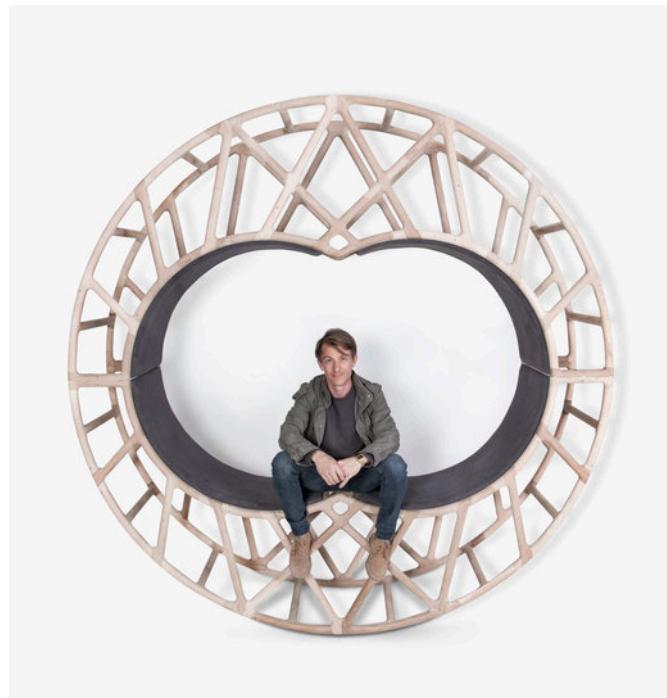


Life Cycle Assessment Playbench 2 by David Krynauw

The large scale and elaborate nature of the Playbench 2 design compared to other Seed to Seat designs results in a higher environmental impact. However, the efficient use of U.S. hardwood has helped to mitigate this impact, both due to the low energy requirement to supply this material and the significant amount of carbon stored in the finished design. As a unique, playful and elegant design in a strong and warm material, the Playbench 2 is likely to remain in use for many years, continuing to store carbon and avoiding the environmental impacts associated with replacement.

Red oak: the most abundant U.S. hardwood

The Playbench 2 is designed in red oak, the most abundant American hardwood with forest volume equivalent to around 2,500 million cubic meters, 18% of the total U.S. hardwood resource. Every year, the volume of red oak in U.S. forests grows by 55 million cubic meters, of which only 34 million is harvested. This means the volume standing in U.S. hardwood forests expands by 21



Replacement time of
harvested timber

0.32
seconds

Carbon footprint (Kg of
CO₂ equivalent)

157 Kg

Equivalent distance in a
family car (Km)

1044 Km

Equivalent carbon
footprint for average
South African

7 days

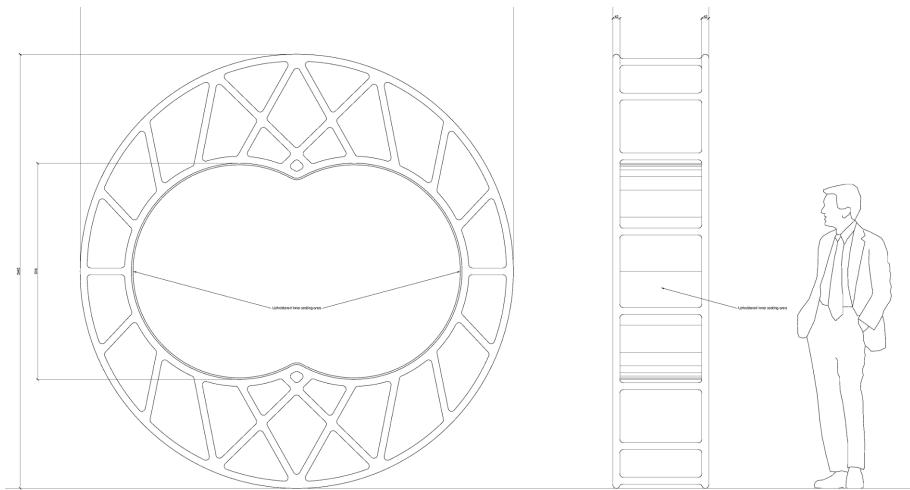
million cubic meters per year. It takes no more than one third of a second for forest growth to replace the red oak used to manufacture the Playbench 2. The Playbench 2 shows off the special properties of red oak, which combines high strength with low weight, allowing use of a small amount of material to produce a large and striking design.

