in which it is burned and in the year in which it is burned. Similarly, the producing country reports emissions from the production of emissions intensive goods, such as aluminium, even when the goods are exported.
Source: UN FCCC (2005b): FCCC/SBSTA/2005/MISC.9

2.9.1 Time

The default assumption ("Zero"Tier from 2006 IPCC GI, Tier 1 from 2003 GPG for LULUCF and earlier methodology[12]) that all carbon removed in wood and other biomass from forests is oxidized in the year of removal is often a target of criticism. This assumption could be problem for review, if it is not justified carefully. Because during the GHG inventory review under the UNFCCC some reviewers ask for higher tier methodology if the use of lower tier methodology is not appropriately described. Typical example is 2003 GPG and definition (chapter 3.2.1.2.1.1) of Tier 1 (Default): The IPCC Guidelines, consistent with reporting under Tier 1, assume that the average transfer rate into the dead wood pool is equal to the transfer rate out of the dead wood pool so the net change is zero. In that case, review experts argue that without quantification, the Party is not able to say that the net change is really zero and ask for quantification. Also review experts can easily ask Party for providing

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[10]There is no such information in Czech Republic and probably in any developing country.
[11]Tier 3 methodology use national circumstance, data, statistics and the national methodology could be not applicable in any other country.
Tier 3 methodology must be transparently described in National Inventory Report, so there is no reason (or benefit) to provide this kind of information in 2006 IPCC GI.
[12]This assumption is not included in 2006 IPCC GI.

justification or assessment, how they match to the national circumstances, for used parameters.
Tier, which needs application of higher tier methodology for its justification is inapplicable or the review process have to be revised.

2.9.2 Area

HWP accounting[13] for Production approach (and for Stock Change of Domestic Origin approach and Production Approach with Partitioning of Exports) do not follow emissions definition from the point of area as provided in the UN Framework Convention on Climate Change (UN FCCC, 1992). In that case definition of area will be different compared to the rest of inventory. Some countries should interpret it as slight move from current position when inventories are product based (in national inventories are reported and accounted emissions where they are emit) to consumption based (in national inventories are reported and accounted emissions which are connected with all product that are consumed in given country). The main political disadvantage of production approach is that selling country has no possibility how to control sold products and how to prevent or minimalize emissions, except to finish trading with other countries.

2.9.3 Transparency

Some of the parameters entering the HWP calculation form are poorly documented in the methodology. This is mainly problem of defaults half-life values. Default half live values in 2006 IPCC GI. are provided only with reference to 2003 GPG for LULUCF, which includes table 3a.1.3 with defaults and some country specific values. Wood product categorization is different in both guidelines (Saw wood; Veneer, plywood and structural panels; Nonstructural panels versus Solid wood products) see Table 1. Both guidelines do not provide any reference or description; how values were obtained, by whom, under what conditions etc. National inventory expert will not be able to asses if values are appropriate or not, nor assess uncertainty (except values provided in 2006 IPCC GI.).

Table 1. Default half-lives provided in IPCC guidelines

2003 GPG for LULUCF	2006 IPCC GI.
Saw wood - 35ys	Solid wood products - 30ys
Veneer, plywood and structural panels - 30ys	
Nonstructural panels - 20ys	

2.9.4 Accuracy

Tier 1 as described in 2006 IPCC GI. is based on data which are available from FAO database. The whole list of parameters is provided in the Table 12.5. of the 2006 IPCC GI. and includes e.g. Roundwood; Other industrial roundwood; Sawnwood; Wood panel; Paper and paperboard and information about production, import and export. All these products do not belongs to the final products, but represents semi-finished products. 2006 IPCC guidelines do not provide any estimation how much of “carbon in semi-finished products” is transformed into the stored carbon in HWP. From that point of view the HWP methodology

[13]Accounting is problem with political background, which is outside of the IPCC scope.

as described in 2006 IPCC Gl. above estimated removals on the beginning and emissions on the end of life time of wooden products.

Decay profiles define speed of wood transformation into the CO_2 emissions. First order as is implemented in the HWP calculation form is suitable for cases where there is no important increase or decrease of carbon stocks in the HWP. In other cases different decay profiles should be implemented. This approach is in line with 2006 IPCC Gl. and documents quoted in 2006 IPCC Gl. (Ford-Robertson, 2003). For more information about different decay profiles see chapter 0.

2.9.5 Good Practice Guidance

Ties application for the HWP estimation is exception, when GPG and key category analysis is applied. Let's illustrate this case on citation in BOX 5 and compare with general GPG requirement described in BOX 6.

BOX 5. 2006 IPCC Gl., Chapter 12.2.1, p. 12.8

The HWP Contribution can be reported as zero if the inventory compiler judges that the annual change in carbon in HWP stocks is insignificant. Either the stocks in the country (Variable 1A + Variable 1B), or the annual change in carbon in HWP stocks originating from wood harvested in the country (including exported HWP) (variable 2A + variable 2B) may be considered. ***The term 'insignificant' in this context means that the annual change in carbon in HWP stocks, using one of the measures of carbon change above, is less than the size of any key category. Countries are encouraged to use the Tier 1 methods to estimate HWP variables to aid in judging if the annual change is insignificant.***

BOX 6. 2006 IPCC Gl., Chapter 4.1.2, p. 4.5

4.1.2 Purpose of the key category analysis

As far as possible, key categories should receive special consideration in terms of three important inventory aspects.

Firstly, identification of key categories in national inventories enables limited resources available for preparing inventories to be prioritized. It is good practice to focus the available resources for the improvement in data and methods onto categories identified as key.

Secondly, ***in general, more detailed higher tier methods should be selected for key categories.*** Inventory compilers should use the category-specific methods presented in sectoral decision trees in Volumes 2-5 (see Figure 4.1). ***For most sources/sinks, higher tier (Tier 2 and 3) methods are suggested for key categories, although this is not always the case.*** For guidance on the specific application of this principle to key categories, it is good practice to refer to the decision trees and sector-specific guidance for the respective category and additional good practice guidance in chapters in sectoral volumes.

Does the term "*any key category*" refer only to key category level assessment or also to trend assessment? Is it clear that is necessary to compare values in GHG equivalents? If the

Tier 1 methodology is fully based on default values and activity data are public available for many countries is it necessary to reduce the requirements for applying the higher Tiers methodology? Why the rule "***higher tier (Tier 2 and 3) methods are suggested for key categories***" is not valid in this case? If the result of Tier 1 methodology will be available, why is possible to report and accounted "zero" instead of Tier 1 results?
It can be expected that once the issues surrounding the accounting of the HWP will be resolved, the GPG will be followed and zero option will be canceled.

2.9.6 International comparability

Tier 1 methodology (based on semi-finished products) and its result is not compatible with tier 3 methodology, especially, when national inventory is based on carbon stock in building and other solid wood product (based on finished products). It is expected that if the methodology is based on different type of activity data that it will be difficult to compare results.

2.9.7 Reporting versus accounting

Inventory experts and UN FCCC negotiators strictly distinguish (e.g. Pingoud, 2008b) between reporting requirements under the UN FCCC and the accounting requirements under the Kyoto Protocol (or any new post-Kyoto Protocol). In some reports (UN ECE, 2008) the difference between reporting and accounting is not distinguished. The statement that "The suggested HWP accounting methods improve the accuracy of GHG balances compared to the IPCC default approach." is not correct. It illustrates the confusion between reporting and accounting issues.
It easily can happen (similarly as for LULUCF accounting) that there will be two types of the HWP methodology and inventory, one for UN FCCC and another for post-Kyoto Protocol. The first will be based on scientific and inventory principles and the second one on COP/MOP decision. This stance will solve all previous problems (cases) and will make inventory and review process more complicated.

2.9.8 Completeness

Flugsrud et al, 2001 mentioned that completeness could be problem, because in a total balance of harvested carbon it is difficult to account for all carbon, both due to inaccuracies in the figures on production and foreign trade, and uncertainties in the estimates of emissions and storage. Whether these 'missing sinks' are accounted as emissions or stock change may influence the results significantly.
If the methodology will not be very accurate and unambiguous, we can expect many different solutions with different degree of transparency. It should be useful to ask Parties to provide wood biomass balance and paper balance, which will be prepared by similar way as described in chapters 8.3 and 0.

2.9.9 Science

The role of IPCC and TFI TSU is to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts. There are only few scientific articles dealing with the HWP issue. Is it possible to provide clear scientific view on the HWP if there is no scientific literature? The list of literature provided on the end of this report summarizes many of available sources, but only few of them are regular scientific articles. The main proportion is UN FCCC reports and other documents, reports from meetings, presentations and inventory reports.

2.9.10 Consistency with other methodology

In waste sector, methodology for the CH4 emissions estimates from landfilled waste calculates with delay between waste deposition and start of CH4 generation. The reason and background processes are described in the 2006 IPCC GI. (chapter 3.2.3 p. 3.19). But this assumption is not implemented in the waste model. The model also works without distinction of first and other years. The HWP calculation sheet calculate that decay starts immediately after harvest or paper production. Because statistics works with annual cycle, the HWP calculation sheet assumes for the first year that the decay takes half of the year. The difference between mathematical and method, used in the HWP calculation sheet is illustrated on the Figure 3.

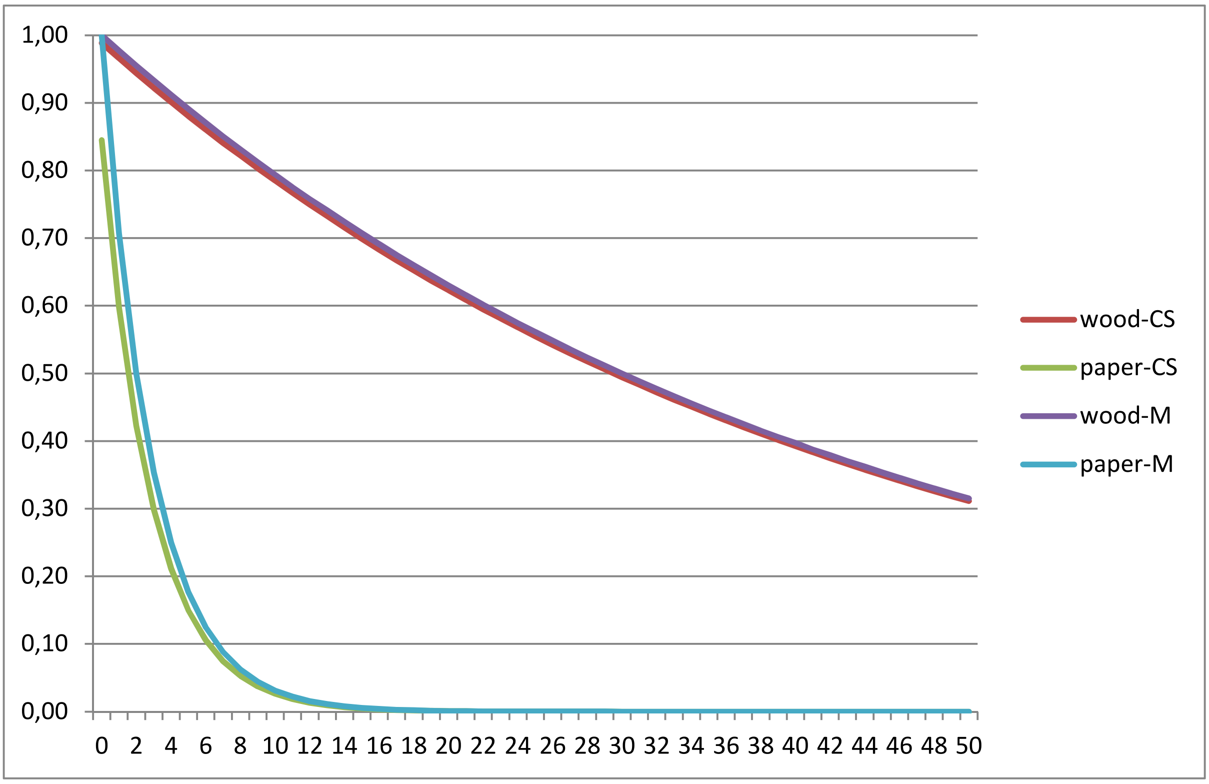


Figure 3. The difference between mathematical (M) and method, used in the HWP calculation sheet (CS) for wood and paper

3 Approaches for HWP estimate

UN FCCC and specifically SBSTA has set out a policy process on the HWP accounting and reporting that may lead to decisions by the COP and/or COP/MOP. The complexity of this issue, the focus on other more "important" issues[14] (Kirkman G.A., 2011) and different negotiating position of the Parties lead to the fact that an agreement has not been reached. This situation leads to the conditions that Parties do not estimate the HWP (they use the default assumption is that HWP pools are not increasing) and if yes, the estimates are carried out by using its own methodology and procedures.
It is also necessary to distinguish between emissions estimations preparation and their reporting, which should be process driven by science and best available knowledge (and which shall be in line with IPCC GI.) and emissions accounting that is politically driven process, which follows UN FCCC reporting guidelines (e.g. UNFCCC guidelines on reporting and review; UN FCCC, 2000[15]). Accounting issue is political problem, which is negotiated on the level of UN FCCC and should be in line with some UN FCCC reporting and accounting guidelines.
It is important to bear in mind that like any other model the application lower tiers in approaches is only very rough estimate, which has with real world only few common points. Only the use of detailed data and precise knowledge of all processes, which generates GHG emissions or changes of wood based material stocks may lead to an accurate determination of emissions and sinks in the HWP.

3.1 Accounting approaches

Accounting approaches represent political view on the HWP issue. This is illustrated on the schemes published in 2003 IPCC GPG for LULUCF, 2006 IPCC GI. and Brown S., Lim D., Schlamadinger B., 1998, where the HWP system boundaries includes also Forest Ecosystems/LULUCF/AFOLU category. It is basically the result of the politicization of technical problems such as the use of wood and wood products and emissions at their end use.
This report is focused on technical problems related to the emissions estimates from HWP, the Forest Ecosystems/LULUCF/AFOLU part is neglected and it is used narrow definition of the HWP as presented in the chapter 2.1 and Figure 2.
Definitions used in Annex 12.A.1 of the 2006 IPCC gl. are presented in the following chapters. All definitions are exactly presented as in gl., some parts which shall be omitted from definitions are highlighted by **bold and red color**. The same way of the HWP description is used, when mathematical equations are used (2006 IPCC GI.) in that case LULUCF part is not presented[16] or presented as “Forest growth”, (Flugsrud et al, 2001). That

[14]e.g. reduction targets, funds for adaptation, technology transfer, MRV, ...
[15]Part 1: Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UN FCCC reporting guidelines on annual inventories and Annex: Common reporting format.
[16]IPCC Default Approach
Emissions = 0, Δ stock change products = 0
Stock change Approach
Emissions = Δ stock change products

there is different understanding of calculation with and without LULUCF (in IPCC methodology and in other documents it is called net exchange with atmosphere) should be illustrated on (Ford-Robertson, 2003), which suggests Simple Decay approach. The Simple Decay approach is described in chapter Simple Decay approach and as the basic activity data and other parameters requirements are listed in BOX 7.
From the technical-biological point of view, there are only few additional parameters e.g. the carbon content in wood and wood products that is the same for all approaches, there is only one additional assumption that inflow before 1900 are excluded from the HWP calculation. Basic description and illustration of main features of individual approaches is provided in Table 1 (UN FCCC, 2004d). Report (Flugsrud et al, 2001) define 4 approaches (as listed in Table 1) and then also 2 different methods for emissions quantification the stock data method and the flux data method. Flugsrud et al, 2001 define these methods as:

- Flux-based methods requires estimation of carbon release from biomass going out of storage and factors for the rate of oxidation of different product groups. This can be done through an inflow-outflow analysis or as a lifetime analysis. The flux method based on a lifetime analysis is sensitive to the assumptions about lifetimes of the different products, while an inflow-outflow analysis requires accurate waste data. For some product groups it is a good option, either because flux data are readily available or because stock data are unavailable (e.g. for paper, stocks are difficult to estimate because of the short life cycle of many paper products).
- With estimation made by stock data, the amount of carbon in a product pool is estimated by calculating the standing stock of product times the carbon content of the product in question. The net accumulation of carbon is estimated from changes in total storage. A major advantage of stock methods over flux methods is that the accumulated stock change over longer periods can be estimated with less uncertainty. With the flux methods, there is usually no gain in precision from longer periods.

Flugsrud et al, 2001 also proposed combination of both methods, which leads to the higher quality and accuracy, except production approach, where flux method have to be used, because stock change method is unable to track the origin of wood and the fate (and consequently lifetime) of exported products is often not known accurately. The two methods give the same results if all data sources are complete, exact and consistent. It can be expected, that the use of many different sources will make the data collection and processing more expensive, difficult and sensitive for making mistakes.

Table 2. Basic description and illustration of main features of individual approaches

Estimates of:	When and where	When
Stock Change	Stock change	Production
Emissions	Atmospheric flow	Simple decay

Source: UN FCCC, 2004d

Production Approach
Emissions = Δ Stock change forest + Δ stock change domestic grown products
Atmospheric Flow Approach
Emissions = Δ Stock change forest + Δ stock change products + net export

3.1.1 IPCC default approach

IPCC default approach (DA) is described in 2006 IPCC GI. as "The HWP Contribution can be reported as zero if the inventory compiler judges that the annual change in carbon in HWP stocks is insignificant[17]". Please compare this definition with the HWP default assumption in 1996 Revised IPCC GI. Although the result is the same, it is a fundamental shift in the understanding and description of carbon flux. The IPCC default approach could be illustrated on Figure 4.

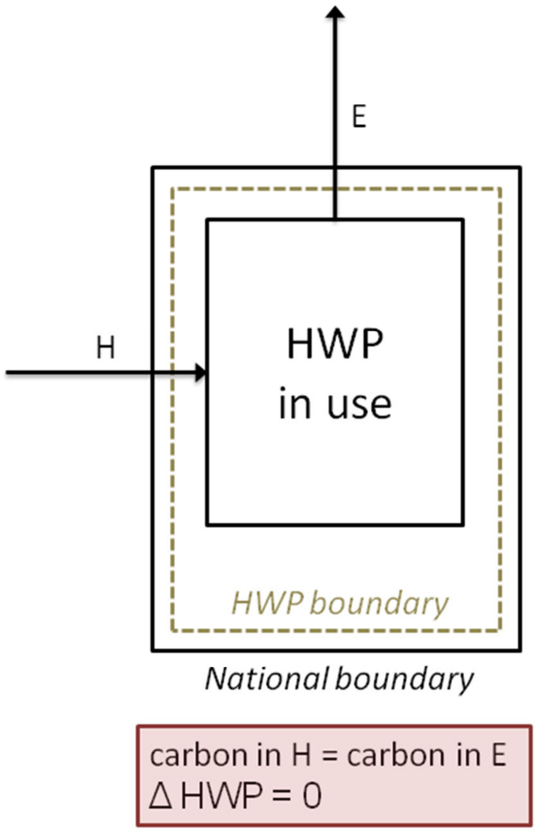


Figure 4. Boundary and principle of the IPCC default approach
Note: E = carbon release to the atmosphere from HWP in use, H = carbon transfer in the form of harvested wood biomass transported from harvest sites

The basic balance of carbon in harvest and in emissions is very often ignored[18] and IPCC default approach is marked as inaccurate. ***But in all cases where there is no significant change in carbon included in HWP any another approach will not provide more accurate results!***
There is one negative point on the IPCC default approach, DA provides no incentive to increase the carbon reservoir in the HWP and thus reduce CO2 emissions. 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 (Suadicani, 2010).

[17]As clarified in (IPCC, 2011) "The term 'insignificant' in this context means that the annual change in carbon in HWP stocks, using one of the measures of carbon change above, is of a comparable size to a key category."
[18]Also by HWP experts, e.g. "At the moment C balance of HWP are not accounted for ("IPCC default approach" applied)." (Pingoud, 2009a) or by Fischlin in UNECE, 2008).

The IPCC default approach can be considered as special case of Stock-Change approach, when Δ (change of) stock-change is 0.

3.1.2 Stock-Change approach

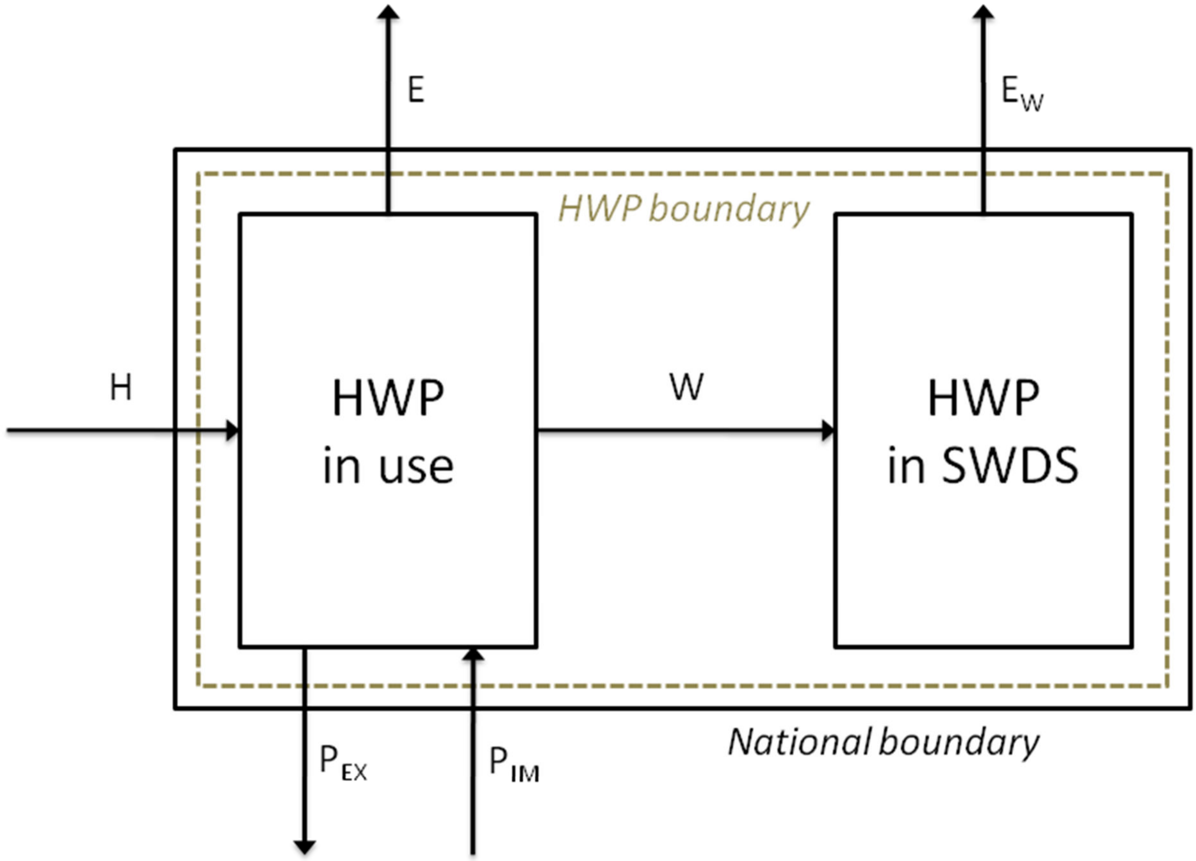


Figure 5. Boundary of the Stock-Change approach
Note: E = carbon release to the atmosphere from HWP in use, E_W = carbon release to the atmosphere from HWP in SWDS, H = carbon transfer in the form of harvested wood biomass transported from harvest sites[19], W = carbon transfer in the form of wood waste into SWDS, P_{EX} = carbon transfer in the form of HWP exports, P_{IM} = carbon transfer in the form of HWP imports.

The Stock-Change Approach (SCA) estimates changes in wood carbon stocks in the **forest pool (and other wood producing lands) and** wood-products pool in the reporting country. **Changes in carbon stock in forests and other wood producing land categories are**

[19]This may be broaden by including some other flows, e.g. by dead wood and litter (2006 IPCC GI., chapter 8.5) Dead wood is a class variously composed of fallen or pruned branches or trees, or dead standing trees not yet replaced with live individuals. This dead wood may be burned or disposed of as solid waste, used for composting, left to decay either in-site or off-site. This material is treated in this methodology as a loss from the live biomass term. Because dead wood is likely to be carried off-site in elements (rather than left on-site to decay as in forests), a more detailed methodology developed in the future might account for the proportion of dead wood taken to landfills, disposed of in compost piles, burned, or left on-site to decay. The portion taken to landfills or composted might be treated as the HWP or as waste, both of which are treated in other sections of the Guidelines.

reported by the country in which the wood is grown, referred to as the producing country. Changes in the products pool are reported by the country where the products are used, referred to as the consuming country. Because the stock changes actually occur in the reporting country the report indicates when and where the stock changes occur (2006 IPCC Gl., Annex 12.A.1).
The Stock-Change approach does not reflect emissions and removals accurately, since they focus on stocks (Ford-Robertson, 2003).

3.1.3 Atmospheric Flow approach

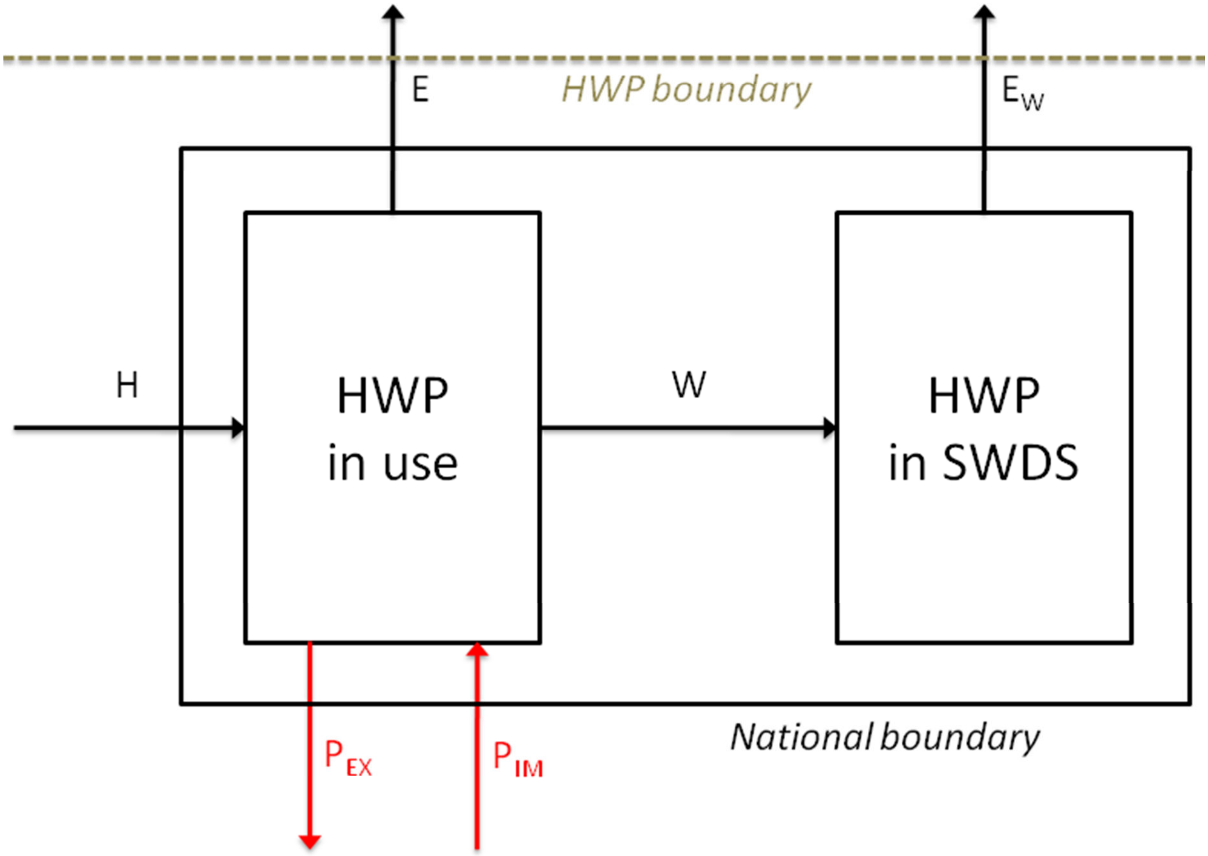


Figure 6. Boundary of the Atmospheric Flow approach
Note: E = carbon release to the atmosphere from HWP in use, E_W = carbon release to the atmosphere from HWP in SWDS, H = carbon transfer in the form of harvested wood biomass transported from harvest sites (see previous footnote), W = carbon transfer of wood waste into SWDS, P_{EX} = carbon transfer in the form of HWP exports, P_{IM} = carbon transfer in the form of HWP imports.

The Atmospheric Flow Approach (AFA) estimates fluxes of carbon **to/**from **the atmosphere for the forest pool (and other wood producing lands) and** wood products pool within national boundaries, and reports where and when these emissions and removals occur. A country includes in its estimate **of emissions/ removals the gross removals of carbon from the atmosphere due to tree biomass growth in forests and other wood producing land categories (net of decay within forests), and** the carbon release to the atmosphere from oxidation of harvested wood products that are consumed in their country. The carbon release to the atmosphere from harvested wood products includes carbon release from imports to the reporting country (2006 IPCC Gl., Annex 12.A.1).

Information about P_{EX} a P_{IM} are not necessary entry parameters for emissions estimations. Key parameters are flows into the atmosphere (E and E_W), they should take into account P_{EX} a P_{IM}.
Canada in (UN FCCC, 2001) raised some issues related to the approaches implementation and their compliance with Kyoto Protocol (KP), specifically with Article 3.3, which states that net changes in emissions and removals from ARD since 1990 are to be measured ***as verifiable changes in stock*** in each commitment period[20]. This issue is relevant only in the case that

a. this HWP approach will be used for emissions accounting under KP by Party included in Annex I of the KP,
b. HWP would be understood as special case of afforestation, reforestation and deforestation.

This is the approach, which estimates emissions when and where they occur (Ford-Robertson, 2003), but this message does not come through from the party submissions (e.g. UN FCCC, 2001; UN FCCC, 2003a; UN FCCC, 2003b; UN FCCC, 2003c).

[20]The full wording of paragraph is: "The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, ***limited to afforestation, reforestation and deforestation*** since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each ***Party included in Annex I***. The greenhouse gas emissions by sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner and reviewed in accordance with Articles 7 and 8."

3.1.4 Production approach

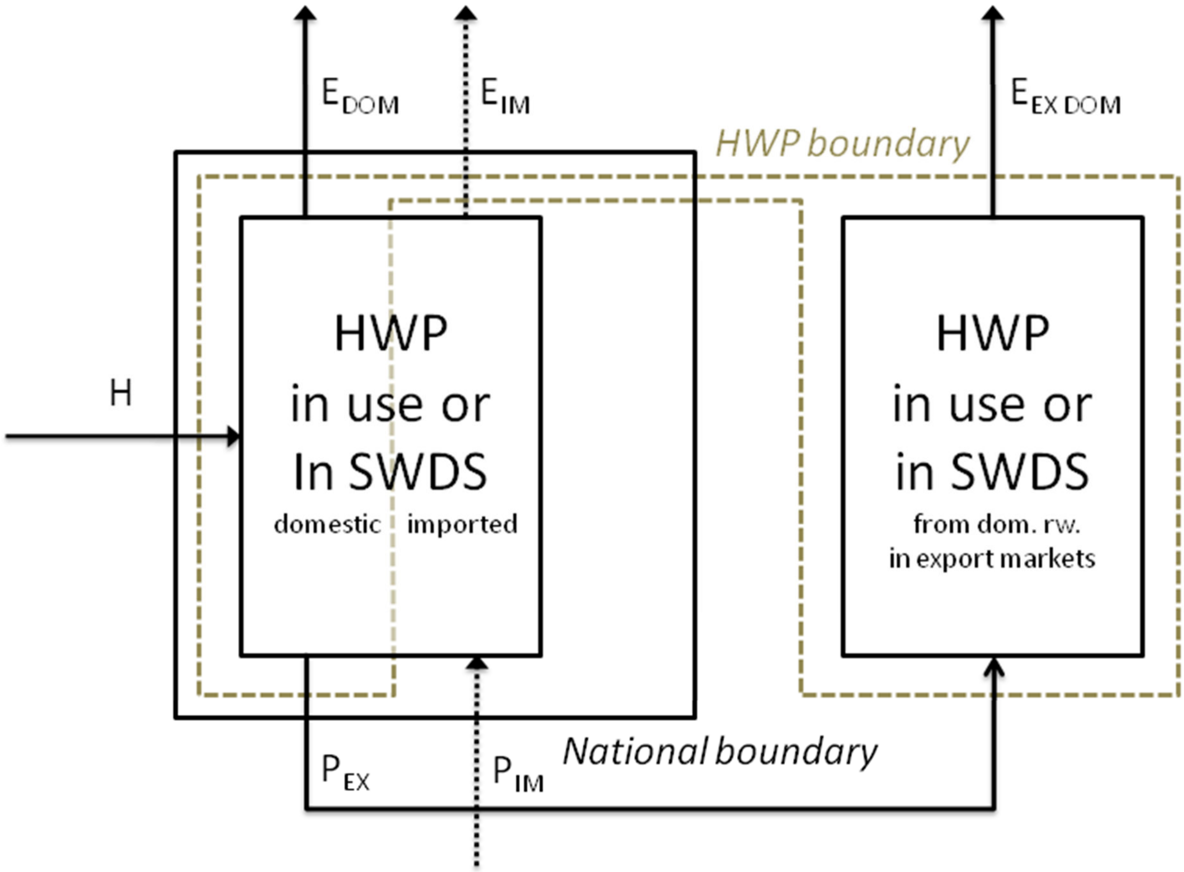


Figure 7. Boundary of the Production approach

Note 1: E_{DOM} = carbon release to the atmosphere from the pools of domestically grown HWP in use and in SWDS, E_{IM} = carbon release to the atmosphere from the pools of imported HWP in use and in SWDS, $E_{EX\ DOM}$ = carbon release to the atmosphere from the pools of domestically grown but exported HWP in use and in SWDS, H = carbon transfer in the form of harvested wood biomass transported from harvest sites, P_{EX} = carbon transfer in the form of HWP exports, P_{IM} = carbon transfer in the form of HWP imports,

Note 2: Only those HWP in the export markets that are produced from domestic roundwood are within the system boundary, not those only processed in the reporting country but made from imported roundwood. The transfer P_{EX} can in principle include both.

The Production Approach (PA) estimates changes in carbon stocks in the **forest pool (and other wood producing lands) of the reporting country and the** wood products pool containing products made from wood harvested in the reporting country. The wood products pool includes products made from domestic harvest that are be exported and stored in uses in other countries. This approach inventories carbon in wood products from domestically harvested wood only and does not provide a complete inventory of wood carbon in national stocks. Because some of the stock changes reported by a country may occur in other countries (where exports are held), the stock change report indicates when changes occur but not where they occur.

If note 2 shall be applied on the national level, wood have to be “tracked”. Production approach is the most complex and its implementation on the national level will be the most complicated (and the most expensive).
It is not clear what would happen in the case that wood will be traded through more countries? Probably nothing, because “the stock change report indicates when changes occur but not where they occur”. Does it mean that, UNFCCC will ask to the IPCC develop uniform methodology, how to estimate emissions from exported wood and wood products? The Production approach does not reflect emissions and removals accurately, since they focus on stocks (Ford-Robertson, 2003). Second important issue is how emissions from exported wood will be estimated. FAO statistics[21] can provide basic information about export of wood and wood products. The basic information means that for total wood and wood product only information about monetary units and not mass are provided. But this data shows, that there can be great differences among Parties and also that in some cases important part of exports go to the developing countries. Figure 8 a Figure 9 shows two cases:

- Figure 8 - USA has one important export partner and relatively short export list (95 % of production in monetary units was exported in 2008 into 12 developed countries and 7 developing)
- Figure 9 - Belgium has many export partner and almost twice long export list as USA (95 % of production in monetary units was exported in 2008 into 22 developed and 11 developing countries) and important part (11 %) of the export is not localized.

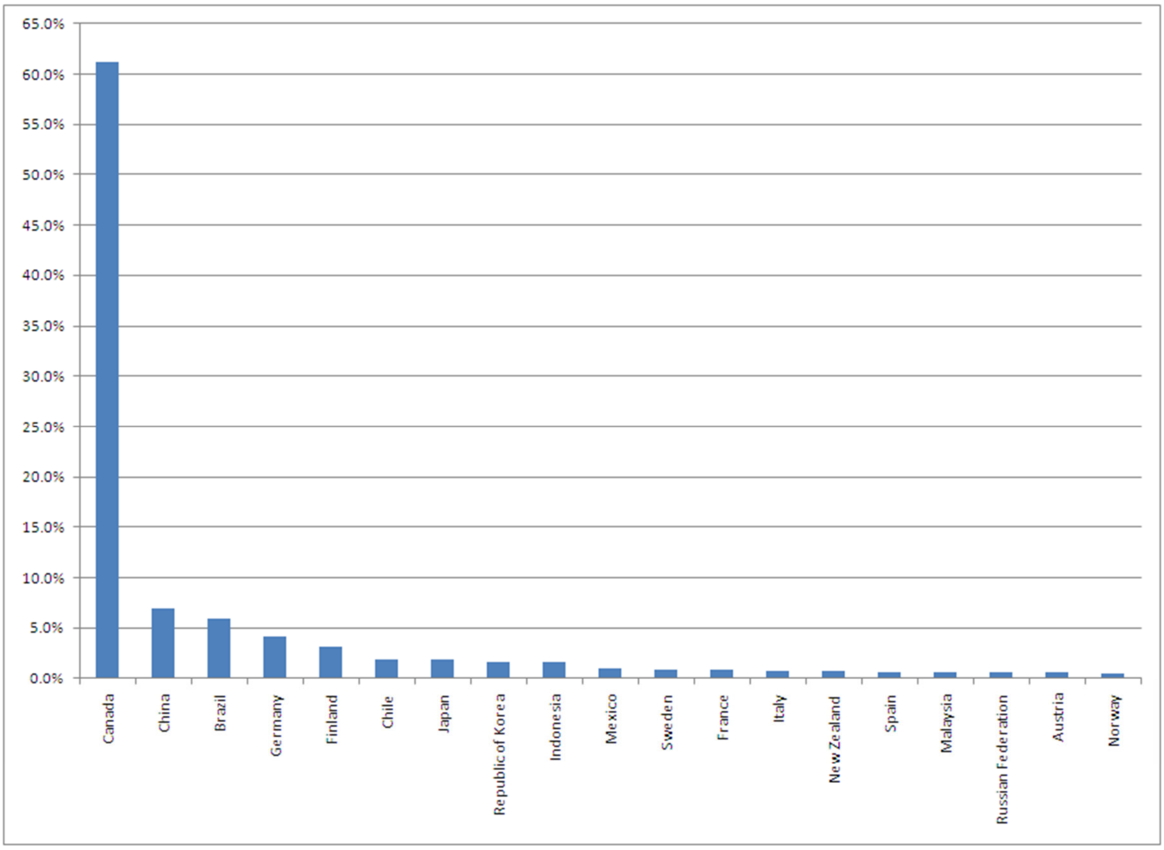


Figure 8. Total export from USA as % of wood and wood product values

Source: FAO

[21] http://faostat.fao.org/site/628/default.aspx

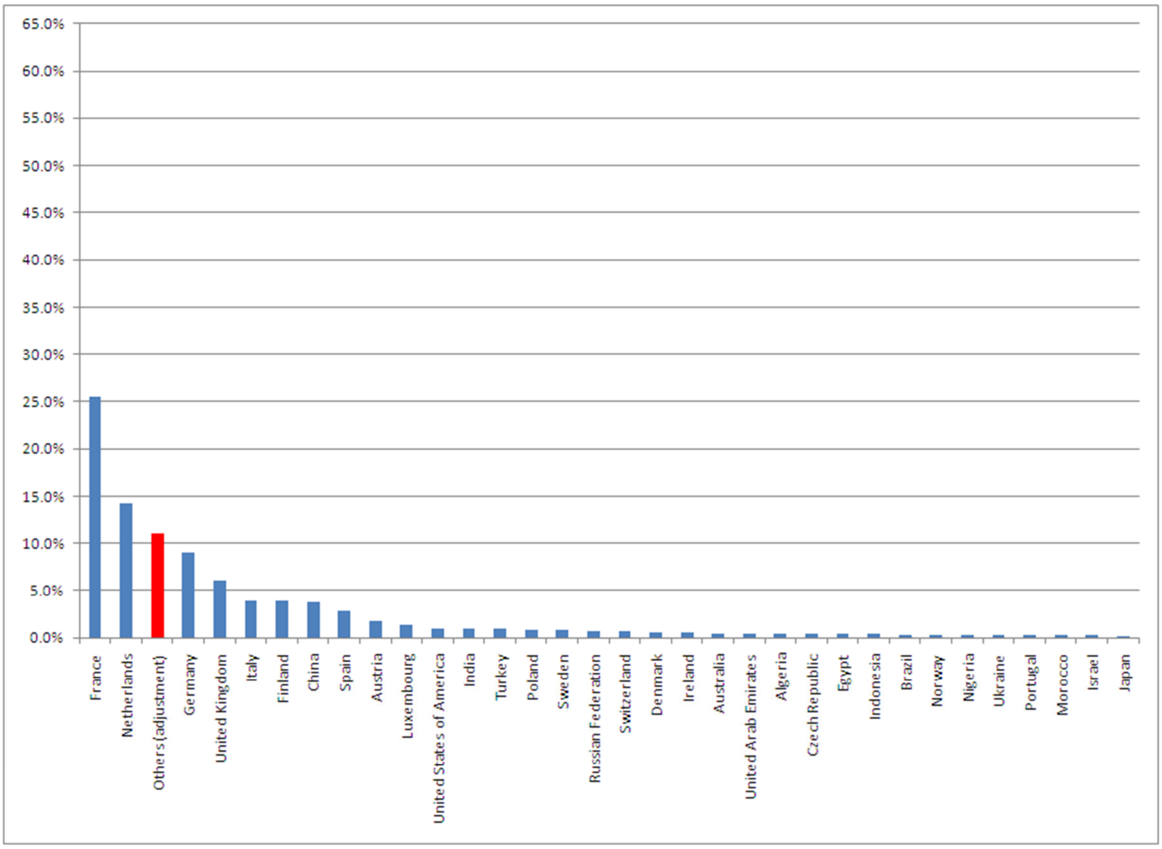


Figure 9. Total export from Belgium as % of wood and wood product values

Source: FAO

3.1.5 Simple Decay approach

Simple Decay Approach (SDA) can be described as IPCC default approach (instant oxidation) with delayed emission by defined decay profile or as approach, which estimates net emissions/removals of carbon to and from the atmosphere (similar to AFA) when, but not where they occur if products are traded (Bache-Andreassen, 2009). Simple Decay approach was firstly introduced by Ford-Robertson in 2003 (Ford-Robertson, 2003). Simple Decay approach is described in BOX 7. The Simple Decay approach has been developed in response that:

- Parties are not able to agree on one approach,
- approach should follow UN FCCC (and IPCC) principles and definitions,
- other approaches are data intensive and their implementation will be complicated.

