Sustainable design of Chair design Concepts

using GaBi i-report

Floating chair

Bobby Petersen & Tom Gottelier

1 Disclaimer

The results shown in the report are based on a generic model of a life cycle of a chair and the specific parameters per chair as shown in the parameter chapter and the modelling assumptions as described in the modelling chapter.

The specific parameters have been collected by each student specific per chair during manufacturing of the prototypes at Benchmark's workshop and validated by Sean Suttcliff before being entered into the i-report.

The results have to be seen in context with the parameters and assumptions shown in this report. They are representative for the manufactured prototypes and may change during mass mproduction. They should not be used for comparison of the different chairs due to the different nature of the chairs like different application and size.

Goal of this excersise was to raise the environmental awareness of future product designers and provide an easy to use solution to make the environmental view an integral part of product design.

2 Out of the Woods: Adventures of 12 Hardwood Chairs

The American Hardwood Export Council teams up with the Royal College of Art to merge design with sustainability

The American Hardwood Export Council has collaborated with product design students at the Royal College of Art in London to produce and exhibit chairs during the London Design Festival.

Under the leadership of tutors Sebastian Wrong (Established & Sons) and Harry Richardson (Committee), the use of wood as a material and its associated Life Cycle impacts have been added to the Design Products programme and the students have been set the challenge of designing a functional chair or seat in an American hardwood of their choice.

The designs have been developed in to working prototypes with the help of Benchmark, internationally renowned for its craftsmanship in wood and long-standing relationship with designer Terence Conran. The students camped out on Terence Conran's lawn by night and descended on Benchmark's workshops by day in early July where the company's highly skilled craftsmen, led by owner Sean Sutcliffe, helped them turn their ideas into reality.

“I was very impressed with the quality of the designs and the students' enthusiasm for their projects,” says Sutcliffe. “As experts in woodworking, we saw some very strong pieces come to fruition.”

The American Hardwood Export Council (AHEC) is well known in the international design community for its creative promotion of hardwood, having worked with the likes of David Adjaye, Matteo Thun, Sou Fujimoto, Arup and Amanda Levete. But now its attention has turned to the potential stars of the future with a unique and ground-breaking project for students.

Education and research provides a unique element to the project because AHEC is using, for the first time, its ground-breaking Life Cycle Assessment (LCA) research. AHEC has recently announced the publication of the ISO-conformant report on the Life Cycle Assessment (LCA) of rough-sawn kiln-dried hardwood lumber. The report, which has been prepared by sustainability experts PE International after an intensive process of data collection, analysis, and review, is the first stage of AHEC's LCA project. The report covers the environmental life cycle of hardwood lumber from point of harvest in the U.S. through to delivery at the importers yard in major export markets. It provides quantitative data on Global Warming Potential, Acidification Potential, Eutrophication Potential, Photochemical Ozone Creation Potential, and Ozone Depletion Potential. It also provides a qualitative assessment of toxicity, biodiversity, land use and land use change, and water resource impacts. The report includes a sensitivity analysis to show how environmental impacts vary according to key factors such as species, lumber thickness, and transport distance and mode.

Using this data and data collected during the manufacturing process, including time spent on each machine and quantities of material used, each chosen prototype has been environmentally profiled using an 'i-report' system developed for AHEC by PE International. In producing detailed Life Cycle “cradle-to-grave” impact assessments for their designs this project allows the young designers to develop genuine understanding of the real and very direct environmental impact of their decisions when using U.S. hardwoods.

According to Sebastian Wrong, the project “offers a pioneering opportunity for students to create designs within the context of a stark reality.” His co-tutor Harry Richardson added, “it is not only a

Floating chair Bobby Petersen & Tom Gottelier case of designing a chair that will survive physically far in to the future, it is also to produce a chair whose design will remain relevant far in to the future."

David Venables, AHEC's European Director who developed the idea for the project with Sebastian Wrong, says: "The talent amongst these students is astounding. This project has given them the opportunity to work with hardwood and the fact that they can also see and understand the full environmental impact of their design gives this collaboration extra relevance to today's world, whilst setting it apart from other student design projects.".

The project team who made this project reality are:

American Hardwood Export Council www.americanhardwood.org

Benchmark Furniture www.benchmarkfurniture.com

Royal College of Art www.designproductsrca.com

PE INTERNATIONAL www.pe-international.com

More information on the team members can be found in the last chapter.

3 Chair design

Bobby Petersen and Tom Gottelier wanted to create an experience, not just a seat. Fascinated with the longevity and solidness of boat construction, they decided to design a floating chair. The boat has been built in marine ply and veneered in American cherry, which was chosen both for its high strength-to-weight ratio and for its colour, which will darken in sunlight. The keel is in American white oak, which is both durable and heavy – a desirable property for a keel. In an unusual twist, the boat can be controlled by a smart phone working with GPS, and the software will drive the propulsion system allowing you to sit back and relax while the boat takes you for a ride.

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Floating chair   Bobby Petersen & Tom Gottelier

4 LCA brief introduction

Life cycle assessment (LCA) is a standardized scientific method for systematic analysis of flows (e.g. mass and energy) associated with the life cycle of a specified product, a technology, a service or manufacturing process systems (ISO 2006). The approach in principle aims at a holistic and comprehensive analysis of the above items including raw materials acquisition, manufacturing as well as use and End-of-life (EoL) management. According to the International Organization for Standardization (ISO) 14040/44 standards, an LCA study consists of four phases : (1) goal and scope (framework and objective of the study); (2) life cycle inventory (input/output analysis of mass and energy flows); (3) life cycle impact assessment (evaluation of environmental relevance, e.g. global warming potential); and (4) interpretation (e.g. optimization potential) (ISO 2006).

The goal and scope stage outlines the rationale of the study, the anticipated use of the results of the study, the boundary conditions, the data requirements and the assumptions to analyze the product system under consideration, and other similar technical specifications for the study. The goal of the study is to answer the specific questions which have been raised by the target audience and the stakeholders involved, while considering potential uses of the study's results. The scope of the study defines the systems' boundary in terms of technological, geographical, and temporal coverage of the study, attributes of the product system, and the level of detail and the complexity addressed by the study.

