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Carbon footprint of toilet tissue paper: Comparison of toilet tissue using 100% fresh fiber pulp and 100% recovered fiber pulp.

Carbon footprint reported according to the order placed on the 30th of May 2008.

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ENCLOSURES	Appendices 1 and 2
DISTRIBUTION	Phil Mogel. David Spitzley, Martina Eisenbeis, Kimmo Lahti-nuuttila,
DATA	Results are available electronically in the following files:
	Carbon footprint of toilet tissue report22.1.2009__.pdf Appendix 1, Summaries Appendix 2 Power point presentation

Carbon footprint of toilet tissue paper: Comparison of toilet tissue using 100% fresh fiber pulp and 100% recovered fiber pulp.

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1. Introduction

The CO2 equilvalents (including CO_2, CH_4 and N_2O) were calculated for two toilet tissue products taking into account the main production process plus related processes and transports from harvesting to customer. The studied products are the following:

1. Toilet Tissue 100 % Fresh fiber pulp
2. Toilet tissue 100% recovered fiber pulp

The data used is from KCL EcoData database as follows:

- Forestry
  - Harvesting
    - Birch
    - Pine
  - Pulp production
    - HW
    - SW
    - Eucalyptus
- Chemicals production including:

	Fresh fiber	RCF
NaOH	x	x
$NaClO_3$, manufacturing (IIASA)	x	
O_2, (gas)	x	
H_2SO_4	x	

- Tissue production 100% fresh fiber
- Tissue production 100% recovered fiber
- Internal energy production
- External energy production
- Transportations to the mill including the following assumed distances and modes of conveyance:
  - Wood: 100 km by 42 t truck for wood transports
  - Chemicals: 200km by 25t truck 50%, train el 25%/train diesel25%
  - HW eucalyptus pulp from South America: 11700km bycontainer ship ocean 275 000DWT, 100km ship barge 8000 DWT, 400km 38t truck
  - SW pulp from North America: 5050km by container ship ocean 275 000DWT, 350 km 25t truck, 350km 38t truck
  - SW and HW from Europe: 1000km by ship 4500 DWT
  - Recovered fiber paper to DIP: 200km by 25t truck
  - Tissue to customer by: 500km by 25t truck
  - DIP waste to landfill: 30km by 9t truck

Table 1. Modes of conveyance and distances

Material	Mode of transportation	Distance (km)	Specific / Assumption
Chemicals to tissue mill	truck 25t, EURO 3 50/ Train el /diesel 50/50	200	assumption
Pulp NA to tissue mill	truck 38t, Containership, ocean; 275 000, truck 25t, Euro3,	350 + 5050 + 350	calculated
Pulp SA to tissue mill	Containership, ocean; 275 000, ship barge 8000, truck 25t, Euro3,	11700 + 100 + 400	calculated
Pulp Eur to tissue mill	Ship 4500DWT, lolo, truck 25t, Euro 3 100	1000 + 100	assumption
Recycled paper to DIP	Truck 25t, Euro 3	200	assumption
Wood transport	truck 42t wood	100	assumption
Tissue paper to customer	Truck 25t, Euro3	500	assumption

The electricity modules are based on EcoInvent data.

The harvesting modules are also agglomerated and are based on the real finnish proportions of harvesting operations i.e 1st thinning / 2nd thinning / reg.felling represents 6.7 % / 20.3 % / 73 % of all harvesting operations in Finland in 1999.

The modules for HW Eucalyptus pulp and SW pulp NA are also agglomerated data and include harvesting, chemicals production and transports to the pulp mill.

The transport of tissue to customer is assumed to be half full by weight load and the empty return is taken into account. An empty truck consumes approximately 70% of the fuel a fully loaded truck consumes.

In the recovered fiber case a sensitivity analysis was made for the footprint of the waste paper coming into the system.

According to the study made by ERM[1] the allocation of environmental impacts of waste papers first life to the waste paper collected for tissue production was considered explained as follows.

It is considered that some account of the environmental impact associated with the loss of fiber resource from recycling system should be made, since the tissue product can not be recovered.

[1] Environmental Resource Management (ERM), Life Cycle Assessment of Tissue Products, sponsored by Kimberly Clark, Final Report December 2007

Using the principles of ISO 14049 for allocating first life and assuming 5 uses prior to tissue production and applying a 30% recycling rate the footprint of waste paper would be (30%+9%+2,7%+0,81%+0,24%)/5 = 8,55%. The formula shows how much fiber is left after every use when it is assumed that 30% of fibers are recovered fiber.