The Simple Decay approach indicates when emissions occur but not where they occur (producer has responsibility for emissions, see BOX 7 below). BOX 7 also illustrates the issue, if and how “Forest stock change” data shall be used for the HWP estimates.

The issue of the decay profile is mentioned (Ford-Robertson, 2003) and three different profiles are considered:

- linear decay over the lifetime,
- exponential decay with a given half-life,
- instant decay of all emissions at the end of the product life (at average life time).

The main problem of this approach is how to set up above mentioned life-times. (Ford-Robertson, 2003) do not provide any default values. However, the report shows application of the Simple Decay approach to fictitious sample data. The most important message from application of the model is that, in the case that modeled period is long enough (60 years for 16 year life time, 8 years half-life[22]) results of instant oxidation is close to the any of the decay profiles.

BOX 7. Simple Decay approach (as published by Ford-Robertson, 2003)

Rather than assuming all carbon in harvested biomass is emitted instantly, the emissions are assumed to decay over time. All the carbon in the harvested logs is still emitted, creating no additional credits (offsets) and hence retaining atmospheric integrity, but the more accurate time profile means some emissions are delayed until future commitment periods. The delay also means that some of the inter-annual fluctuations in harvest (and hence assumed emissions) can be minimalized. Scientific accuracy would suggest that the emissions liabilities are allocated to the consumer country if trade occurs, but in order to keep the approach relatively simple and due to concern over trade impacts, this approach suggests the emissions remain the responsibility of the producer. This is the main similarity with Production Approach. The main difference compared to the PA (focused on stock change, as activity data sawnwood production is used in HWP calculation sheet) is that the Simple Decay approach focuses on the total harvest volume. The condition is considered an important and logic difference from the PA[23]. This condition was not implemented in HWP calculation sheet or included in 2006 IPCC GI. If it has been implemented correctly results (CO2 emissions) could not be the same as well as the Production approach. The change of this basic assumption transformed in 2006 IPCC GI. one approach to another one. This mistake is also repeated in other reports, articles and presentations (e.g. Pingoud, 2008a). There is also interesting and important side effect, some reports ignores Simple Decay Approach or just provides short explanation that it is the same approach as the PA.

Three Tiers methodology is suggested:

- Tier 1: no verifiable national data – use current IPCC default i.e. decay at harvest.
- Tier 2: limited national data – use conservative on and off-site decay rates.
- Tier 3: national lifetimes determined by log types, product categories or other verifiable data.

The basic data requirements for the Simple Decay approach are:

- Annual stock change (forest or stand level).
- Annual harvest volume[24].
- Lifetime of products.

Stock change can be derived from the difference between stocks at two points in time. The stock change in the forest (or stand) integrates all the flows to and from it. The simple equation for this is:

Forest stock change = net exchange with atmosphere - harvest

[22] 95 % of original wood mass will decay after 35 years.
[23] The PA was defined under the UN FCCC negotiation process before 1998, SDA was desecrated in 2003.
[24] This condition was not implemented in HWP calculation sheet or included in 2006 IPCC GI.

therefore

Net exchange with atmosphere = forest stock change + harvest

The annual harvest is currently assumed to be emitted instantly, whereas the residues left in the forest decay over time. This approach assumes a similar decay over time for the products as it does for the residues left in the forest.

Lifetimes can be estimated for product categories, as in the Dakar approaches, but the creation of categories might be challenging for some Parties, particularly when logs are exported (unknown processing/products). Furthermore, some concern has been expressed over the categories proposed to date. For example, paper is derived from a variety of different types of pulp and additives leading to different product characteristics and decay profiles.

SDA should be simplified by calculation only with non-energy use of wood based biomass. Deduction of wood biomass, which is used for energy production, facilitates set up of life-time parameter and significantly improves emissions quantification in the term of uncertainty. The report (Ford-Robertson, 2003) does not mentioned use of different life-time parameters for different years, but it is theoretically possible. The principle of SDA is not compatible with “five variables” methodology as described in 2006 IPCC gl., nevertheless the HWP calculation sheet provide GHG estimates for SDA.

3.1.6 Other approaches

There is also another approaches e.g. Stock Change of Domestic Origin approach (SCAD) (described in Cowie et al., 2006; taken into account in FCCC/ KP/AWG/2010/CRP.3) or Production Approach with Partitioning of Exports (PAPE) (taken into account in FCCC/ KP/AWG/2010/CRP.3)[25], which makes issue of HWP more confusing, emissions estimation more complicated, data and resource more intensive by additional assumptions (e.g. that take into account domestically produced and consumed wood - SCAD, make estimates of HWP contribution separately for exports to each importing country - PAPE[26]).

[25] PAPE approach was not described in scientific literature; it is product of UN FCCC negotiation.

[26] As described in the Production Approach chapter, this would mean for some Party to track and prepare estimates for more than 40 countries. This approach is financially inapplicable unless it is substantially simplified.

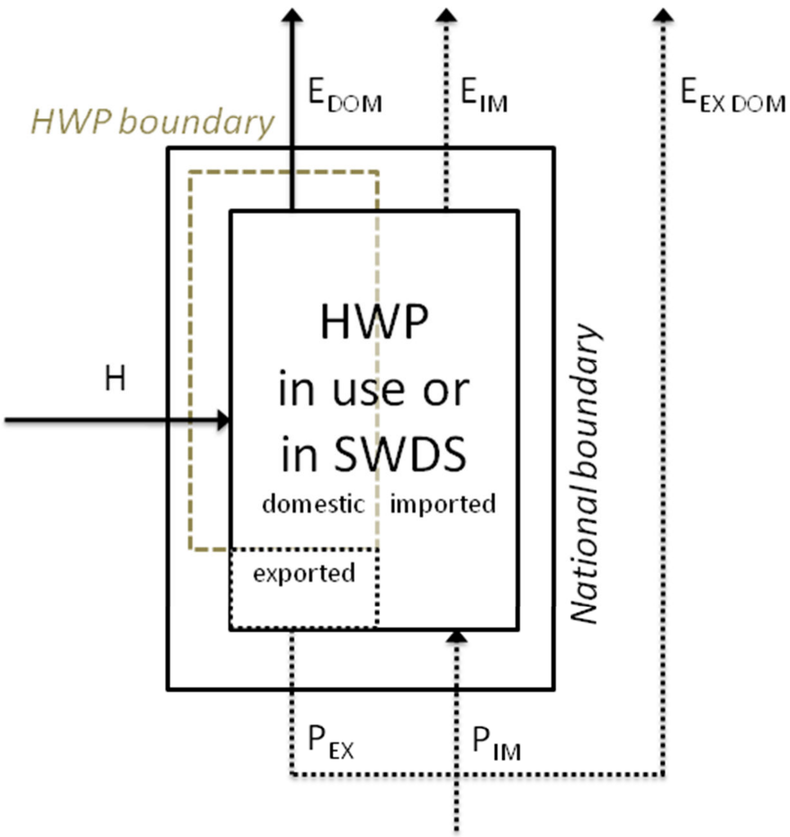


Figure 10.Boundary of the Stock Change of Domestic Origin approach
Note 1: E_{DOM} = carbon release to the atmosphere from the pools of domestically grown and domestically use wood in HWP and in SWDS, E_{IM} = carbon release to the atmosphere from the pools of imported HWP in use and in SWDS, $E_{EX\ DOM}$ = carbon release to the atmosphere from the pools of domestically grown but exported HWP in use and in SWDS, H = carbon transfer in the form of harvested wood biomass transported from harvest sites, P_{EX} = carbon transfer in the form of HWP exports into the $E_{EX\ DOM}$, P_{IM} = carbon transfer in the form of HWP imports.

3.2 Inventory approach

Inventory approach (IA) is fully based on inventory principles, closely follows principles that emissions should be estimated when and where they occur. Inventory approach is similar to the Atmospheric Flow Approach. There is only difference that all data are available from current version of national inventories. Another similarity with SDA is that IA is data non-intensive and easy for implementation.
Inventory approach uses data which are now used and reported in national inventories, there isn't need for any additional data or information. There are two main advantages of:

1. IA is simple and non-intensive for data,
2. all necessary information comes from national inventories, which are reviewed by UN FCCC secretariat and Expert Review Teams. All information should be reliable and complete[27].

[27]There are probably some small flows of wood and wood biomass which is not covered under inventory in Energy and Waste sector. See Figure 2 and highlighted flows in red.

IA should be illustrated on Figure 11. Main flows are recognized, estimated and reported in national inventories under:

- Energy - CO2, CH4 and all other compound with carbon (CO, NM VOC, etc.) emissions from biomass combustion (or CO2 emissions plus non-oxidized part), except CO2 emissions from biomass burned in transport sector,
- LULUCF – harvested wood (carbon), on-site residual biomass burning and forest fires (CO2, CH4, NMVOC, CO or CO2 plus non-oxidized part),
- Waste - CH4 emissions from wood based biomass decay on landfills (CO2 emissions could be easily estimated) and CO2 and CH4 emissions from wood based wastes incineration.

Other flows could be estimated

- CO2 emissions from wood decay (e.g. wood loses, bark use for gardening)
  $W_d = H - W_f - W_p - W_{ie}$
  (H, W_p, W_{ie} are known from FAO or national statistics or from national inventories,

but W_f could be only estimated because wood combustion in households),

- CO2 emissions from product decay (it could be expected that this flow is small, because in other cases emissions from wastes or energy are underestimated).

Updated Waste model is attached as Annex 12.3 of this report. Into the model were added some equations, which quantify CO2 emissions as the rest to the CH4 emissions from degradable carbon included in the landfilled wastes. No any additional changes were made into the waste model.

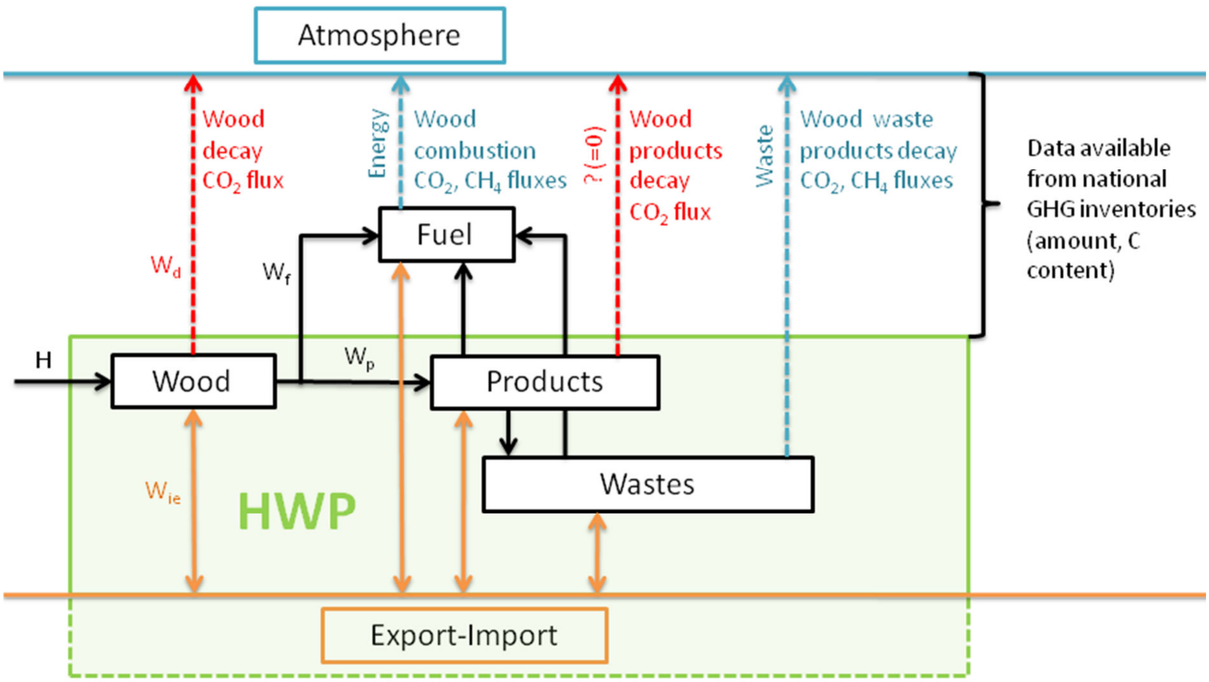


Figure 11.Boundary and flows in the Inventory approach

As there is lots of common elements with AFA the same compatibility problem with Article 3.3 of KP (see chapter 3.1.3 or UN FCCC, 2001) should be expected.

There is probably some losses (unknown) when wood in processed and probably not all waste (relatively small amount) are land-filed or incinerated.

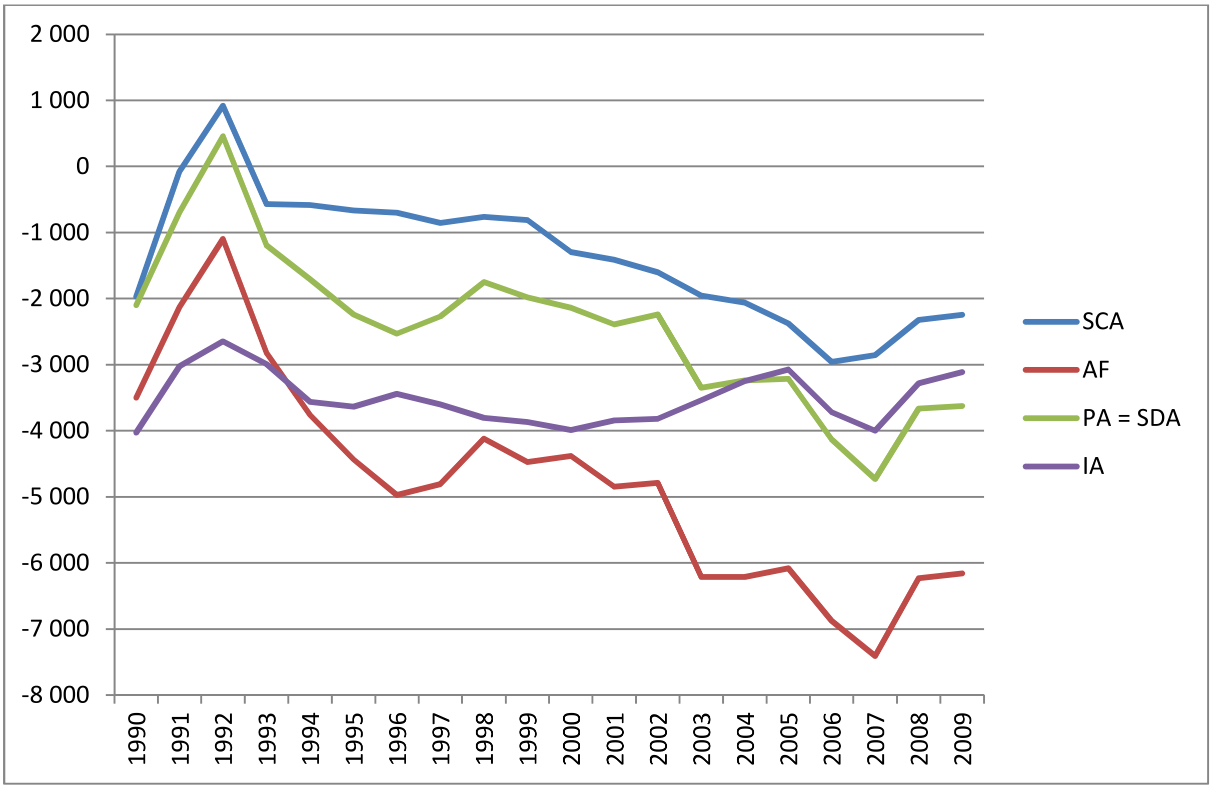


Figure 12. Comparison of the Inventory approach with Stock Change, Atmospheric Flow, Production and Simple Decay Approach

Results calculated by using the procedure described above are shown on the Figure 12, where also results for Stock Change, Atmospheric Flow, Production and Simple Decay Approach are presented. For Stock Change, Atmospheric Flow, Production and Simple Decay Approach the HWP calculation sheet with fixed mistakes (see chapter 4.2) was used. You can observe different trend compared to the other approaches, which is surprisingly not in line with Atmospheric Flow. The IA HWP calculation was based on data presented in the national inventory. I believe that the inventory approach much better represents reality than other approaches.

The results showed that:

- Models based on semi-finished products produce completely different picture,
- Results of models could be far from reality (in the term of trend and level).

The simplicity of the Inventory approach as well as the data availability are the main advantages and also disadvantages.

3.3 Another discussed assumption

It is very likely that, the post-2012 reporting and accounting system for the HWP will differ from current approaches and basic assumptions. Some new assumptions are mentioned in Pingoud, 2008b e.g. will be possible to estimate emissions only from new products and ignore the decay of old products? Or as proposed in the Stock Change of Domestic Origin approach, that only accounted carbon in wood, which is domestically produced and consumed. All these new assumptions will make the possible system more complicated, data and finance intensive.

3.4 Advantages and disadvantages of approaches

When different HWP approaches are assessed, different issues are taken into account. Because the HWP issues is associated with forest and land use, there are no only inventory related problems, but also issues related to the international trade, forest and biodiversity conservation. Many parties (in their submissions to UN FCCC, UN FCCC misc documents) highlight the value of fossil fuel substitution both directly (bioenergy) and indirectly (wood products replacing more energy intensive materials, extending wood product life), and favor an accounting approach that encourages this. Encouragement could be interpreted, for example, either as not penalizing emissions from biofuels, or providing "credit" for emissions avoided (Ford-Robertson, J.B., 2003). How to avoid to "penalization" emissions from biofuels is big question. Storage brings bonuses in the term of avoiding (postponing to future) emissions, biomass combustion reduce this bonus. Different strong and weak points are discussed in the Annex 12.4 Table 21 as were collected from different literature.

3.5 Carbon multiple-counting problem with paper production

Paper production in FAO statistics represents total paper production. The mass of paper production represents carbon, which comes from wood (wood pulp) and **also recycled paper**. As paper products are recycled more and more, the share of recycled paper in the total paper production had increased (CEPI 2010, ERPC 2010) in last few years. This trend should be observed in all developed countries and also in Czech Republic (Figure 13).

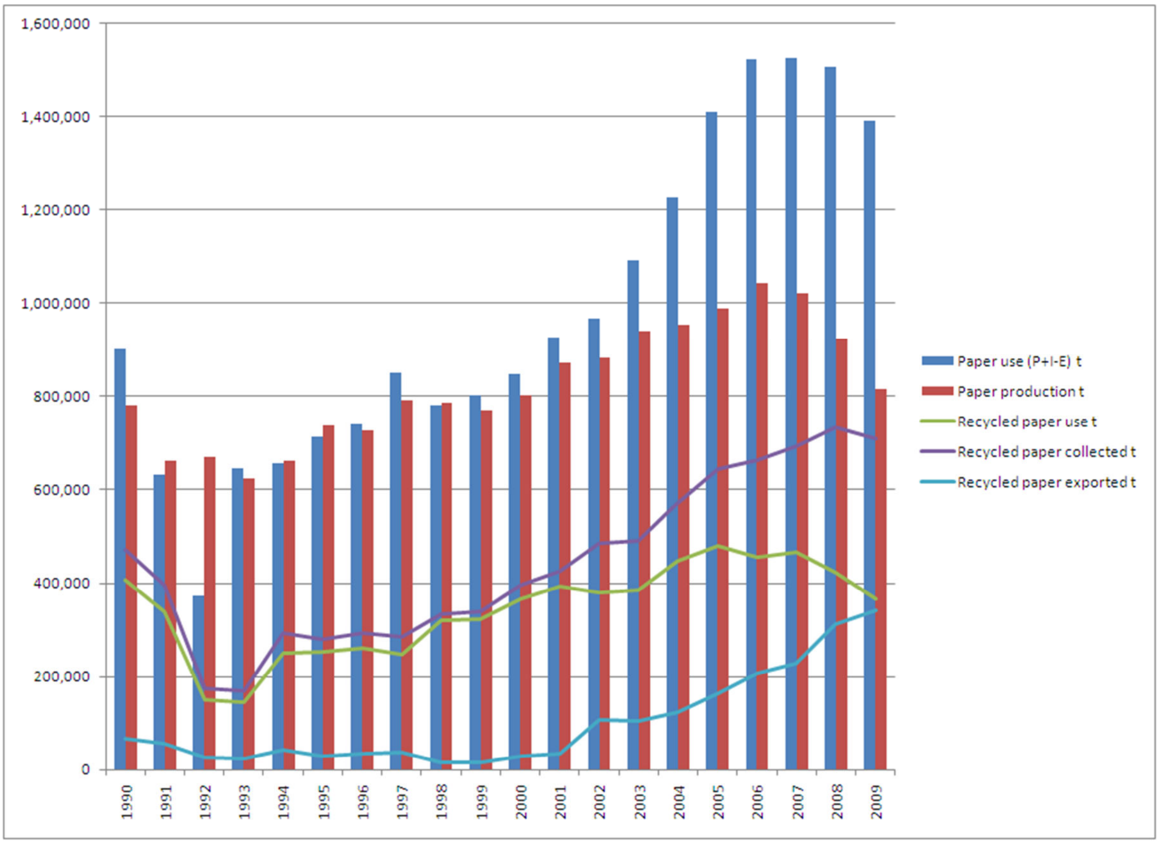


Figure 13.Total paper use, production, collection and recycling

Source: FAOSTAT, SVP

From data about amount used and recycled paper we can calculate rough estimate of life-time for part of the paper products. The estimate is rough because:

- it is based on presumption that all recycled paper comes from paper which was used in previous year,
- it is based on the paper production and do not take into account paper products import and export, paper packages import and export,
- if we do not take into account amount of paper combusted and landfilled, the life-time of paper in the period 1990 – 2009 is estimated to 0,9 - 1,5 year,
- **if we take into account amount of paper combusted and landfilled, the life-time of paper will be even shorter, less than 1 year!** In that case the use of the IPCC default approach is appropriate and we can overlook the issue of paper in the HWP models.

Life-time as it is used in the IPCC methodology means time from product to recycle, not from product to emissions! Data about amount of paper incinerated as part of the municipal solid waste and landfilled should be estimated from national GHG inventories.

The 2006 IPCC GI. does not provide clear definition of life time (half-life) of wood and wood based products. Author (Pingoud, 2011) of calculation sheet, which is provided as part of the methodology, assumed, that "The time constant (half-life) means the product life until it goes to recycling or landfill or whatsoever." **There is discrepancy between product life and production of GHG emission. If the paper is recycled it is the end of its life, but there is no emissions!**

Chapter 12.2.2 of 2006 IPCC GI. provides slightly different definition:
Tier 1 and Tier 2 use the assumption that HWP are discarded from use at a constant rate, k, applied to the carbon in the pool. This constant rate of discard can be specified by an associated ***half-life in years for products in the pool. The half-life is the number of years until half of the amount goes out of use.*** Default half-life values, and associated discard rates (k) are provided in Table 12.2 (see BOX 8) for solid wood products and paper products.

BOX 8. Table 12.2 (2006 IPCC GI.)

TABLE 12.2
DEFAULT HALF-LIVES FOR "PRODUCTS IN USE" CARBON POOLS AND ASSOCIATED FRACTION RETAINED EACH YEAR

	Solidwood products	Paper products
Half-life (years)	30	2
Decay rate k (k = ln(2)/ half-life)	0.023	0.347

Source: Based on values used in previous studies summarized in HWP Appendix Table 3a.1.3 of the IPCC report on *GPG-LULUCF* (IPCC, 2003). Table 3a.1.3 gives values for more product categories.

What in the case of paper production, use and recycling? Does the term pool cover also recycled paper or recycled paper is covered under the term "out of use"?

Explanation should be provided by the Introduction chapter (12.1), where carbon reservoir (pool) is defined as "*a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored*" and add "*The time carbon is held in products will vary depending on the product and its uses.*" Since the recycled paper represents carbon storage (and not GHG emissions into the atmosphere), should be included in the reservoir (pool) values and not into the emissions.
It can be considered, that the system as was established and set up follow procedures and uses information from economic studies on material flow analysis (e.g. life-time). But in some cases there is fundamental difference between material and emissions flows. Material flow analyses calculated the time-life of material till the end of use because it is important for economic and material analysis. It should be carefully monitored when at the end of the life cycle emissions occur and when not.

4 Methodology

The latest version of available methodology for emissions and removals estimation from HWP was published in 2006 IPCC GI. Information about HWP estimates are available from National Inventory Reports (NIR) of USA, United Kingdom, Finland, Australia, which report HWP under their GHG inventories or from countries like Norway or Finland, which planning to report the HWP in near future and in their NIR (or background reports) provides preliminary results and methodology description. A UN FCCC misc document provides only limited information about methodology, proposed changes or problems.

4.1 Parameters

As parameters are marked all input data, which enter into the equations/calculations. Next chapters describe activity data, carbon content, decay methods and decay parameters. The list starts with the most important, which determine the total carbon pool / emissions and ends with those that determine the timing. The determination of total carbon pool (and thus total potential sinks and emissions) is considered crucial issue for the HWP estimates. Carbon content, decay method and its parameters are expert issues which have to be described and discussed in IPCC methodology. All of them are to some extend described or at least mentioned in the IPCC guidelines.
Until activity data will not be defined and overall system will not be set up, methodological guidance on the estimation of HWPs provided in the IPCC GI. will not be fully applicable for future reporting and review purposes.

4.1.1 Activity data

Activity data represents the absolutely key and basic parameter that determine the total amount of C stored in HWP or CO2 emissions from HWP decay. Since the UN FCCC (SBSTA or any other body) was not able to determine and define all necessary parameters e.g. which type of wood and wooden products, how to take into account imports and exports, type of method (stock, input/output flows, flux to atmosphere, their combination) for emissions estimates), the IPCC methodology provides only general process and procedures description.
Activity data for Tier 1 emissions estimates and the HWP calculation sheets are probably overestimated. Australia reported in its National Inventory Report (Australian Government, Department of climate change and energy efficiency, 2012b) that up to 10% of Sawnwood mass is transformed into the waste and combusted.
Until this issue is not resolved, the preparation of a detailed methodology is not possible.

4.1.2 Carbon content

Information about carbon content (density, water content and other technical parameters) for different wood and wood based material (products) are available in IPCC methodology as well as in many other documents. National specific values are generally available, e.g. parameters for different types of wood are used for GHG inventory from LULUCF category. Carbon content can be identified as the second most important parameter, since determines the total amount of carbon (CO_2) and thus set up preconditions for the total sinks and emissions.

4.1.3 Decay parameters (half time)

Decay parameters enter into the decay function or methods. They are specific for different wood product and decay methods or functions. Different decay functions need 1 to 3 different parameters (See chapter 0). In IPCC guidelines this parameter is described insufficiently, there is more detailed information in the 2003 GPG for LULUCF GI. then in the 2006 IPCC GI. IPCC methodologies provide decay parameters only for simple decay method (half-life).

Decay parameter is not key issue, because does not determine total carbon release or CO2 emissions. Together with the decay methods parameters determine timing of emissions.

The possibility that decay parameters are not stable during the time is only mentioned in the IPCC gl., because this is issue for higher tier methodology, which should be applied on the national level (so national data are necessary).

Lifetimes of products are much more difficult to ascertain and they may change dramatically and rapidly according to a range of factors (e.g., economic prosperity, building codes, fashion) and determining the fate of products once they have served a useful life is also challenging UN FCCC (2003b). **There should be possibility in the HWP calculation sheet to use different decay parameters (half time) for different years.**

4.1.4 Decay methods

Decay methods define the pathway of carbon (CO_2) release from wood and wooden products. This is not key parameter, because does not determine total carbon release or CO2 emissions nor the exact timing[28]. Together with the decay methods parameters determine timing of emissions. This parameter is poorly described in the IPCC methodology; there is no identification of possible choices.

4.2 Calculation sheet

It is important to bear in mind that like any other model the application lower tiers in approaches is only very rough estimate, which has with real world only few common points. Only the use of detailed data and precise knowledge of all processes, which generates GHG emissions or changes of wood based material stocks may lead to an accurate determination of emissions and sinks in the HWP.

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories provides Microsoft Office Excel calculation sheet (spreadsheet model) for the HWP emissions estimation for all 4 approaches:

- Stock Change approach
- Atmospheric Flow approach
- Production approach
- Simple Decay approach

[28] The reason, why decay method / function is identified as the least important, are results presented in chapter 6.2, that application of different decay method / function can produce similar results.

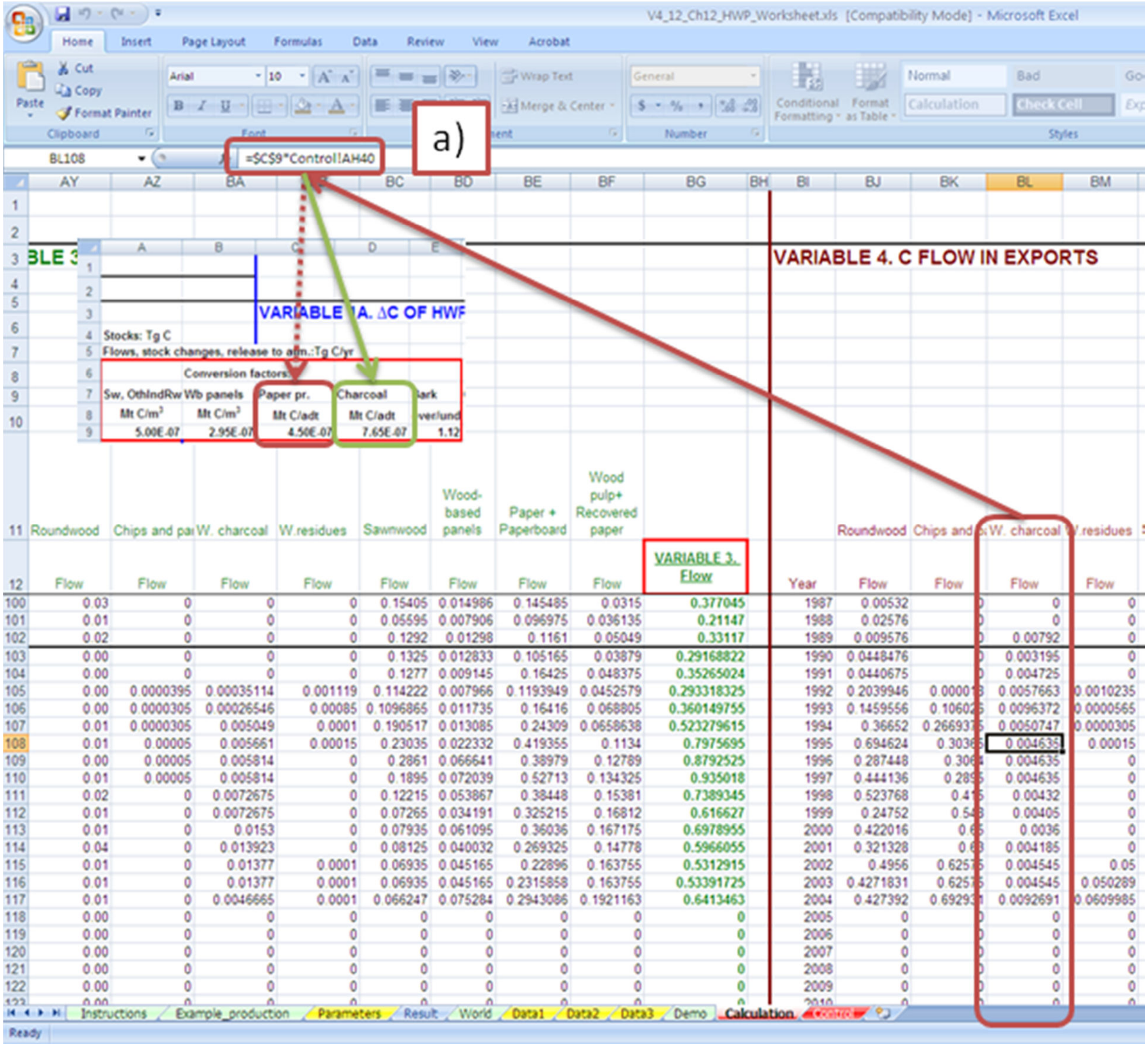
The calculation sheet is part of the 2006 IPCC Gl., could be downloaded from the web pages[29], which are managed by TSU or copy from a CD accompanying the paper version of the 2006 IPCC Gl.
The calculation algorithm, its application to practice and set up of key parameters were checked as well as the general principle, that emissions and removals shall be reported where and when they occur, was taken into account. Next paragraphs and chapters presents results of these checks.
Careful inspection of the calculation sheet (version from November 2010), set of tests for different scenarios and time periods revealed the following deficiencies and poor performance of the model (e.g. it is not possible to use the model for the whole Kyoto protocol period):

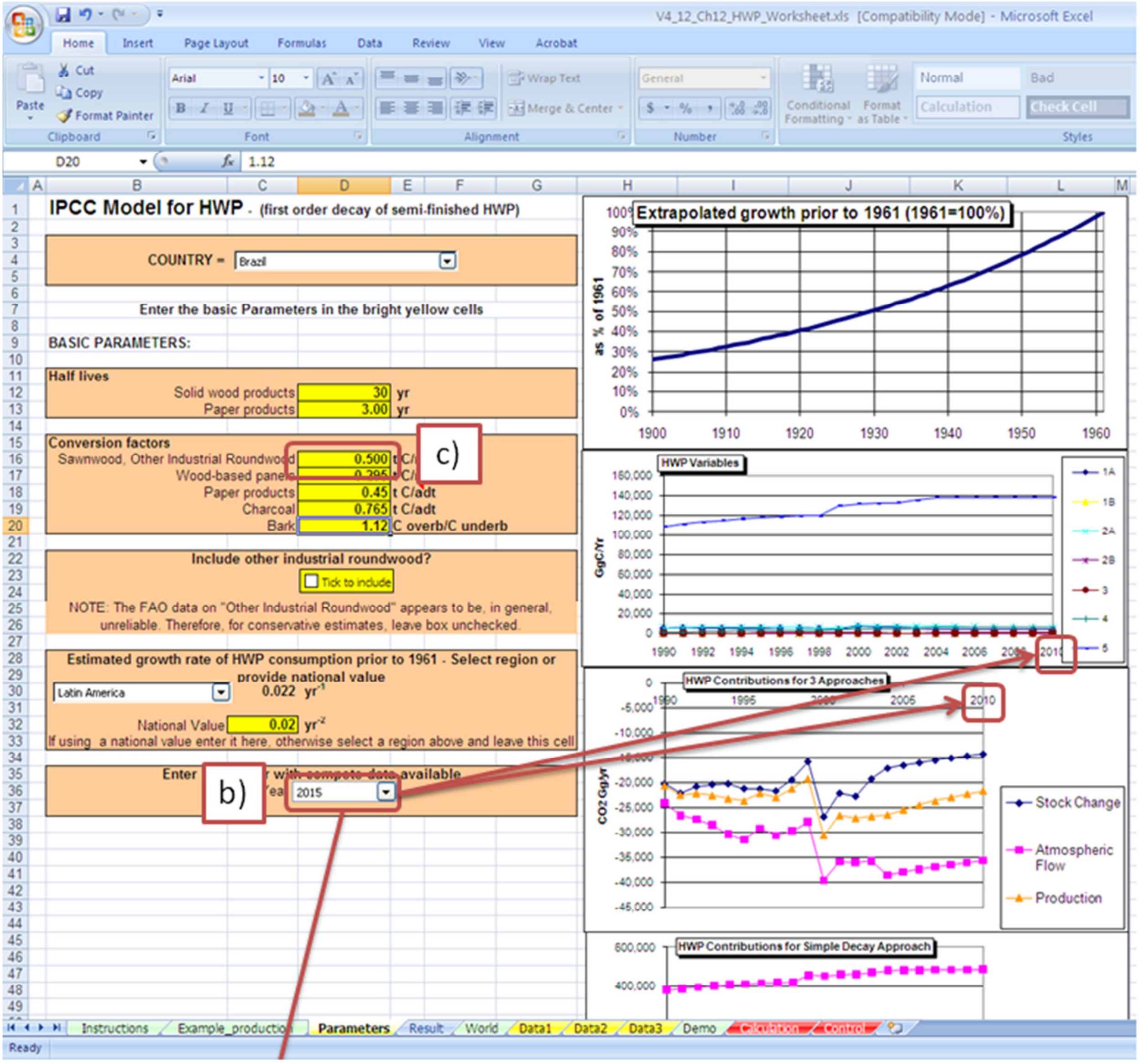
a. **incorrect use of conversion factor for exported wood charcoal;**
b. **short period (only till 2010) for emissions and removals calculation;**
c. **value for conversion factor for Sawnwood, Other industrial wood is incorrectly in the model presented as 0.5 t C / m^3;**
d. **size of the file is unreasonably large,**
e. **recycled paper problem,**
f. **inter annual variation of static parameters,**
g. **implementation of Simple Decay approach,**
h. **wood product definitions and use of conversion factors.**

Some deficiencies are illustrated on the Figure 14 (a - d). Problems e and f will be important in the case when HWP calculation sheet will be used for higher Tier methodology application.