The life cycle inventory (LCI) stage qualitatively and quantitatively analyzes the materials and energy used (inputs) as well as the products and by-products generated, the environmental releases in terms of non-retained emissions to the environmental compartments and the wastes to be treated (outputs) for the product system being studied. The LCI data can be used on its own to: understand total emissions, wastes and resource-use associated with the material or the product being studied; improve production or product performance; or be further analyzed and interpreted to provide insights into the potential environmental impacts from the system (life cycle impact assessment and interpretation, LCIA).

5 Environmental Impact categories considered

A comprehensive set of environmental impact categories has been investigated. The choice of categories was made based on the recommendations of the ILCD Handbook (ILCD Handbook, 2010) and the choice of indicators was made based on the European EPD rules for construction products (EN 15804, 2012).

The study life cycle impact assessment includes the following inventory flows and environmental categories: primary energy demand (total and non-renewable sources), global warming potential, photochemical oxidant creation potential (smog formation), acidification potential, stratospheric ozone depletion and eutrophication potentials.

In the selected impact categories the CML indicators were calculated. The methods and indicators for each category were chosen based on the European EPD rules for construction products (EN 15804, 2012).

The details of each impact category and its indicator are shown in the following table.

Category Indicator	Impact category	Description	Unit	Reference
Energy Use	Primary Energy Demand (PE)	A measure of the total amount of primary energy extracted from the earth. PE is expressed in energy demand from non-renewable resources (e.g. petroleum, natural gas, uranium, etc.) and energy demand from renewable resources (e.g. hydropower, wind energy, solar, etc.). Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account.	MJ	Guinée et al., 2001, factors updated in 2010
Climate Change	Global Warming Potential** (GWP)	A measure of greenhouse gas emissions, such as CO_2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, magnifying the natural greenhouse effect.	kg CO_2 equivalent	IPCC, 2006, *100 year GWP is used*
Eutrophication	Eutrophication Potential (CML)	A measure of emissions that cause eutrophying effects to the environment. The eutrophication potential is a stoichiometric procedure, which identifies the equivalence between N and P for both terrestrial and aquatic systems	kg Phosphate equivalent	Guinée et al., 2001, factors updated in 2010
Acidification	Acidification Potential (CML)	A measure of emissions that cause acidifying effects to the environment. The acidification potential is assigned by relating the existing S-, N-, and halogen atoms to the molecular weight.	kg SO2 equivalent	Guinée et al., 2001, factors updated in 2010
Ozone creation in troposphere	Photochemical Ozone Creation Potential (POCP)	A measure of emissions of precursors that contribute to low level smog, produced by the reaction of nitrogen oxides and VOC's under the influence of UV light.	kg Ethene equivalent	Guinée et al., 2001, factors updated in 2010
Stratospheric Ozone Depletion	Stratospheric Ozone Depletion	Refers to the thinning of the stratospheric ozone layer as a result of emissions. This effect causes a greater fraction of solar UV-B radiation to reach the surface earths, with potentially harmful impacts to human and animal health, terrestrial and aquatic ecosystems etc. referring trichlorofluoromethane, also called freon-11 or CFC 11	Kg CFC-11 equivalent or trichlorofluoro methane, also called freon-11 or R11	Guinée et al., 2001, factors updated in 2010

Biogenic carbon

During growth, carbon is stored in the wood via photosynthesis. This biogenic carbon is stored in the lumber and its subsequent products. The carbon stored in biomass will - sooner or later- be released – at the end of the product's life cycle. The end of the product's life cycle is not included in this study. The potential benefits from carbon storage, delayed emissions or substituting effect could be fully excluded or accounted differently according to different standards. To enable study stakeholders to utilise the data for different applications, and to avoid the AHEC communication being perceived as “green washing”, the stored (biogenic) carbon will be clearly quantified in the inventory for transparent carbon balance, and treated as a separate element in the report whilst not being subtracted from the Global Warming impact of the product.

Stored carbon that does not end up in the final lumber product, e.g. carbon stored in forest leftover biomass (e.g. small branches) or saw-mill co-products (e.g. chips, dust) is not assigned to the lumber. It is assumed to be eventually converted back to CO2 and emitted. Carbon in the forest floor or forest soil is not assigned to the lumber. Only the carbon that is stored in the final lumber product is accounted as stored carbon.

Not enough data is available on the carbon content in different hardwood species and a conservative value 46.27% carbon in abs dry mass was modeled as carbon storage for all hardwood species. This is a minimum value reported for hardwoods (Lamlom, Savidge, 2003).

Besides the carbon stored in the final lumber product, removals from the atmosphere from biogenic sources are not modeled in this study. Therefore, Biogenic carbon dioxide emissions are modeled as carbon neutral (no impact of the GWP) as they are offset by the uptake in biomass

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6 Modelling assumption

The follwing general assumptiion has been applied:

Handling of waste at workshop:

80% of the wood waste is burned in a boile with heat recovery - as oil is used at the workshop for heat generation, a credit for avoided heat manufacturing using oil has been given

20% of the wood waste is collected and potentially used in different applications - no credit has been assigned to this share

all other non inert waste materials are incinerated in a municipal waste incineration and truck 100 km - inert materials = metals

Transportation of material:

For all material used at the workshop the following distances have been assumed

100 km by train

100 km by ship

100 km by truck

Only exception is the bench made from green wood. No transportation is assumed as it is manufactured and used in the forest.