Three different scenarios were compared:

a) 8,55% of the burdens from the paper manufacturing was allocated to recovered paper. Assumption: The paper has 5 uses prior to tissue production
b) 19,55% of the burdens from the paper manufacturing was allocated to recovered paper. Assumption: The paper has 2 uses prior to tissue production.
c) Cut-off, no burden allocated

The sourcing of fresh fiber pulp was divided according to ETS as follows:

- Europe 64.1%
- North America 9.4%
- South America 26.5%
- Asia 0%

It was assumed that the deinked pulp was 50% high grade paper (woodfree) and 50% low grade (70% news and 30% magazine).

Deink Pulp waste usage/disposal was divided as follows

- Landfill 5.7%
- Energy 7.4%
- Other 86.8%

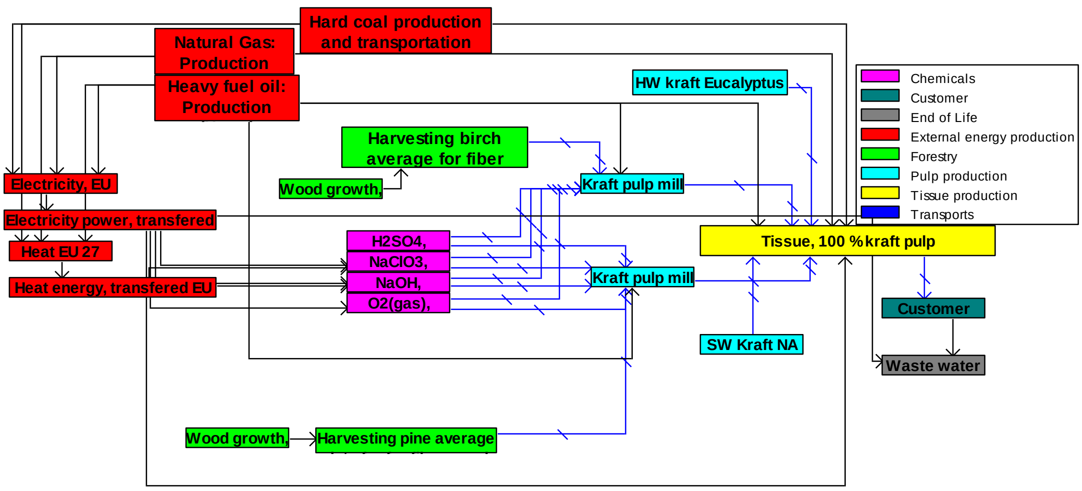

Figure 1. Flowsheet of the fresh fiber toilet tissue

The above figure shows the life cycle stages of fresh fiber toilet tissue and the processes included in these. The eucalyptus pulp and the SW kraft NA are cradle to gate data, including harvesting, transports etc. The external energy production includes fuel production and electricity and heat generation needed for the processes.