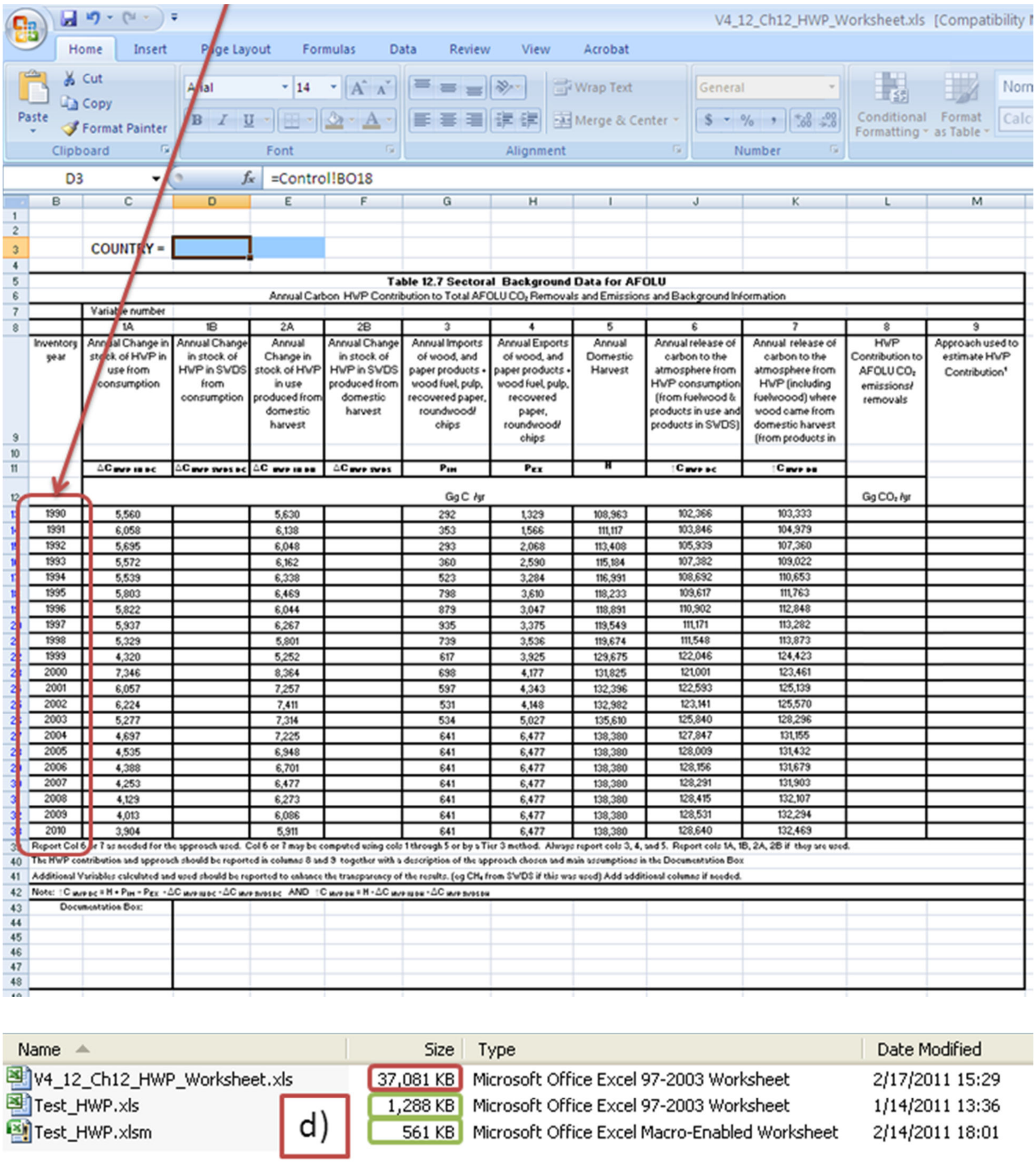
[29] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_12_Ch12_HWP_Worksheet.zip

Figure 14.HWP calculation sheet deficiencies (a - d)





V4_12_Ch12_HWP_Worksheet.xls [Compatibility Mode] - Microsoft Excel
IPCC Model for HWP - (first order decay of semi-finished HWP)
COUNTRY = Brazil
Enter the basic Parameters in the bright yellow cells
BASIC PARAMETERS:
Half lives
Solid wood products 30 yr
Paper products 3.00 yr
Conversion factors
Sawnwood, Other Industrial Roundwood 0.500
Paper products 0.45 t C/adt
Charcoal 0.765 t C/adt
Bark 1.12 C overb/C underb
Include other industrial roundwood?
Tick to include
NOTE: The FAO data on "Other Industrial Roundwood" appears to be, in general, unreliable. Therefore, for conservative estimates, leave box unchecked.
Estimated growth rate of HWP consumption prior to 1961 - Select region or provide national value
Latin America 0.022 yr-1
National Value 0.02 yr-1
If using a national value enter it here, otherwise select a region above and leave this cell
2015
b)
c)
Extrapolated growth prior to 1961 (1961=100%)
HWP Variables
HWP Contributions for 3 Approaches
Stock Change
Atmospheric Flow
Production
HWP Contributions for Simple Decay Approach



All deficiencies was removed by (i - a) changing equations, (ii - b) extension of the calculation formulas for the following years, charts modification and macros update, (iii - c) entering updated value, which is in line with 2006 IPCC GI. and (iv - d) new file creation and macros rearrangement. Changes in file size are illustrated on Figure 14d. The file size change has a significant impact on work with the file; especially opening process is much faster.

Updated version of HWP calculation sheet is attached to this report. Attached are both versions, one for Microsoft Office Excel version 97-2003 and second for Microsoft Office Excel version 2007 (in this format, the file has approximately 1 % of the original size).

Time-series data entry and calculation was prolonged to the year 2055. This change will not only enable use of the calculation sheet for long period without changes, but also **preparation of the HWP projections.** The file can be used to model the impact of policies and measures on emissions from the HWP.
Impact of deficiency, the incorrect equation, is illustrated on Czech data in chapter 6.2. Generally speaking, the impact is marginal. Production, import and export of charcoal are compared with other flows considerably lower. The influence of incorrect value for conversion factor for Sawnwood, Other industrial wood is incorrectly is much more important.

Problem (e) which relates to the recycled paper should be illustrated on the two situations, with the same presumption that:

- production is stable for 3 years (1990 to 1992) on the level of 1 000 000 t and then is stopped so we can observe paper decay,
- there is no any other flows of carbon from HWP,
- half-life of product is the same[30].

First scenario (without paper recycling), all paper produced comes from wood. 1 000 000 t per year production enter into the HWP model calculation sheet. Results are shown on the Figure 15. Second scenario (with paper recycling), 500 000 t of collected paper is reused for paper production, 500 000 of paper comes from wood. Results are shown on the Figure 16. For better comparison the same ranges of emissions and sinks were used.

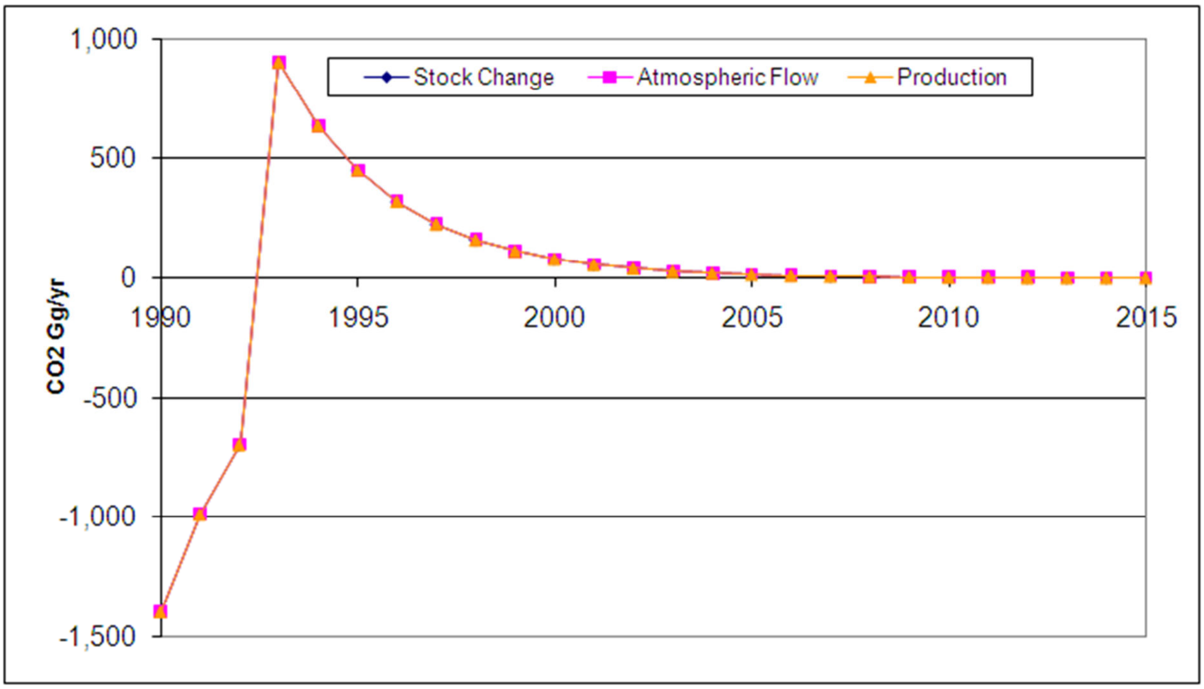


Figure 15. Influence of paper recycling on sinks and emissions – first scenario

[30]Half-time set up the speed of carbon discard.

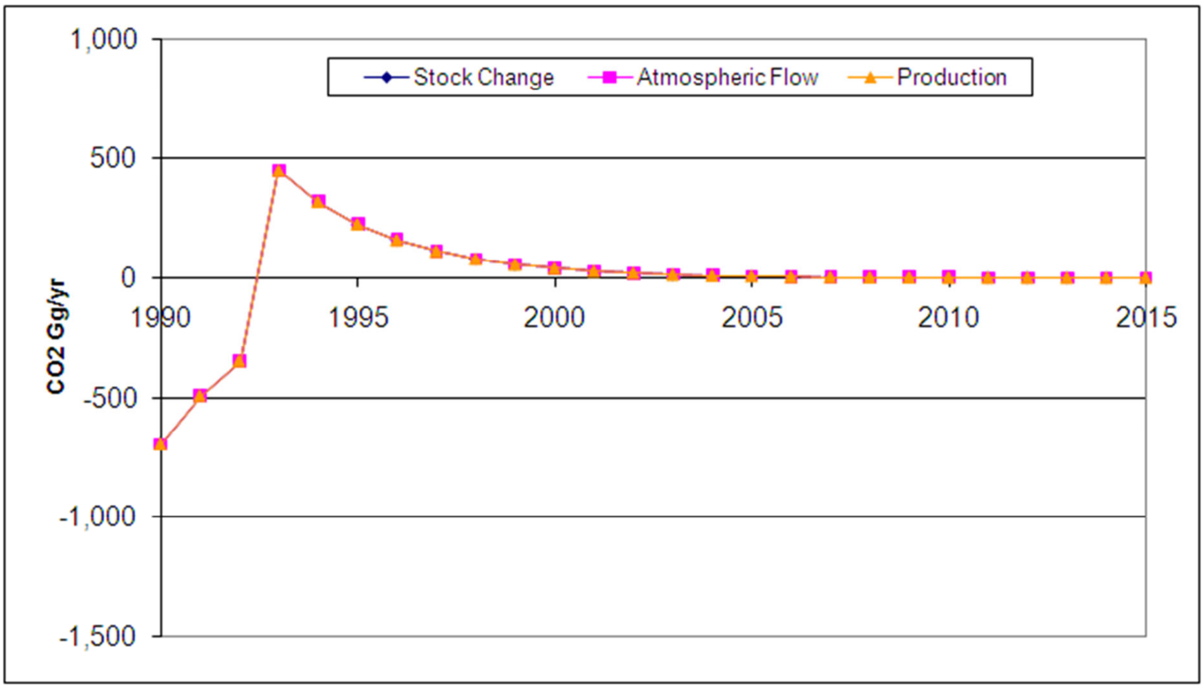


Figure 16. Influence of paper recycling on sinks and emissions – second scenario

Figure 15 and Figure 16 show very different flows of CO_2 (in the term of absolute values), but the total balance (and trend) of emissions and removals is the same (it is 0). The speed of paper discard is the same for both, life-time influences time horizon where emissions will be 0 or close to 0. But ways how carbon pool from paper production and recycling are threaded carbon (CO_2 emissions) drive annual amount of removals and annual emissions. When paper recycling practice is ignored, the amount of C in the system is higher than in reality and all flows seems to be more intensive.

This problem disappears

- if the production and consumption is stable,
- if different life-times are used,
- if you calculate with carbon balance in produced and decaying paper.

In that case as input parameter is used amount of harvested wood and this parameter is balanced with paper decay. Calculation sheet for HWP calculate in all cases with the balance of C and not individual flows, the solution thus does not have a problem with estimating emissions from recycled paper. Since the lifetime of paper and paper products is lower compared to the life of wood products the amount of stored carbon in the paper is lower.
Quantification of potential impact is presented in Annex 12.1, which also shows the underlying data. Based on calculations presented in Annex 12.1, we can estimate for the use of Tier 1 and the default parameters that emissions and removals uncertainty from the production and use of paper products is about ± 50%.

With the previous problem one additional (f) issue is closely connected. As also is in the 2006 IPCC gl. mentioned: half-life likely vary over the time. In the current version of the HWP calculation sheet is not possible to apply different life-times for different period of time. It is assumed that life time is constant during the whole period. This simplification should be considered as an important limiting element of the HWP calculation sheet, if it can be seen that significant changes in life time occurred during the period, such a methodology (model) should be applied, which takes it into account. Application of different life times will be easier in models which use different probability distribution function for decay description.

(g) In the case of implementation of Simple Decay approach basic condition as described in (Ford-Robertson, 2003) was not fulfilled:

a. ***this approach suggests the emissions remain the responsibility of the producer*** (Ford-Robertson, 2003) it means, that import and export of wood and wood products is not taken into account.
b. the report also define activity data as ***Annual harvest volume***, but the HWP calculation sheet calculate emissions based on FAO data about different types of wood and wood products.

The result is that IPCC in the 2006 IPCC GI. define its own version of Simple Decay approach, which produces the same result as production approach. All equations used for the HWP are in the 2006 IPCC GI. published in table A12.1 (BOX 9).
It is clear that:

a. FOA data are not applicable for Simple Decay approach,
b. Decay parameter as described for SCA, AFA, PA is defined by different way as for SDA.

Simple Decay approach differs from SCA, AFA and PA. SDA should be in the 2006 IPCC GI. described as separate approach and in the HWP calculation sheet should be implemented in way which will correspond with its basic principles.

BOX 9. Table A12.1 (2006 IPCC GI.)

TABLE A12.1
SUMMARY OF HOW TO COMPUTE *HWP CONTRIBUTION* USING VARIALBES IN TABLE 12.7

Approach	How to estimate *HWP Contribution* using HWP Variables 1-5	How to estimate *HWP Contribution* using carbon release estimates (Variables 6 and 7) and HWP Variables 3-5
Stock-Change	-44/12 • $\Delta C_{HWP\ DC}$, [i.e. -44/12 • (Var 1A + Var 1B)]	-44/12 • ($H + P_{IM} - P_{EX} - \uparrow C_{HWP\ DC}$), [i.e. -44/12 • (Var 5 + Var 3 – Var 4 – Var 6)]
Atmospheric Flow	-44/12 • ($\Delta C_{HWP\ DC} + P_{EX} - P_{IM}$), [i.e. -44/12 • (Var 1A + Var 1B – Var 3 + Var 4)]	-44/12 • ($H - \uparrow C_{HWP\ DC}$), [i.e. -44/12 • (Var 5–Var 6)]
Production	-44/12 • $\Delta C_{HWP\ DH}$, [i.e. -44/12 • (Var 2A + Var 2B)]	-44/12 • ($H - \uparrow C_{HWP\ DH}$), [i.e. -44/12 • (Var 5– Var 7)]
Simple Decay	NA	Under these guidelines report *HWP Contribution* as -44/12 • ($H - \uparrow C_{HWP\ DH}$), [i.e. -44/12 • (Var 5– Var 7)] Proposal for a change in reporting report (-44/12 • H) as part of the AFOLU land area (forest or land area) removals report *HWP Contribution* as CO_2 release from HWP (44/12 • $\uparrow \mathbf{C_{HWP\ DH}}$)

(h) Wood product definitions and use of conversion factors.
FAO definition for Roundwood is “Wood in the rough. Wood in its natural state as felled, or otherwise harvested, ***with or without bark***, round, split, roughly squared or other forms (e.g. roots, stumps, burls, etc.). It may also be impregnated (e.g. telegraph poles) or roughly shaped or pointed. It comprises all wood obtained from removals, i.e. the quantities removed from forests and from trees outside the forest, including wood recovered from natural, felling and logging losses during the period - calendar year or forest year. Commodities included are sawlogs and veneer logs, pulpwood, other industrial roundwood (including pitprops) and fuel wood. The statistics include recorded volumes, as well as estimated unrecorded volumes as indicated in the notes. Statistics for trade include, as well as roundwood from removals, the estimated roundwood equivalent of chips and particles, wood residues and charcoal.”[31]
The UN FCCC, 2003d provides additional information that “The international agreed convention to record statistical information on roundwood is to measure it ***under (without) the bark***.” The HWP calculation sheet calculate is based on the same presumption. **There should be control on the national level, if values in statistics are reported with or without bark.**

The HWP calculation sheet will be part of the IPCC 2006 GI. software. The software was not finished yet so it not possible to assess functionality. It could be expected that uncertainty analysis for HWP will not be part of the software or the IPCC will need do develop uncertainty analysis for HWP (e.g. How will be estimated uncertainty for data before the year1960?).

[31] http://faostat.fao.org/site/626/default.aspx#ancor

5 Decay methods

Decay methods should be also described as probability distribution function (life-time distribution function). In the Microsoft Office Excel program we can found several distribution functions:

- normal (Gaussian),
- standard normal,
- lognormal,
- exponential,
- Weibull,
- Student's t-distribution,
- F-distribution (Fischer-Schnedecorov),
- beta,
- gamma.

There are also another types of distribution function which was not implemented in the Microsoft Office Excel e.g. Cauchy–Lorentz, Maxwell–Boltzmann and Laplace distribution. Figure 17, Figure 18 and Figure 19 show cumulative distribution function, probability mass and probability distribution for functions implemented in the MS Excel. Another possibility is to use a decay profiles (e.g. linear or instant) (Ford-Robertson 2003), see Figure 20 and compare with probability mass (Figure 18). There is broad range of possibilities with different level of complexity and ability to accurately describe the HWP processes.

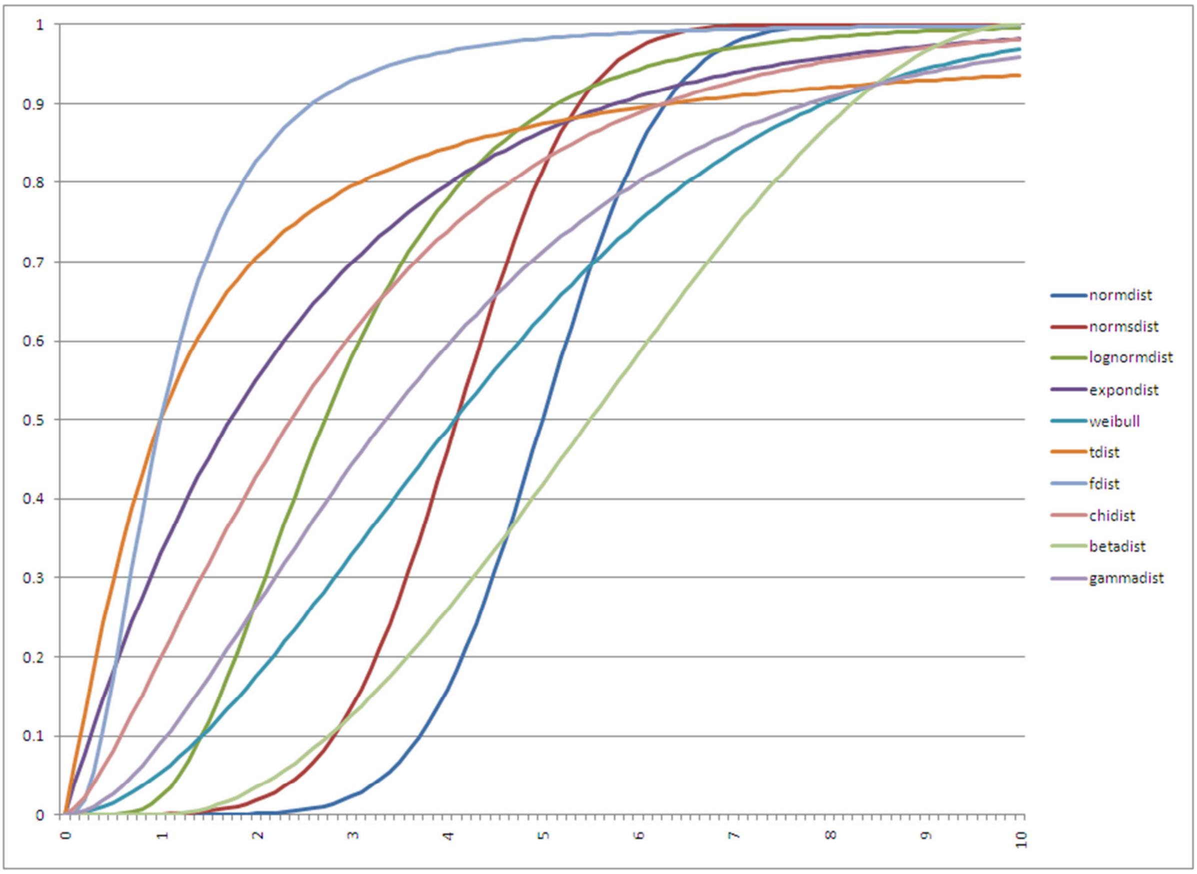


Figure 17.Cumulative distribution function

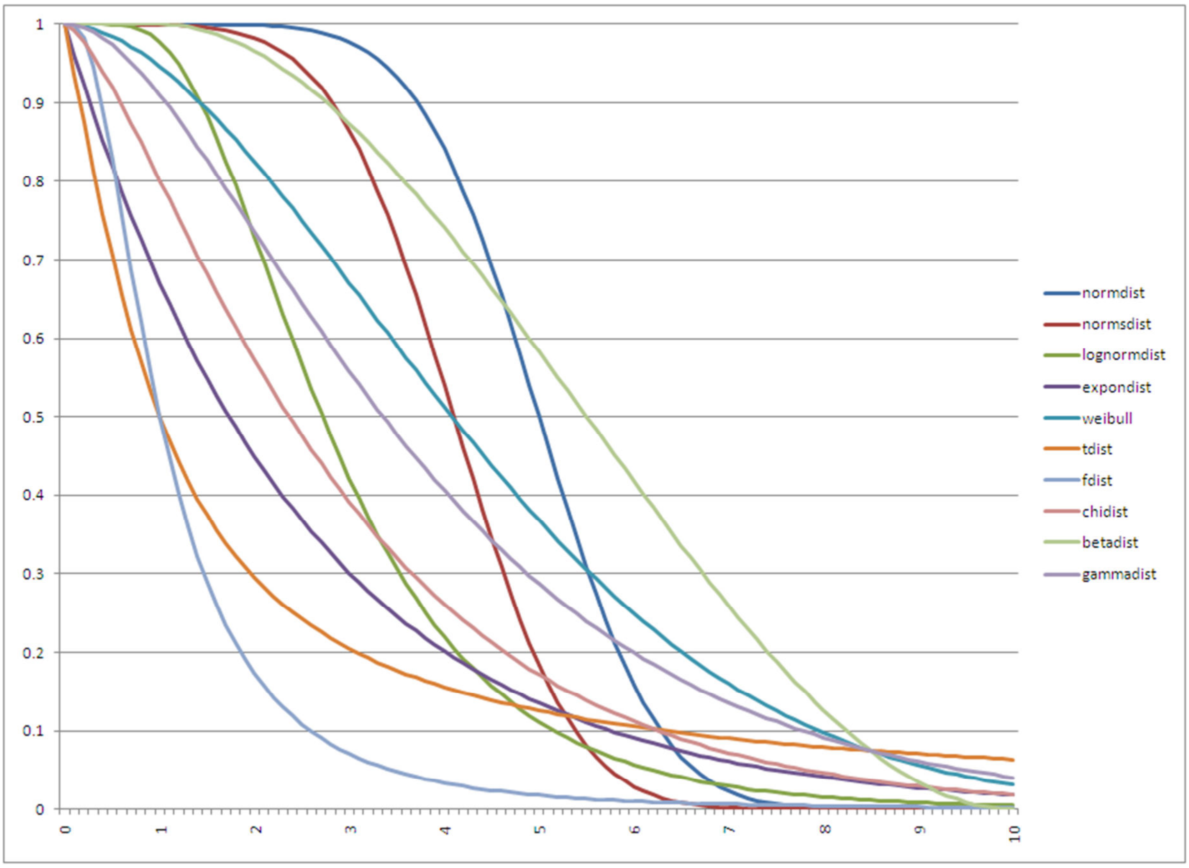


Figure 18.Probability mass

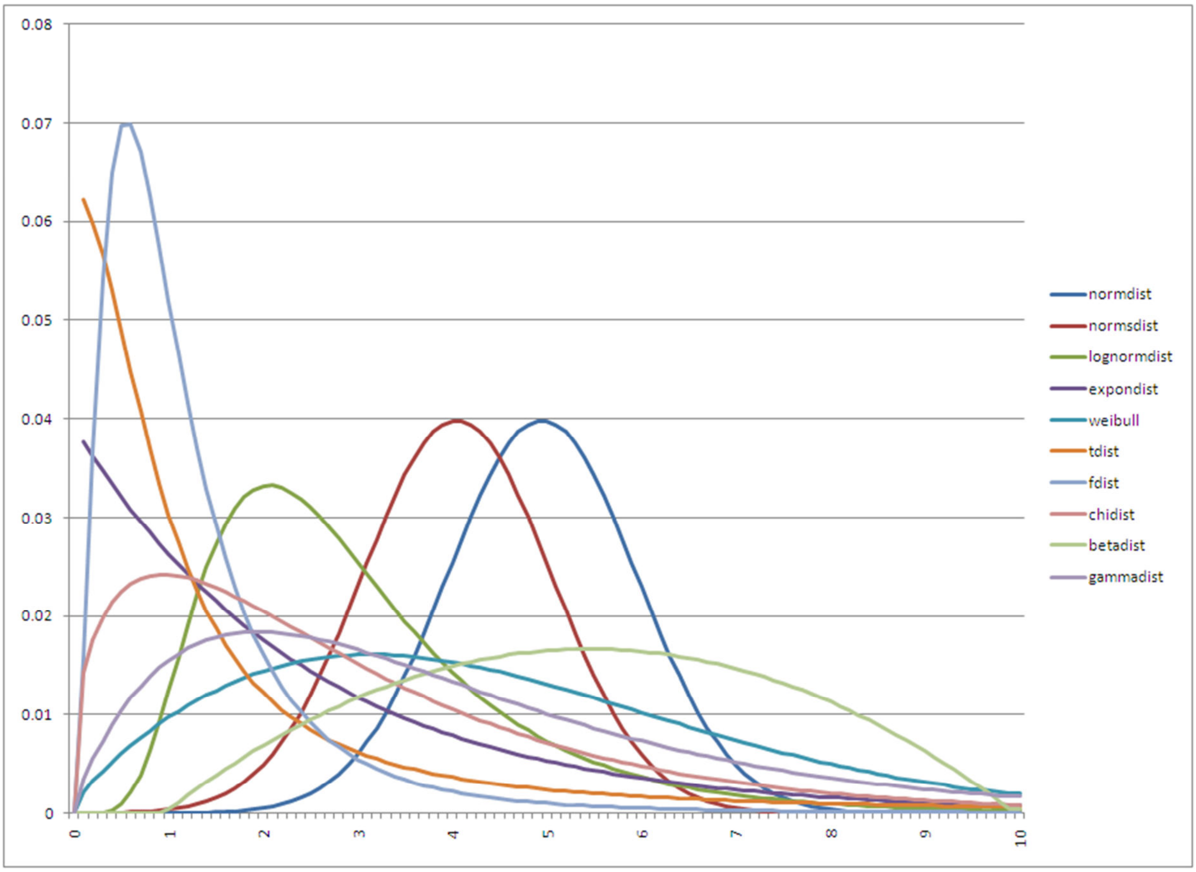


Figure 19.Probability distribution lines

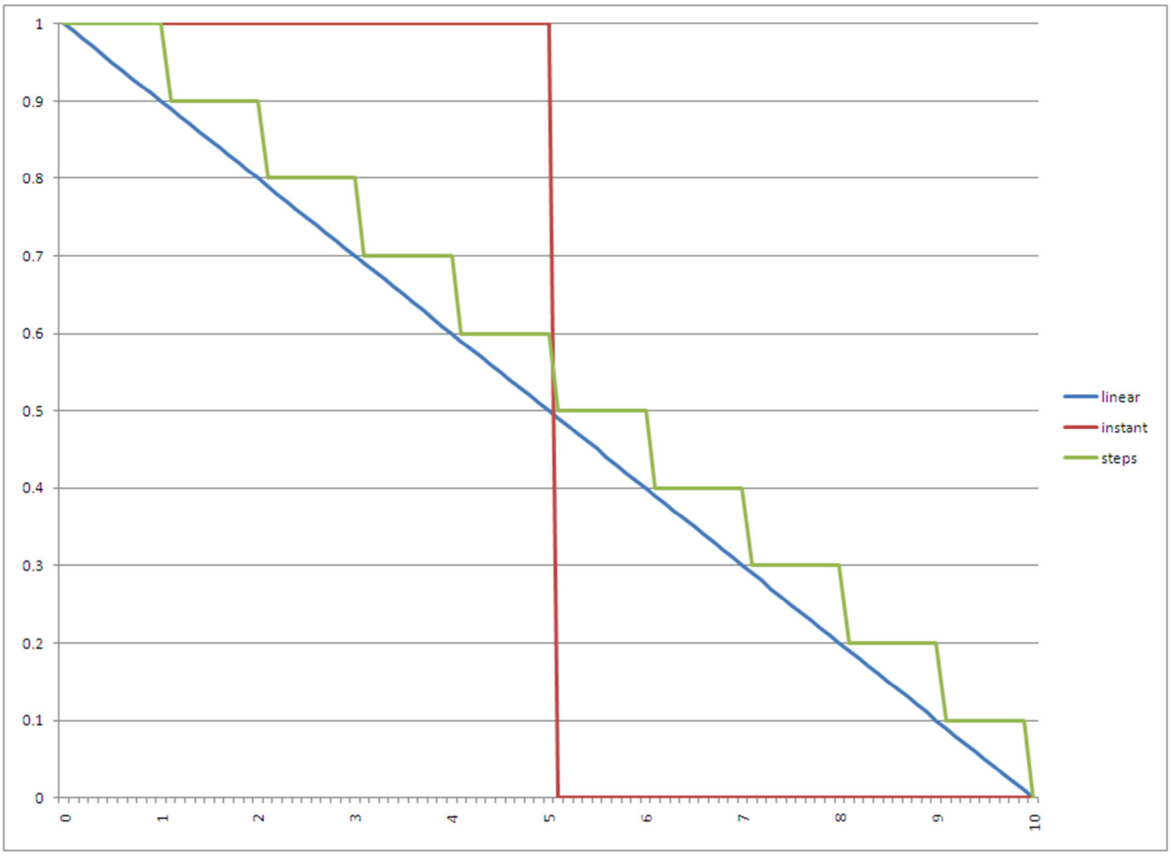


Figure 20.Decay profiles lines

Implementation of different distribution function brings different problems with function parameterization and implementation in models. Distribution function (decay method) drives the way how (annual speed) is carbon transformed from pool to emissions and how is released into the atmosphere. Exponential (Simple decay) distribution function is very simple for implementation.
Studies and articles about material flow analysis (MFA) should provide remarkable information about different distribution function use for different types of product (Komatsu et al. 1992, Melo 1999, Muller et al. 2006).
When the function is implemented and parameters of the decay function are set up, it is necessary to ensure that the function is not limited on the beginning (or on the end). The sum of probability has to be 1 or expressed in % - 100. This issue is important for some functions e.g. normal distribution function.

5.1 Simple decay

Use of simple (exponential) decay has a long tradition for GHG inventories and emissions estimates. Simple decay function was firstly used for CH_4 emissions estimates from landfilled waste decomposition. For this case it is absolutely appropriate because:

- decay starts immediately after waste is landfilled or in short period after that (and it is possible to calculate with this period in model).
- decay rate can be described as constant for given material.

Simple decay method should be described by formula

$$E = N * e^{-k*t} \quad (1)$$

where, E = emissions in given year x, N = amount at time t_0, k = ln(2) / half-time, t = t_x - t_0.

Graphically is simple decay function illustrated on Figure 21, where curves for 1, 2, 5, 10, 15, 20, 25 half-life are presented.

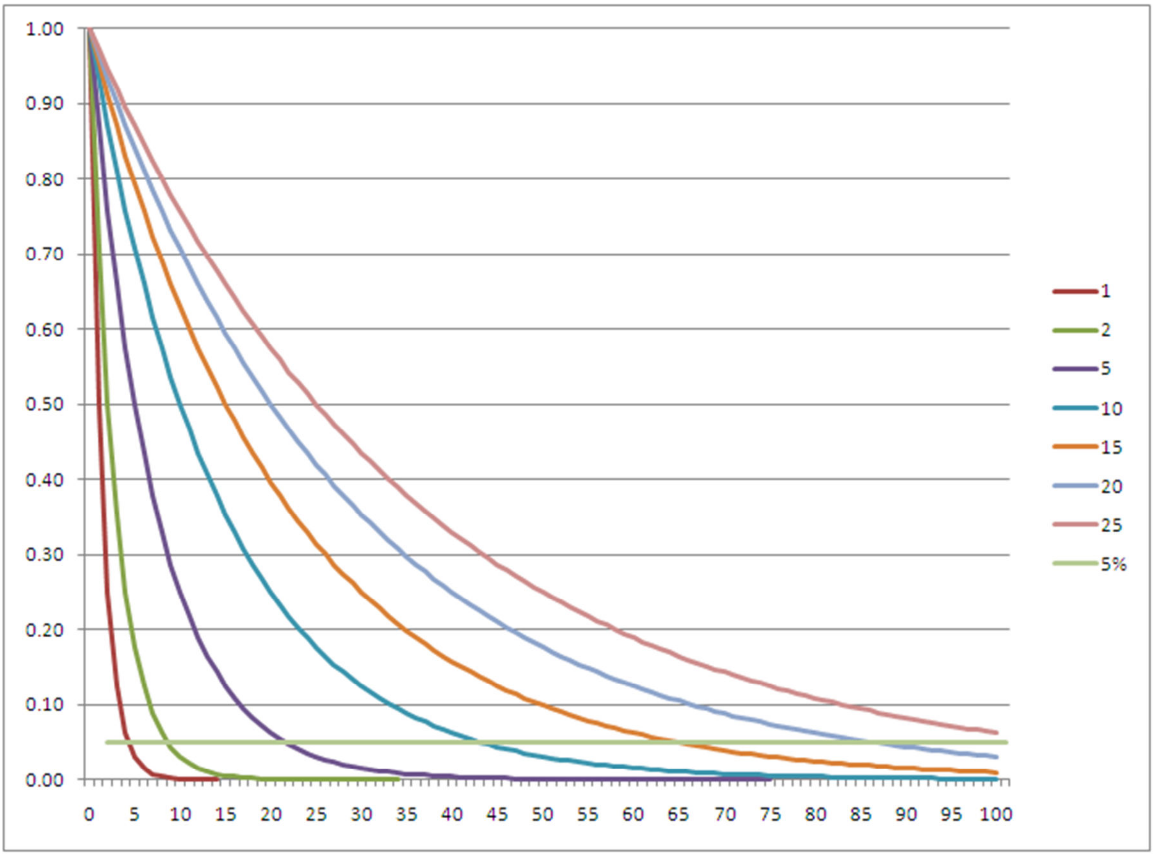


Figure 21.% of original amount for different life-times and exponential (simple) decay function

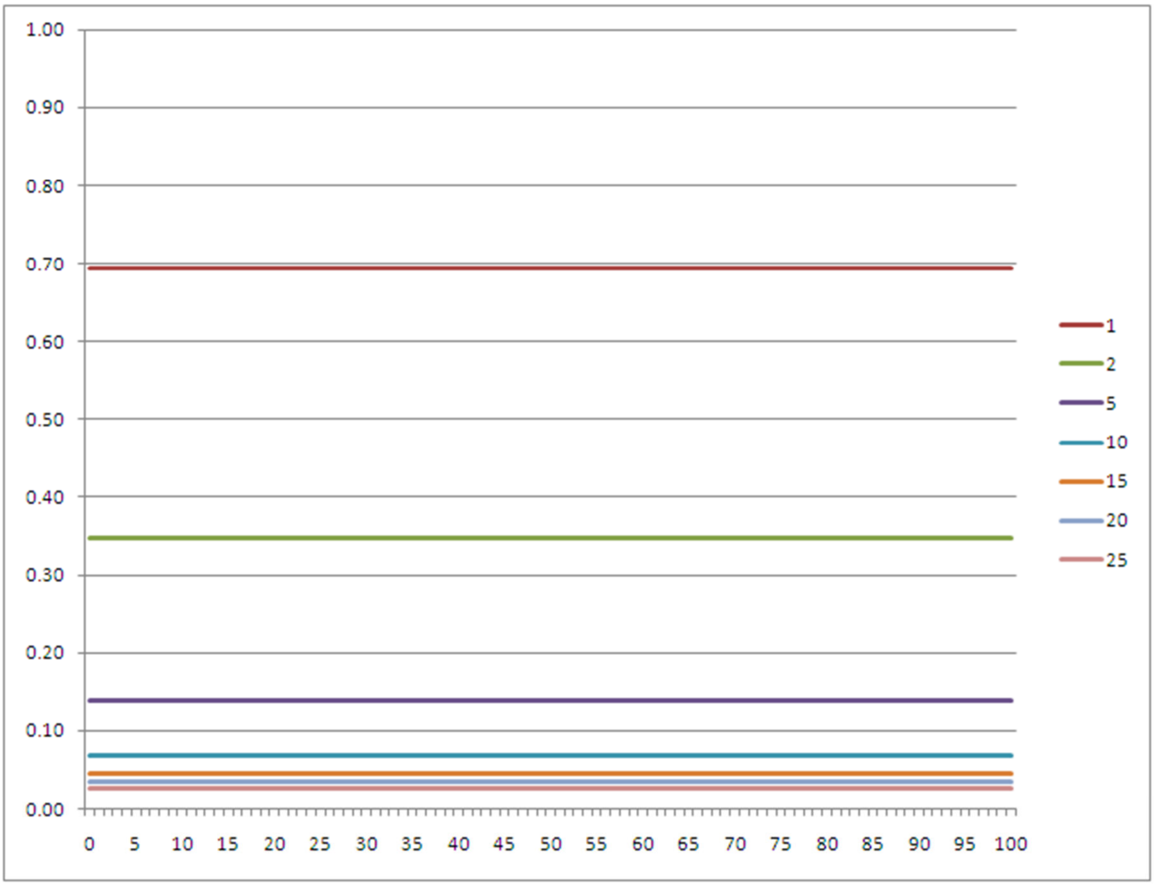


Figure 22.Annual decay rates (%) for different half-life and exponential (simple) decay function.

Exponential (simple) decay function was also implemented in the HWP calculation sheet as compromise between the issue that carbon in harvested biomass is not emitted instantly and simplicity. Use of simple decay for the HWP estimates should be restricted to the case, where there is no rapid and important change of carbon stock in reservoirs, because:

- decay does not start immediately after wood / paper is produced, especially for wood products,
- decay rate cannot be described as constant for all the time, it can be assumed that there is some period during which the product is used (“active life-time”) and then started to be converted into the waste (and produce GHG emissions).

In the case that reservoirs are constant, that there is no rapid increase or decrease of carbon inflow or outflow, above mentioned problems are minimalized by averaging different flows (speed) rates from different years. In all other cases another methodologies should be used as described in the 2006 IPCC Gl. (e.g. tier 3) or lognormal (Komatsu et al. 1992) or Weibull (Melo 1999, Muller et al. 2006) distribution function.

5.2 Gamma decay

The use of gamma was proposed by Gregg Marland in Tonn and Marland, 2007, Marland et al, 2010a; Marland et al, 2010b and in his presentation “The 2006 IPCC Guidance on Harvested Wood Products and Some Possible Refinements” at the IPCC Expert Meeting on HWP, Wetlands and Soil N2O, which was held in Geneva, Switzerland (19-21 October 2010)

(IPCC, 2001[32]). He stressed that simple decay is not accurate and do not describe correctly life-cycle of wood products and proposed a gamma distribution decay function to better represent the probabilistic nature of the decay of products. He also explained that the HWP follow a distributed decay function with the probability of decay or replacement of the HWP depending on the age of the product (IPCC, 2001). He presented the gamma parameters for the various wood products based on his research and UK forest research data.