Transportation to Museum:

The distance from Benchmark to the museum is 100 km by truck

Chair's life end (EoL):

Transportation to incineration plant: 100km by truck

Incinerated with eneryg recovery

Additional comment

Electricity consumption for tools are entered as sum value
Engines and battery not included - considered additional equipment
0,24 l thinner excluded - in line with cut off

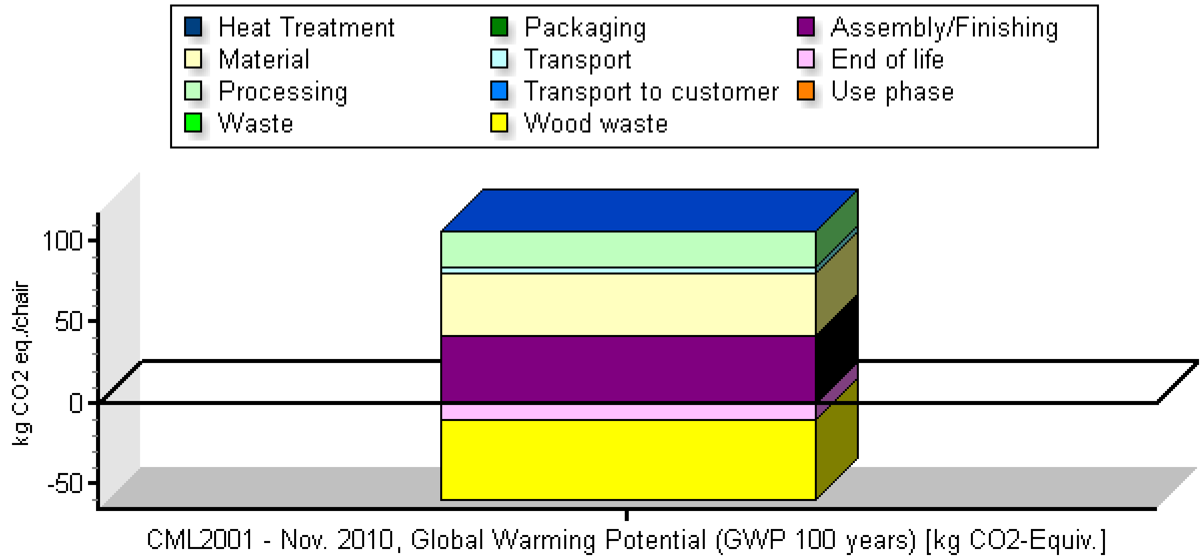
7 Results

This chapter shows the environmental performance for the different life cycle stages of the considered impacts.

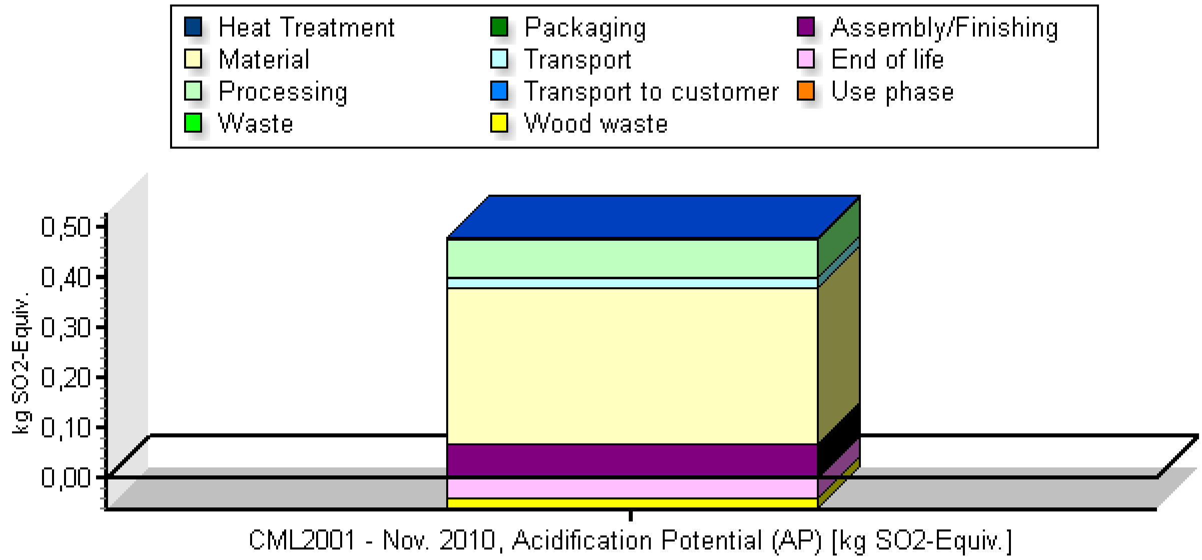
Overview Impact Assessment one chair prototype

	CML2001 - Nov. 2010, Acidification Potential (AP) [kg SO2-Equiv.]	CML2001 - Nov. 2010, Eutrophication Potential (EP) [kg Phosphate-Equiv.]	CML2001 - Nov. 2010, Global Warming Potential (GWP 100 years) [kg CO2-Equiv.]	CML2001 - Nov. 2010, Ozone Layer Depletion Potential (ODP, steady state) [kg R11-Equiv.]	CML2001 - Nov. 2010, Photochem. Ozone Creation Potential (POCP) [kg Ethene-Equiv.]	Primary energy demand from ren. and non ren. resources (net cal. value) [MJ]	Primary energy from resources (net cal. value) [MJ]
Assembly/Finishing	0,0697	0,0102	41,7	1,34E-007	0,0993	894	820
End of life	-0,0409	-0,00346	-10,1	-2,28E-008	-0,00251	-447	-438
Heat Treatment							
Material	0,313	0,0344	37,7	3,18E-007	0,0952	2,87E003	595
Packaging							
Processing	0,0774	0,0067	22,3	2,07E-007	0,00428	366	349
Transport	0,0183	0,00404	3,74	1,38E-009	-0,00402	53,7	51,7
Transport to customer	0,00285	0,000652	0,676	2,5E-010	-0,000904	9,72	9,36
Use phase							
Waste							
Wood waste	-0,0172	-0,00756	-49,7	-1,79E-008	-0,00428	-677	-676