Efficient use of material

Wood material efficiency is also quite high with 62% of wood supplied ending up in the finished prototype.

Efficient use of material reduces environmental impacts associated with bulk transport of lumber to the factory and with waste disposal.

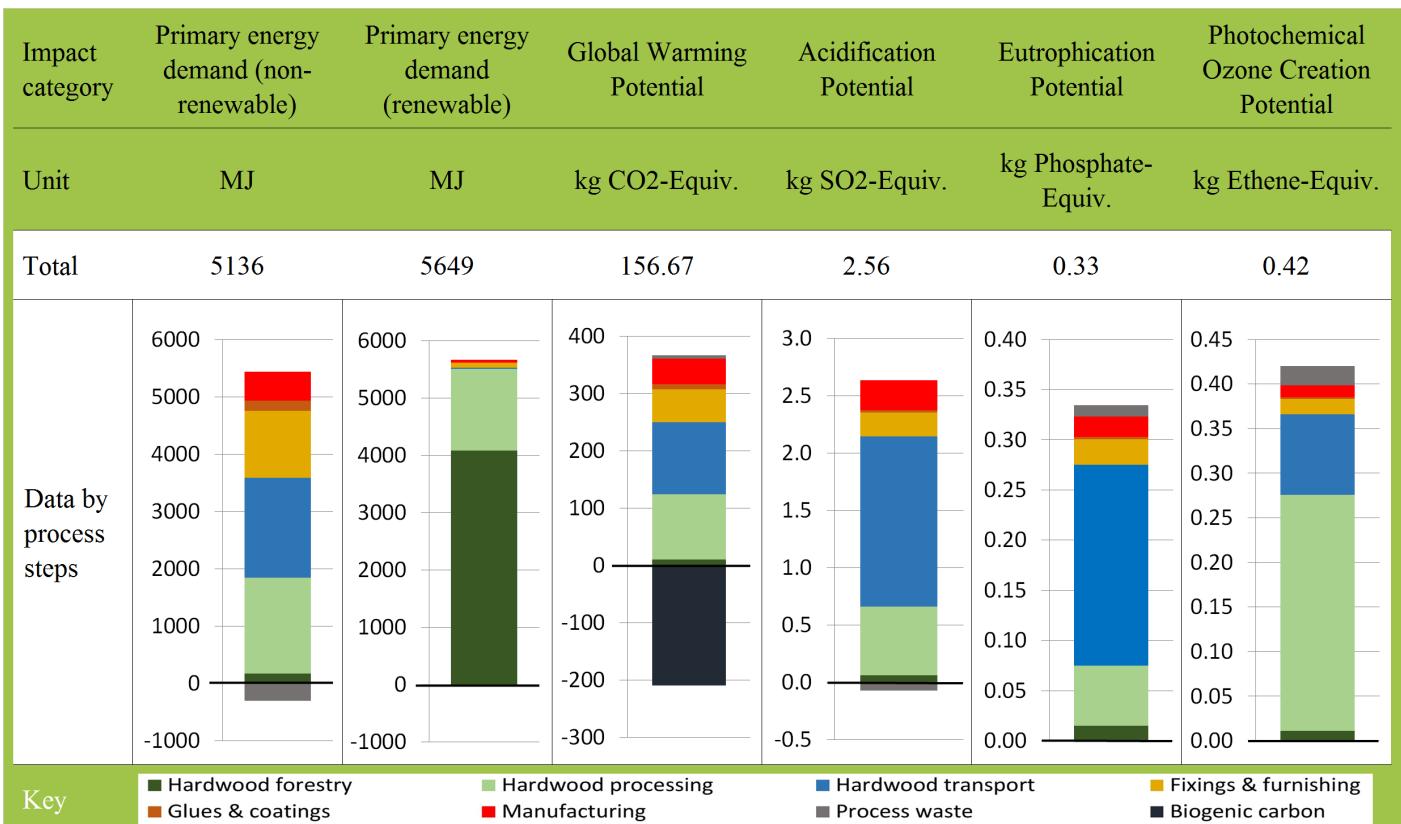
The carbon footprint of the Playbench 2 is 157 kg CO₂ equivalent, about the same as a 1000 km drive and equal to the carbon emissions of the average South African over a 7-day period.