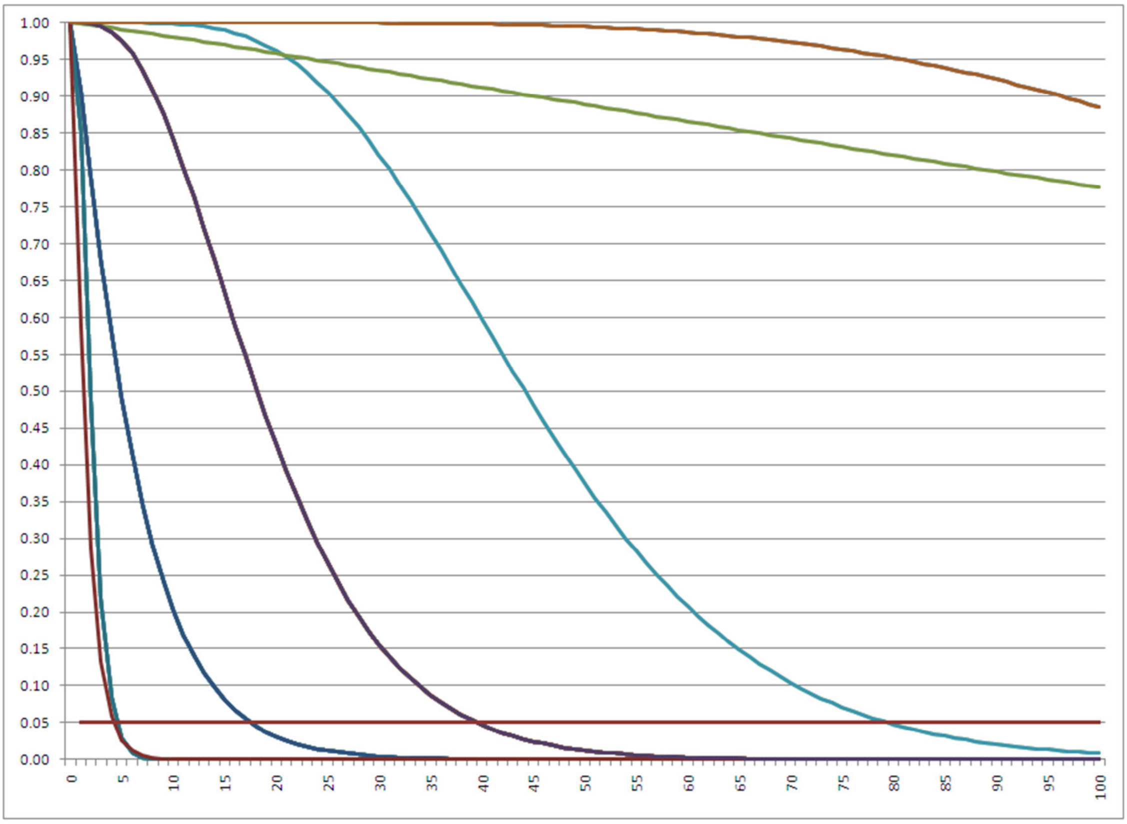


Figure 23.% of original amount for different parameters (wood product) and gamma decay function. (based on data presented by Marland et. al, 2010a)

[32]Meeting report, presentations and other document related to that meeting are available on http://www.ipcc-nggip.iges.or.jp/meeting/meeting.html.

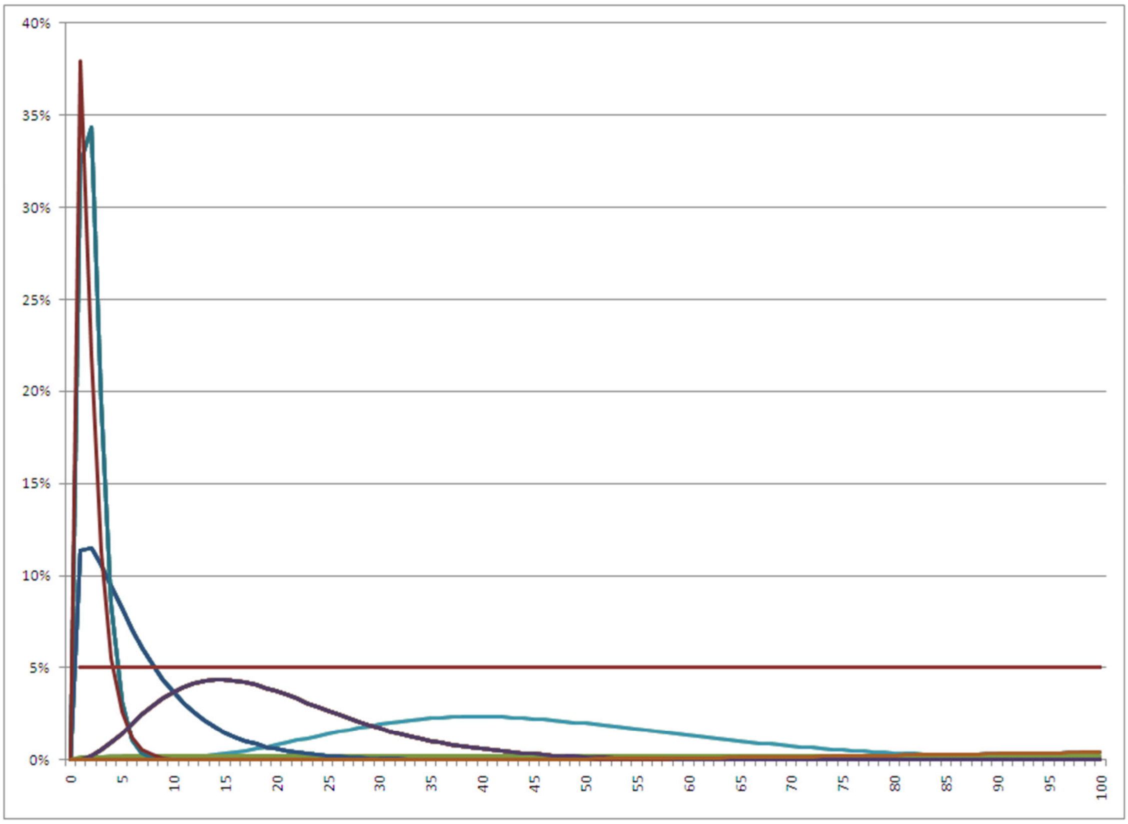


Figure 24.Annual decay rates for different parameters (wood product) and gamma decay function. (based on data presented by Marland et al, 2010a)

Parameterization and application of gamma decay function is more difficult compared to the Simple decay. As shown on the case of Czech Republic and presented in the chapter 7.3 it is possible by using the MS Office Excel software.

5.3 Normal distribution function

Normal distribution function is also known as the Gaussian distribution. It is often used as a first approximation to describe real-valued random variables that tend to cluster around a single mean value. If we adopt a similar idea that mean life-time represent mean value and that decay is cluster around this value, we can consider normal distribution function as possible decay function. There are only two parameters which are used for function definition - the arithmetic mean (μ) and standard deviation (σ) of the distribution. Normal distribution function and its parameters are illustrated on the Figure 25Figure 23.

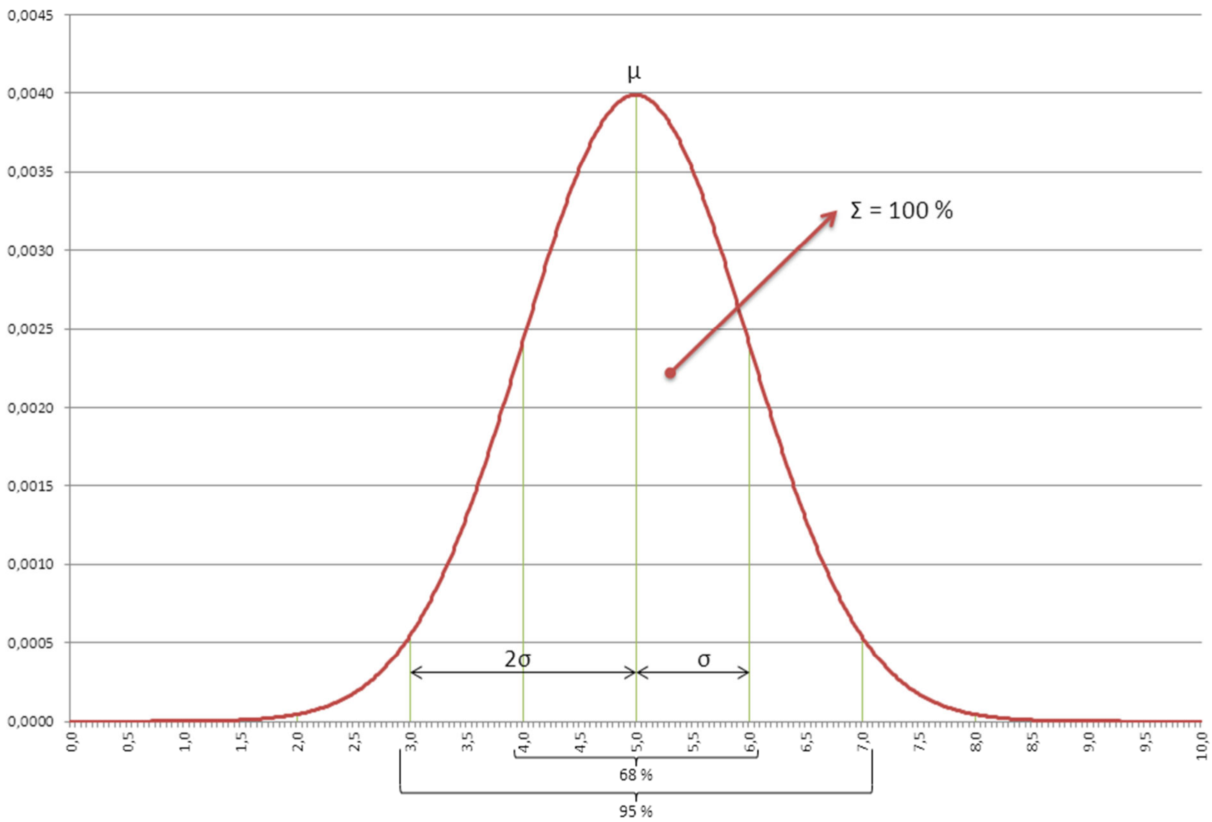


Figure 25.Normal distribution function and its parameters

Figure 25 shows normal distribution function, which is very easy to parameterize compared to the other function. Both parameters, the arithmetic mean (μ) and standard deviation (σ), should be parameterized without any special mathematical knowledge or software. This property determines the normal distribution function to describe the decay of the HWP and implement it in the Excel calculation sheet for the HWP in the case that the function starts in [0,0]. In the case that $3*\sigma>\mu$ it is necessary to adjust function and its implementation in the MS Excel will be a little bit more complicated.
Application of normal distribution function can be illustrated on the case of Czech Republic (see the chapter 7.4). For the function parameterization was used similar presumptions (time when maximal decay occur and period when 95% of original amount was decayed) as presented by Marland et al, 2010a.

BOX 10. Influence of different normal distribution function parameterization on the HWP calculation

The identical model as for data presented in chapter 7.4 was used. 4 different scenarios were defined and compared. The main difference is average life-time for wood (presumptions for paper were not changed):

- Scenario „0“ - arithmetic mean (average life-time) for wood is 40 years (and standard deviation is 15),
- Scenario „+5“ years - arithmetic mean for wood is 45 years,
- Scenario „+10“ years - arithmetic mean for wood is 50 years,
- Scenario „+20“ years - arithmetic mean for wood is 60 years,

Decay profiles are presented on the Fifure BOX 10.1, please compare with Figure 52.

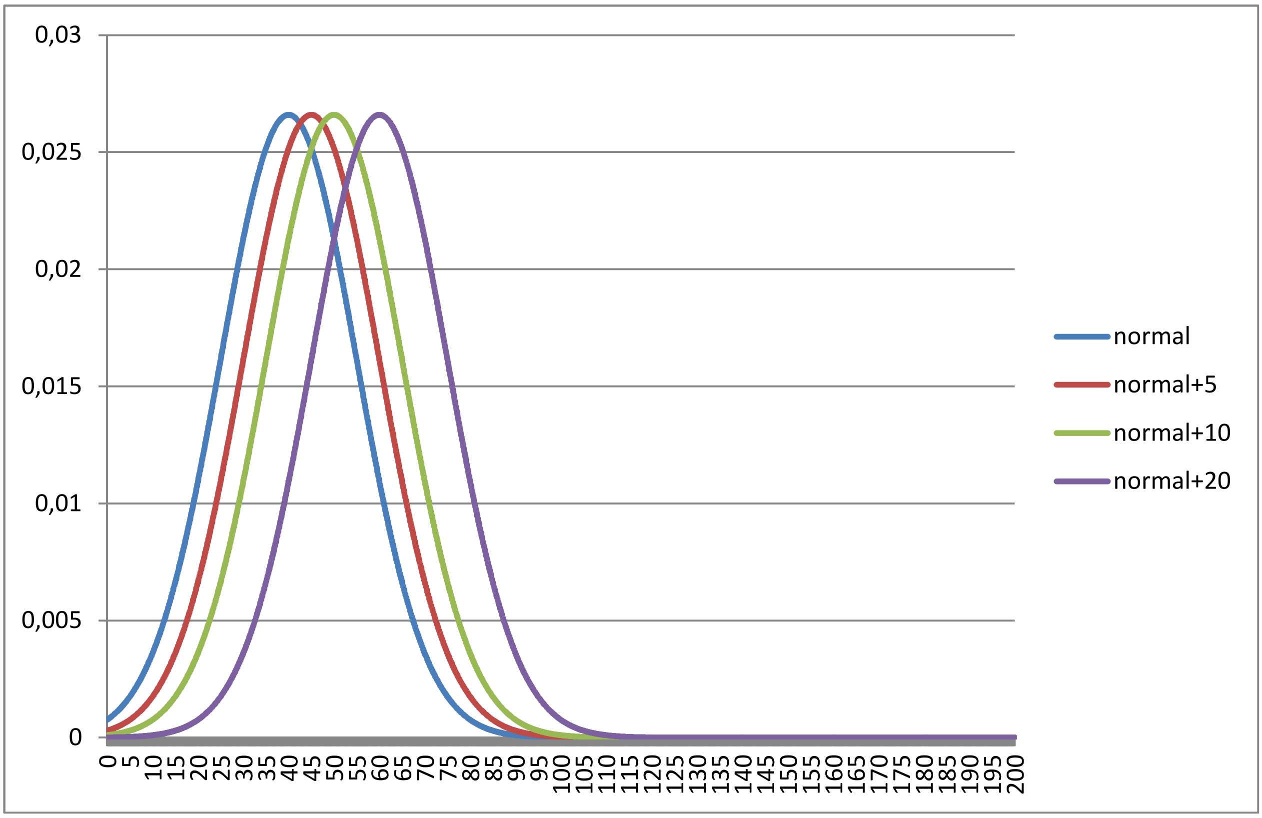


Figure BOX 10.1 Decay profiles for wood and different scenarios

Results for different scenarios and HWP approaches are shown on Fifures BOX 10.2 to BOX 10.4. With the extension of the average life time emissions move into the future and sinks increase. The increase of sink is in inverse proportion to the size of sinks. So we can observe the greatest change for Stock Change Approach, where sinks are the smallest and the smallest change for Atmospheric Approach, where sinks are the greatest. The extension of average life time by 5 years brings greater changes in emissions and sinks than used type of decay (simple, normal, gamma, Weibull).

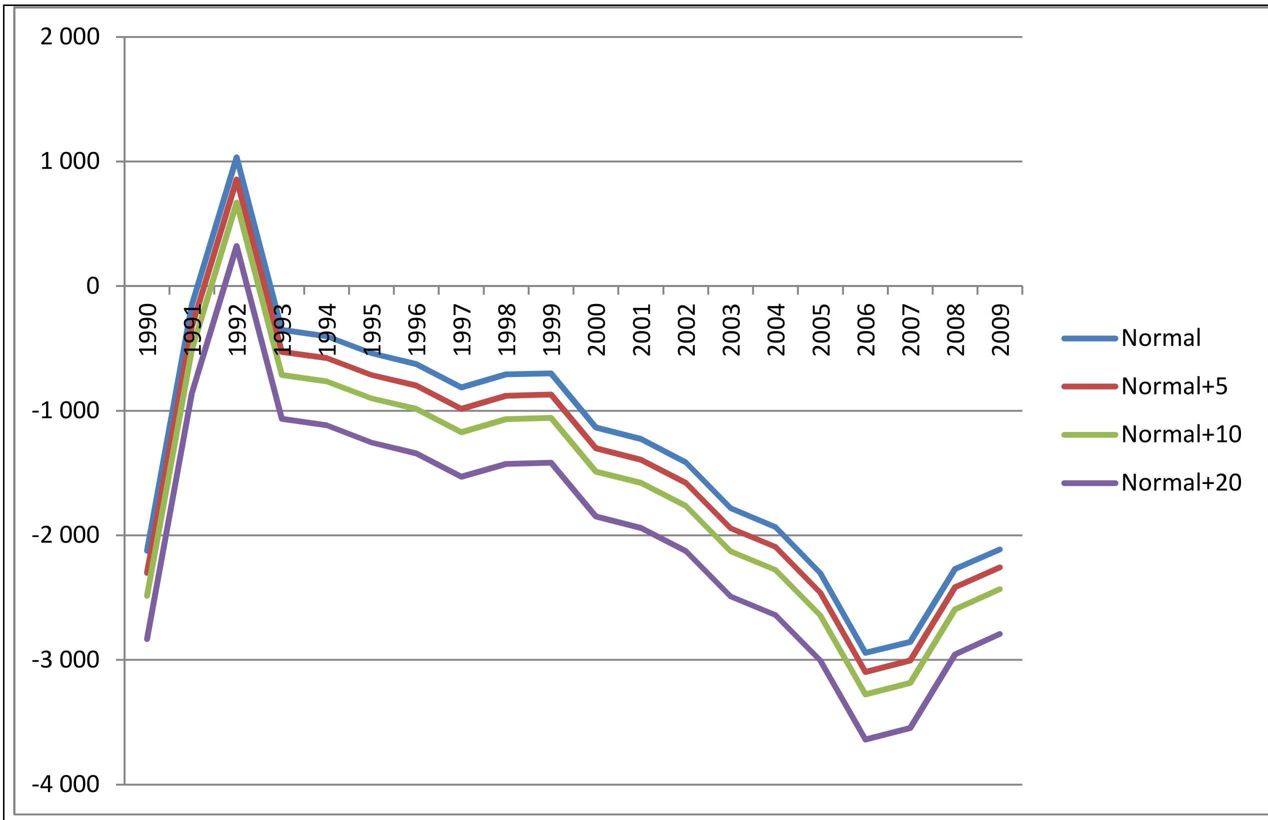


Figure BOX 10.2 CO2 emissions and removals for Stock Change Approach and different scenarios

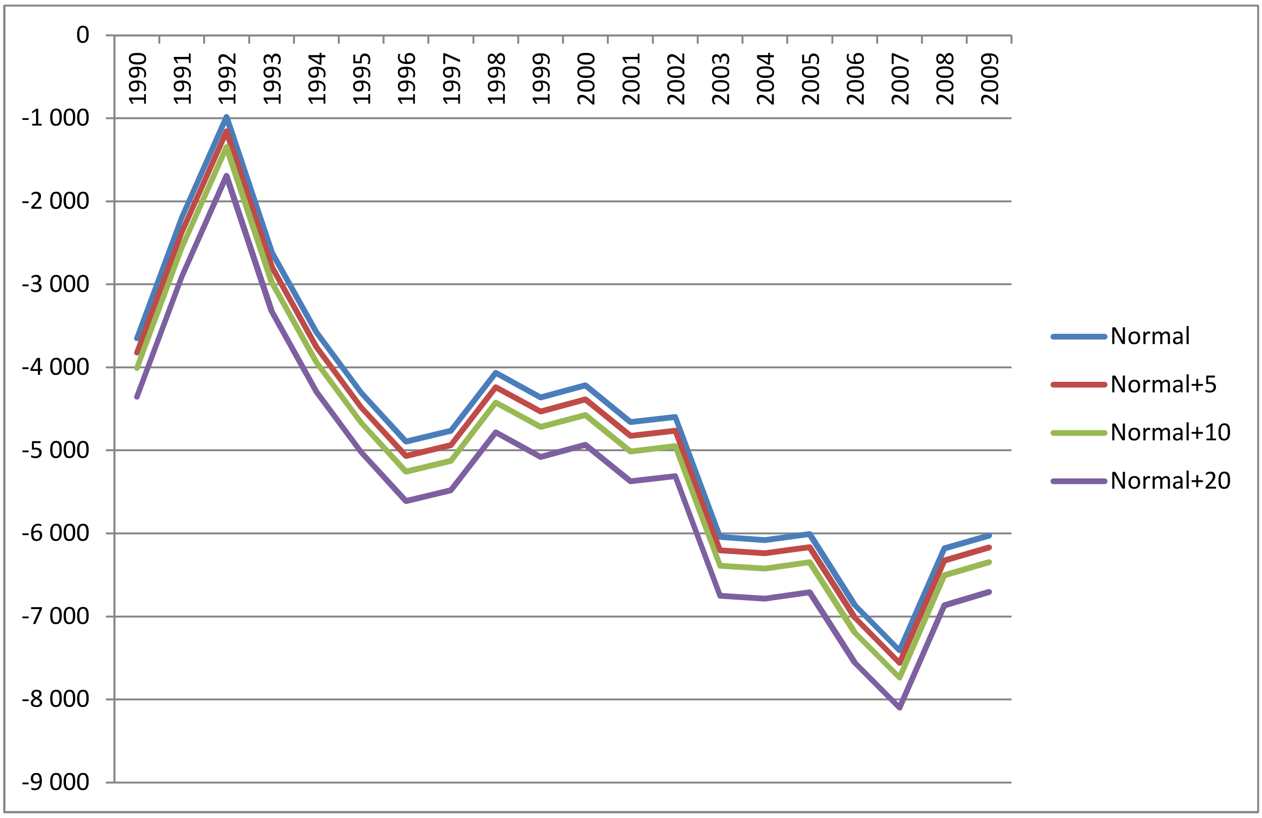


Figure BOX 10.3 CO2 emissions and removals for Atmospheric Flow Approach and different scenarios

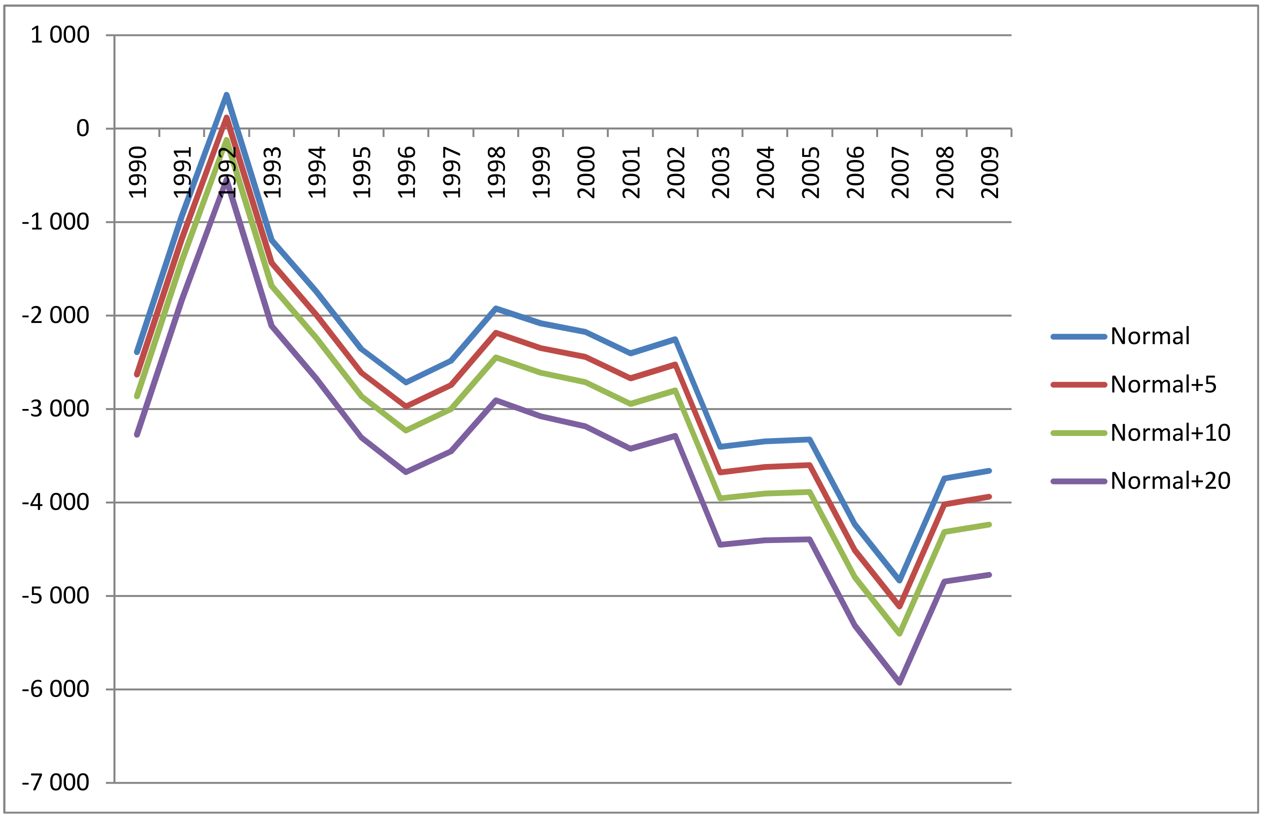


Figure BOX 10.4 CO2 emissions and removals for Production Approach and different scenarios

5.4 Weibull distribution function

Weibull distribution function is not so well known as normal distribution. It is used by environmental economist in material flow analysis (Hatayama et. al, 2008). This type of studies could provide important source of information for this type of function parameterization. Hatayama et. al, 2008 presents data about average lifetime for aluminium use for "Building and construction" category in different regions. This data should be used on national level for housing sector.

Weibull distribution function has two parameters, where $k > 0$ is the shape parameter and $\lambda > 0$ is the scale parameter of the distribution[33]. The influence of parameters on the behavior of a function is illustrated on the Figure 26 and Figure 27.

The shape parameter defines decay rate over time:

- if $k < 1$ then the decay rate decreases,
- if $k = 1$ then the decay rate is constant (similar to the exponential),
- if $k > 1$ then the decay rate increases.

[33] In MS Excel are named as alpha and beta parameter.

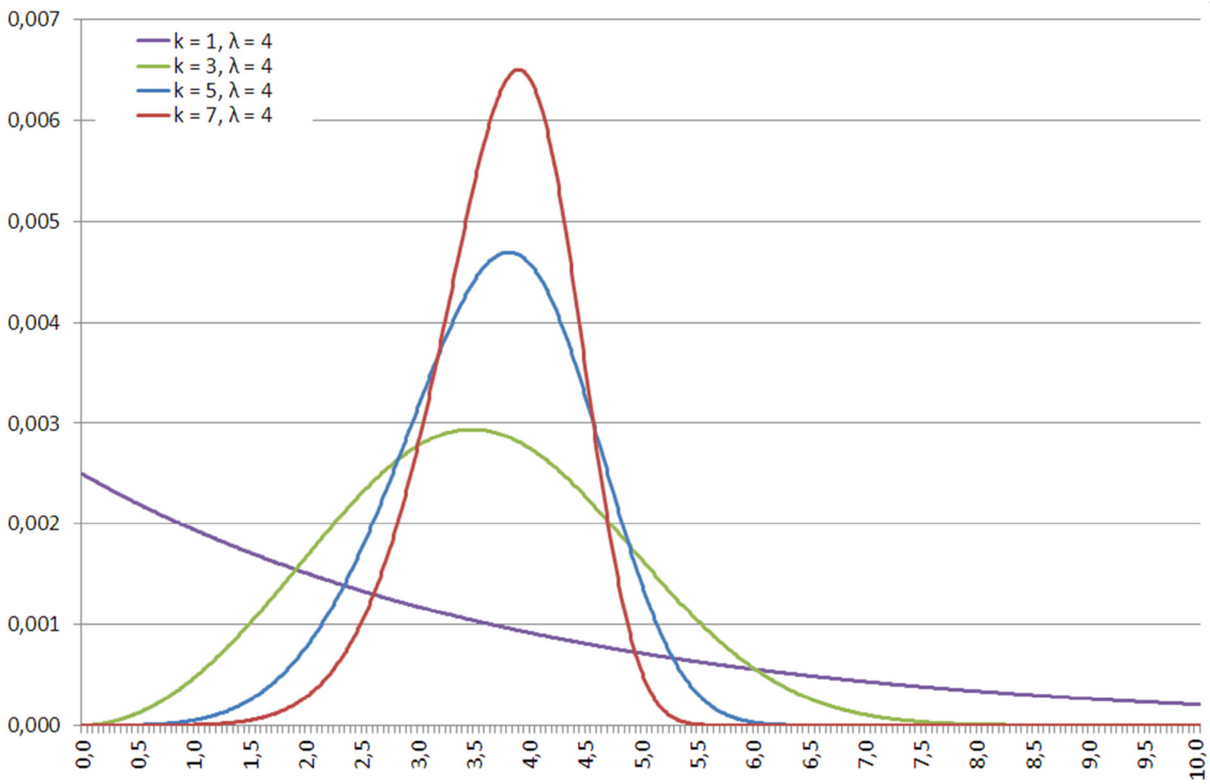


Figure 26.Weibull distribution function, influence of parameterization of k

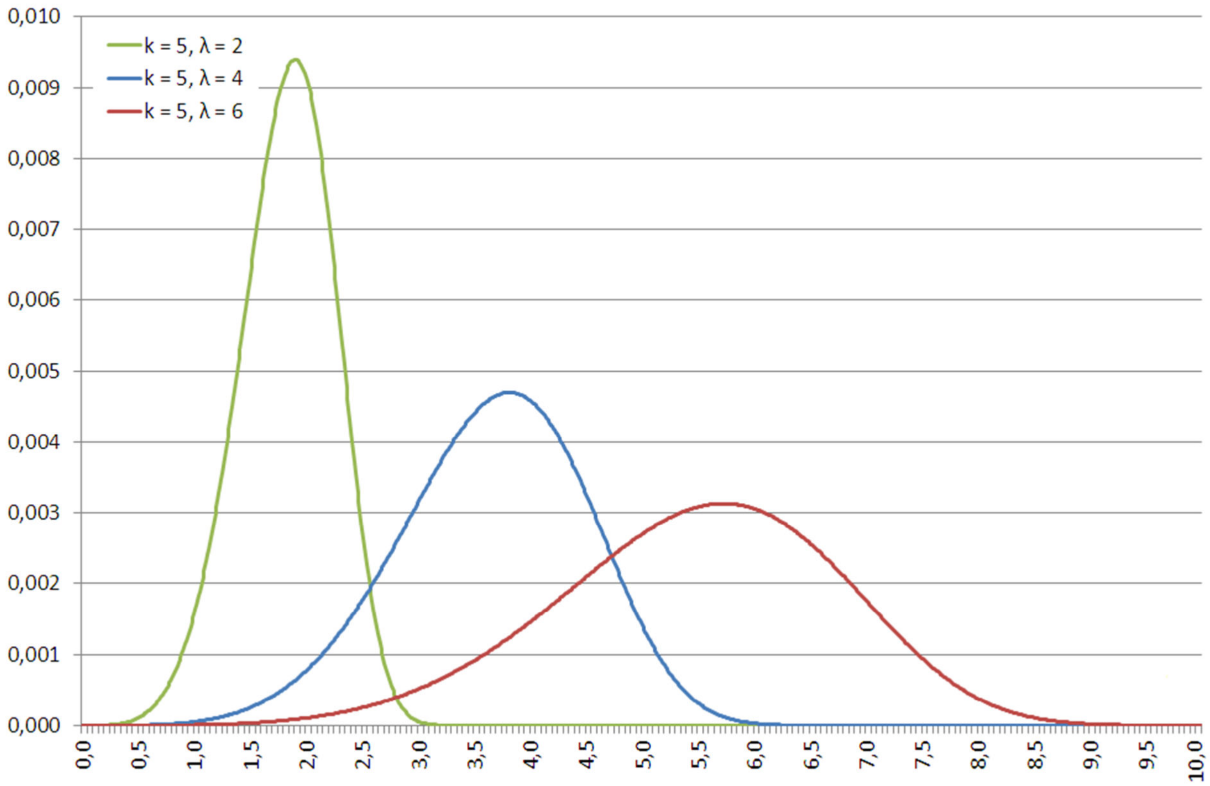


Figure 27.Weibull distribution function, influence of parameterization of λ

5.5 Recommendations for decay methods use in HWP methodology

Choose of decay function (or profile) should be solely on the inventory experts, because:

- adaptation of the HWP model/calculation sheet for using different decay functions or profiles is relatively easy with relevant software and basic mathematical knowledge,
- the use of simple decay profile do not fit to the life-cycle of products, but can produce emissions estimates with the same accuracy and uncertainty (in general, very depends on exact conditions) compared to the other decay functions (see chapter 6.2 as example for the Czech Republic),
- decay methods parameterization is more important issue compared to the decay method use, correct settings of parameters is more important for accurate timing of emissions,
- decay profile do not influence total amount of GHG emissions,
- national conditions should be different as well as data availability for different decay functions parameterization,
- there should be reasons for different decay profiles application for different wood products, if applicable,

The side effect of my work on the modeling and application of different decay methods is development of model which can use different parameterization (decay profiles) for different years. These models were used for results presented in chapter 6.2, which also shows that the use of different decay function can produce very similar results.

6 HWP reporting

This report describes situation as described in 2010 and 2011 official submission of GHG inventories to the UN FCCC[34] as published in November 2010 and May 2011, where only Australia, Finland, Great Britain and USA reported emissions and sinks from the HWP. Especially in USA the poll called harvested wood products in solid waste disposal sites is very important, in the case of USA is even more important compared to the harvested wood products in use.

Also other countries (e.g. Norway, Sweden, Germany, Austria, France, Denmark) prepared HWP pool and emissions estimates some of results are presented in UN ECE, 2008. This information were used for set up of national policies, preparation for international negotiations, but not for official UN FCCC reporting.

In its National Inventory Reports Australia, Finland, Great Britain and USA provides basic information about HWP. Model and methodology description is rather simple and not fully transparent. Only Australia provide as precise description with some flowcharts and parameters. None of the Parties publish its activity data in the NIR or CRF tables, therefore, a reconstruction of the calculation or comparison of the results calculated for Tier 1 and the national model is impossible. The Tier 1 model is based on the FAO Stat data as published in April 2011 and the calculation do not take into account carbon accumulation in waste category.

6.1 Australia

Australia developed its own HWP model, which is based on a national database of domestic wood production, including import and export quantities, which has been maintained in Australia since the 1930s. The database is consistent and includes detailed collection of time-series data which provides a sound basis for the development of a national wood products model. Together with the National carbon Accounting system (NcAs) was developed a national carbon accounting model for wood products, which is used for the HWP monitoring and reporting under the UNFCCC and KP.

The Australia's HWP model is much more developed and data intensive compared to the Tier 1 methodology and the HWP calculation sheet. Broad ranges of national parameters are used for emissions estimates as well as detailed life-time modeling for different products. Figure 28 compares results for national approach with Tier 1 methodology and different approaches. Data for Australia in the FAO Stat are neither complete not time-series consistent. Also is interesting very broad range of removals among different approaches and especially production approach.

[34]public available at
http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5270.php

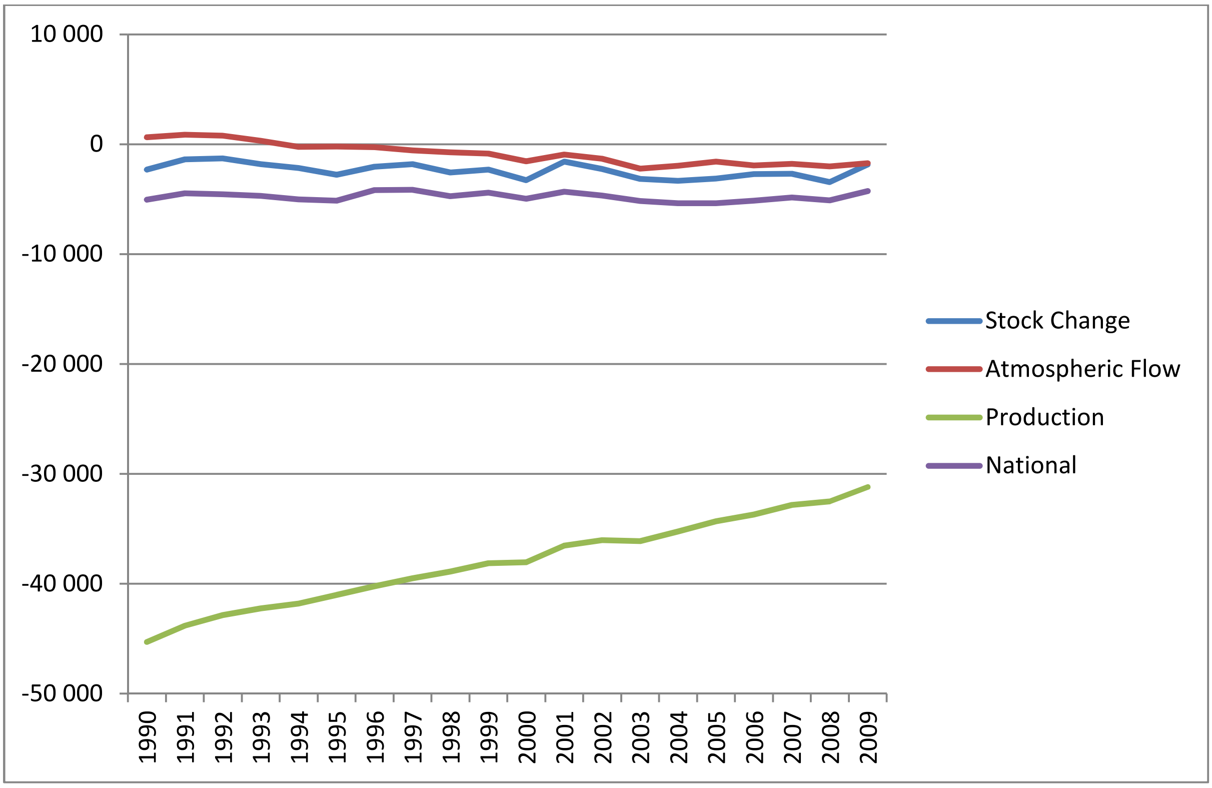


Figure 28. Comparison of estimates prepared by the national specific methodology and Tier 1 results for Australia.

6.2 Finland

Finland (Statistics Finland, 2011) as well as Australia developed its own model. In the Finland's model the emission/removal from harvested wood products is estimated by the stock change approach and, further, only HWP in use are considered. The emission/removal from HWP in solid waste disposal sites is excluded from the reporting.

Finland's national model is based on the carbon stock of solid wood products in Finland that has been estimated on 5-year intervals based on building stock and other statistics. The stock in the other, non-inventory years is then estimated by fitting first the HWP worksheet of the 2006 IPCC Guidelines to the direct inventories and then estimating by the fitted HWP worksheet the carbon stock and its annual change in other years. The HWP model was thus used as an interpolation/extrapolation tool to the direct stock inventories. The carbon stock in paper products and its annual change is estimated straightforwardly by the HWP worksheet with default parameters (Statistics Finland, 2011). The NIR marks this model as combination of the Tier 3 for wood and Tier 1 for paper.

On the Figure 29 you can observe very good correlation between national approach and Stock change approach - Tier 1 methodology.