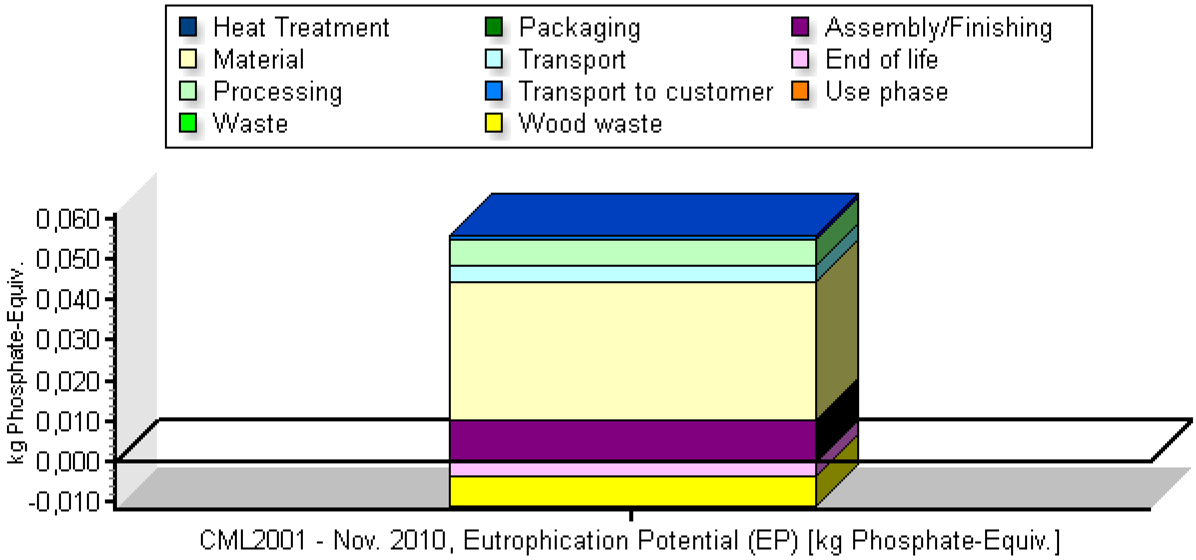
Global Warming Potential of life time of one chair prototype



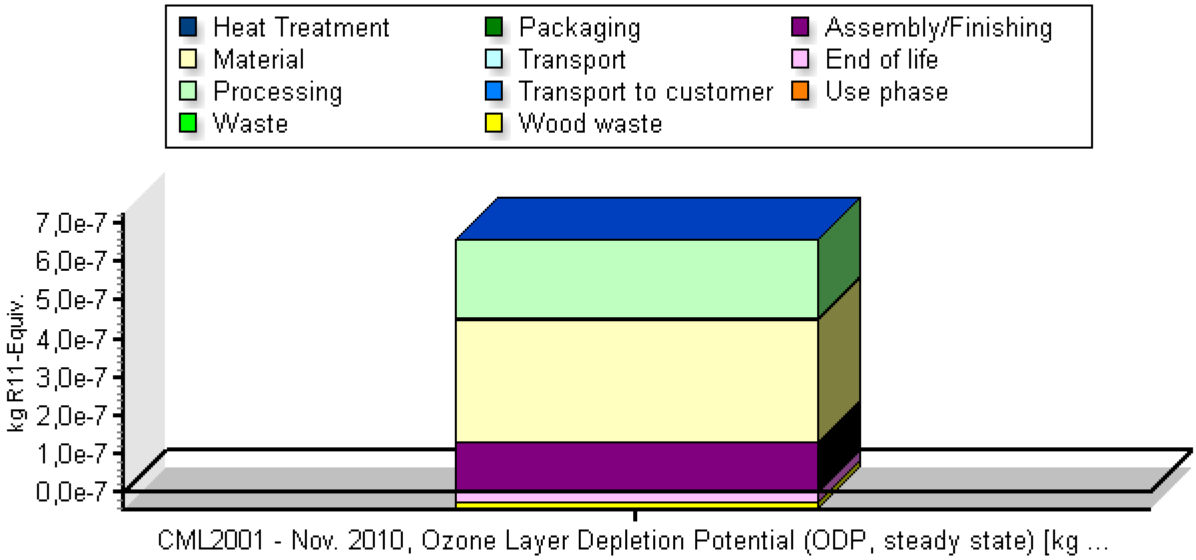
Acidification Potential of one chair prototype



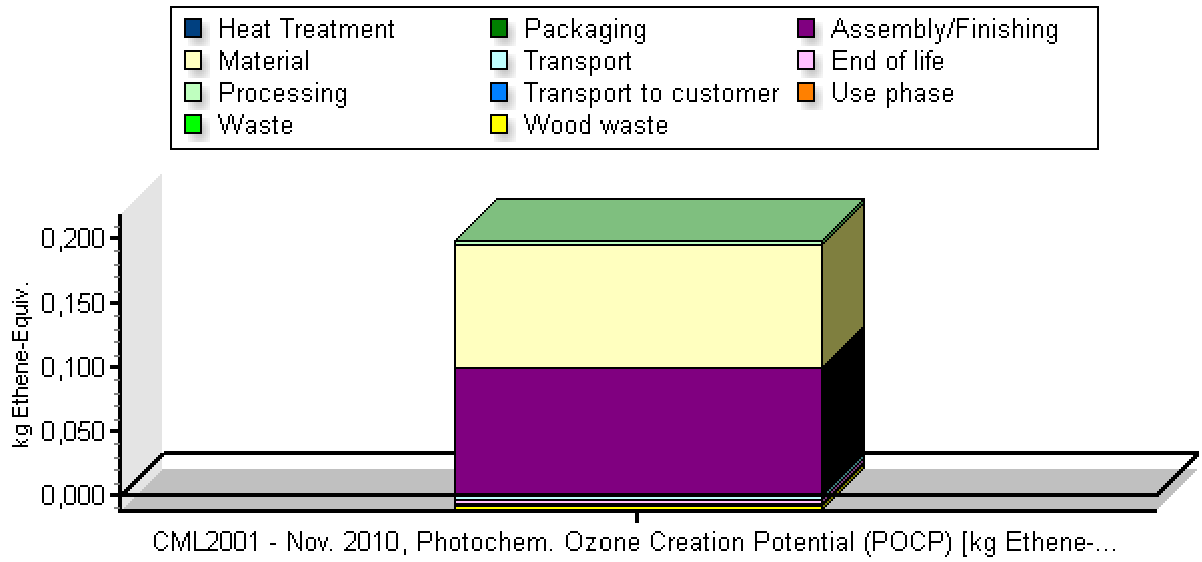
Eutrophication Potential of one chair prototype