Emissions of 399 kg CO₂ eq. are offset by 32 kg CO₂ eq. due to burning of process wood waste in South Africa (which substitutes for fossil fuel) and 210 kg CO₂ eq. of carbon stored in the finished design.

Because inputs of other materials and of energy during manufacturing are low, a large proportion of environmental impact across all categories – carbon footprint, acidification potential, eutrophication potential, and POCP – occurs during hardwood processing (notably due to the energy needed to power fans during kiln drying) and transport from the U.S. to South Africa.

FIGURE 1: CRADLE TO FACTORY GATE ENVIRONMENTAL IMPACT



Impact Category	Unit	Hardwood forestry	Hardwood processing	Hardwood transport	Fixings & furnishing	Glues & coatings	Manufacturing	Process waste	Biogenic carbon	Total	
Primary energy demand (non-renewable)	[MJ]	PED (NR)	172.20	1671.76	1745.45	1164.51	179.68	501.33	-299.12	n/a	5135.81
Primary energy demand (renewable)	[MJ]	PED (R)	4078.48	1423.37	25.28	83.10	9.59	42.85	-13.87	n/a	5648.80
Global Warming Potential (ex. biogenic carbon)	[kg CO ₂ -Equiv.]	GWP	10.52	113.42	125.89	57.57	8.91	44.11	6.02	-209.76	156.67
Acidification Potential	[kg SO ₂ -Equiv.]	AP	0.0639	0.5955	1.4873	0.2069	0.0172	0.2613	-0.0692	n/a	2.5628
Eutrophication Potential	[kg Phosphate-Equiv.]	EP	0.0152	0.0598	0.2003	0.0250	0.0024	0.0207	0.0111	n/a	0.3345
Photochemical Ozone Creation Potential	[kg Ethene-Equiv.]	POCP	0.0112	0.2643	0.0905	0.0174	0.0019	0.0130	0.0219	n/a	0.4204

Table 1: LCA Key Facts

Seat to Seat Designer: David Krynauw		
Functional Unit: 1 playbench		
American hardwood delivered to factory gate		
Hardwood species: Red oak		
Quantity	m3	0.284
	kg	200.46
Replacement time ⁽¹⁾	seconds	0.32
Carbon footprint	Emissions	242.55
	Wood carbon store	-318.13
	Total	-75.58
Wood balance		
Wood delivered to factory		213.1
Wood in product	kg	132.2
Waste wood		81.0
Wood material efficiency	%	62
Completed Seed to Seat prototype for display at 100% Design 2017		
Quantity in product	Hardwood	132.2
	Other material	15.0
	Total	147.1
Sawdust ⁽²⁾	kg	8.1
Waste to incinerator ⁽²⁾	Quantity	kg
	Energy generated	MJ
Waste to land fill ⁽²⁾	Quantity	kg
	Energy generated	MJ
Carbon footprint	Emissions	398.5
	Biogenic carbon	kg CO ₂
	Waste offset ⁽³⁾	eq
	Total footprint	
	Equivalent drive ⁽⁴⁾	km

(1) The time required for new growth in the U.S. hardwood forest to replace the wood harvested for the design.

(2) For wood waste, assumed that 10% is saw dust emitted to the air or otherwise lost to the local environment, 30% is incinerated for energy production and 60% is sent for landfill.

(3) The offset due to production of energy from incineration of wood offcuts and (a much smaller amount) from landfill gas which replaces use of fossil fuels.

(4) Estimate of equivalent driving distance based on 155g CO₂/km average emissions of cars sold in South Africa from Journal of Energy in Southern Africa, Vol.27 No.4 Nov 2016