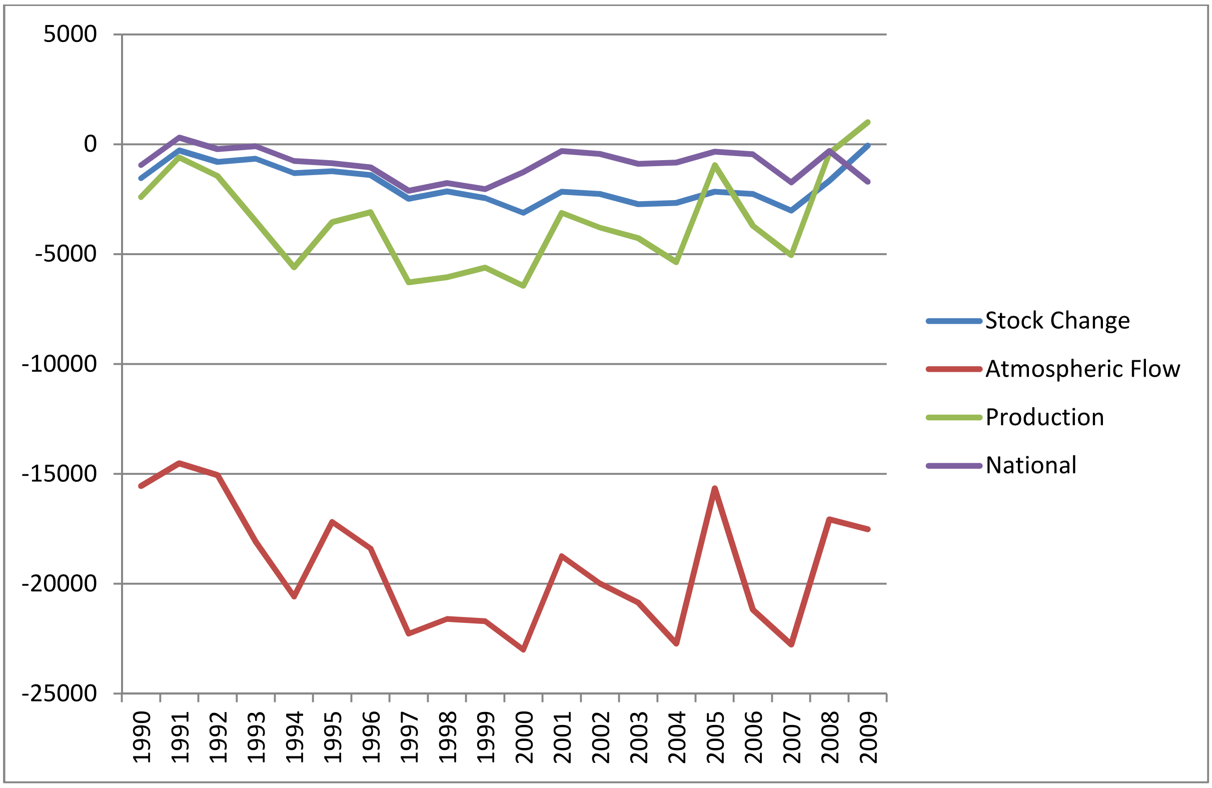


Figure 29.Comparison of estimates prepared by the national specific methodology and Tier 1 results for Finland.

6.3 United Kingdom

In United Kingdom (AEA, 2011) the carbon accounting model (C-Flow) is used to calculate the net changes in carbon stocks of harvested wood products, in the same way as it is used to estimate carbon stock changes in 5.A. The C-Flow method does not precisely fit with any of the approaches to HWP accounting described in the IPCC Guidelines (2006) but is closest to the Production Approach (see Figure 30, Thomson and Milne, 2005). The UK method is a top-down approach that assumes that the decay of all conifer products and all broadleaf products can be approximated by separate single decay constants (AEA, 2011). The United Kingdom's estimate is for almost all years below Tier 1 methodology for all approaches as is illustrated on the Figure 30.

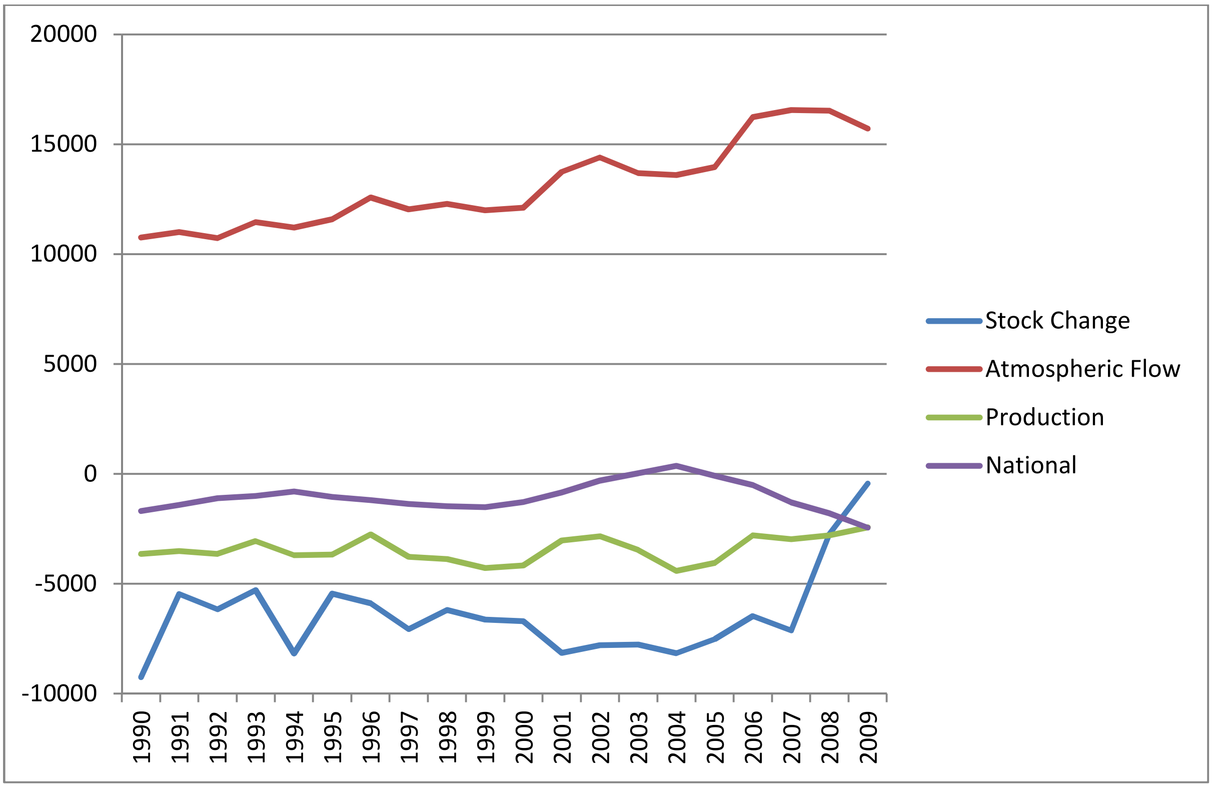


Figure 30.Comparison of estimates prepared by the national specific methodology and Tier 1 results for United Kingdom.

6.4 USA

In the USA the calculation of the HWP is prepared for:

- Harvested wood products in use.
- HWP in solid waste disposal sites (SWDS).

The amount of the HWP in solid waste disposal sites is more important in the term of absolute amount compared to the Harvested wood products (HWP) in use. Emissions and removals in harvested wood products in use and HWP in solid waste disposal sites is very different (see Figure 31). The absolute values also illustrate the importance of in solid waste disposal sites for carbon storage in some countries.

Estimates of the HWP contribution to forest C sinks and are based on methods described in Skog, 2008 using the WOODCARB II model. The method is based on the 2006 IPCC GI. estimating HWP C. The United States uses the production accounting approach to report HWP contribution, where the carbon in exported wood is estimated as if it remains in the United States, and the carbon in imported wood is not included in inventory estimates (U.S. Environmental Protection Agency, 2011).

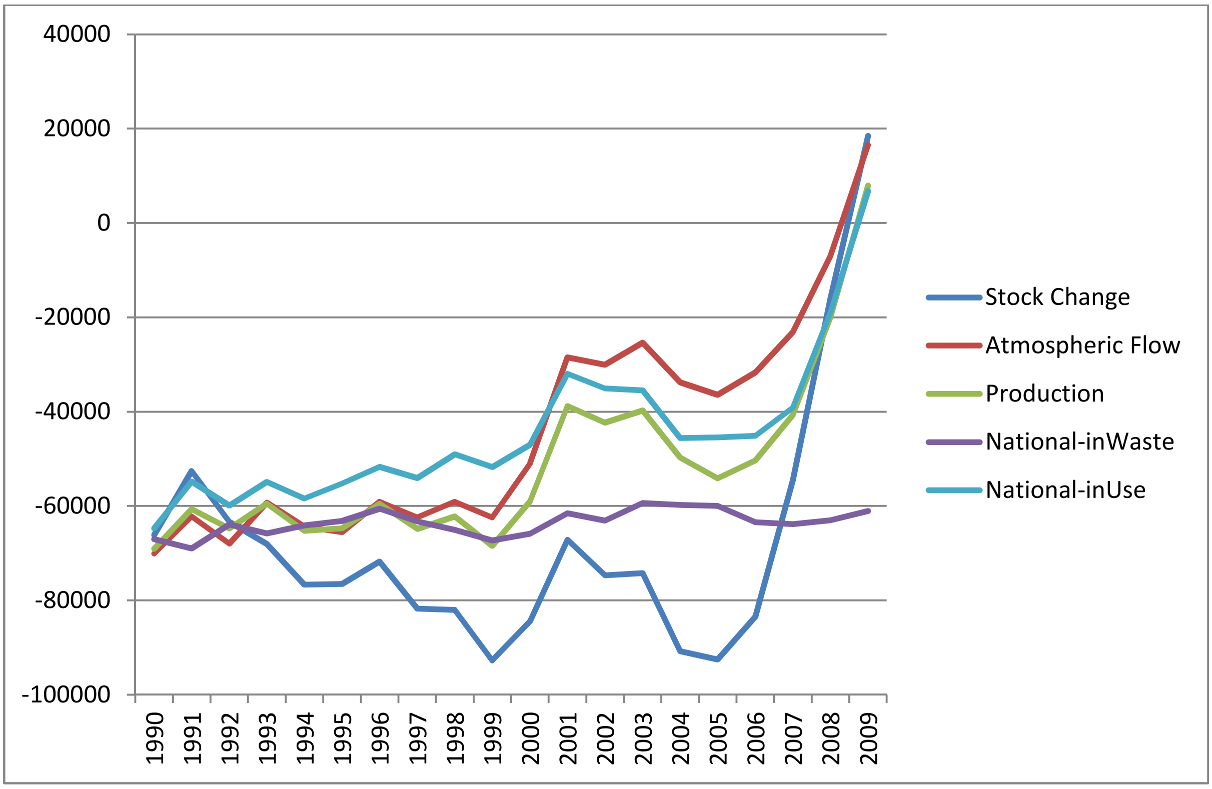


Figure 31.Comparison of estimates prepared by the national specific methodology and Tier 1 results for USA.

7 Results for the Czech Republic

The HWP calculation sheet from 2006 IPCC GI. is based on data from UN Food and Agriculture Organization (FAO, FAO Stat[35]) and some additional basic parameters. The methodology includes four groups of data entry:
the wood harvest (production, imports, exports):

- roundwood

the semi-products (production, imports, exports):

- sawn wood,
- woodbased panels,
- industrial roundwood,
- other industrial roundwood (non-mandatory entry) and
- paper and paperboard.

other wood derived materials (imports, exports):

- wood pulp and recycled paper,
- chips and particles,
- wood charcoal,
- wood residues,

and landfilled biomass (voluntarily and as additional data):

- SWDS data from Waste sector.

These groups are considered (by IPCC) to be a good estimation for all the woodbased products at this level in the production chain. The issue is connected with the set up of parameters of decay function. Because the background of life-time and half-live is unknown, the author of this study has the contrary opinion. **Without knowledge of decay pathway, it is not possible to access the whole product chain.**
All calculations were based on the same data from FAO Stat[36] on the import, export or production of the aforementioned products, parameters and conversion factors as presented on Figure 32.
For Simple Decay method, parameters from the 2006 IPCC GI. were used (see Figure 32). For other methods of decay different parameters were used. It is possible to set up parameters of decay function to produce similar results as Simple Decay methods. The decay pathway will be the same or very similar (except simple decay). For other functions are applied parameters as published in scientific literature.

HWP estimates were calculated for

- the original HWP calculation sheet and
- the updated HWP calculation sheet;
    - with fixed mistakes;
    - with gamma distribution function;
    - with normal distribution function;
    - with Weibull distribution function.

[35]http://faostat.fao.org/site/626/default.aspx#ancor
[36]http://faostat.fao.org/site/626/default.aspx#ancor as of March 30, 2011

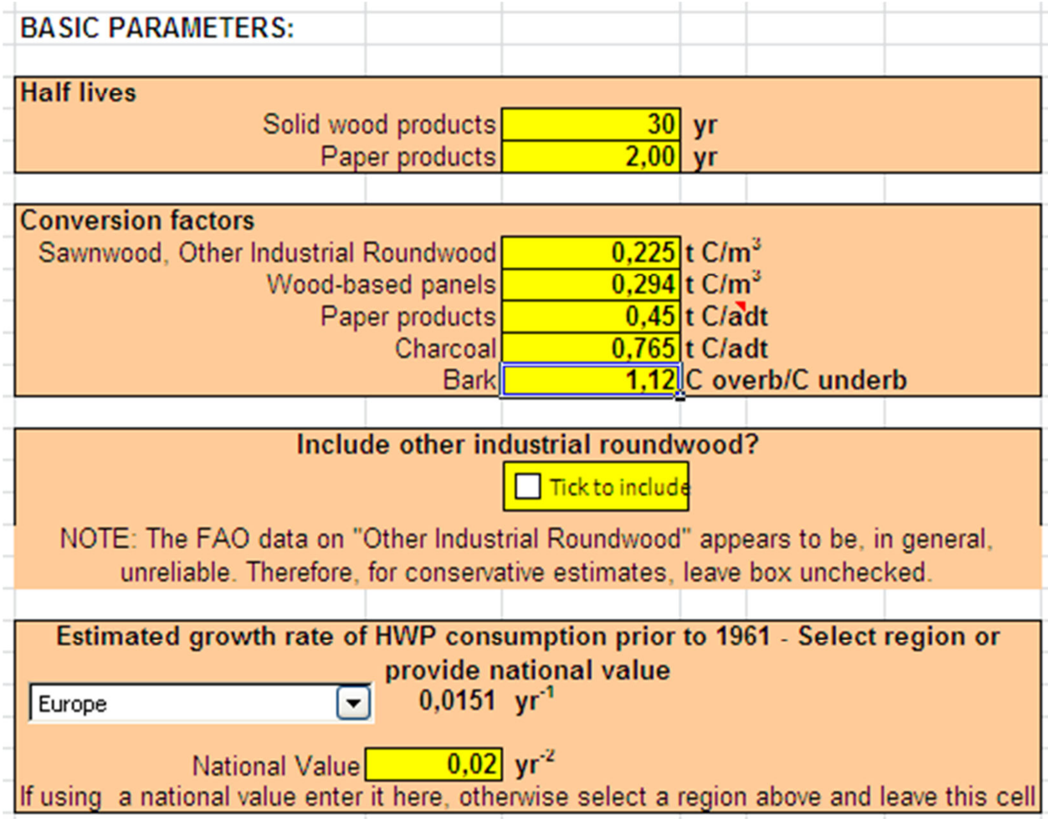


Figure 32.Parameters and conversion factors used for HWP estimates

For the completeness, results for Inventory Approach are presented in chapter 3.2. Because no decay function or profile is used, the data are not presented under this chapter.

7.1 Original HWP calculation sheet

Table 3 and Table 4 show results for the original HWP calculation sheet (simple decay method is used) as part of the IPCC 2006 GI. (downloaded from the official IPCC TSU web page http://www.ipcc-nggip.iges.or.jp/[37]) in November 2010.

[37]http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_12_Ch12_HWP_Worksheet.zip

Table 3. Table 12.7 - results for the original HWP (simple decay) calculation sheet

Table 12.7 Sectoral Background Data for AFOLU Annual Carbon HWP Contribution to Total AFOLU CO_2 Removals and Emissions and Background Information											
	Variable number										
	1A	1B	2A	2B	3	4	5	6	7	8	9
Inventory year	Annual Change in stock of HWP in use from consumption	Annual Change in stock of HWP in SWDS from consumption	Annual Change in stock of HWP in use produced from domestic harvest	Annual Change in stock of HWP in SWDS produced from domestic harvest	Annual Imports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Exports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Domestic Harvest	Annual release of carbon to the atmosphere from HWP consumption (from fuelwood & products in use and products in SWDS)	Annual release of carbon to the atmosphere from HWP (including fuelwoood) where wood came from domestic harvest (from products in use and products in SWDS)	HWP Contribution to AFOLU CO_2 emissions/ removals	Approach used to estimate HWP Contribution[1]
	$\Delta C_{HWP IU DC}$	$\Delta C_{HWP SWDS DC}$	$\Delta C_{HWP IU DH}$	$\Delta C_{HWP SWDS DH}$	P_{IM}	P_{EX}	H	$\uparrow C_{HWP DC}$	$\uparrow C_{HWP DH}$		
	Gg C /yr									Gg CO_2 /yr	
1990	654	142	753	139	123	905	7 097	5 519	6 204		
1991	-177	143	94	138	190	1 147	5 968	5 045	5 736		
1992	-663	148	-445	143	203	1 194	5 682	5 206	5 985		
1993	-31	152	319	144	314	1 589	5 827	4 432	5 365		
1994	-9	153	553	141	527	2 292	6 692	4 784	5 998		
1995	-24	157	819	145	526	2 667	6 924	4 650	5 961		
1996	2	160	939	149	498	2 923	7 056	4 469	5 968		
1997	18	164	776	148	743	2 987	7 555	5 129	6 631		
1998	46	167	571	148	951	2 807	7 835	5 766	7 115		
1999	47	157	713	138	1 049	3 127	7 954	5 672	7 103		
2000	268	167	826	144	1 228	2 953	8 087	5 927	7 117		
2001	268	169	866	144	1 291	3 218	8 049	5 685	7 039		
2002	385	150	806	127	1 404	3 200	8 143	5 812	7 211		
2003	450	175	1 198	151	1 212	3 655	8 478	5 411	7 129		
2004	477	179	1 183	153	1 370	3 790	8 737	5 661	7 401		
2005	569	183	1 167	149	1 846	4 077	8 686	5 702	7 369		
2006	936	192	1 695	160	1 905	4 219	9 900	6 457	8 045		
2007	927	198	1 995	167	1 780	4 398	10 364	6 622	8 203		
2008	637	205	1 428	169	1 728	3 964	9 065	5 986	7 468		
2009	605	212	1 399	175	1 728	3 964	9 065	6 011	7 491		

Table 4. Table 12.1 - results for the original HWP (simple decay) calculation sheet

Excel Table 12.1 - HWP Contribution to AFOLU emissions/ removals by Approach						
Inventory Year	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals		
				Simple Decay Approach		
Inventory Year	Stock Change	Atmospheric Flow	Production	Annual harvest	Annual CO2 release	Total Contribution
1990	-2 916	-5 784	-3 271	-26 021	22 750	-3 271
1991	125	-3 383	-850	-21 883	21 032	-850
1992	1 888	-1 745	1 110	-20 834	21 943	1 110
1993	-443	-5 117	-1 697	-21 367	19 670	-1 697
1994	-526	-6 997	-2 545	-24 537	21 992	-2 545
1995	-487	-8 340	-3 534	-25 389	21 855	-3 534
1996	-595	-9 487	-3 990	-25 872	21 882	-3 990
1997	-667	-8 894	-3 388	-27 702	24 314	-3 388
1998	-783	-7 587	-2 639	-28 728	26 089	-2 639
1999	-748	-8 367	-3 119	-29 163	26 044	-3 119
2000	-1 596	-7 920	-3 557	-29 652	26 095	-3 557
2001	-1 601	-8 668	-3 704	-29 515	25 810	-3 704
2002	-1 962	-8 548	-3 419	-29 858	26 439	-3 419
2003	-2 291	-11 249	-4 949	-31 087	26 139	-4 949
2004	-2 404	-11 277	-4 899	-32 034	27 135	-4 899
2005	-2 759	-10 939	-4 827	-31 847	27 020	-4 827
2006	-4 137	-12 622	-6 802	-36 299	29 497	-6 802
2007	-4 123	-13 723	-7 925	-38 003	30 078	-7 925
2008	-3 088	-11 288	-5 856	-33 237	27 381	-5 856
2009	-2 994	-11 195	-5 772	-33 237	27 466	-5 772

7.2 With fixed mistakes

Table 5 and Table 6 show results for the HWP calculation sheet, where mistakes, as described in the chapter 4.2 were fixed.
Figure 33 to Figure 36 shows CO2 emissions from wood and paper decay, when Simple decay function is used for individual years and for total emissions. Parameters and conversion factors as presented on Figure 32 were applied.

Table 5. Table 12.7 - results for the HWP calculation sheet (simple decay), where mistakes were fixed

Table 12.7 Sectoral Background Data for AFOLU Annual Carbon HWP Contribution to Total AFOLU CO_2 Removals and Emissions and Background Information											
	Variable number										
	1A	1B	2A	2B	3	4	5	6	7	8	9
Inventory year	Annual Change in stock of HWP in use from consumption	Annual Change in stock of HWP in SWDS from consumption	Annual Change in stock of HWP in use produced from domestic harvest	Annual Change in stock of HWP in SWDS produced from domestic harvest	Annual Imports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Exports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Domestic Harvest	Annual release of carbon to the atmosphere from HWP consumption (from fuelwood & products in use and products in SWDS)	Annual release of carbon to the atmosphere from HWP (including fuelwood) where wood came from domestic harvest (from products in use and products in SWDS)	HWP Contribution to AFOLU CO_2 emissions/ removals	Approach used to estimate HWP Contribution[1]
	$\Delta C_{HWP IU DC}$	$\Delta C_{HWP SWDS DC}$	$\Delta C_{HWP IU DH}$	$\Delta C_{HWP SWDS DH}$	P_{IM}	P_{EX}	H	$\uparrow C_{HWP DC}$	$\uparrow C_{HWP DH}$		
	Gg C /yr									Gg CO_2 /yr	
1990	397	142	436	137	92	508	3 193	2 240	2 620		
1991	-121	143	54	137	107	666	2 686	2 105	2 495		
1992	-399	148	-267	142	108	657	2 557	2 257	2 682		
1993	3	152	186	139	220	835	2 622	1 852	2 297		
1994	7	153	329	136	343	1 209	3 011	1 986	2 545		
1995	25	157	472	140	352	1 379	3 116	1 907	2 504		
1996	31	160	547	143	353	1 517	3 175	1 819	2 485		
1997	69	164	478	141	517	1 594	3 400	2 089	2 780		
1998	40	167	337	141	624	1 539	3 526	2 403	3 048		
1999	64	157	411	130	706	1 704	3 579	2 360	3 038		
2000	186	167	448	135	816	1 657	3 639	2 445	3 056		
2001	216	169	518	134	875	1 811	3 622	2 301	2 970		
2002	287	150	493	117	947	1 816	3 664	2 359	3 053		
2003	358	175	773	140	885	2 046	3 815	2 121	2 902		
2004	384	179	743	140	1 002	2 133	3 931	2 238	3 048		
2005	465	183	742	135	1 297	2 307	3 909	2 250	3 031		
2006	614	192	980	146	1 325	2 394	4 455	2 579	3 328		
2007	581	198	1 139	152	1 299	2 541	4 664	2 643	3 374		
2008	428	205	848	151	1 288	2 355	4 079	2 379	3 080		
2009	400	212	832	157	1 288	2 355	4 079	2 400	3 090		

Table 6. Table 12.1 - results for the HWP calculation sheet (simple decay), where mistakes were fixed

Excel Table 12.1 - HWP Contribution to AFOLU emissions/ removals by Approach						
Inventory Year	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals		
				Simple Decay Approach		
Inventory Year	Stock Change	Atmospheric Flow	Production	Annual harvest	Annual CO2 release	Total Contribution
1990	-1 974	-3 497	-2 101	-11 709	9 608	-2 101
1991	-80	-2 129	-697	-9 847	9 150	-697
1992	918	-1 098	458	-9 375	9 834	458
1993	-567	-2 824	-1 193	-9 615	8 422	-1 193
1994	-586	-3 762	-1 708	-11 042	9 333	-1 708
1995	-667	-4 434	-2 242	-11 425	9 183	-2 242
1996	-701	-4 972	-2 532	-11 642	9 111	-2 532
1997	-854	-4 805	-2 271	-12 466	10 195	-2 271
1998	-761	-4 118	-1 751	-12 928	11 176	-1 751
1999	-810	-4 471	-1 983	-13 124	11 141	-1 983
2000	-1 294	-4 378	-2 137	-13 343	11 206	-2 137
2001	-1 411	-4 843	-2 392	-13 282	10 889	-2 392
2002	-1 602	-4 786	-2 240	-13 436	11 196	-2 240
2003	-1 952	-6 213	-3 348	-13 989	10 641	-3 348
2004	-2 063	-6 210	-3 239	-14 415	11 177	-3 239
2005	-2 376	-6 079	-3 216	-14 331	11 115	-3 216
2006	-2 958	-6 876	-4 130	-16 334	12 204	-4 130
2007	-2 856	-7 410	-4 731	-17 101	12 370	-4 731
2008	-2 321	-6 233	-3 664	-14 957	11 292	-3 664
2009	-2 245	-6 158	-3 626	-14 957	11 331	-3 626

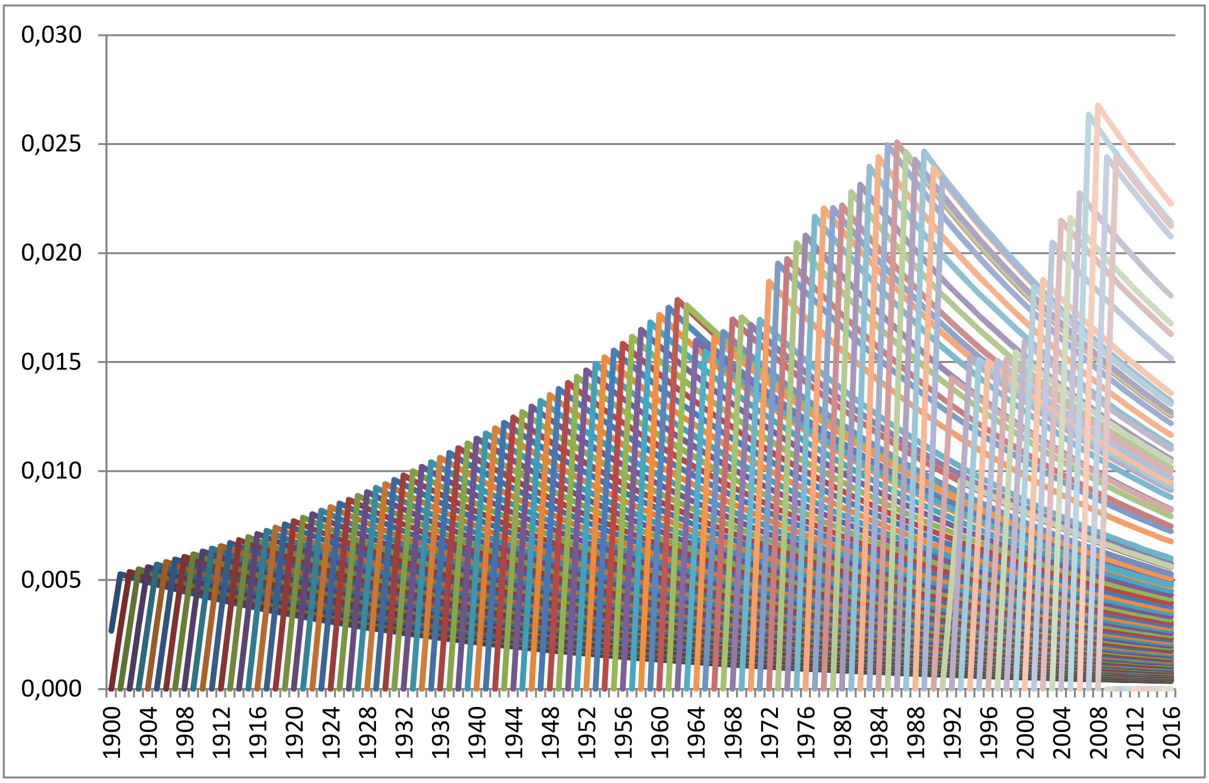


Figure 33.CO2 emissions from wood decay and Simple decay function for individual years

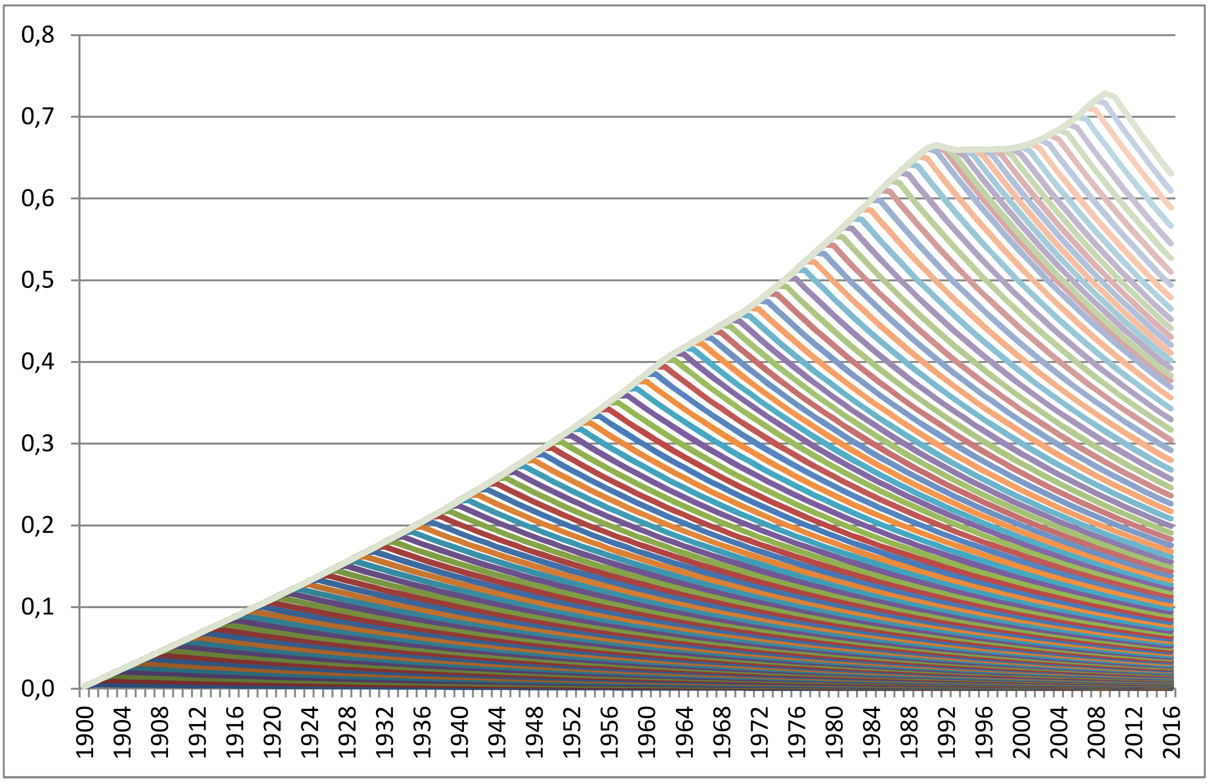


Figure 34.Cumulative CO2 emissions from wood decay and Simple decay function

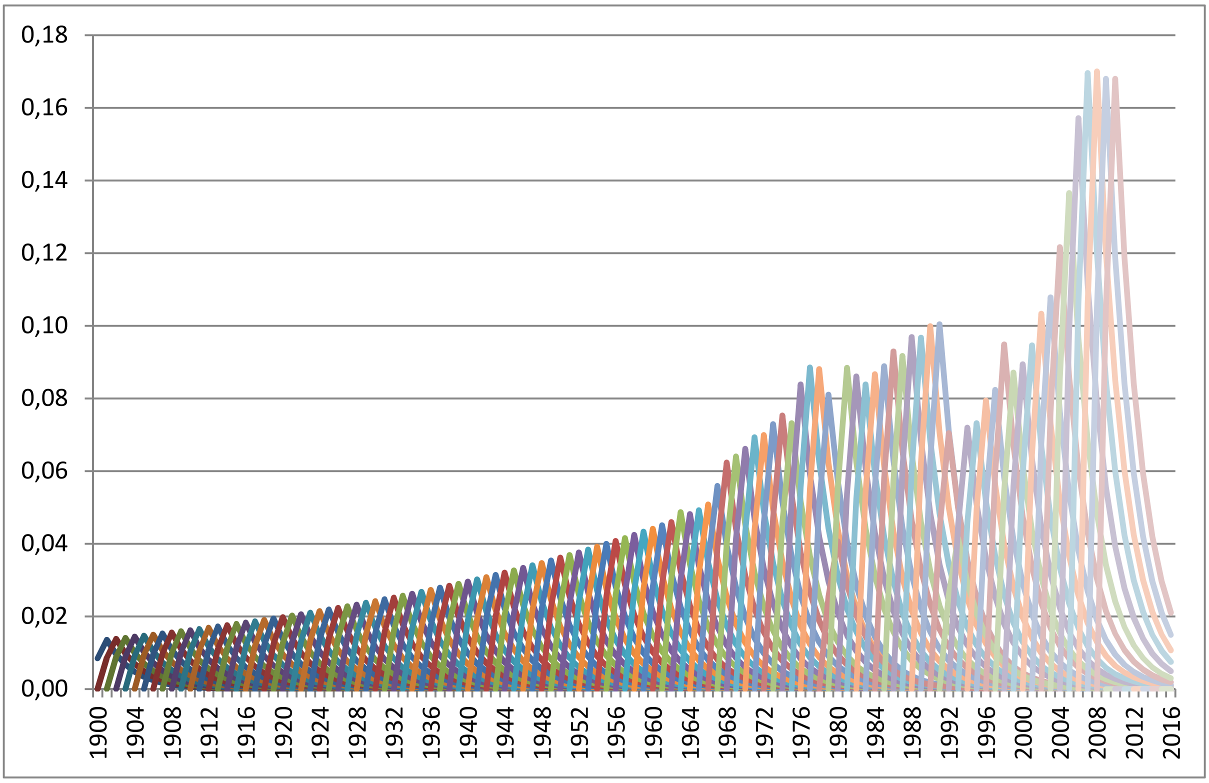


Figure 35.CO2 emissions from paper decay and Simple decay function for individual years

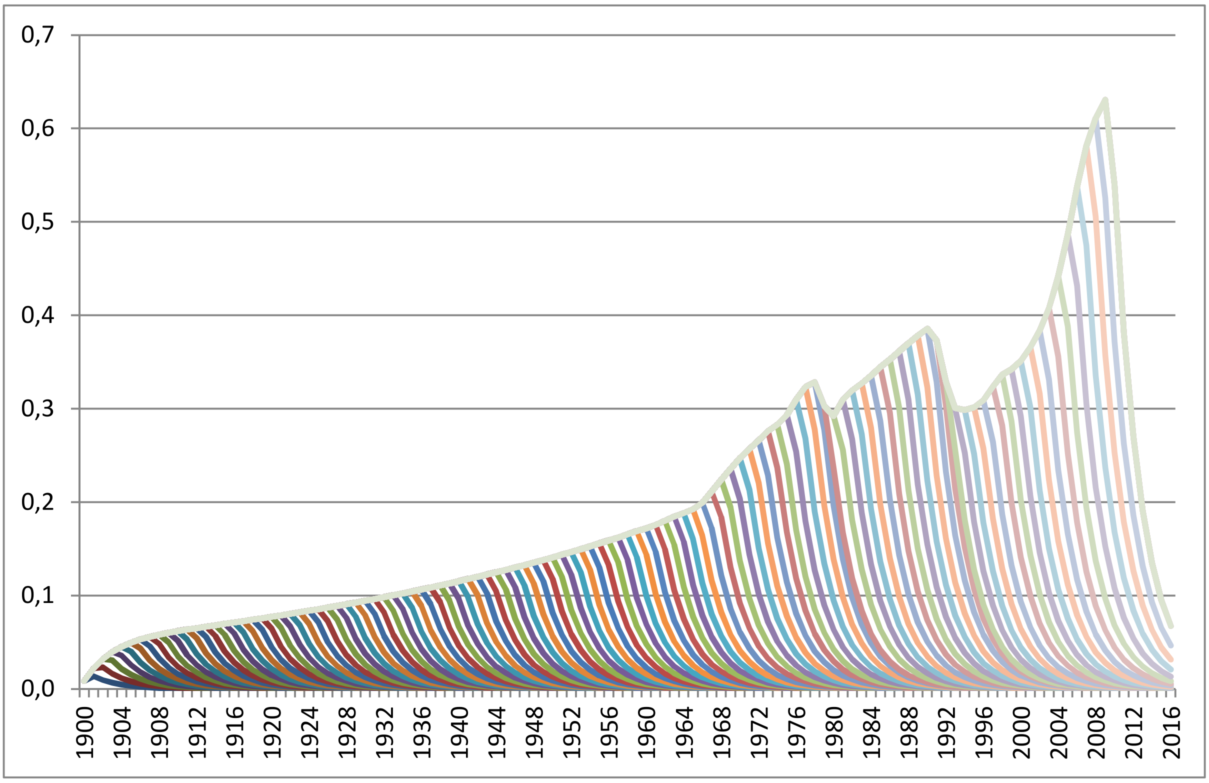


Figure 36.Cumulative CO2 emissions from paper decay and Simple decay function

7.3 With gamma distribution function

Table 7, Table 8 and Figure 37 to Figure 40 show CO2 emissions from decay of wood and paper in the Czech Republic, when adapted IPCC calculation sheet is used and Gamma Decay function is applied. Conversion factors as presented on Figure 32 were applied. Parameters for wood and paper decay were obtained from (Marland et al, 2010a) for pulpwood and fencing category. These two categories were chosen because 95 % of decay for simple decay and gamma decay occur in similar period (9 years compared to 5 for paper and 130 years compared to the 80 for wood).