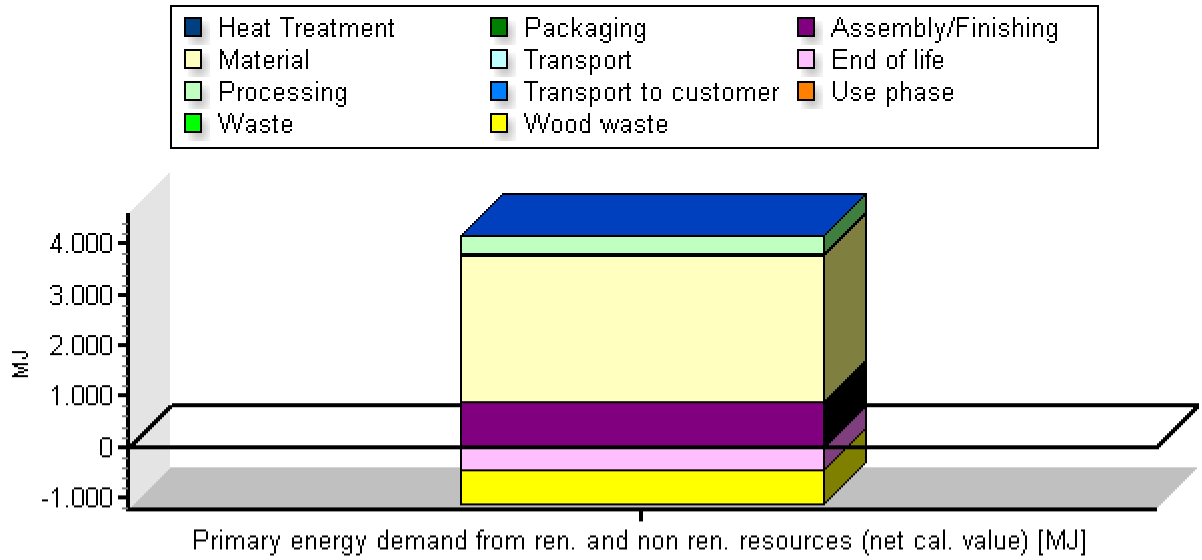
Ozone Depletion Potential of one chair prototype



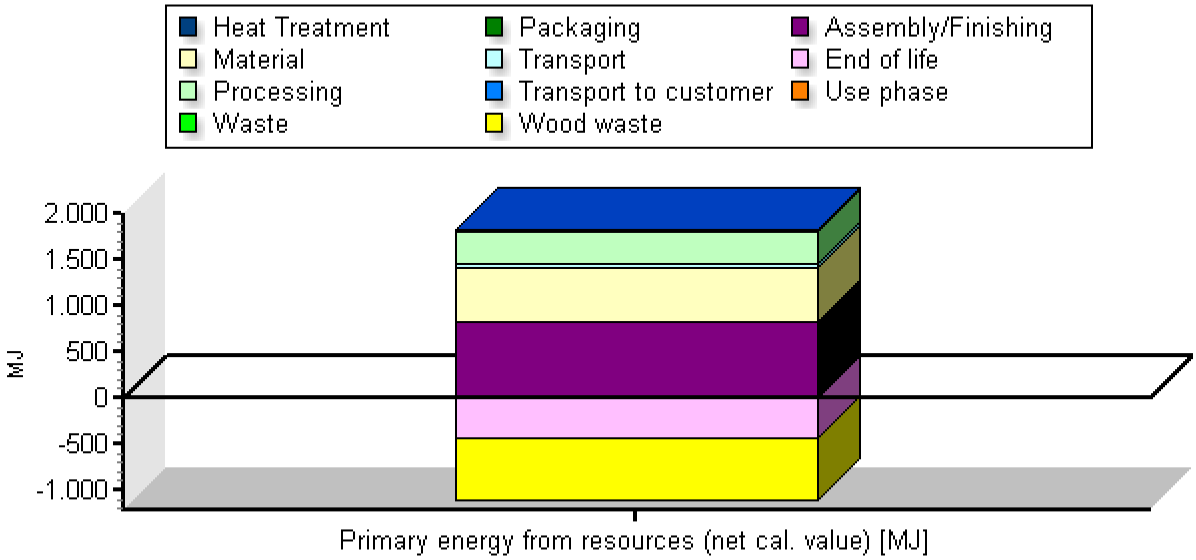
Photochem. Ozone Creation Potential of one chair prototype



Primary energy demand from ren. and non ren. resources of one chair prototype



Primary energy from non-renewable resources of one chair prototype



8 Impact Assessment of Material input

This chapter shows the impact for the different impact categories related to the material input needed during manufacturing of one chair prototype.

Acidification Potential (AP) [kg SO2-Equiv.]

Materials

	CML2001 - Nov. 2010, Acidification Potential (AP) [kg SO2-Equiv.]
American Hardwood Lumber 1	0,0556
American Hardwood Lumber 2	0,125
American Hardwood Lumber 3	0,0119
American Hardwood Lumber 4	0,0613
American Hardwood Lumber 5	
American Hardwood Lumber (green lumber)	
Plywood	0,0591
PP reinforced plastic	
Leather	
Rubber band (Bungee cord)	
PE (HD)	
PU	
PU synthetic leather	
PVC synthetic leather	
Stainless steel	
Steel sheet	
Steel	
Aluminium sheet	
Brass	
Cotton fabric	
Polyamid 6.6 (PA 6.6) fabric	
Polyester (PET) fabric	
Polypropylene (PP)	

Materials used during assembly/finishing step - please note that the table "Overall impact assessment of chair" assembly/finishing also covers the energy consumption of tools.

	CML2001 - Nov. 2010, Acidification Potential (AP) [kg SO2-Equiv.]
Coating (solvent based)	0,00605
Coating (water based)	0,00303
Epoxy glue	0,0455
Nuts and bolds	
PU glue	0,00995
PVA glue	
Wax	
Plant based oil	0,00523

Eutrophication Potential (EP) [kg Phosphate-Equiv.]