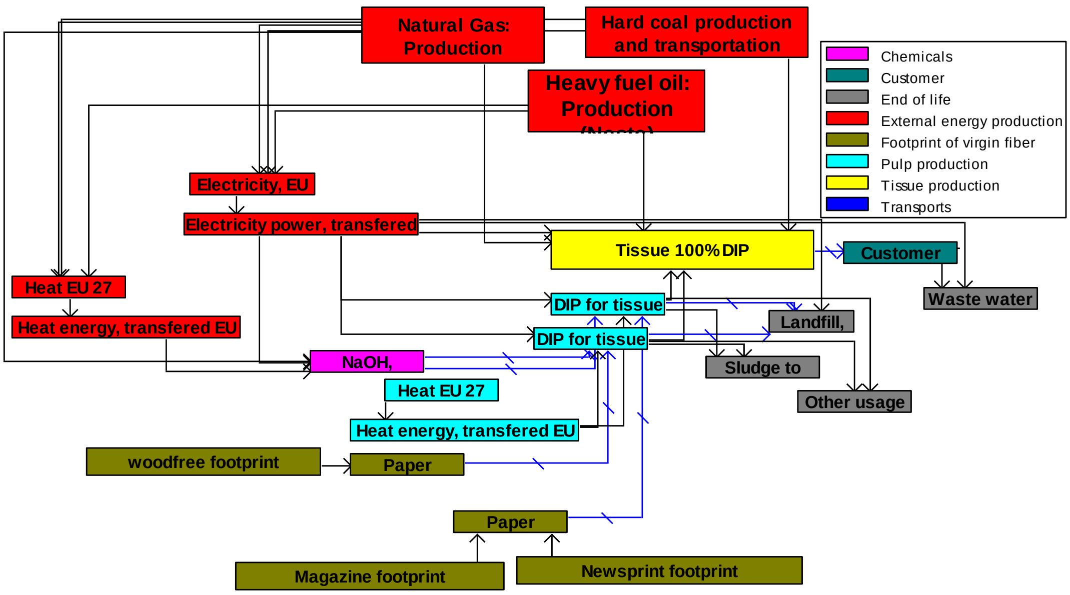

Figure 2. Flowsheet of the recovered fiber toilet tissue

The above figure shows the life cycle stages of recovered fiber toilet tissue and the processes included in these. In this figure also the footprint modules for recovered paper are included. The generation of electricity needed for e.g. DIP production is included in the external energy life cycle stage.

2. Results

The carbon footprint is calculated by adding CO_2 (fossil), CH_4 and N_2O according to the CO_2 eq factors:

- CO_2 (fossil) = 1
- CH_4 = 25
- N_2O = 298

The source modules of CO2 emissions can be found in appendix 1. The summary on the total inputs and outputs can be found in appendix 2.

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The CO_2eq by life cycle stages from cradle to customer are presented in *figure 3* below:

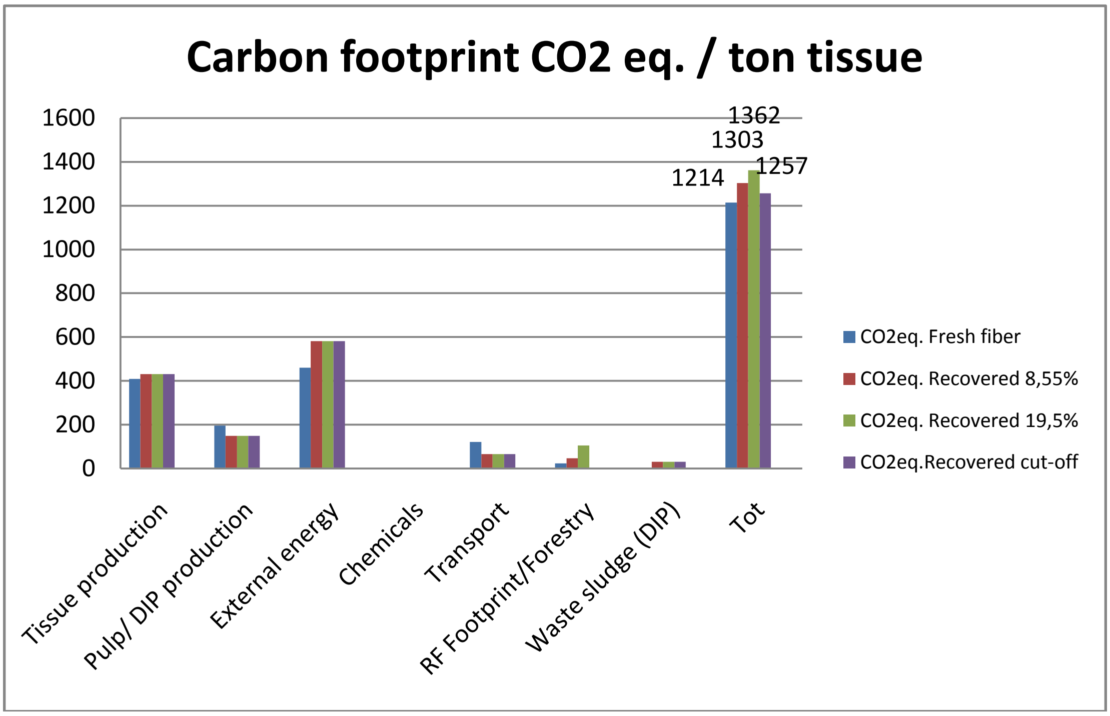

Figure 3. CO2 eq. for the fresh fiber and recovered fiber toilet tissue.

As can be seen in *figure 3* above the results are very much the same for the virgin and recovered fiber case. The result mostly depends on the footprint/burden chosen for the recovered fiber paper. The result vary less than 10% procent for cut off and the 19,5% burden.