Table 7. Table 12.7 - results for the gamma function

Table 12.7 Sectoral Background Data for AFOLU											
Annual Carbon HWP Contribution to Total AFOLU CO_2 Removals and Emissions and Background Information											
	Variable number										
	1A	1B	2A	2B	3	4	5	6	7	8	9
Inventory year	Annual Change in stock of HWP in use from consumption	Annual Change in stock of HWP in SWDS from consumption	Annual Change in stock of HWP in use produced from domestic harvest	Annual Change in stock of HWP in SWDS produced from domestic harvest	Annual Imports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Exports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Domestic Harvest	Annual release of carbon to the atmosphere from HWP consumption (from fuelwood & products in use and products in SWDS)	Annual release of carbon to the atmosphere from HWP (including fuelwoood) where wood came from domestic harvest (from products in use and products in SWDS)	HWP Contribution to AFOLU CO_2 emissions/ removals	Approach used to estimate HWP Contribution[1]
	$\Delta C_{HWP IU DC}$	$\Delta C_{HWP SWDS DC}$	$\Delta C_{HWP IU DH}$	$\Delta C_{HWP SWDS DH}$	P_{IM}	P_{EX}	H	$\uparrow C_{HWP DC}$	$\uparrow C_{HWP DH}$		
	Gg C /yr									Gg CO_2 /yr	
1990	471	142	592	137	92	508	3 193	2 165	2 464		
1991	-18	143	221	137	107	666	2 686	2 002	2 328		
1992	-271	148	-77	142	108	657	2 557	2 130	2 492		
1993	89	152	340	139	220	835	2 622	1 766	2 143		
1994	71	153	452	136	343	1 209	3 011	1 921	2 423		
1995	65	157	572	140	352	1 379	3 116	1 867	2 404		
1996	52	160	635	143	353	1 517	3 175	1 798	2 397		
1997	65	164	560	141	517	1 594	3 400	2 094	2 699		
1998	32	167	421	141	624	1 539	3 526	2 411	2 964		
1999	47	157	490	130	706	1 704	3 579	2 377	2 959		
2000	158	167	526	135	816	1 657	3 639	2 473	2 978		
2001	174	169	581	134	875	1 811	3 622	2 344	2 907		
2002	235	150	549	117	947	1 816	3 664	2 411	2 998		
2003	290	175	804	140	885	2 046	3 815	2 189	2 872		
2004	298	179	777	140	1 002	2 133	3 931	2 323	3 014		
2005	358	183	779	135	1 297	2 307	3 909	2 357	2 995		
2006	499	192	1 021	146	1 325	2 394	4 455	2 695	3 288		
2007	475	198	1 192	152	1 299	2 541	4 664	2 749	3 321		
2008	339	205	926	151	1 288	2 355	4 079	2 469	3 002		
2009	324	212	921	157	1 288	2 355	4 079	2 476	3 001		

Table 8. Table 12.1 - results for the gamma function

Excel Table 12.1 - HWP Contribution to AFOLU emissions/ removals by Approach						
Inventory Year	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals		
				Simple Decay Approach		
Inventory Year	Stock Change	Atmospheric Flow	Production	Annual harvest	Annual CO2 release	Total Contribution
1990	-2 247	-3 771	-2 674	-11 709	9 035	-2 674
1991	-457	-2 507	-1 311	-9 847	8 537	-1 311
1992	451	-1 565	-238	-9 375	9 138	-238
1993	-885	-3 141	-1 756	-9 615	7 859	-1 756
1994	-821	-3 997	-2 158	-11 042	8 884	-2 158
1995	-813	-4 580	-2 610	-11 425	8 815	-2 610
1996	-779	-5 049	-2 854	-11 642	8 789	-2 854
1997	-838	-4 788	-2 571	-12 466	9 895	-2 571
1998	-731	-4 088	-2 061	-12 928	10 866	-2 061
1999	-748	-4 409	-2 273	-13 124	10 850	-2 273
2000	-1 192	-4 276	-2 424	-13 343	10 920	-2 424
2001	-1 256	-4 689	-2 622	-13 282	10 660	-2 622
2002	-1 413	-4 597	-2 444	-13 436	10 992	-2 444
2003	-1 703	-5 964	-3 459	-13 989	10 530	-3 459
2004	-1 750	-5 897	-3 362	-14 415	11 053	-3 362
2005	-1 985	-5 689	-3 350	-14 331	10 981	-3 350
2006	-2 535	-6 453	-4 278	-16 334	12 056	-4 278
2007	-2 469	-7 023	-4 926	-17 101	12 175	-4 926
2008	-1 992	-5 904	-3 949	-14 957	11 007	-3 949
2009	-1 964	-5 878	-3 953	-14 957	11 004	-3 953

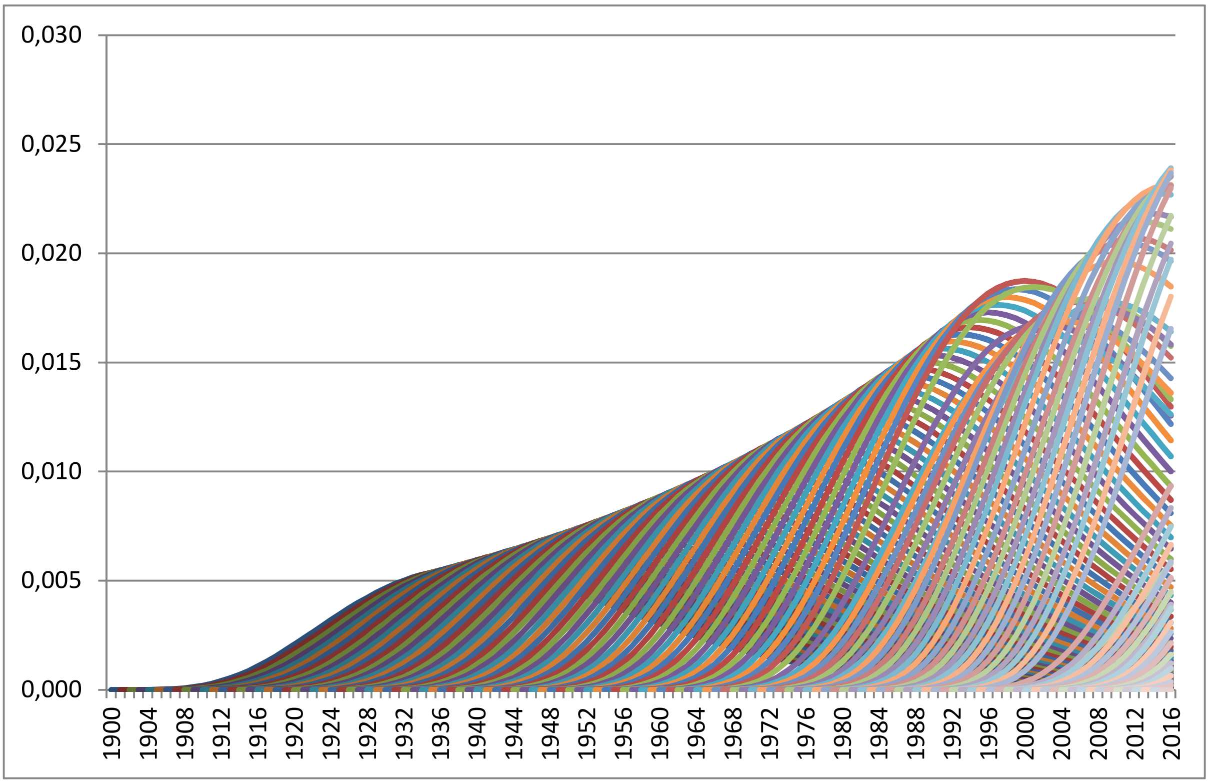


Figure 37.CO2 emissions from wood decay and gamma function for individual years

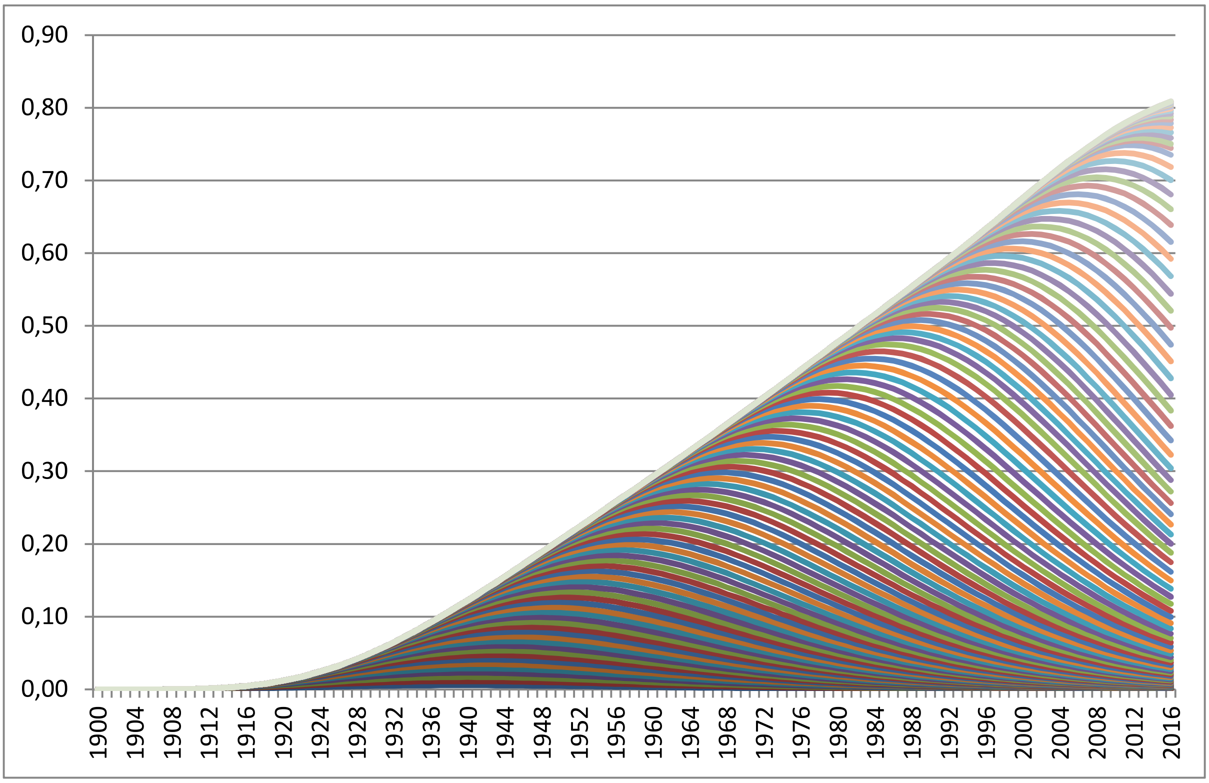


Figure 38.Cumulative CO2 emissions from wood decay and gamma function

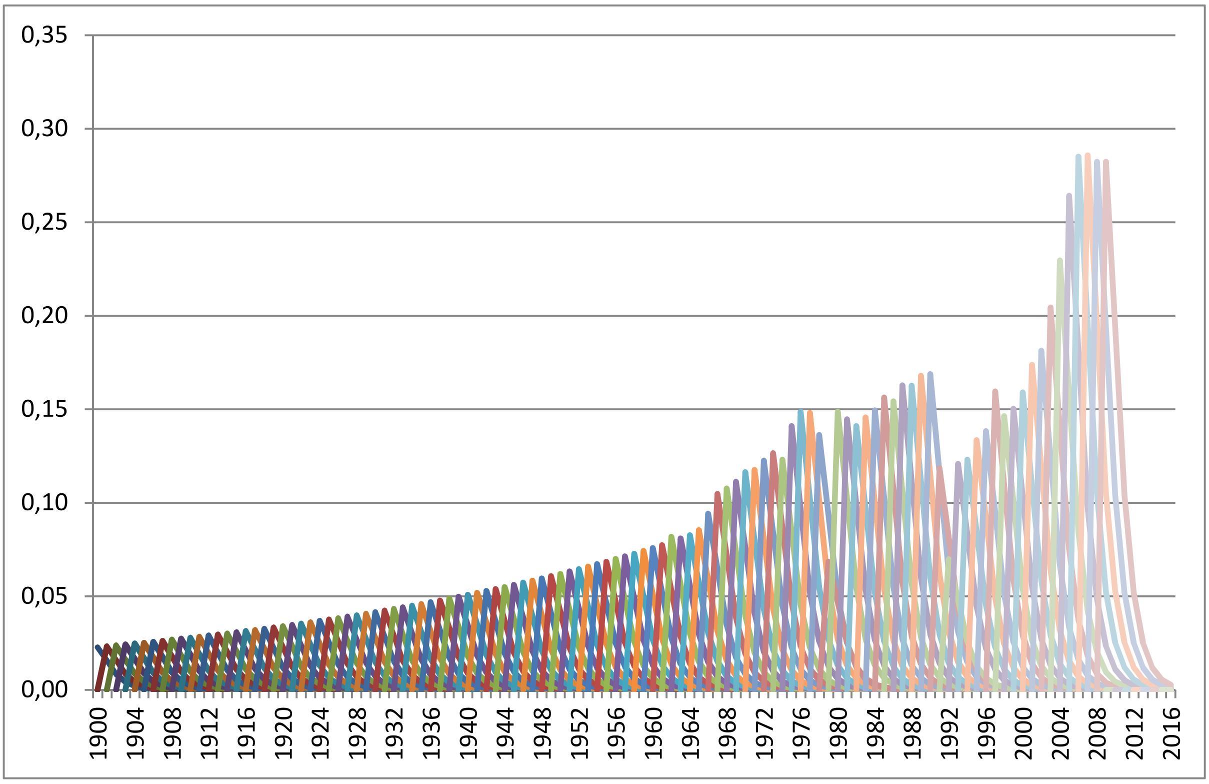


Figure 39.CO2 emissions from paper decay and gamma function for individual years

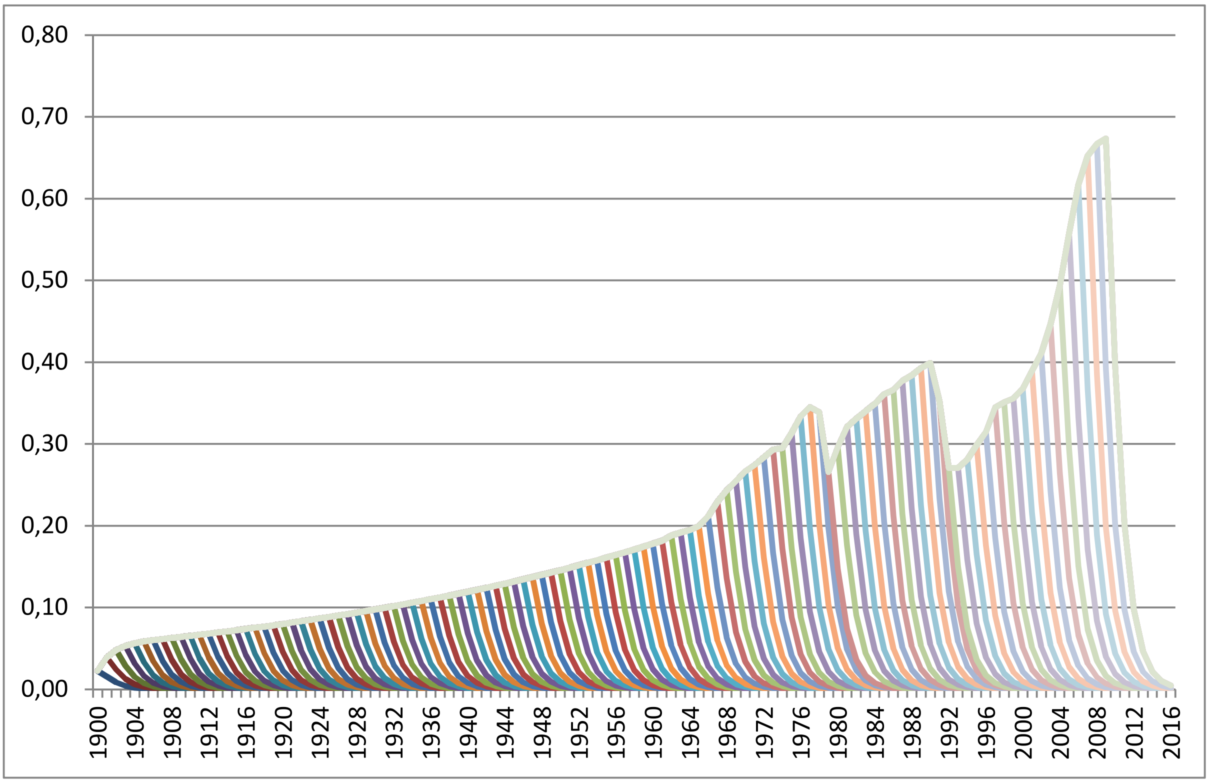


Figure 40.Cumulative CO2 emissions from paper decay and gamma function

7.4 With normal distribution function

Table 9, Table 10 and Figure 41 to Figure 44 show CO2 emissions from decay of wood and paper in the Czech Republic, when adapted IPCC calculation sheet is used and normal Decay function is applied. Conversion factors as presented on Figure 32 were applied. Parameters for wood and paper decay were inspired by the parameters published in (Marland et al, 2010a) for wood arithmetic mean is 40 and standard deviation is 15 and for paper arithmetic mean is 4,5 and standard deviation is 2,25.

Table 9. Table 12.7 - results for the normal function

Table 12.7 Sectoral Background Data for AFOLU											
Annual Carbon HWP Contribution to Total AFOLU CO_2 Removals and Emissions and Background Information											
	Variable number										
	1A	1B	2A	2B	3	4	5	6	7	8	9
Inventory year	Annual Change in stock of HWP in use from consumption	Annual Change in stock of HWP in SWDS from consumption	Annual Change in stock of HWP in use produced from domestic harvest	Annual Change in stock of HWP in SWDS produced from domestic harvest	Annual Imports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Exports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Domestic Harvest	Annual release of carbon to the atmosphere from HWP consumption (from fuelwood & products in use and products in SWDS)	Annual release of carbon to the atmosphere from HWP (including fuelwoood) where wood came from domestic harvest (from products in use and products in SWDS)	HWP Contribution to AFOLU CO_2 emissions/ removals	Approach used to estimate HWP Contribution[1]
	$\Delta C_{HWP IU DC}$	$\Delta C_{HWP SWDS DC}$	$\Delta C_{HWP IU DH}$	$\Delta C_{HWP SWDS DH}$	P_{IM}	P_{EX}	H	$\uparrow C_{HWP DC}$	$\uparrow C_{HWP DH}$		
	Gg C /yr									Gg CO_2 /yr	
1990	438	142	515	137	92	508	3 193	2 198	2 541		
1991	-102	143	120	137	107	666	2 686	2 086	2 429		
1992	-430	148	-240	142	108	657	2 557	2 289	2 655		
1993	-56	152	186	139	220	835	2 622	1 911	2 297		
1994	-43	153	339	136	343	1 209	3 011	2 036	2 536		
1995	-9	157	503	140	352	1 379	3 116	1 942	2 473		
1996	10	160	598	143	353	1 517	3 175	1 840	2 434		
1997	58	164	536	141	517	1 594	3 400	2 101	2 722		
1998	26	167	384	141	624	1 539	3 526	2 417	3 001		
1999	34	157	438	130	706	1 704	3 579	2 390	3 011		
2000	142	167	458	135	816	1 657	3 639	2 489	3 046		
2001	166	169	521	134	875	1 811	3 622	2 351	2 967		
2002	236	150	497	117	947	1 816	3 664	2 410	3 050		
2003	311	175	789	140	885	2 046	3 815	2 167	2 887		
2004	348	179	772	140	1 002	2 133	3 931	2 273	3 019		
2005	445	183	772	135	1 297	2 307	3 909	2 270	3 002		
2006	610	192	1 009	146	1 325	2 394	4 455	2 584	3 300		
2007	580	198	1 167	152	1 299	2 541	4 664	2 644	3 345		
2008	414	205	870	151	1 288	2 355	4 079	2 393	3 058		
2009	365	212	842	157	1 288	2 355	4 079	2 435	3 080		

Table 10. Table 12.1 - results for the normal function

Excel Table 12.1 - HWP Contribution to AFOLU emissions/ removals by Approach						
Inventory Year	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals		
				Simple Decay Approach		
Inventory Year	Stock Change	Atmospheric Flow	Production	Annual harvest	Annual CO2 release	Total Contribution
1990	-2 125	-3 648	-2 393	-11 709	9 316	-2 393
1991	-150	-2 199	-941	-9 847	8 906	-941
1992	1 033	-983	360	-9 375	9 735	360
1993	-352	-2 608	-1 192	-9 615	8 423	-1 192
1994	-402	-3 578	-1 745	-11 042	9 297	-1 745
1995	-539	-4 306	-2 358	-11 425	9 067	-2 358
1996	-625	-4 895	-2 718	-11 642	8 924	-2 718
1997	-813	-4 764	-2 483	-12 466	9 982	-2 483
1998	-709	-4 066	-1 924	-12 928	11 003	-1 924
1999	-701	-4 361	-2 084	-13 124	11 039	-2 084
2000	-1 134	-4 218	-2 176	-13 343	11 167	-2 176
2001	-1 227	-4 660	-2 404	-13 282	10 878	-2 404
2002	-1 415	-4 599	-2 254	-13 436	11 182	-2 254
2003	-1 782	-6 043	-3 405	-13 989	10 584	-3 405
2004	-1 933	-6 080	-3 346	-14 415	11 069	-3 346
2005	-2 303	-6 007	-3 325	-14 331	11 006	-3 325
2006	-2 943	-6 861	-4 234	-16 334	12 101	-4 234
2007	-2 854	-7 408	-4 837	-17 101	12 265	-4 837
2008	-2 270	-6 182	-3 744	-14 957	11 213	-3 744
2009	-2 114	-6 028	-3 663	-14 957	11 294	-3 663

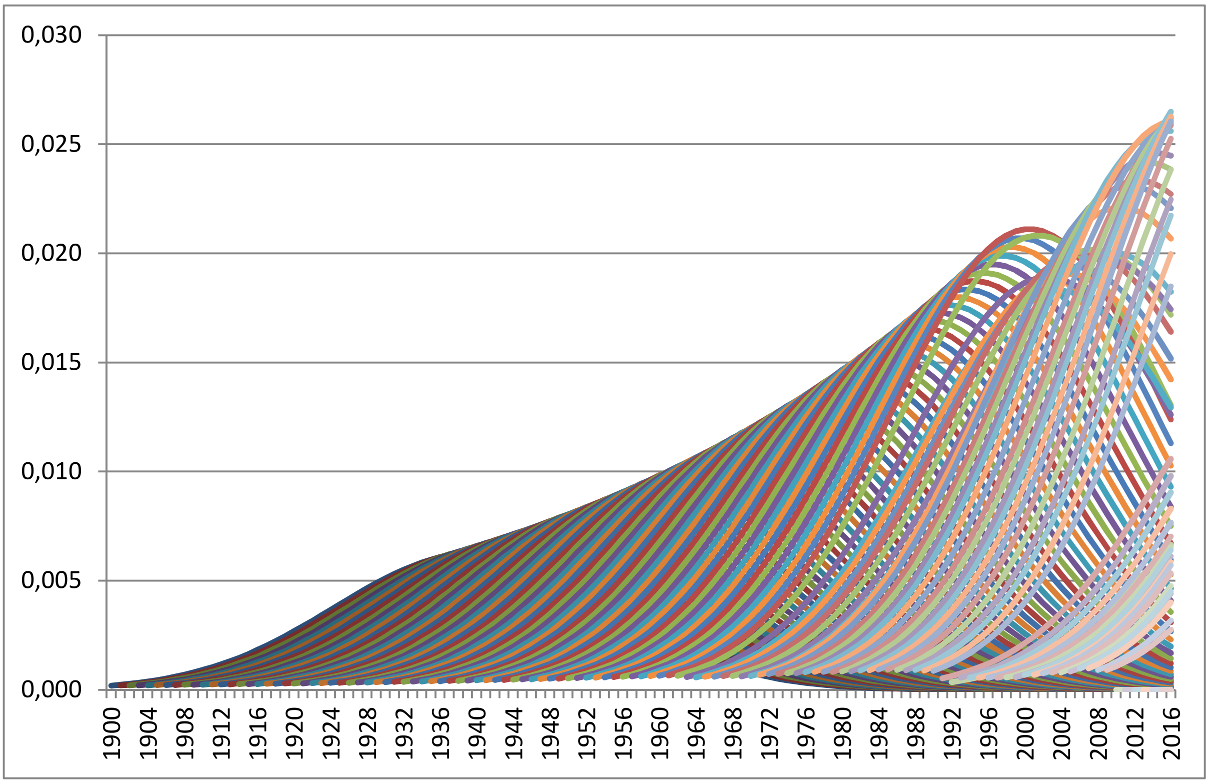


Figure 41.CO2 emissions from wood decay and normal function for individual years

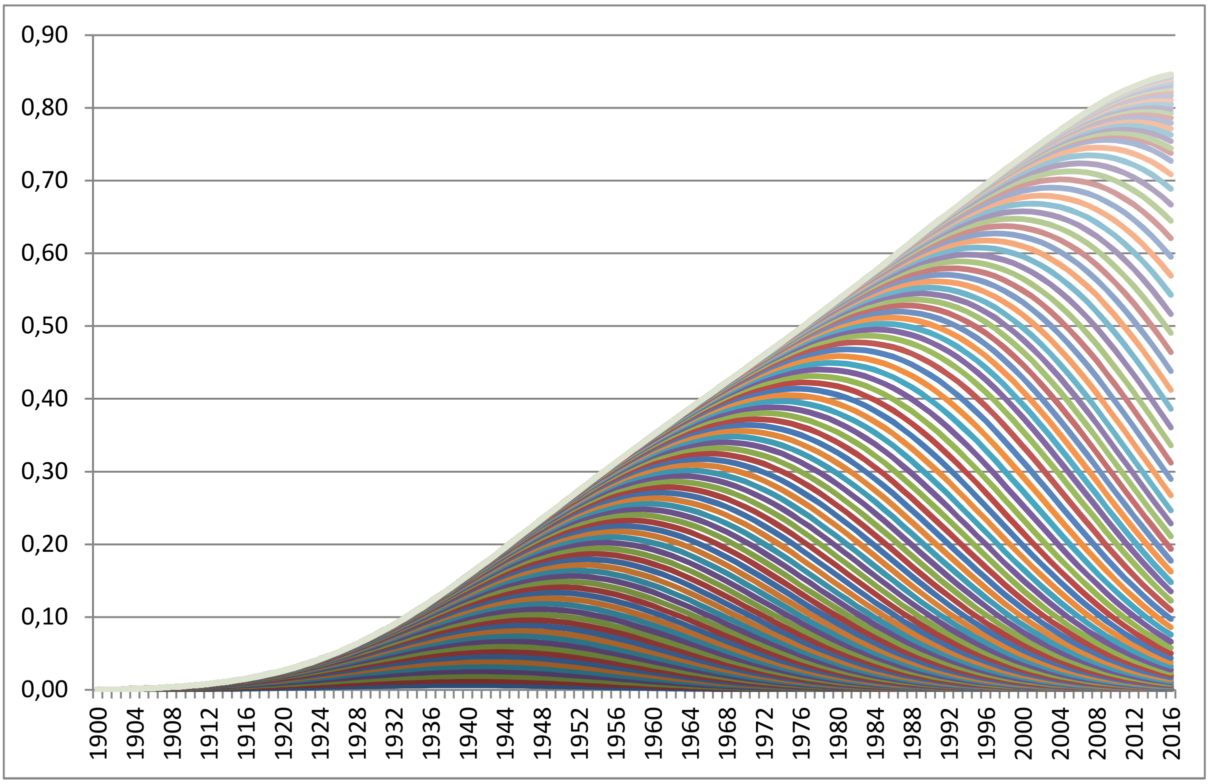


Figure 42.Cumulative CO2 emissions from wood decay and normal function

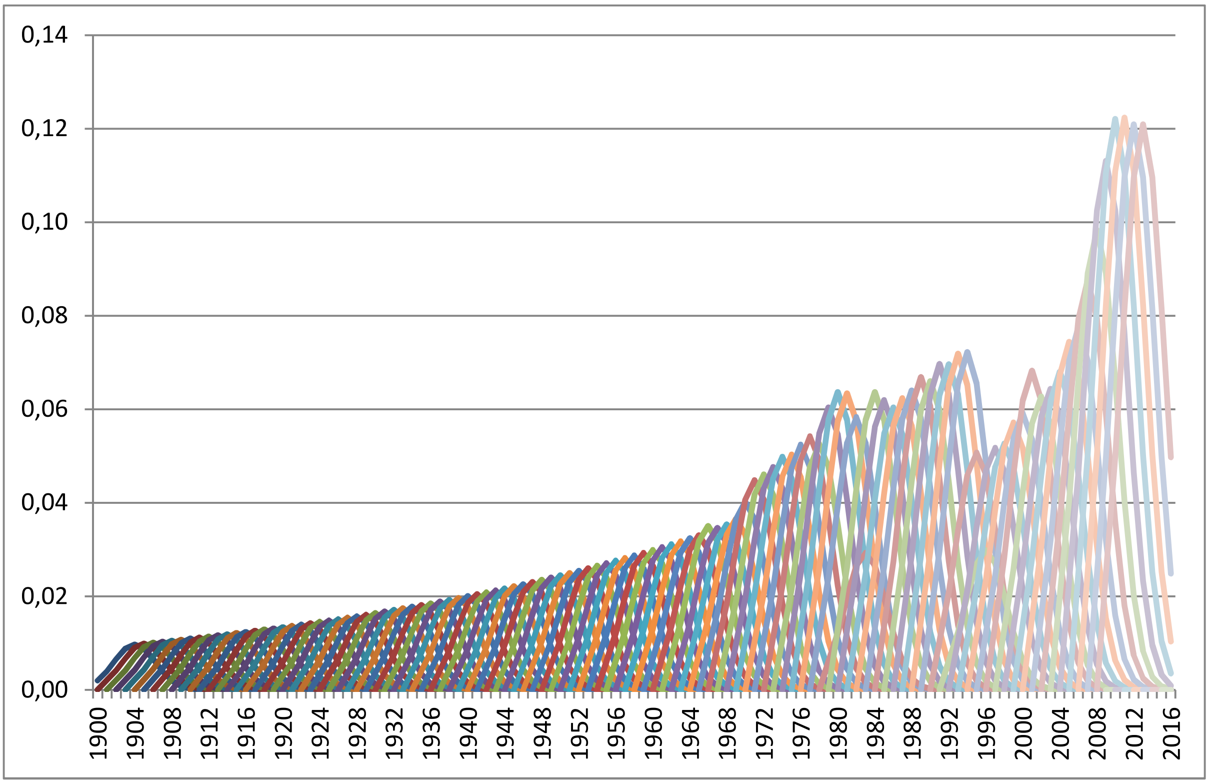


Figure 43.CO2 emissions from paper decay and normal function for individual years

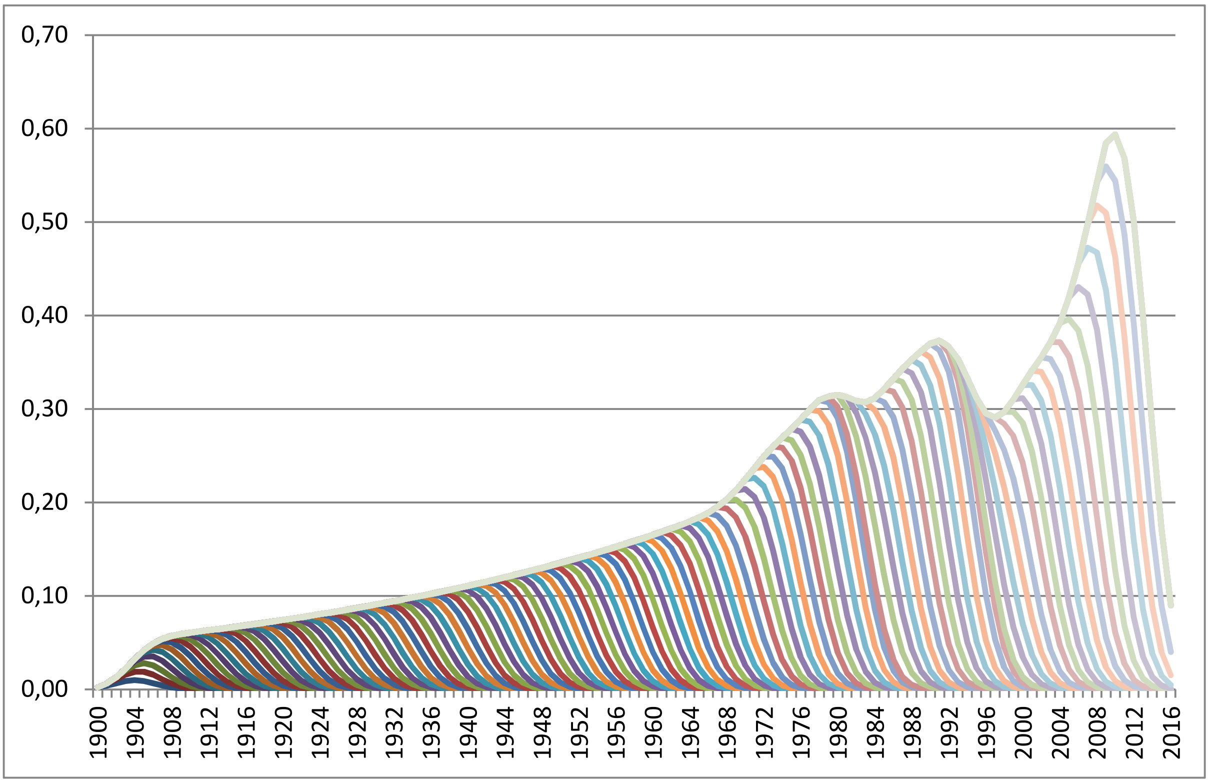


Figure 44.Cumulative CO2 emissions from paper decay and normal function

7.5 With Weibull distribution function

Table 11, Table 12 and Figure 45 to Figure 48 show CO2 emissions from decay of wood and paper in the Czech Republic, when adapted IPCC calculation sheet is used and Weibull decay function is applied. Conversion factors as presented on Figure 32 were applied. Parameters for wood and paper decay were inspired by the parameters published in (Marland et al, 2010a) for wood Alfa is 50 and Beta is 2,4; for paper Alfa is 2,35 and Beta is 1,45.

Table 11. Table 12.7 - results for the Weibull function

Table 12.7 Sectoral Background Data for AFOLU											
Annual Carbon HWP Contribution to Total AFOLU CO_2 Removals and Emissions and Background Information											
	Variable number										
	1A	1B	2A	2B	3	4	5	6	7	8	9
Inventory year	Annual Change in stock of HWP in use from consumption	Annual Change in stock of HWP in SWDS from consumption	Annual Change in stock of HWP in use produced from domestic harvest	Annual Change in stock of HWP in SWDS produced from domestic harvest	Annual Imports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Exports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Domestic Harvest	Annual release of carbon to the atmosphere from HWP consumption (from fuelwood & products in use and products in SWDS)	Annual release of carbon to the atmosphere from HWP (including fuelwoood) where wood came from domestic harvest (from products in use and products in SWDS)	HWP Contribution to AFOLU CO_2 emissions/ removals	Approach used to estimate HWP Contribution[1]
	$\Delta C_{HWP IU DC}$	$\Delta C_{HWP SWDS DC}$	$\Delta C_{HWP IU DH}$	$\Delta C_{HWP SWDS DH}$	P_{IM}	P_{EX}	H	$\uparrow C_{HWP DC}$	$\uparrow C_{HWP DH}$		
	Gg C /yr									Gg CO_2 /yr	
1990	450	142	552	137	92	508	3 193	2 186	2 504		
1991	-59	143	169	137	107	666	2 686	2 043	2 380		
1992	-330	148	-148	142	108	657	2 557	2 189	2 563		
1993	56	152	288	139	220	835	2 622	1 799	2 195		
1994	49	153	417	136	343	1 209	3 011	1 944	2 458		
1995	48	157	543	140	352	1 379	3 116	1 884	2 433		
1996	36	160	605	143	353	1 517	3 175	1 814	2 427		
1997	54	164	527	141	517	1 594	3 400	2 104	2 731		
1998	15	167	382	141	624	1 539	3 526	2 428	3 003		
1999	29	157	452	130	706	1 704	3 579	2 394	2 997		
2000	144	167	488	135	816	1 657	3 639	2 487	3 016		
2001	166	169	553	134	875	1 811	3 622	2 351	2 936		
2002	231	150	524	117	947	1 816	3 664	2 415	3 023		
2003	293	175	792	140	885	2 046	3 815	2 186	2 884		
2004	309	179	762	140	1 002	2 133	3 931	2 312	3 029		
2005	378	183	761	135	1 297	2 307	3 909	2 337	3 012		
2006	521	192	1 005	146	1 325	2 394	4 455	2 672	3 304		
2007	491	198	1 175	152	1 299	2 541	4 664	2 733	3 337		
2008	346	205	902	151	1 288	2 355	4 079	2 461	3 026		
2009	327	212	897	157	1 288	2 355	4 079	2 472	3 026		

Table 12. Table 12.1 - results for the Weibull function

Excel Table 12.1 - HWP Contribution to AFOLU emissions/ removals by Approach						
Inventory Year	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals		
				Simple Decay Approach		
Inventory Year	Stock Change	Atmospheric Flow	Production	Annual harvest	Annual CO2 release	Total Contribution
1990	-2 169	-3 693	-2 527	-11 709	9 183	-2 527
1991	-307	-2 357	-1 121	-9 847	8 726	-1 121
1992	666	-1 351	23	-9 375	9 398	23
1993	-761	-3 017	-1 566	-9 615	8 049	-1 566
1994	-739	-3 915	-2 029	-11 042	9 013	-2 029
1995	-752	-4 519	-2 503	-11 425	8 922	-2 503
1996	-721	-4 991	-2 745	-11 642	8 898	-2 745
1997	-799	-4 750	-2 451	-12 466	10 015	-2 451
1998	-670	-4 027	-1 918	-12 928	11 010	-1 918
1999	-683	-4 344	-2 133	-13 124	10 991	-2 133
2000	-1 140	-4 224	-2 286	-13 343	11 058	-2 286
2001	-1 228	-4 661	-2 518	-13 282	10 764	-2 518
2002	-1 397	-4 581	-2 352	-13 436	11 084	-2 352
2003	-1 715	-5 976	-3 416	-13 989	10 573	-3 416
2004	-1 791	-5 938	-3 309	-14 415	11 107	-3 309
2005	-2 059	-5 763	-3 287	-14 331	11 044	-3 287
2006	-2 618	-6 536	-4 219	-16 334	12 116	-4 219
2007	-2 526	-7 081	-4 865	-17 101	12 237	-4 865
2008	-2 019	-5 932	-3 860	-14 957	11 097	-3 860
2009	-1 978	-5 892	-3 862	-14 957	11 094	-3 862

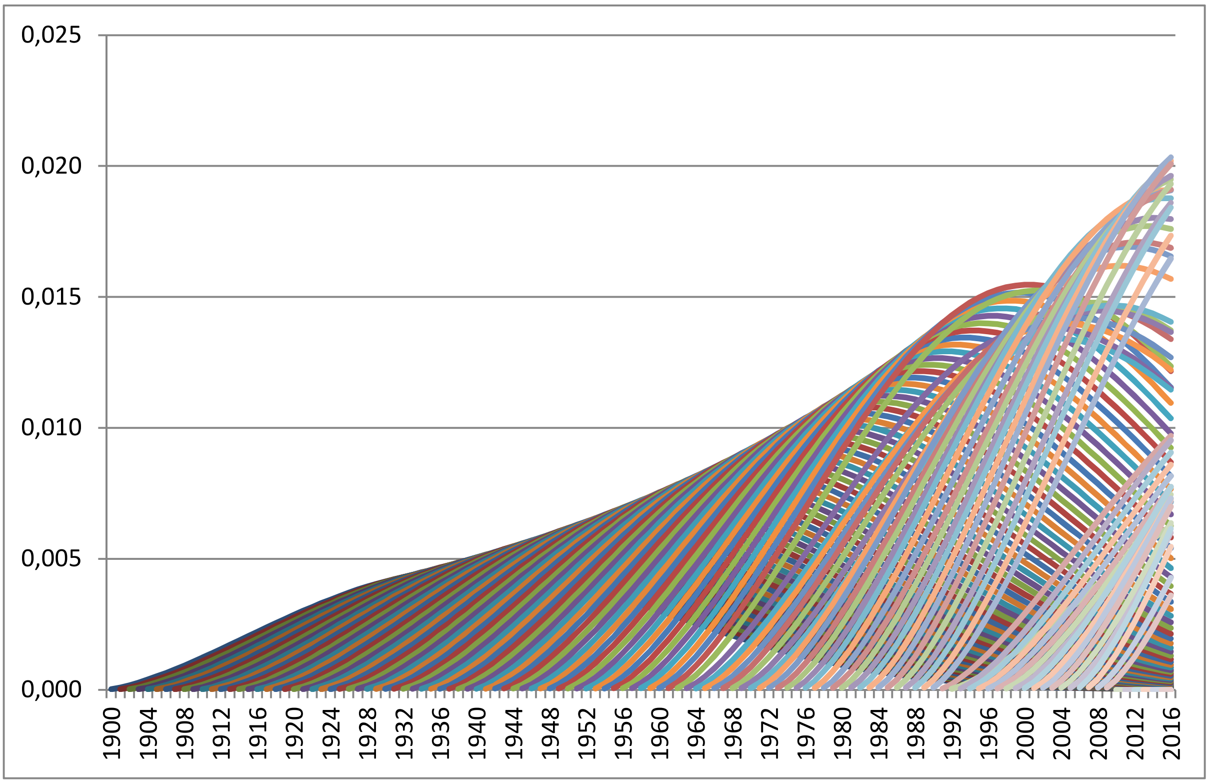


Figure 45.CO2 emissions from wood decay and Weibull function for individual years