Materials

	CML2001 - Nov. 2010, Eutrophication Potential (EP) [kg Phosphate-Equiv.]
American Hardwood Lumber 1	0,00606
American Hardwood Lumber 2	0,0139
American Hardwood Lumber 3	0,00133
American Hardwood Lumber 4	0,00682
American Hardwood Lumber 5	
American Hardwood Lumber (green lumber)	
Plywood	0,00631
PP reinforced plastic	
Leather	
Rubber band (Bungee cord)	
PE (HD)	
PU	
PU synthetic leather	
PVC synthetic leather	
Stainless steel	
Steel sheet	
Steel	
Aluminium sheet	
Brass	
Cotton fabric	
Polyamid 6.6 (PA 6.6) fabric	
Polyester (PET) fabric	
Polypropylene (PP)	

Materials used during assembly/finishing step - please note that the table "Overall impact assessment of chair" assembly/finishing also covers the energy consumption of tools.

	CML2001 - Nov. 2010, Eutrophication Potential (EP) [kg Phosphate-Equiv.]
Coating (solvent based)	0,000837
Coating (water based)	0,000358
Epoxy glue	0,00629
Nuts and bolds	
PU glue	0,00153
PVA glue	
Wax	
Plant based oil	0,00119

Global Warming Potential (GWP 100 years) [kg CO2-Equiv.]

Materials

	CML2001 - Nov. 2010, Global Warming Potential (GWP 100 years) [kg CO2-Equiv.]
American Hardwood Lumber 1	6,83
American Hardwood Lumber 2	15,2
American Hardwood Lumber 3	1,45
American Hardwood Lumber 4	7,45
American Hardwood Lumber 5	
American Hardwood Lumber (green lumber)	
Plywood	6,81
PP reinforced plastic	
Leather	
Rubber band (Bungee cord)	
PE (HD)	
PU	
PU synthetic leather	
PVC synthetic leather	
Stainless steel	
Steel sheet	
Steel	
Aluminium sheet	
Brass	
Cotton fabric	
Polyamid 6.6 (PA 6.6) fabric	
Polyester (PET) fabric	
Polypropylene (PP)	

Materials used during assembly/finishing step - please note that the table "Overall impact assessment of chair" assembly/finishing also covers the energy consumption of tools.

	CML2001 - Nov. 2010, Global Warming Potential (GWP 100 years) [kg CO2-Equiv.]
Coating (solvent based)	3,46
Coating (water based)	1,63
Epoxy glue	28,9
Nuts and bolds	
PU glue	6,55
PVA glue	
Wax	
Plant based oil	1,15

Carbon uptake (biogenic Carbon dioxide)

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As stated above (3.4) the stored (biogenic) carbon is quantified seperately here for transparent carbon balance, and not being subtracted from the Global Warming impact of the product.

	Carbon dioxide biotic without GWP
Carbon uptake Hardwood lumber 1	-18,27
Carbon uptake Hardwood lumber 2	-41,87
Carbon uptake Hardwood lumber 3	-4,004
Carbon uptake Hardwood lumber 4	-20,56
Carbon uptake Hardwood lumber 5	
Carbon uptake green lumber	

	Carbon dioxide biotic without GWP
Leather	
Plant based oil	-4,206
Cotton fabric	

Ozone Layer Depletion Potential (ODP, steady state) [kg R11-Equiv.]

Materials

	CML2001 - Nov. 2010, Ozone Layer Depletion Potential (ODP, steady state) [kg R11-Equiv.]
American Hardwood Lumber 1	7,8E-008
American Hardwood Lumber 2	1,5E-007
American Hardwood Lumber 3	1,43E-008
American Hardwood Lumber 4	7,35E-008
American Hardwood Lumber 5	
American Hardwood Lumber (green lumber)	
Plywood	2,62E-009
PP reinforced plastic	
Leather	
Rubber band (Bungee cord)	
PE (HD)	
PU	
PU synthetic leather	
PVC synthetic leather	
Stainless steel	
Steel sheet	
Steel	
Aluminium sheet	
Brass	
Cotton fabric	
Polyamid 6.6 (PA 6.6) fabric	
Polyester (PET) fabric	
Polypropylene (PP)	

Materials used during assembly/finishing step - please note that the table "Overall impact assessment of chair" assembly/finishing also covers the energy consumption of tools.

	CML2001 - Nov. 2010, Ozone Layer Depletion Potential (ODP, steady state) [kg R11-Equiv.]
Coating (solvent based)	3,4E-008
Coating (water based)	1,82E-008
Epoxy glue	6,9E-008
Nuts and bolds	
PU glue	1,22E-008
PVA glue	
Wax	
Plant based oil	5,7E-010

Photochem. Ozone Creation Potential (POCP) [kg Ethene-Equiv.]

Materials

	CML2001 - Nov. 2010, Photochem. Ozone Creation Potential (POCP) [kg Ethene-Equiv.]
American Hardwood Lumber 1	0,0157
American Hardwood Lumber 2	0,0459
American Hardwood Lumber 3	0,00439
American Hardwood Lumber 4	0,0226
American Hardwood Lumber 5	
American Hardwood Lumber (green lumber)	
Plywood	0,00666
PP reinforced plastic	
Leather	
Rubber band (Bungee cord)	
PE (HD)	
PU	
PU synthetic leather	
PVC synthetic leather	
Stainless steel	
Steel sheet	
Steel	
Aluminium sheet	
Brass	
Cotton fabric	
Polyamid 6.6 (PA 6.6) fabric	
Polyester (PET) fabric	
Polypropylene (PP)	

Materials used during assembly/finishing step - please note that the table "Overall impact assessment of chair" assembly/finishing also covers the energy consumption of tools.

	CML2001 - Nov. 2010, Photochem. Ozone Creation Potential (POCP) [kg Ethene-Equiv.]
Coating (solvent based)	0,0648
Coating (water based)	0,023
Epoxy glue	0,00803
Nuts and bolds	
PU glue	0,00243
PVA glue	
Wax	
Plant based oil	0,00107

Primary energy demand from fossil sources (non renewable resources) [MJ]

Materials

	Primary energy from resources (net cal. value) [MJ]
American Hardwood Lumber 1	95,2
American Hardwood Lumber 2	209
American Hardwood Lumber 3	20
American Hardwood Lumber 4	103
American Hardwood Lumber 5	
American Hardwood Lumber (green lumber)	
Plywood	167
PP reinforced plastic	
Leather	
Rubber band (Bungee cord)	
PE (HD)	
PU	
PU synthetic leather	
PVC synthetic leather	
Stainless steel	
Steel sheet	
Steel	
Aluminium sheet	
Brass	
Cotton fabric	
Polyamid 6.6 (PA 6.6) fabric	
Polyester (PET) fabric	
Polypropylene (PP)	

Materials used during assembly/finishing step - please note that the table "Overall impact assessment of chair" assembly/finishing also covers the energy consumption of tools.