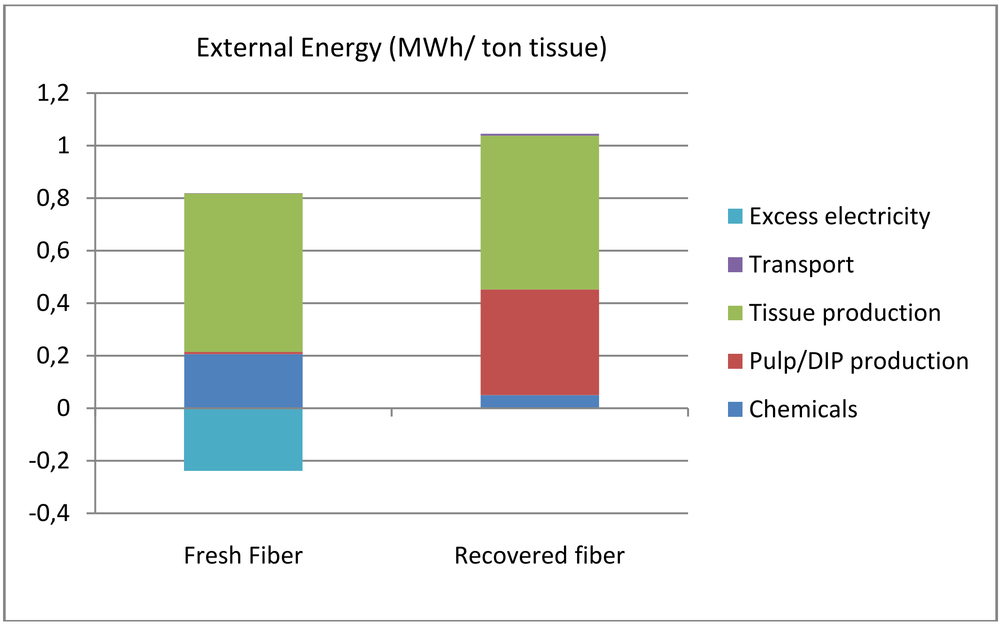

Figure 4. External energy use divided by life cycle stage

The small part of external energy going to the fresh fiber pulp production is due to the agglomerated data for Eucalyptus pulp and North American pulp. The electricity of those is for the chemicals used e.g.

The external energy use is higher for the recovered case as the DIP process is electricity intensive and the fresh fiber production on the other hand does not use any electricity. The excess electricity from fresh fiber production is not taken into account as a benefit the fresh fiber use in the calculations of *figure 3*. The excess electricity from pulp production equals 0,238 MWh and is shown in *figure 4* above. This equals 58 kg of CO_2 eq. So if the excess electricity produced at the fresh fiber pulpmill would be utiliced in this system the CO_2 eq. would be 58 kg lower for the fresh fiber case.

The end of life of the toilet tissue paper is very hard to estimate and thus no carbon footprint of it is included in the results. At the Finnish environmental institute they thought it would be impossible to estimate how or the energy use and emissions of a waste water treatment plant could be allocated to the toilet tissue paper. An expert point of view was that some of the toilet tissue will stay in the primary sedimentation and the rest in the biosludge. As the tissue is pulp cellulose it won't degrade aerobically and thus does not use any electricity for aeration. If the plant has a methane tank some of the tissue might decompose and form methane which will be used for electricity and heat production. The undecomposed share will go to the sludge drying, but what the share of toilet tissue of the total sludge is is unknown. The cleaning of waste water uses process electricity 1,44MJ/t TS waste water. This equals to 0,06 kg of CO_2 eq. per ton of tissue and can be considered as neglible.

3. Conclusions

The allocation of environmental impacts of the waste papers first life to the waste paper is not of very high significance when using the allocation percentages we have. Of course if all burdens (system expansion would be used the result would be different). Here the influence is less than 10%. Using cut off makes the recoverd fiber the better choice but when a burden from previous life is allocated to the recovered fiber the fresh fiber has a lower carbon footprint. However, cut-off methodology is not in accordance with ISO standards, and therefore it is recommended to allocate burdens to recovered paper.

The excess energy produced at a fresh pulp mill is not included in the calculations. This amount of electricity produced, if utilized in this system, equals a reduction of 58 kg of CO_2 eq for fresh fiber tissue. The excess energy of a pulp mill can better be utilized when the pulp and paper mill is integrated, however most pulp mills are unintegrated and therefore the calculations of this study are made according to that.