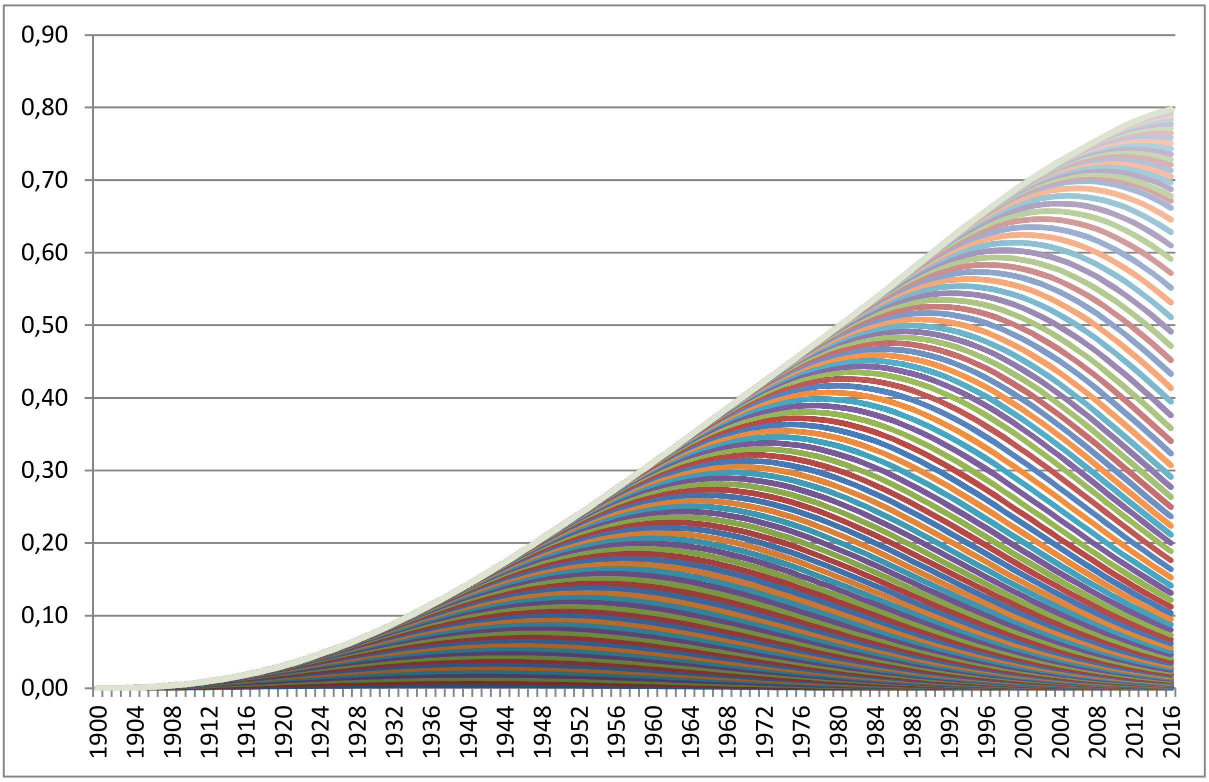


Figure 46.Cumulative CO2 emissions from wood decay and Weibull function

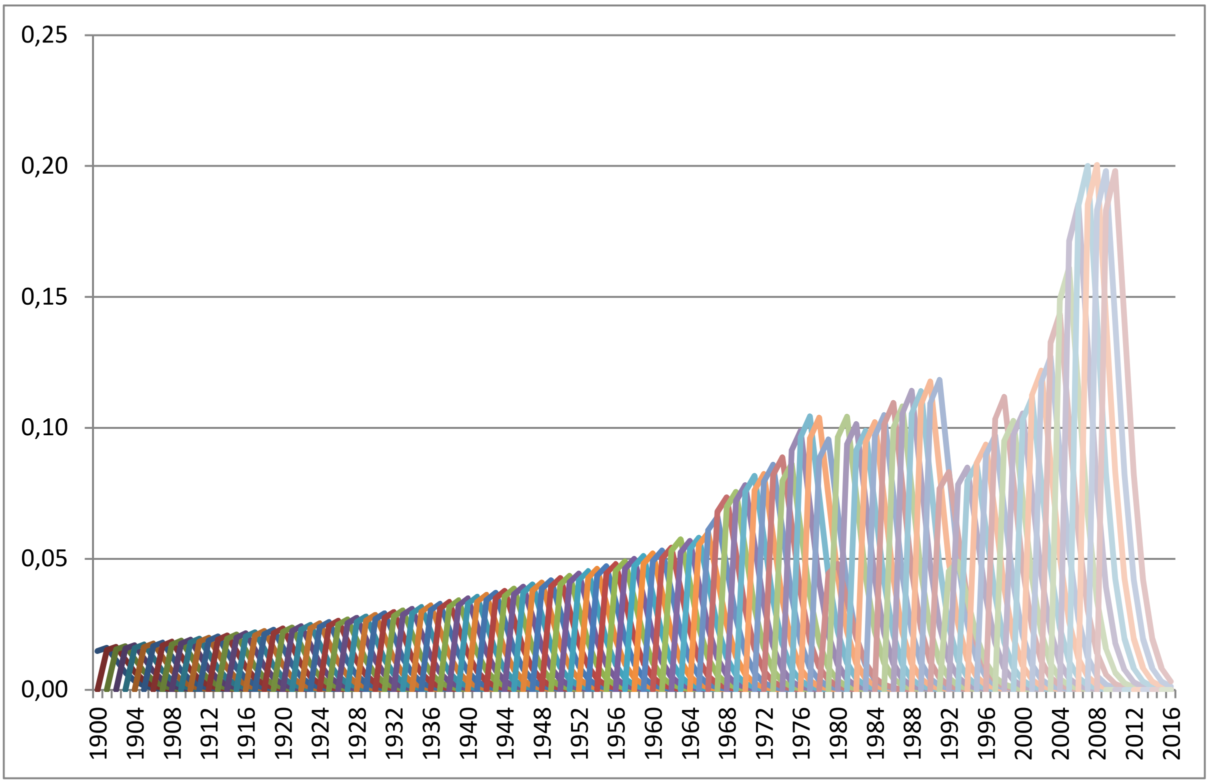


Figure 47.CO2 emissions from paper decay and Weibull function for individual years

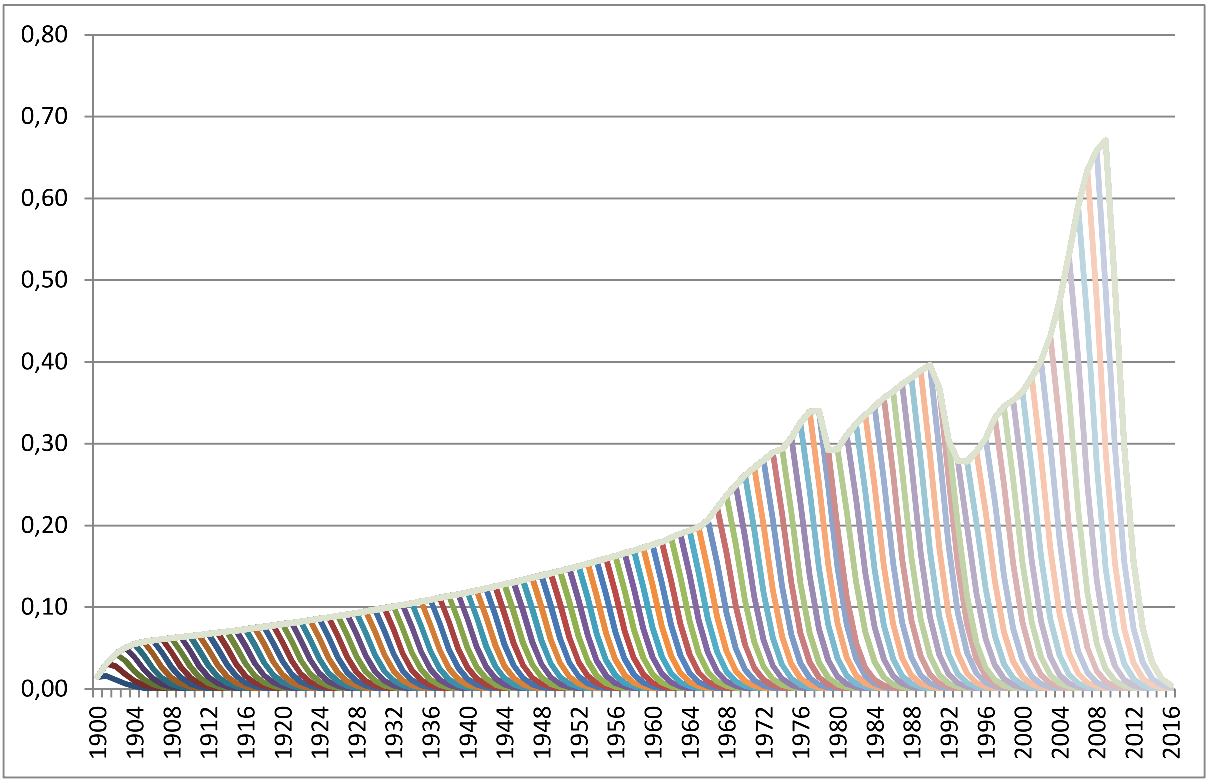


Figure 48.Cumulative CO2 emissions from paper decay and Weibull function

7.6 Comparison of different distribution function

The results of the different distribution function application are similar. It is surprising that simple, gamma, normal and Weibull decay functions produce almost the same results especially for atmospheric and production approach, where differencie for the period 1990 – 2009 are ±2%, when simple and other decay methods are compared. It is probably result mathematical function parameterization and shape of decay profile, which is very similar for normal, gamma and Weibull (see Figure 52). When different decay parameters for normal function were used, higher difference was observed.

The use of correct and accurate conversion factors[38] is more important than type of decay function. When we compare 20 years averages (1990-2009), the difference between simple and other distribution functions is -2 % for Atmospheric Approach, -7 % for Stock Change Approach and +13% for Production Approach, but the difference compared to the uncorrected Simple Decay is much greater.

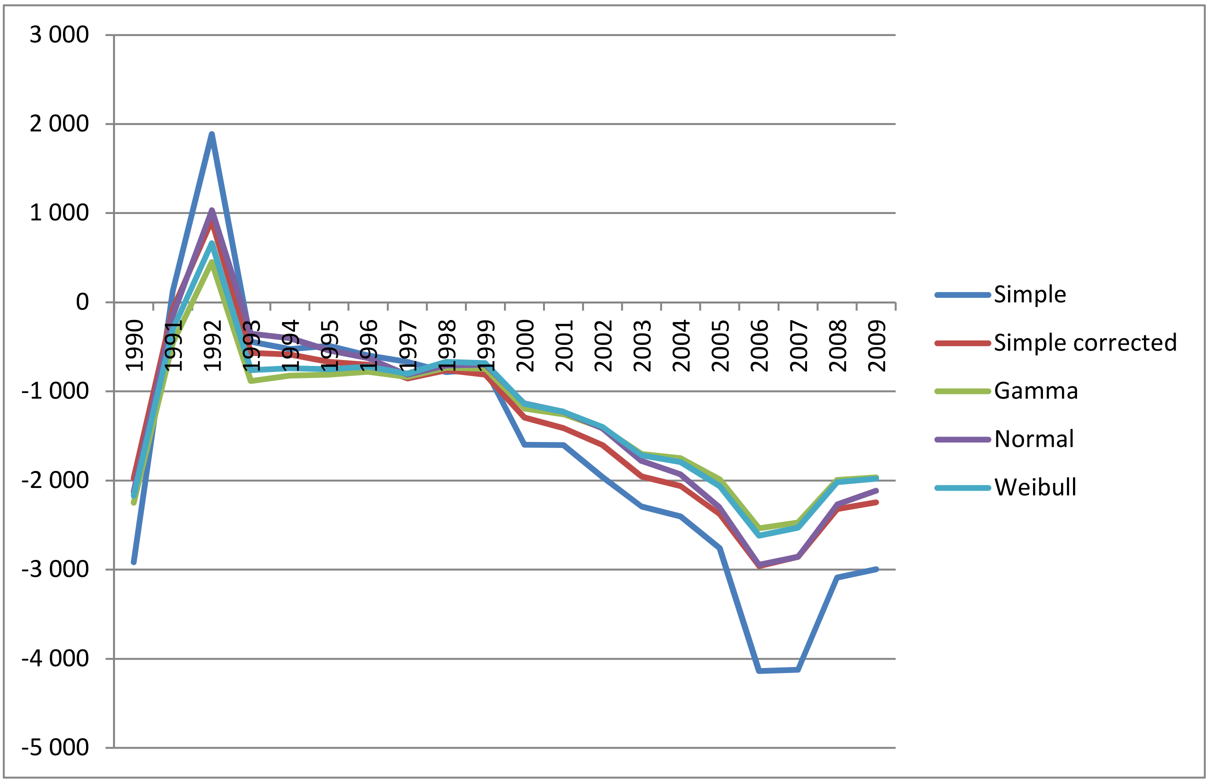


Figure 49.CO2 emissions and removals for Stock Change Approach and different decay methods

[38] The influence of the use of correct conversion factor for sawnwood and other industrial roundwood is much more important compared to the correct value for charcoal.

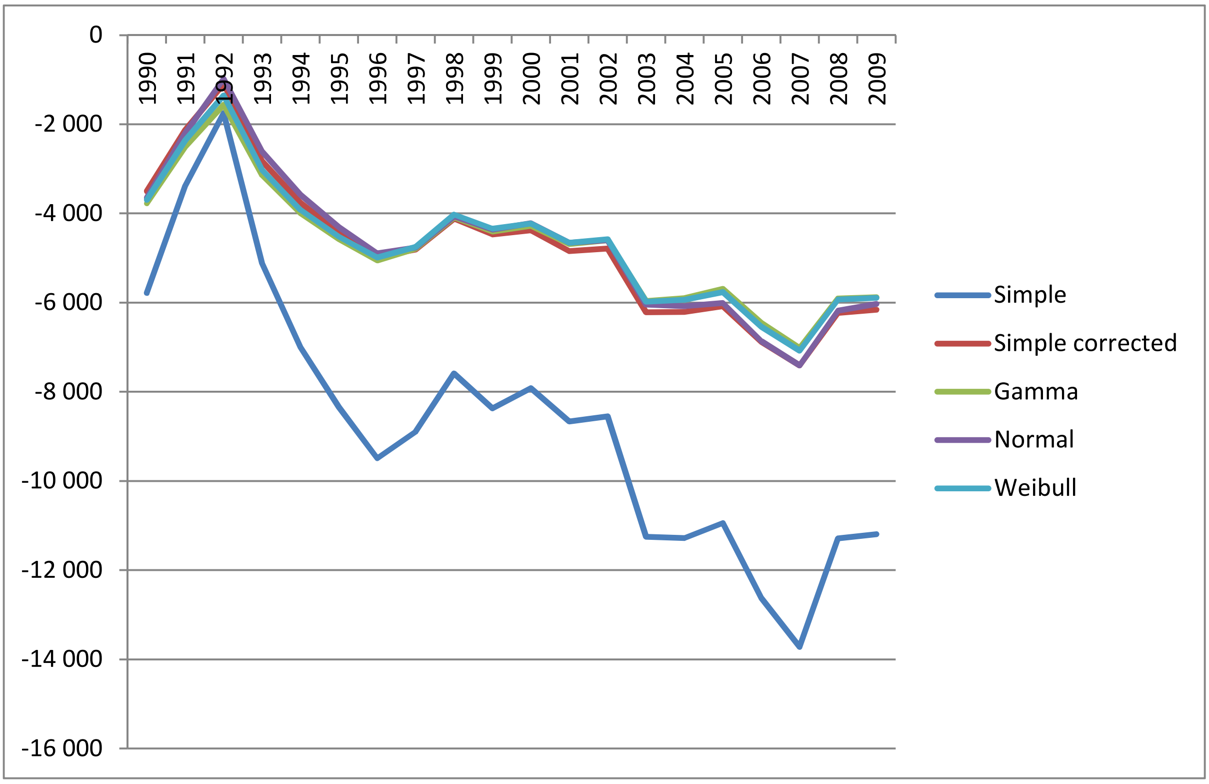


Figure 50.CO2 emissions and removals for Atmospheric Flow Approach and different decay methods

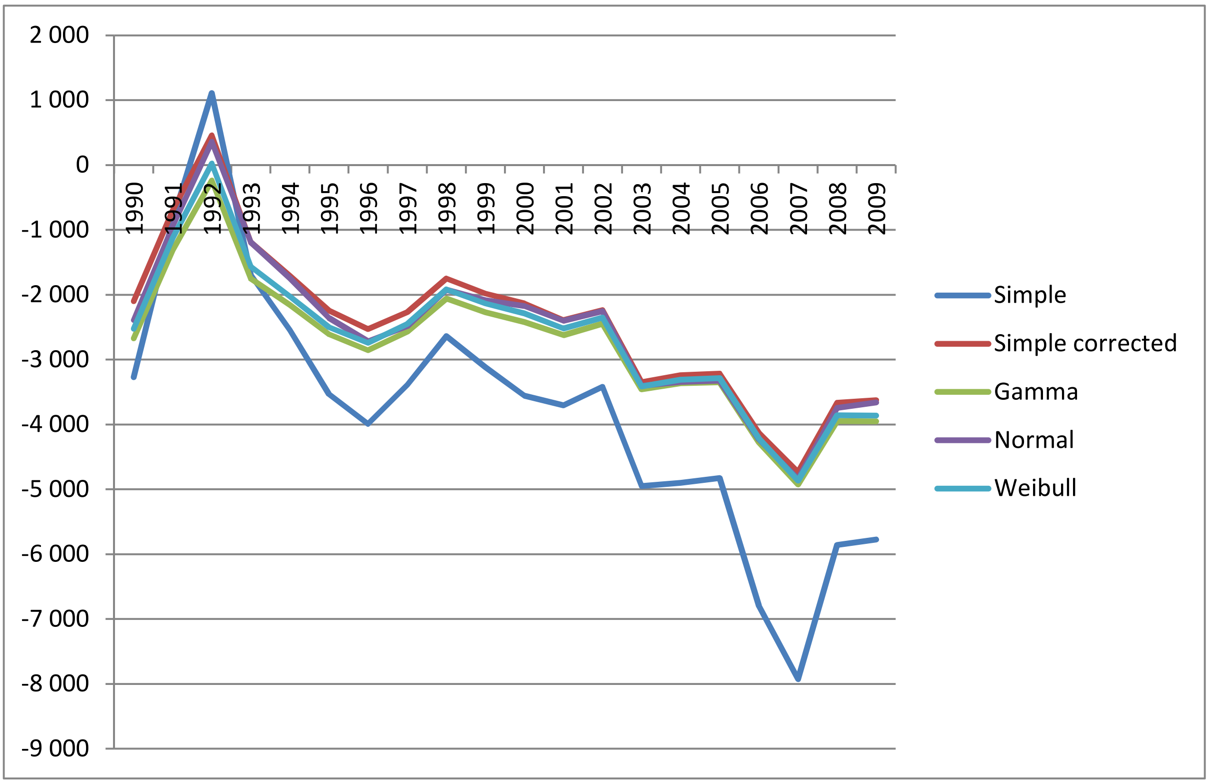


Figure 51.CO2 emissions and removals for Production Approach and different decay methods

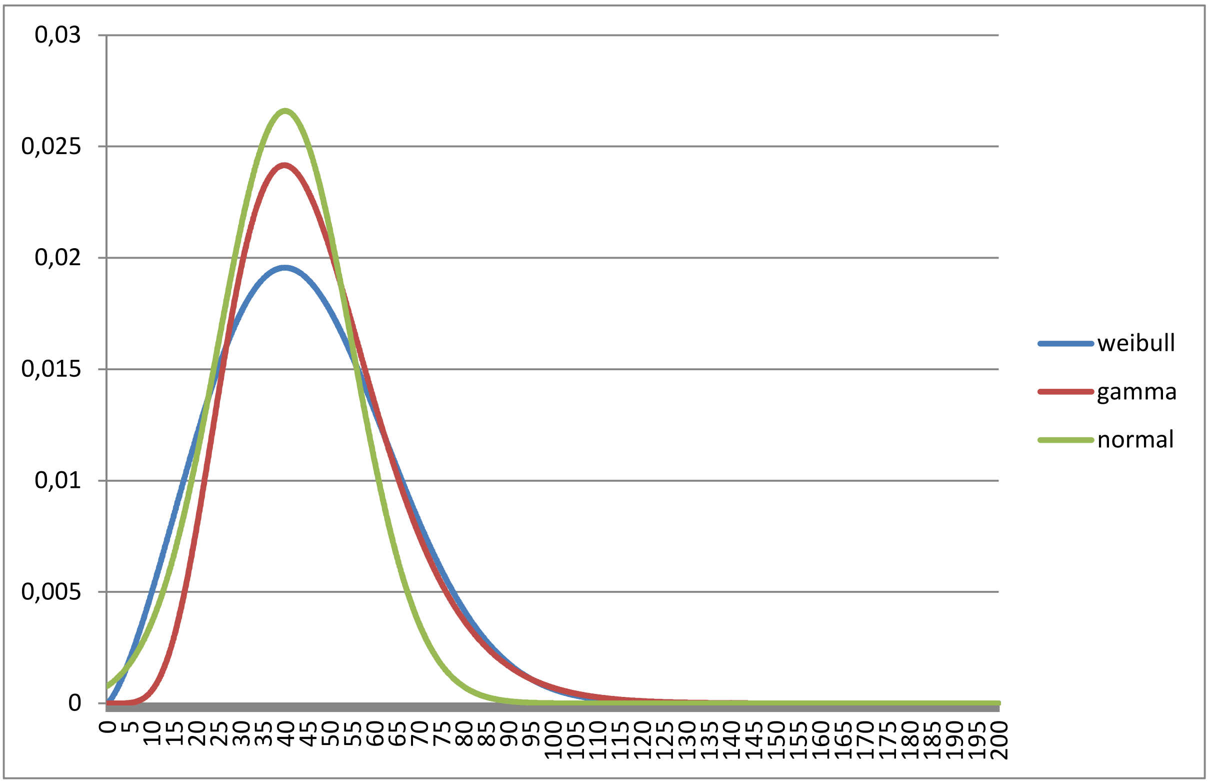


Figure 52.Decay profiles for wood and different functions used in models

8 Quality of national data

Quality of national data (in the term of completeness and accuracy) and IPCC default parameters (in the term of applicability and accuracy) are key elements for preparation of accurate emissions estimates. Type of decay profile will change only the timing of emission, but activity data and conversion factor will determine the total CO2 emissions. Correct and appropriate use of control mechanism will increase accuracy and transparency of the HWP inventory.

QA/QC control mechanism should be applied in the field of the HWP. Wood biomass balance and paper balance should be two types of possible control mechanisms as well as tool for inventory review. Similar type of control mechanisms are applied in the Energy, Industrial Processes, LULUCF/AFOLU and other sectors and categories. Typical example is energy balance in the Energy sector or Land balance in the LULUCF/AFOLU sector. On the national level another types of balances are prepared, e.g. Germany prepares limestone and dolomite balance, which identify all limestone and dolomite producers and users. Similar approach is proposed to be used in the HWP sector for wood (and paper). The Inventory approach needs different type of QA/QC activities, because it is based on different type of data. National inventory system under UN FCCC and KP provides enough QA/QC activities so there is no need for any specific one for Inventory approach.

It must be highlighted that it is very important to keep in mind in which units we prepare balance. The balance will take into account different processes when we calculate in mass unit (total paper production / collection / recycling) or in carbon / CO2 emissions and sinks (there is no carbon / CO2 flows when paper is collected and recycled).

8.1 Activity data

In the Czech Republic and probably in all other countries are under national statistics reported only official logging (production of roundwood). Information about unofficial logging are collected and estimated for the preparation of national GHG inventory (e.g. CHMI, 2011). In the case of calamitous situations, which requiring additional logging, is the difference between “unofficial” logging and official statistics higher. Table 13 compares data from official statistics, which is in line with FAOStat database and data from Czech national GHG inventory. Data shows, that under the national inventory are reported higher values for wood timber by approximately 9%. The HWP calculation sheet is based on data about semi-finished products. Change in the total harvested wood will not result in any effect.

Table 13. Difference between official statistics (FAO data) and GHG inventory

	Unit	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Official	mil. m^3	13,33	10,75	9,85	10,41	11,95	12,37	12,58	13,49	13,99	14,20
GHG inventory	mil. m^3	14,95	11,80	10,72	11,75	13,48	13,77	13,71	14,48	14,93	15,15
Difference	in %	12,1%	9,7%	8,9%	12,9%	12,8%	11,4%	9,0%	7,3%	6,7%	6,7%

	Unit	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Official	mil. m^3	14,44	14,37	14,54	15,14	15,60	15,51	17,68	18,51	16,19	15,50
GHG inventory	mil. m^3	15,36	15,22	15,54	16,59	16,72	16,55	19,17	20,92	18,07	16,94
Difference	in %	6,4%	5,9%	6,9%	9,6%	7,2%	6,7%	8,4%	13,0%	11,6%	9,3%

Groups of semi-finished wood products as listed in chapter 6.2 are considered (by IPCC, IPCC 2006) to be a good estimation for all the wood based products at this level in the production chain. The 2006 IPCC Gl. does not provide any additional information or procedures, how to assess the impact on the total HWP emissions and removals.
The obvious problem is how import and the export of finished products could influence the total wooden carbon balance. Figure 53 and Figure 54 show cross border trade in the Czech Republic for the period 1990 – 2009. The share of import and export of finished wooden product is relatively important (more than 30% of the total cross border trade in the term of mass unit), but import and export is relatively well balanced. Despite the fact, that export is only 5 % higher compared to the import of finished wooden product, it represents approximately export of 16 Tg CO2 for the whole period of 1990 to 2009. **Compared to the total emissions and removals from HWP (-13[39] to -80[40] Tg CO2 in the period 1990 - 2009) is the amount of Net exported wooden products (and embodied emissions) important. The basic presumption of the IPCC methodology, which is quoted on the beginning of this paragraph, is not valid under the conditions in the Czech Republic.**
Data from the international trade statistics about semi-finished products are relatively in line with data from FAOstat, see Figure 55. It is necessary to mention that the calculation of carbon embodied in the imported and exported semi-finished wooden products are based on similar but not the same datasets. Presented data represents preliminary and unpublished results provided by Mr. Havránek from CUEC. The data shows relatively good match. It is clear that the estimates, which were prepared for import and export of finished products, will be less accurate.
Similar comparison was prepared for paper production and paper products, but produce completely different results. Import (9%) and export of finished (9%) paper products is less important compared to the semi-finished products on the total cross border trade. Also the import is equal to the export of finished paper products. Import and export of finished paper product could be not taken into account, when HWP estimates are prepared for the Czech Republic.
It must be mentioned that only paper products were taken into account, amount of wooden and paper packages were not estimated. Wooden and mainly paper packages could influence the amount of paper which crosses borders. But their determination is very difficult and subject to considerable uncertainty.

[39]Stock Change Approach
[40]Atmospheric Flow Approach

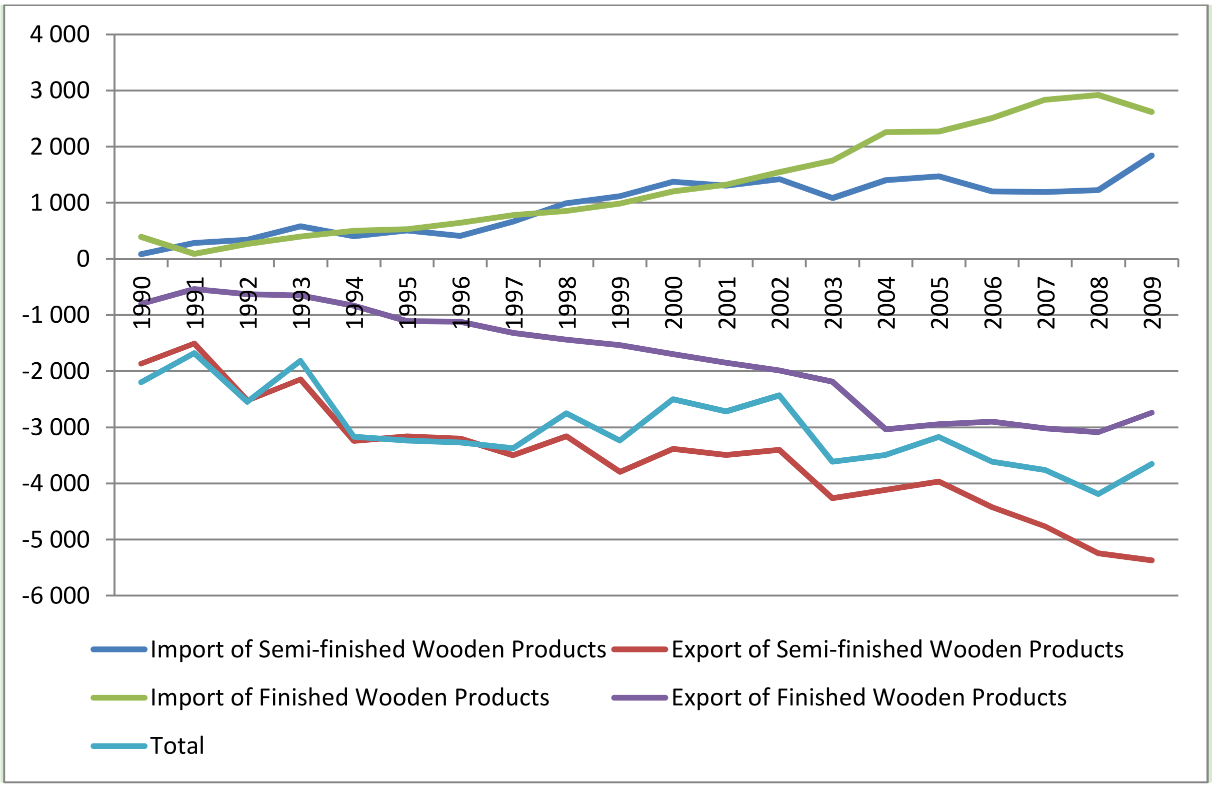


Figure 53.Development of imported and exported semi-finished and finished wooden products into and from the Czech Republic [1 000 t]

Source: CSO, CUEC

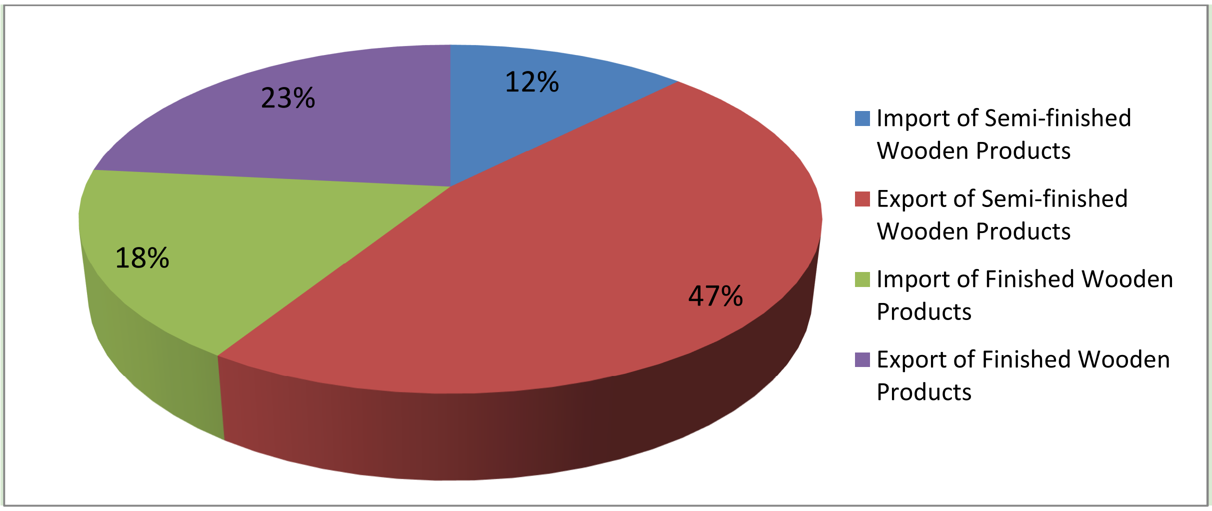


Figure 54.Share of individual flows in the total cross-border trade in the Czech Republic for the period 1990-2009

Source: CSO, CUEC

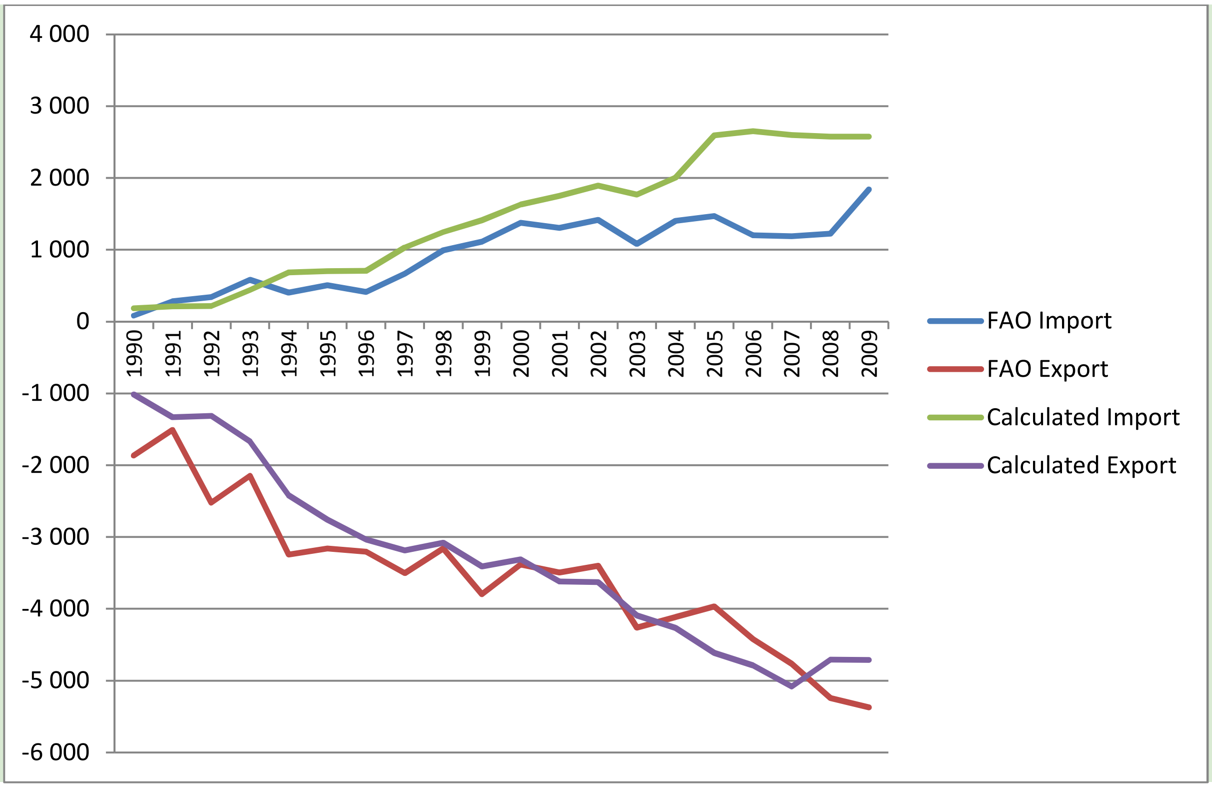


Figure 55.Exported and imported amount of wood in CO_2 Gg as reported under FAO stat and calculated based on CSO international trade statistics in 1990-2009

Source: CSO, CUEC, IPCC, FAO

8.2 Balance of biomass carbon

Special type of balance, which should be applied also in the current version inventory is biomass carbon balance. Biomass carbon balance should ensure that CO_2 and CH_4 emissions from carbon will not lead to the double-counting. In the current version of the IPCC methodology (IPCC, 1997; IPCC 2000 and IPCC 2003) CO_2 and CH_4 emissions from biomass are reported under Energy, LULUCF and Waste sector. CH_4 emissions from Energy, LULUCF and Waste sector and CO_2 emissions from LULUCF are accounted. There is no tool in the methodology (IPCC, 1997; IPCC 2000 and IPCC 2003), which will help to the user to avoid double counting of CH_4 emissions from biomass in Energy, LULUCF and Waste sector. In the Czech Republic all CO_2 emissions from harvested wood are reported under LULUCF category plus

a) CH_4 emissions from on-site wood residues burning (LULUCF category);
b) CH_4 emissions from wood based biomass burning (Energy category);
c) CH_4 emissions from wood based biomass wastes decay (Waste category);
d) CH_4 emissions from wood based biomass wastes incineration (Waste category) [41].

CH_4 emissions from a) are known, CH_4 emissions from c) and d) should be estimated based on data about waste composition, but CH_4 emissions from b) should be only estimated under current methodology and statistics data availability (in the inventory is mix of wood based biomass and agricultural biomass). All 4 cases are potential double counting examples for the Czech Republic.

[41] Insignificant CH_4 emissions, close to 0.

Size of the problem should be illustrated on the CH4 emissions and carbon flows in above mentioned categories (see Table 14). Values in row “Equivalent of CO2” should be subtracted from the LULUCF category otherwise this carbon is double counted in the Czech Republic’s GHG inventory.

Table 14. Potential cases of CH4 emissions double counting in the Czech Republic [Gg]

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Energy	2,7	2,7	2,5	2,1	2,2	2,3	2,5	2,0	3,2	3,2
LULUCF	4,8	3,6	3,7	4,3	4,4	4,2	5,5	5,9	5,2	4,8
Waste - landfilling*)	47,5	47,4	49,5	51,5	53,6	55,8	57,9	58,5	57,5	58,9
Total	54,9	53,6	55,8	57,9	60,3	62,3	65,8	66,5	65,9	66,9
Equivalent of CO2	151,0	147,4	153,4	159,3	165,8	171,2	181,0	182,8	181,1	183,9

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Energy	3,3	3,3	3,7	11,4	12,3	12,5	13,5	15,6	14,8	14,8
LULUCF	4,4	4,6	4,9	6,2	5,6	5,4	6,7	8,7	6,8	5,8
Waste - landfilling*)	60,7	62,5	64,0	65,1	65,9	67,6	69,2	69,8	69,2	72,2
Total	68,4	70,4	72,6	82,7	83,9	85,4	89,3	94,1	90,8	92,8
Equivalent of CO2	188,0	193,6	199,6	227,4	230,7	235,0	245,7	258,7	249,7	255,2

*) CH4 emissions only form wood based biomass

8.3 Balance of the wood and wood products

Preparation of the wood and wood products balance is much more complicated compared to the energy or paper balance, because wood is embodied in many different products and the share of wood is not very well known. Also for different products different units are used (mass, volume or amount). First step could be preparation of the basic wood balance, which is relatively simple process, where you can use data from CRF tables and FAO Stat. The balance should be based on data about:

- wood harvest with(without) bark;
- roundwood production, import and export;
- sawnwood production;
- woodpanels production;
- paper (pulp) production, (for paper production, estimate the share which is produced from new wood[42]);
- net import of chips and particles, wood charcoal and wood residues;
- wood and wood wastes used for energy production[43];

As the main issue can be considered the question: is there enough wood for all semi-products manufacture, net export and use for energy purpose?
The key parameter is the amount of available biomass (wood with bark). As was shown in chapter 8.1 and Table 13 the official national statistics does not provide information about all

[42] In the Czech Republic up to 50% of the carbon in the paper comes from recycled paper.
[43]Biomass, which comes from agriculture, is not accounted.

available wooden biomass. Also part of the biomass residues, which comes from wood harvest, are collected and used for energy generation. Surprisingly, data on available biomass is loaded with the largest error and is an expert estimate.

Figure 56 shows results of the wood balance for the Czech Republic. Negative balance in the recent years could be result of uncertainty, change of biomass stocks or important use of biomass, which comes from agriculture (e.g. straw). More precise biomass balance could be prepared by using national data about biomass production and use, but national statistics do not provide sufficient data for such kind of balance.