	Primary energy from resources (net cal. value) [MJ]
Coating (solvent based)	68,3
Coating (water based)	33,7
Epoxy glue	582
Nuts and bolds	
PU glue	131
PVA glue	
Wax	
Plant based oil	4,51

Primary energy demand from renewable and fossil sources [MJ]

Materials

	Primary energy demand from ren. and non ren. resources (net cal. value) [MJ]
American Hardwood Lumber 1	383
American Hardwood Lumber 2	1,04E003
American Hardwood Lumber 3	99,1
American Hardwood Lumber 4	509
American Hardwood Lumber 5	
American Hardwood Lumber (green lumber)	
Plywood	840
PP reinforced plastic	
Leather	
Rubber band (Bungee cord)	
PE (HD)	
PU	
PU synthetic leather	
PVC synthetic leather	
Stainless steel	
Steel sheet	
Steel	
Aluminium sheet	
Brass	
Cotton fabric	
Polyamid 6.6 (PA 6.6) fabric	
Polyester (PET) fabric	
Polypropylene (PP)	

Materials used during assembly/finishing step - please note that the table "Overall impact assessment of chair" assembly/finishing also covers the energy consumption of tools.

	Primary energy demand from ren. and non ren. resources (net cal. value) [MJ]
Coating (solvent based)	70,1
Coating (water based)	35
Epoxy glue	601
Nuts and bolds	
PU glue	136
PVA glue	
Wax	
Plant based oil	51,4

9 Parameters

The following table illustrates the parameters for the chair prototype designed by Bobby Petersen & Tom Gottelier and collected at Benchmark's workshop during manufacturing of the prototyp.

Szenario-Parameter		
	Chair 1	
Materials		
Wood		
Hardwood lumber 1		
Mass	10,77	[kg; material use, total input] Wood use
Species	WhiteOak	specify hardwood species
Thickness	1	[inch] please choose the value between 0-5 inch
loss	7,04	[kg; material loss] Wood waste
Hardwood lumber 2		
Mass	24,68	[kg; material use, total input] Wood use
Species	Cherry	
Thickness	1	[inch] please choose the value between 0-5 inch
loss	16,14	[kg; material loss] Wood waste
Hardwood lumber 3		
Mass	2,36	[kg; material use, total input] Wood use
Species	Cherry	
Thickness	1	[inch] please choose the value between 0-5 inch
loss	1,54	[kg; material loss] Wood waste
Hardwood lumber 4		
Mass	12,12	[kg; material use, total input] Wood use
Species	Cherry	
Thickness	1	[inch] please choose the value between 0-5 inch
loss	7,93	[kg; material loss] Wood waste
Hardwood lumber 5		
Mass	0	[kg; material use, total input] Wood use
Species	Cherry	
Thickness	1	[inch] please choose the value between 0-5 inch

loss	0	[kg; material loss] Wood waste
Green wood		
green_lumber	0	kg of green lumber
Species (green lumber)	American Tulipwood	
Plywood		
Plywood	26,88	[kg; material use, total input] Plywood use
Plywood loss	17,58	[kg; material loss] Plywood waste
Recycled wood		
Recycled Hardwood	0	[kg; material use, total input] Recycled hardwood use
Recycled Hardwood loss	0	[kg; material loss] Recycled hardwood waste
Metals		
Steel sheet	0	[kg; material use, total input] Steel use (sheet)
Steel sheet losses	0	[kg; material loss] Steel waste (sheet)
Steel	0	[kg; material use, total input] Steel use (wire)
Steel losses	0	[kg; material loss] Steel waste (wire)
Stainless steel	0	[kg; material use, total input] Steel use (stainless)
Stainless steel losses	0	[kg; material loss] Steel waste (stainless)
Aluminum	0	[kg; material use, total input] Aluminum use
Aluminum losses	0	[kg; material loss] Aluminum waste
Brass	0	[kg; material use, total input] Brass use
Brass losses	0	[kg; material loss] Brass waste
Polymers		
Polyethylene	0	[kg; material use, total input] Use of plastic (Polyethylene, high density)
Polyethylene losses	0	[kg; material loss] waste of plastic (Polyethylene, high density)
Polyurethan foam/pad	0	[kg; material use, total input] Use of foam/pad (Polyurethane)
Polyurethan foam/pad losses	0	[kg; material loss] waste of foam/pad (Polyurethane)
Polypropylen	0	[kg; material use, total input] Use of plastic (Polypropylen)
Polypropylen losses	0	[kg; material loss] waste of plastic (Polypropylen)

Reinforced Polymer	0	[kg; material use, total input] Use of plastic (reinforced polymer)
Reinforced Polymer losses	0	[kg; material loss] waste of plastic (reinforced polymer)
Bio Resin	0	[kg; material use, total input] Bio Resin
Bio Resin loss	0	[kg; material loss] Bio Resin
Rubber (Bungee cord)	0	[kg] rubber band (bungee cord)
Textiles		
Cotton fibre	0	[kg; material loss] Fabric (Cotton)
Cotton fibre losses	0	[kg; material use, total input] Fabric (Cotton)
Leather	0	[kg; material use, total input] Leather
Leather losses	0	[kg; material loss] leather waste
PUR synthetic leather	0	[kg; material use, total input] PUR synthetic leather
PUR synthetic leather losses	0	[kg; material loss] PUR synthetic leather waste
PVC sythetic leather	0	[kg; material use, total input] Fabric (synthetic leather)
PVC sythetic leather losses	0	[kg; material loss] Fabric (synthetic leather)
Polyamid fabric	0	[kg; material use, total input] Fabric (Polyamid)
Polyamid fabric losses	0	[kg; material loss] Fabric (Polyamid)
Polyester fabric	0	[kg; material use, total input] Fabric (Polyester)
Polyester fabric losses	0	[kg; material loss] Fabric (Polyester)
Heat treatment wood		
Gas needed for steaming/ heat treatment	0	kg of gas needed
Assembly/finishing		
Machinery		
Machinery Use		
Cross cut saw	60	[min] Time cross cut saw is used
Straight line edger	0	[min] Time straight line edger is used
Four side planer	0	[min] Time four side planer is used
CNC	0	[min] Time CNC is used
Morticer	0	[min] Time morticer is used
Through feed sander	0	[min] Time through feed speed sander is used
Press	0	[min] Time press is used