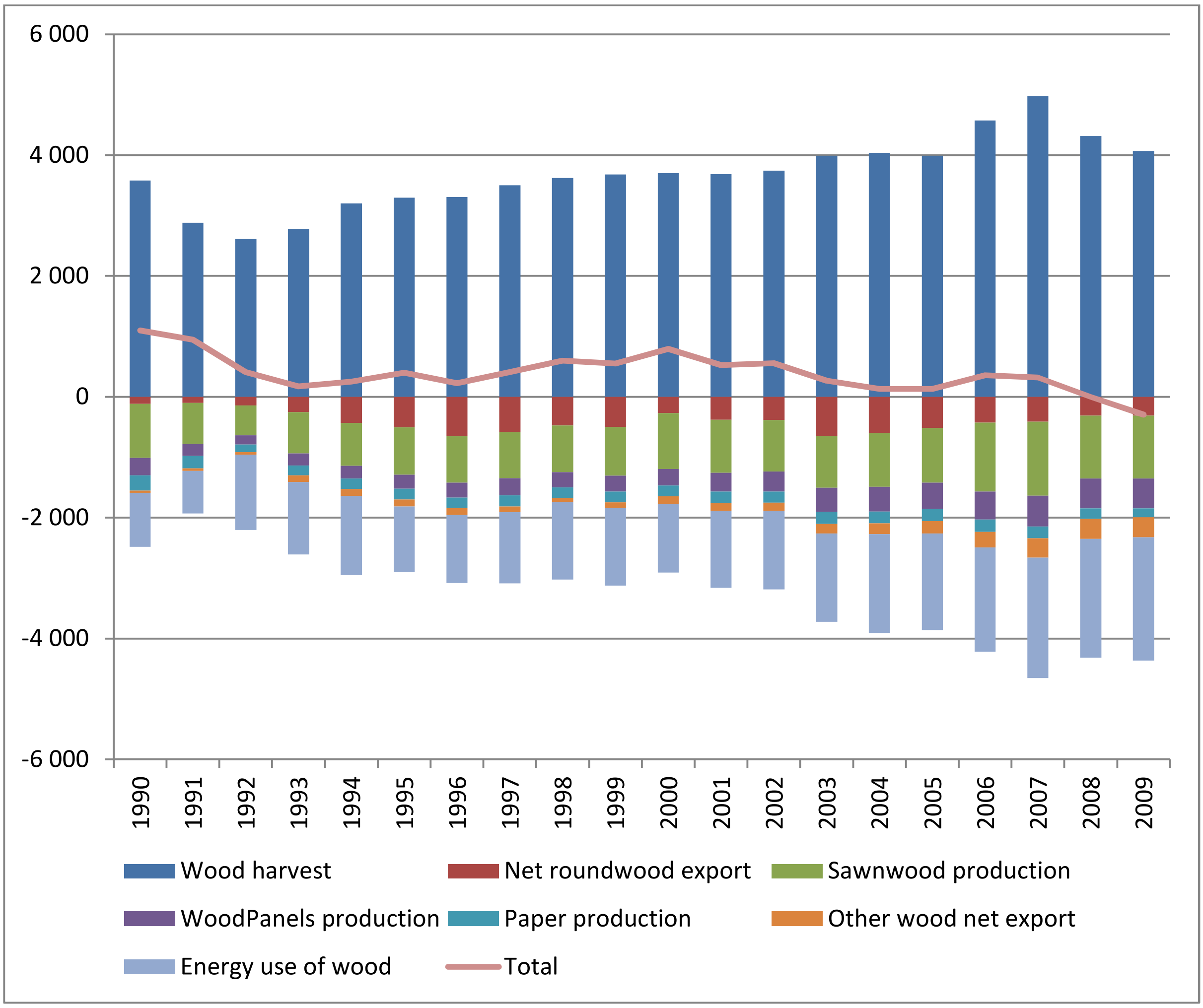


Figure 56.Wood biomass balance in the Czech Republic [1 000 t]

Source: CZ NIR, FAO Stat

8.4 Balance of the paper and paper products

Balance of the paper and paper products should be understand as part of the wood and wood products balance. But it is independent control of mass balance of paper and paper products, which is based on information provided by

- national statistics (paper and paper products production),
- industrial statistics (paper and paper products production, recycled paper use),
- waste statistics (amount of recycled and collected paper, landfilled and incinerated paper),
- other sources (waste composition and changes of waste composition).

In the case of Czech republic data were provided by the Pulp and Paper Association (paper production, rate of old paper collected and recycled), FAO Stat (paper production, import and export), Czech National Inventory Report - System (amount of paper landfilled and incinerated), from other sources information about waste composition and waste composition development was obtain.

Paper balance is set up by:

Production and Import of Paper (and Paper Products) = Paper destruction,
where individual parts represents:

$Paper_{Production} + Paper_{NetImport}$ ($+Paper_{InPruductsNetImport}$) $= Paper_{Landfilled} + Paper_{Incinerated} + Paper_{Combusted} + Paper_{Collected}$

Data about $Paper_{Production}$ and $Paper_{NetImport}$ are available in FAOStat database as well as from national statistics[44]. Emissions from landfiled and incinerated paper products are reported under the GHG inventory (CHMI, 2011). Information about paper combustion in households was estimated on the base of different waste composition in summer and winter. Information about paper collection and recycling comes from Paper Producers Associations or from CEPI database (CEPI, 2010).

Results of the paper balance, which was based on FAO Stat data, national data and CRF data (e.g. waste composition data) is presented on the Figure 57. At first glance you can see the negative balance, i.e. the pose of the paper exceeds it is production.

[44] National data quite well match with FAO Stat data. There is reported more paper produced and used in Czech Republic in national statistics compared to the FAO Stat in average by 4% (ranging from -4 to 12 %). This data should be used for estimating uncertainty of paper production and/or use.

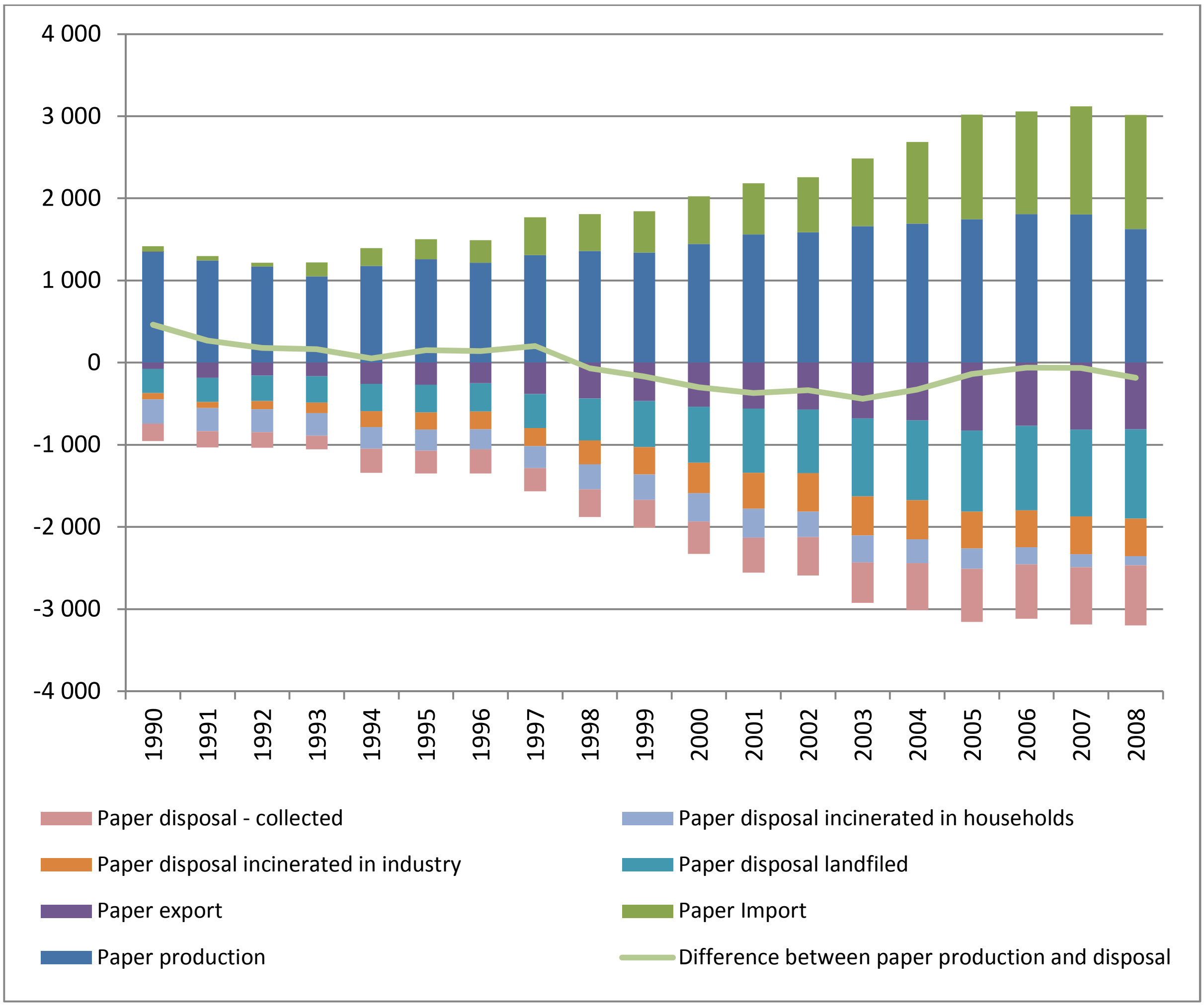


Figure 57.Paper balance in the Czech Republic [1 000 t]

Source: PPA, CZ NIR

Data analysis and paper balance for the Czech Republic show some interesting issues:

a) Activity data for paper (production, import, export, consumption) are slightly different compared to the FAO stat data. Data from Association of the Pulp and Paper Industry of the Czech Republic shows in average 4% higher values compared to the FAO Stat for period 1993-2008[44]. It can be assumed that the data sources are independent. Uncertainty of activity data for paper production is in the Czech Republic approximately 15 %.
b) Data about composition of wastes, which provided different values for heating and non-heating season, shows that important part of paper was burned in the early 90's despite the fact that paper was broadly collected and recycled.

Net import of paper packages (and products[45]) should be important source of paper. The HWP estimates without information about net import of paper and wood products and packages cannot be complete and accurate.

[45]It is not the case of the Czech Republic, cross border balance of paper products is zero (see chapter 8.1).

9 Key Point Summary and Recommendations

This report has raised a number of issues, which can be summarized as follows:

1. Complete revision of the HWP issue and application of the Inventory approach could provide quick and reliable data for many countries, without any or very limited need for additional research. The use of complex approaches, which will be data intensive, will not lead to success and will not provide internationally comparable data.
   Inventory approach is the best ant the most accurate HWP estimate, which is now available. There are no other major anthropogenic flows of wood based carbon (in the form of GHG) except those described in national inventories and the IPCC methodology.

2. On one side Parties ignore the issue of the HWP in their GHG inventories. The negotiation process under UN FCCC takes too long (*see chapter 2*). There is also weak support from Parties on science and development (there are few scientific articles, which were published by limited number of experts - *see reference list*). On the other hand the importance of HWP in climate change mitigation (emissions reduction) is overestimated and many other effects and functions of forests are discussed (*see chapter 1*). Some of these issues are more developed than other. For example sustainable forest management and biomass use as fuel are discussed very often, but wood substitutes for more energy-intensive materials is only mentioned without any analysis or impact (meant as emission reduction) quantification.

3. **IPCC default approach is incorrectly marked as inaccurate approach**, which does not take into account HWP. That is the basic misunderstanding of IPCC default approach. For more information and explanation *see chapter 3.1.1*. Simple accounting and reporting approach for HWP should be preferred to sophisticated solutions. The main positive feature of IPCC default approach is the simplicity.

4. Logic 2 step approach should be applied for the HWP development and set up

- UN FCCC will finish their negotiation, define the HWP and all necessary matters,
- IPCC will prepare methodology, which accommodate all UN FCCC requirement,

or

- IPCC can prepare special report on the HWP, where all necessary issues will be discussed and which will serve as the basis for the UN FCCC negotiations[46].

If not, table tennis game between UN FCCC and IPCC about the HWP and its development and set up all necessities will continue.

[46]But it is unlikely that the report will include answers to all raised questions on the UN FCCC negotiations, first option should be preferred.

5. **There should be two new versions of the HWP calculation sheet prepared, approved and published by IPCC or TSU:**
- where all deficiencies will be fixed,
- first designed for Tier 1, where all necessary cells will be locked and
- second designed for Tier 2 implementation on the national level, where all cells will be unlocked, which would permit a different set of decay profiles[47].

This allows easy inventory review for Tier 1 application. Tier 2 application will be easier on national level as structure (framework) of the HWP calculation sheet should be used for different decay profiles application. There should be possibility in the HWP calculation sheet to use different decay parameters (half time) for different years / periods. For reasons and more information *see chapters 4 and 5*.

6. **The HWP system (UN FCCC system set up, the IPCC methodology) should be focused on long lived products** (and not to paper, which has minor role in HWP 0 – 10% in the Czech Republic, see Annex 12.2). This is also proposed by some countries under the UN FCCC negotiation (e.g. by Denmark, UN FCCC, 2003a) or mentioned in some studies[48].

7. **Biomass (and paper and paper products) balance should be part of the NIR and/or CRF** (as reference approach is used for control of sectoral approach in the Energy sector) because completeness of HWP estimates is more important than exact emissions timing.

8. Currently, under the UN FCCC the HWP issue is understood as part of management in forests (carbon accounting) compared to the IPCC methodology, where it is understood as two separate issues. In the future this separation will need to unite.

9. **Simple Decay approach should be in the 2006 IPCC GI. described as separate approach and in the HWP calculation sheet should be implemented in a way which would correspond with its basic principles.**

10. The issue of uncertainty is not sufficiently described in the IPCC methodology, reports and articles, which provide only short description and notice that one approach is less uncertain than the other. Use of data about semi-final products brings special type of uncertainty. In some cases import and export of paper products could be very important (see Chapter 8.4). It can be expected, that analogical situation as for the paper and paper balance could occur for wood products.

[47]In optimal case, model can be developed in such way, that different decay methods will be incorporated into the model. User will chose one (which will fit the best to the national circumstance of for which national decay parameters are known) and set up decay parameters.

[48]Paper and paper products have only 2% on the total carbon stock in HWP (Flugsrud et al, 2001).

11. Some of the IPCC methodology presumptions (e.g. half live, decay profile, focus on the semi-finished products[49]) should be revised and additional methodological guidance should be prepared by IPCC.

12. **IPCC should improve QA/QC procedures to avoid mistakes in the methodology, especially in the calculation sheets** (e.g. HWP – see chapter 4.2 or in calculation sheet for estimating emissions from F-gases).

13. The IPCC should also improve transparency by providing background information about parameters and basic presumptions. **If the IPCC does not carry out their own research, the IPCC methodology has to provide quotes for all emission factors and other parameters of the calculations.**

14. There should be better cooperation with scientific community, especially with environmental economist on wood, wood based and paper material flows as well as with waste experts. Helpful information can be found in material flow analysis articles, both for life-time information (decay profile and its parameters) and for activity data (e.g. Marko et. al, 2000; Hatayama et. al, 2008). **Better cooperation should be reached by setting up an open process for expert nomination for TFI-TSU IPCC meeting.** Under current conditions, expert, who is not involved in national inventory preparation (or any related issue) has no chance to know about workshops and meetings, which are organized by the TFI-TSU IPCC and provide relevant information, articles.

[49] Australia reported in its National Inventory Report (Australian Government, Department of climate change and energy efficiency, 2012b) that up to 10% of Sawnwood mass is transformed into the waste and combusted.

10 Conclusion

The issue of HWP seems to be over politicized and overestimated in the term of “direct emission reduction” potential. No final decision about monitoring and reporting was accepted by the UN FCCC since the first version of approaches was published and political discussion started in 1995-1996. Harvested wood products do not remove GHGs from the atmosphere, but only change timing of emissions – postpone emissions to the future. Substitution (indirect) effect of wood use, when wood is replacing more energy or GHG emissions intensive materials, is not described in this report (except wood use for energy production). The substitution effect of wood use leads to the decrease of GHG emissions in absolute values, but the emission reductions occur in other sectors and not in the LULUCF (AFOLU). That is the reason, why the reduction of emissions is monitored and reported in other sectors (Industrial Processes, Energy). Quantification in the term of GHG emissions would be more important and interesting compared to the direct effect.

It seems that the HWP issue was considered by many Parties as “unimportant” as well as for the national inventories and national inventory compilers, whose do not use the HWP methodology for emissions and removal estimate. Other issues are that the implementation of the HWP methodology does not increase quality of inventories in the term of completeness or lowering uncertainty.

On the other hand negotiation under the UNFCCC does not take under consideration only GHG emissions and GHG “reduction” potential of the HWP, but also other issues related to the forest and biodiversity as well as source of renewable materials, fuels and food (important part of national economy) and producer of environmental, social, cultural, science services. Breadth of issues discussed heavily over the possibility of any individual expert.

If negotiation under the UN FCCC will not be finished with success, it could be expected that Parties (national inventory experts and compilers) will apply their own approach or choose one of them which are discussed in the IPCC methodology, the UN FCCC documents or any other relevant document (e.g. special national reports and studies
It is clear that the HWP will not be accounted for in the first (and second[50]) commitment period), except few exceptions. The HWP accounting in the next commitment period is under the UN FCCC discussion, there will be time pressure on Parties

- to reach consensus, how and what have to be estimated, reported and accounted;
- to develop methodology, which will be approved by the IPCC;
- to implement the IPCC methodology on the national level.

In the case that there will be no consensus on next commitment period (post-Kyoto), reporting under UNFCCC will continue, accounting will not be issue and countries will be able to decide which approach and tier they will use.). In such case, inventories will be less compatible and comparable.

[50]The time is the most important limit. IPCC needs clear task and at least 2 years for developing new methodology. In the next stage the methodology must be approved by IPCC plenary and UN FCCC.

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12 Annexes

12.1 Annex 1 - Quantification of potential impact of paper production data

There are described 2 scenarios which differ in production assumptions (stable and increasing production) and 2 variant. The first assumes that 100% of paper comes from harvested wood. The second assumes that 50% of paper comes from recycled paper and that's why paper production is doubled compared to the first variant. The life-time is default value from 2006 IPCC GI.

12.1.1 Scenario 1

Harvest, saw wood and paper production is stable for the whole period 1960 - 2009 as show Figure 58, result and impact quantification is in the Table 15. There are no differences in results between first and second variant.

U55 f_x

	A	B	C	F	G	H	N	O	P	Q	R
1	**Test-paper100%orrigin**										
2	**FAOSTAT**										
3			**Roundwood**			**Sawnwood**			**Paper+Paperboard**		
4			Production			Production			Production	Imports	Exports
23		1978	1 000 000			500 000			300 000		
24		1979	1 000 000			500 000			300 000		
25		1980	1 000 000			500 000			300 000		
26		1981	1 000 000			500 000			300 000		
27		1982	1 000 000			500 000			300 000		
28		1983	1 000 000			500 000			300 000		
29		1984	1 000 000			500 000			300 000		
30		1985	1 000 000			500 000			300 000		
31		1986	1 000 000			500 000			300 000		
32		1987	1 000 000			500 000			300 000		
33		1988	1 000 000			500 000			300 000		
34		1989	1 000 000			500 000			300 000		
35		1990	1 000 000			500 000			300 000		
36		1991	1 000 000			500 000			300 000		
37		1992	1 000 000			500 000			300 000		
38		1993	1 000 000			500 000			300 000		
39		1994	1 000 000			500 000			300 000		
40		1995	1 000 000			500 000			300 000		
41		1996	1 000 000			500 000			300 000		
42		1997	1 000 000			500 000			300 000		
43		1998	1 000 000			500 000			300 000		
44		1999	1 000 000			500 000			300 000		
45		2000	1 000 000			500 000			300 000		
46		2001	1 000 000			500 000			300 000		
47		2002	1 000 000			500 000			300 000		
48		2003	1 000 000			500 000			300 000		
49		2004	1 000 000			500 000			300 000		
50		2005	1 000 000			500 000			300 000		
51		2006	1 000 000			500 000			300 000		
52		2007	1 000 000			500 000			300 000		
53		2008	1 000 000			500 000			300 000		
54		2009	1 000 000			500 000			300 000		
55		2010									

Figure 58. Activity data for Scenaŕio 1, 1st variant

Table 15. Table 12.1 Results for Scenario 1 and both variants

Excel Table 12.1 - HWP Contribution to AFOLU emissions/ removals by Approach						
Inventory Year	HWP Contribution to AFOLU emissions / removals	HWP Contribution to AFOLU emissions / removals	HWP Contribution to AFOLU emissions / removals	HWP Contribution to AFOLU emissions/ removals		
				Simple Decay Approach		
Inventory Year	Stock Change	Atmospheric Flow	Production	nnual harve	Annual CO2 release	Total Contribution
1990	-110	-110	-110	-924	814	-110
1991	-107	-107	-107	-924	817	-107
1992	-105	-105	-105	-924	819	-105
1993	-102	-102	-102	-924	822	-102
1994	-100	-100	-100	-924	824	-100
1995	-98	-98	-98	-924	826	-98
1996	-95	-95	-95	-924	829	-95
1997	-93	-93	-93	-924	831	-93
1998	-91	-91	-91	-924	833	-91
1999	-89	-89	-89	-924	835	-89
2000	-87	-87	-87	-924	837	-87
2001	-85	-85	-85	-924	839	-85
2002	-83	-83	-83	-924	841	-83
2003	-81	-81	-81	-924	843	-81
2004	-79	-79	-79	-924	845	-79
2005	-78	-78	-78	-924	846	-78
2006	-76	-76	-76	-924	848	-76
2007	-74	-74	-74	-924	850	-74
2008	-72	-72	-72	-924	852	-72
2009	-71	-71	-71	-924	853	-71

12.1.2 Scenario 2

Harvest, saw wood and paper production is increasing since 1990 as show Figure 59, result and impact quantification is in Table 16. Differences between first and second variant is shown on Table 17.

	A	B	C	F	G	H	N	O	P	Q	R
1	**Test-paper100%orrigin**										
2	**FAOSTAT**										
3			**Roundwood**			**Sawnwood**			**Paper+Paperboard**		
4			Production			Production			Production	Imports	Exports
20		1975	1 000 000			500 000			300 000		
21		1976	1 000 000			500 000			300 000		
22		1977	1 000 000			500 000			300 000		
23		1978	1 000 000			500 000			300 000		
24		1979	1 000 000			500 000			300 000		
25		1980	1 000 000			500 000			300 000		
26		1981	1 000 000			500 000			300 000		
27		1982	1 000 000			500 000			300 000		
28		1983	1 000 000			500 000			300 000		
29		1984	1 000 000			500 000			300 000		
30		1985	1 000 000			500 000			300 000		
31		1986	1 000 000			500 000			300 000		
32		1987	1 000 000			500 000			300 000		
33		1988	1 000 000			500 000			300 000		
34		1989	1 000 000			500 000			300 000		
35		1990	1 000 000			500 000			300 000		
36		1991	1 100 000			500 000			355 000		
37		1992	1 200 000			500 000			410 000		
38		1993	1 300 000			500 000			465 000		
39		1994	1 400 000			500 000			520 000		
40		1995	1 500 000			500 000			575 000		
41		1996	1 600 000			500 000			630 000		
42		1997	1 700 000			500 000			685 000		
43		1998	1 800 000			500 000			740 000		
44		1999	1 900 000			500 000			795 000		
45		2000	2 000 000			500 000			850 000		
46		2001	2 100 000			500 000			905 000		
47		2002	2 200 000			500 000			960 000		
48		2003	2 300 000			500 000			1 015 000		
49		2004	2 400 000			500 000			1 070 000		
50		2005	2 500 000			500 000			1 125 000		
51		2006	2 600 000			500 000			1 180 000		
52		2007	2 700 000			500 000			1 235 000		
53		2008	2 800 000			500 000			1 290 000		
54		2009	2 900 000			500 000			1 345 000		
55		2010									

Figure 59. Activity data - Scenario 2, 1st variant

Table 16. Table 12.1 Results for Scenario 2, 1st variant

Excel Table 12.1 - HWP Contribution to AFOLU emissions/ removals by Approach						
Inventory Year	HWP Contribution to AFOLU emissions / removals	HWP Contribution to AFOLU emissions / removals	HWP Contribution to AFOLU emissions / removals	HWP Contribution to AFOLU emissions/ removals		
				Simple Decay Approach		
Inventory Year	Stock Change	Atmospheric Flow	Production	nnual harve	Annual CO2 release	Total Contribution
1990	-110	-110	-110	-924	814	-110
1991	-190	-190	-190	-1 016	827	-190
1992	-257	-257	-257	-1 109	852	-257
1993	-314	-314	-314	-1 201	887	-314
1994	-365	-365	-365	-1 294	929	-365
1995	-410	-410	-410	-1 386	976	-410
1996	-452	-452	-452	-1 478	1 027	-452
1997	-490	-490	-490	-1 571	1 081	-490
1998	-526	-526	-526	-1 663	1 137	-526
1999	-561	-561	-561	-1 756	1 195	-561
2000	-594	-594	-594	-1 848	1 254	-594
2001	-625	-625	-625	-1 940	1 315	-625
2002	-656	-656	-656	-2 033	1 377	-656
2003	-686	-686	-686	-2 125	1 440	-686
2004	-714	-714	-714	-2 218	1 503	-714
2005	-743	-743	-743	-2 310	1 567	-743
2006	-770	-770	-770	-2 402	1 633	-770
2007	-796	-796	-796	-2 495	1 698	-796
2008	-822	-822	-822	-2 587	1 765	-822
2009	-848	-848	-848	-2 680	1 832	-848

Table 17. Table 12.1 Results for Scenario 2, 2nd variant

Excel Table 12.1 - HWP Contribution to AFOLU emissions/ removals by Approach						
Inventory Year	HWP Contribution to AFOLU emissions / removals	HWP Contribution to AFOLU emissions / removals	HWP Contribution to AFOLU emissions / removals	HWP Contribution to AFOLU emissions/ removals		
				Simple Decay Approach		
Inventory Year	Stock Change	Atmospheric Flow	Production	nnual harve	Annual CO2 release	Total Contribution
1990	-110	-110	-110	-924	814	-110
1991	-261	-261	-261	-1 016	756	-261
1992	-367	-367	-367	-1 109	742	-367
1993	-441	-441	-441	-1 201	760	-441
1994	-493	-493	-493	-1 294	801	-493
1995	-529	-529	-529	-1 386	857	-529
1996	-554	-554	-554	-1 478	925	-554
1997	-571	-571	-571	-1 571	1 000	-571
1998	-582	-582	-582	-1 663	1 081	-582
1999	-590	-590	-590	-1 756	1 166	-590
2000	-594	-594	-594	-1 848	1 254	-594
2001	-597	-597	-597	-1 940	1 343	-597
2002	-599	-599	-599	-2 033	1 434	-599
2003	-599	-599	-599	-2 125	1 526	-599
2004	-599	-599	-599	-2 218	1 619	-599
2005	-598	-598	-598	-2 310	1 712	-598
2006	-597	-597	-597	-2 402	1 805	-597
2007	-596	-596	-596	-2 495	1 898	-596
2008	-595	-595	-595	-2 587	1 992	-595
2009	-594	-594	-594	-2 680	2 086	-594

Table 18. Differences in emissions estimates between 1st and 2nd variant

Excel Table 12.1 - HWP Contribution to AFOLU emissions/ removals by Approach

Inventory Year	HWP Contribution to AFOLU emissions / removals	HWP Contribution to AFOLU emissions / removals	HWP Contribution to AFOLU emissions / removals	HWP Contribution to AFOLU emissions/ removals		
				Simple Decay Approach		
Inventory Year	Stock Change	Atmospheric Flow	Production	nnual harve	Annual CO2 release	Total Contribution
1990	0%	0%	0%	0%	0%	0%
1991	-37%	-37%	-37%	0%	9%	-37%
1992	-43%	-43%	-43%	0%	13%	-43%
1993	-40%	-40%	-40%	0%	14%	-40%
1994	-35%	-35%	-35%	0%	14%	-35%
1995	-29%	-29%	-29%	0%	12%	-29%
1996	-23%	-23%	-23%	0%	10%	-23%
1997	-16%	-16%	-16%	0%	7%	-16%
1998	-11%	-11%	-11%	0%	5%	-11%
1999	-5%	-5%	-5%	0%	2%	-5%
2000	0%	0%	0%	0%	0%	0%
2001	5%	5%	5%	0%	-2%	5%
2002	9%	9%	9%	0%	-4%	9%
2003	13%	13%	13%	0%	-6%	13%
2004	16%	16%	16%	0%	-8%	16%
2005	19%	19%	19%	0%	-9%	19%
2006	22%	22%	22%	0%	-11%	22%
2007	25%	25%	25%	0%	-12%	25%
2008	28%	28%	28%	0%	-13%	28%
2009	30%	30%	30%	0%	-14%	30%

12.2 Annex 2 - The HWP Results without Pulp and Paper

Table 19 and Table 20 show results for the HWP calculation sheet, where updated and adapted HWP calculation sheet was used. Compared to the chapter 7.2 data about paper production, paper and pulp import and export was not taken into account. Figures are not provided because the graphs for wood are the same and for paper values are 0. The same parameters and conversion factors as presented on Figure 32 were applied.

Table 5, Table 6, Table 19 and Table 20shows that the difference in total emissions 1990-2009 from HWP is 10% for Stock Change Approach, 6 % for Atmospheric Flow Approach and 0 % for Production Approach. The influence of paper on the total stored carbon is relatively low.

Table 19. Table 12.7 - results for the HWP calculation sheet, where mistakes was fixed

Table 12.7 Sectoral Background Data for AFOLU											
Annual Carbon HWP Contribution to Total AFOLU CO_2 Removals and Emissions and Background Information											
	Variable number										
	1A	1B	2A	2B	3	4	5	6	7	8	9
Inventory year	Annual Change in stock of HWP in use from consumption	Annual Change in stock of HWP in SWDS from consumption	Annual Change in stock of HWP in use produced from domestic harvest	Annual Change in stock of HWP in SWDS produced from domestic harvest	Annual Imports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Exports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Domestic Harvest	Annual release of carbon to the atmosphere from HWP consumption (from fuelwood & products in use and products in SWDS)	Annual release of carbon to the atmosphere from HWP (including fuelwoood) where wood came from domestic harvest (from products in use and products in SWDS)	HWP Contribution to AFOLU CO_2 emissions/ removals	Approach used to estimate HWP Contribution[1]
	$\Delta C_{HWP\ IU\ DC}$	$\Delta C_{HWP\ SWDS\ DC}$	$\Delta C_{HWP\ IU\ DH}$	$\Delta C_{HWP\ SWDS\ DH}$	P_{IM}	P_{EX}	H	$\uparrow C_{HWP\ DC}$	$\uparrow C_{HWP\ DH}$		
	Gg C /yr									Gg CO_2 /yr	
1990	377	377	377	377	377	377	377	377	377		
1991	-33	-33	-33	-33	-33	-33	-33	-33	-33		
1992	-238	-238	-238	-238	-238	-238	-238	-238	-238		
1993	13	13	13	13	13	13	13	13	13		
1994	10	10	10	10	10	10	10	10	10		
1995	6	6	6	6	6	6	6	6	6		
1996	8	8	8	8	8	8	8	8	8		
1997	10	10	10	10	10	10	10	10	10		
1998	24	24	24	24	24	24	24	24	24		
1999	45	45	45	45	45	45	45	45	45		
2000	155	155	155	155	155	155	155	155	155		
2001	164	164	164	164	164	164	164	164	164		
2002	235	235	235	235	235	235	235	235	235		
2003	274	274	274	274	274	274	274	274	274		
2004	273	273	273	273	273	273	273	273	273		
2005	316	316	316	316	316	316	316	316	316		
2006	467	467	467	467	467	467	467	467	467		
2007	475	475	475	475	475	475	475	475	475		
2008	361	361	361	361	361	361	361	361	361		
2009	352	352	352	352	352	352	352	352	352		

Table 20.Table 12.1 - results for the HWP calculation sheet, where mistakes was fixed

Excel Table 12.1 - HWP Contribution to AFOLU emissions/ removals by Approach						
Inventory Year	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals	HWP Contribution to AFOLU emissions/ removals		
				Simple Decay Approach		
Inventory Year	Stock Change	Atmospheric Flow	Production	Annual harvest	Annual CO2 release	Total Contribution
1990	-1 901	-3 003	-2 102	-11 709	9 607	-2 102
1991	-403	-1 824	-913	-9 847	8 934	-913
1992	327	-1 170	-92	-9 375	9 283	-92
1993	-604	-2 701	-1 286	-9 615	8 329	-1 286
1994	-596	-3 513	-1 630	-11 042	9 411	-1 630
1995	-596	-4 147	-2 113	-11 425	9 313	-2 113
1996	-615	-4 718	-2 406	-11 642	9 236	-2 406
1997	-636	-4 505	-2 187	-12 466	10 279	-2 187
1998	-704	-3 906	-1 789	-12 928	11 139	-1 789
1999	-740	-4 244	-1 992	-13 124	11 131	-1 992
2000	-1 181	-4 016	-2 190	-13 343	11 153	-2 190
2001	-1 221	-4 396	-2 301	-13 282	10 981	-2 301
2002	-1 412	-4 327	-2 174	-13 436	11 262	-2 174
2003	-1 644	-5 702	-3 051	-13 989	10 939	-3 051
2004	-1 658	-5 772	-3 109	-14 415	11 306	-3 109
2005	-1 832	-5 707	-3 127	-14 331	11 204	-3 127
2006	-2 418	-6 523	-4 025	-16 334	12 310	-4 025
2007	-2 469	-7 150	-4 680	-17 101	12 421	-4 680
2008	-2 072	-6 084	-3 808	-14 957	11 149	-3 808
2009	-2 069	-6 082	-3 759	-14 957	11 197	-3 759

12.3 Annex 3 - Upgraded waste calculation sheet

Upgraded waste calculation sheet comes from the 2006 IPCC Guidelines. Only sheet “Results” was slightly modified to provide values for CO2 emissions (direct CO2 emissions, and indirect CO2 from CH4 oxidation and recovery).

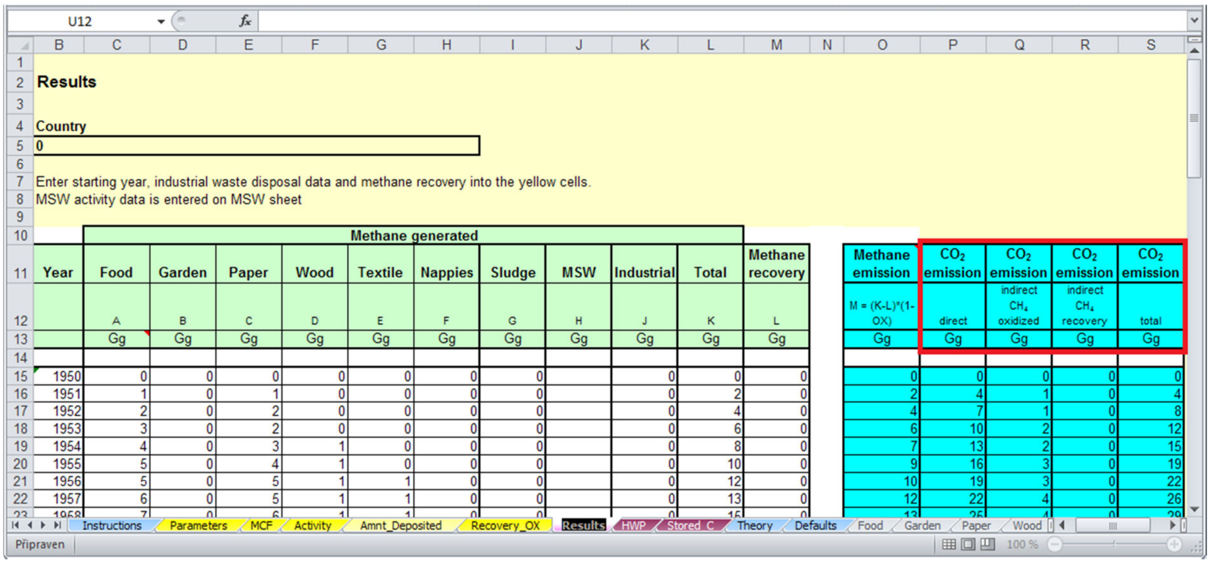

Figure 60. Upgraded waste calculation sheet

The MS Excel sheet is provided in the electronic form.

12.4 Annex 4 - Advantages and disadvantages of approaches

Table 21. Advantages and disadvantages of approaches

Issue	Approach						Source
	IPCC default	SCA	AFA	PA	SDA	SCAD	
Data intensity / applicability / cost / complexity	0	-	-	--	-	---	Ford-Robertson, 2003
	0	-	--	--	--	---	Kim Pingoud, 2008a; Kim Pingoud, 2008b
	0	--	-	---	n.a.	---	Brown S. et. al, 1998
	0	-	-	--	n.a.	n.a.	Flugsrud et al, 2001
	0	-	-	--	n.a.	n.a.	Skog and Pingoud in UN FCCC, 2004
Activity data quality	++	+	+	-	++	-	Ford-Robertson, 2003
Accuracy	0	+	++	+	++	+	Ford-Robertson, 2003
	0	+++	++	+	++	+	Flugsrud et al, 2001
	0	+	++	+	n.a.	n.a.	Brown S. et. al, 1998
Completeness	++	+	+	-	++	---	Ford-Robertson, 2003
	n.a.	-	-	+	n.a.	n.a.	Skog and Pingoud in UN FCCC, 2004
Uncertainty	0	-	+	-	-	--	Kim Pingoud, 2008a
	0	+	+	-	+	-	Kim Pingoud, 2009a
Transparency	0	+	-	--	n.a.	n.a.	Flugsrud et al, 2001
Timing	0	+	++	+	+	+	Ford-Robertson, 2003
Respect national boundaries	-	+	+	-	-	n.a.	Ford-Robertson, 2003
	-	+	+	-	+	n.a.	Kim Pingoud, 2008b
	-	+	+	-	+	n.a.	Kim Pingoud, 2008a
Emissions responsibility	Producer	Consumer	Consumer	Consumer / exporter	Producer	Consumer	Ford-Robertson, 2003
Incentives to use domestically produced biomass	0	0	-	0	0	0	Ford-Robertson, 2003
	+						Kim Pingoud, 2008b
	+	+	+	+	n.a.	n.a.	Brown S. et. al, 1998
	+	+	-	+	n.a.	n.a.	Grêt-Regamey et al, 2008
as biofuel	+	+	-	n.a.	n.a.	n.a.	Flugsrud et al, 2001
Incentives to import biofuel / for deforestration	n.a.	+	n.a.	-	n.a.	No	Kim Pingoud, 2009a
	+	+	-	+	n.a.	n.a.	Brown S. et. al, 1998
Incentives for export of domestically produced biomass	-	-	+	+	n.a.	n.a.	Flugsrud et al, 2001

Issue	Approach						Source
	IPCC default	SCA	AFA	PA	SDA	SCAD	
Incentives for product substitution	0	prefer long-lived	prefer long-lived	prefer long-lived	prefer long-lived	prefer long-lived	Ford-Robertson, 2003
	0	+	+	-+	n.a.	n.a.	Brown S. et. al, 1998
Incentives for recycling	0	+	+	+	+	+	Ford-Robertson, 2003
	++	++	+++	+	n.a.	n.a.	Grêt-Regamey et al, 2008
Incentives for trade	0	-	-	-+	0	-+	Ford-Robertson, 2003
	0	0	0	0	n.a.	n.a.	Grêt-Regamey et al, 2008
Sustainable forest management	-	-	+	?	n.a.	n.a.	Ford-Robertson, 2003
	(+-) incentives for no harvest	(-) incentives for import	+-	(-) incentives for export	n.a.	n.a.	Grêt-Regamey et al, 2008
Conservation of forest carbon stocks	+	+	probably +	+	n.a.	n.a.	Brown S. et. al, 1998
Consistency with LULUCF reporting	0	+	-	+	+	+	Kim Pingoud, 2008b
Kyoto Protocol coverage	+	-	-	-	-	-	Kim Pingoud, 2008a
Possibility for cheating	-	+	++	+	-	++	Kim Pingoud, 2008a
Prevent use of imported wood from unsustainable sources	-	-	n.a.	n.a.	n.a.	n.a.	Kim Pingoud, 2008a
Special request on national (foreign) statistics	-	+	-	+	-	+	Kim Pingoud, 2008a
	-	+	+	+	n.a.	n.a.	Grêt-Regamey et al, 2008
Full cover of HWP-C balance	+	+	+	?	+	-	Kim Pingoud, 2008a
Emissions validation / verification	0	-	+	-	+	--	
Data validation / verification	0	+	+	-	+	--	

+ positive effect, ++ stronger positive effect, +++ the strongest positive effect
- negative effect, -- stronger negative effect, --- the strongest negative effect
0 without effect
n.a. – the effect is not described
? – direction of effect is not clear
-+ sometimes negative and sometimes positive effect