Linisher	0	[min] Time through linisher is used
Machinery Capacity		
Cross cut saw	38,15	[kW] Energy requirement cross cut saw
Straight line edger	0	[kW] Energy requirement straight line edger
Four side planer	0	[kW] Energy requirement four sided planer
CNC	0	[kW] Energy requirement CNC
Morticer	0	[kW] Energy requirement morticer
Through feed sander	0	[kW] Energy requirement through feed speed sander
Press	0	[kW] Energy requirement press
Linisher	0	[kW] Energy requirement linisher
Materials - Assembly/Finishing		
Fixing Materials (nails, screws, bolts)	0	[kg] use of fixing materials (Screws, mails, bolts)
Glue (Epoxy resin)	4,5	[kg] use of Epoxy resin glue
PVA Glue	0	[kg] use of PVA glue
PU glue	1,08	[kg] PU glue
Paint/Laquer (water based)	0,5	[kg] use of water-based paint/laquer
Paint/Laquer (solvent based)	0,5	[kg] use of solvent-based paint/laquer
Plant based oil	0,9	[kg] use of plant based oil
Wax	0	[kg] use of Wax
Packaging		
Packaging foil	0	[kg; material use, total input] PP foil use for packaging
Cardboard	0	[kg; material use, total input] Cardboard for packaging
Transport to customer		
Shipping to customer by rail	0	[km] distance start - end, default = 100 km
Shipping to customer by ship	0	[km] Distance seaborne transport (default=100km)
Shipping to customer by truck	100	[km] distance start - end, default = 100 km
Life span		
Lifetime of chair	1	[years] lifetime of chair (1= impact over complete lifespan; if >1 impact assessment per year of lifetime)

10 Project team

Royal college of Art: Pioneering Design and Art 1837-2012

Celebrating its 175th anniversary this year, the Royal College of Art is the world's most influential postgraduate university of art and design. The RCA specialises in teaching and research, and offers the degrees of MA, MPhil and PhD across the disciplines of fine art, applied art, design, communications and humanities. There are over 1,100 masters and doctoral students and more than a hundred professionals interacting with them, including scholars, leading art and design practitioners, along with specialists, advisors and distinguished visitors.

www.rca.ac.uk

The **Design Products Master's programme, led by Professor Tord Boontje**, has a strong culture of experimentation. The two-year course is arranged in small study groups known as 'platforms', each run by two tutors who define the content and focus for project-based design work. Out of the Woods also includes collaboration with the RCA's Visual Communication programme.

www.designprodcuts.rca.ac.uk

AHEC

The American Hardwood Export Council (AHEC) is the leading international trade association for the US hardwood industry, representing the committed exporters among US hardwood companies and all the major US hardwood production trade associations. AHEC concentrates its efforts on providing architects, designers and end-users with technical information on the range of species, products and sources of supply.

www.americanhardwood.org

Benchmark

English furniture maker Benchmark has a passion for craftsmanship and design, producing handmade furniture in a sustainable way that will last several lifetimes. Established over 25 years ago by Terence Conran and Sean Sutcliffe, in a stable on the disused farm in the grounds of Terence's country home, Benchmark started making prototypes and small batches of furniture for leading retailers. It has expanded steadily over the years and Benchmark is now one of the most technologically advanced workshops in the UK. It has a full service design studio and employs a team of 40 craftsmen in its Berkshire and Dorset workshops. Benchmark works in the UK and internationally with architects, interior designers and private clients on bespoke commercial projects as well as making contemporary furniture for the home which is sold directly to customers from the workshop and showroom in Kintbury, West Berkshire.

www.benchmarkfurniture.com

PE INTERNATIONAL

PE INTERNATIONAL is the global leader in integrated product and enterprise sustainability performance with market leading software solutions, the world's best sustainability databases and unparalleled consulting expertise. With over 20 years of experience and 20 offices around the globe, PE INTERNATIONAL enables clients to understand sustainability, improve their performance and succeed in a marketplace that cares about environmental, social and financial business outcomes. PE INTERNATIONAL is working with 1,500 clients including some of the world's most respected brands to develop the strategies, management systems, tools and processes needed to achieve leadership in sustainability.

Sustainable design using GaBi i-report

The challenge of sustainable product design & communication is finding connecting the expertise of the LCA professional, who ensures precise representation of the product with accurate and up-to-date life cycle data, with the design stakeholders who require accurate yet intuitive information for decision-making.

GaBi i-report is the intuitive, fast and easy solution to integrate LCA, carbon footprinting or other environmental indicators into your product design process, to effectively communicate environmental impacts and to quickly evaluate 'what-if' scenarios in product and process designs.

GaBi i-reports distill the complexity of full-scale LCA models into a set of your key variables such as material selection, region of product manufacture, processing steps and transportation routes. Based on the selection of these key variables via drop-down menus, sliders, or direct entry, GaBi Reader visualises the sustainability performance scenarios tailored to the needs of each stakeholder in the organization.

The tables and diagrams in the report are interactively linked to the underlying product model and are updated automatically whenever the key variables are modified. This allows the designer to immediately see the influence of these changes and thereby compare different product scenarios and answer 'what-if' questions.

The GaBi Reader is essentially a product-specific eco-design tool. It does does not require any expertise by the product designer on the methodology of Life Cycle Assessment nor experience working with the expert GaBi tool for LCA. The results are consistent and the underlying LCA model cannot be altered accidentally, but is simply modified via the variables.

GaBi Reader - the software for accessing GaBi i-reports - is available as a desktop application or as a web-based application.
If you are interested in more information, please visit http://www.gabi-software.com or send an email to: gabi@pe-international.com