Table 2: Environmental Impact Categories

Primary Energy Demand from Resources
Use of fossil fuels in mega-joules. The impact category has limited application on its own because it does not differentiate between energy sources (e.g. oil or coal). Nor does it represent "embodied energy". However it is an important driver of other environmental impacts including global warming, acidification, eutrophication, and resource depletion.
Primary Energy Demand from Renewables
Use of energy derived from renewable raw materials in mega-joules.
Global Warming Potential
Often termed "carbon footprint". Expressed in kg of carbon dioxide equivalent. The sum of the warming potential of all gases emitted (including CO ₂ , methane and water vapour) which influence the energy balance of the atmosphere leading to increased average temperatures.
Acidification Potential
Potential for acidification of soil and damage to plant health resulting from emissions to air, water and land of acidifying compounds such as sulphur dioxide (SO ₂) and nitrogen oxides (NO _x). Expressed in kg of sulphur dioxide equivalent.
Eutrophication Potential
Nutrient enrichment of water by release of phosphorous or nitrogen compounds (such as fertilisers) and organic matter (e.g. in effluents). This causes excess growth of plant matter and depletion of oxygen levels in rivers, lakes and seas. Expressed in kg of phosphate equivalent.
Photochemical Ozone Creation Potential
Often referred to as "photochemical smog". Increased levels of ozone at ground level arise through the reaction of volatile organic compounds, for example ethene, with oxygen compounds or oxides of nitrogen in air and under the influence of sunlight. The problem afflicts modern cities and impacts human health and reduces vegetative production. Expressed in kg of kg ethene equivalent.

WHAT IS LCA?

Life-cycle environmental assessment (LCA) involves the collection and evaluation of quantitative data on all the inputs and outputs of material, energy and waste flows associated with a product over its entire life cycle so that the environmental impacts can be determined. LCA quantifies environmental effects against a range of impact categories. LCA may also provide qualitative assessment of other environmental impacts, such as on biodiversity and land-use, that are less easy to quantify.

WHAT IS INCLUDED IN THE LCA?

The LCA of the Seed to Seat designs covers all processes from extraction of wood and other raw materials, transport of these materials to processing location, all processing steps (notably sawing and kilning in the case of wood), transport of processed products to the factory in South Africa, and manufacture of the finished design. Due to lack of information on durability, maintenance and disposal at end-of-life, the LCA is not a full “cradle-to-grave” assessment, and instead determines the environmental impact of the design when delivered to the customer.

WHO PREPARED THE LCA?

The LCA is commissioned by the American Hardwood Export Council (AHEC) and prepared by Rupert Oliver, Director of Forest Industries Intelligence Ltd, a U.K. based consultant with over 25 years experience of sustainability issues in the forest products sector.

HOW IS THE LCA CARRIED OUT?

The LCA draws on a two-year study, commissioned by AHEC and undertaken by PE International (now Thinkstep), to assess environmental impacts linked to delivery of U.S hardwood into world markets^a. This involved independent assessment of hardwood forestry practices and a survey of the hundreds of U.S. companies engaged in the processing and export of hardwood products. Information from the LCA of U.S. hardwoods is combined with the latest U.S. government forest inventory data^b and data gathered during manufacturing in South Africa. It is also combined with Thinkstep's existing life-cycle inventory database which covers an expanding range of non-wood materials and products.

WHAT ASSUMPTIONS ARE MADE?

In any LCA there will be data gaps and various assumptions have to be made. The analysis errs on the side of caution and aims to over-estimate rather than to under-estimate environmental impact, for example:

- U.S. hardwood is assumed to be delivered to South Africa by a relatively long route: by truck from central harvest point to an East Coast port in the U.S. and by container ship to South Africa. For delivery to Cape Town, wood is assumed to be landed at Cape Town and an additional 100 km is allowed to the factory gate. For delivery to Johannesburg, wood is assumed to be landed at Durban and then transported by truck for 650 km to Johannesburg.
- Due to lack of detailed LCA data on non-wood materials sourced in South Africa (such as steel screws, glues, and coatings), data is used for the closest surrogates available in the Thinkstep database and transport in each case is assumed to be from typical countries of origin for each product.
- Due to lack of detailed data on waste utilisation during manufacturing, it is assumed that 60% of wood waste is sent for landfill and 40% is incinerated for energy production.
- Sulphur content of marine fuels is assumed to be 2.7% compared to estimated international average of 2.4%.

HOW DOES THIS BEING A PROTOTYPE, NOT A PRODUCTION MODEL, AFFECT ENVIRONMENTAL IMPACT?

The environmental impacts of prototypes tend to be high per unit of production due to trial and error during fabrication. When producing finished designs at scale, manufacturers are able to adjust material procurement and production techniques to significantly increase efficiency and reduce waste.

a. The Thinkstep LCA study of U.S. sawn hardwood is available at http://www.forestindustries.info/images/Final_LCA_Lumber_report.pdf

b. Latest U.S. forest inventory data is drawn from the U.S. Forest Service Forest Inventory and Analysis (FIA) database at <http://apps.fs.fed.us/fia/fido/index.html> (last accessed in January 2016 and using 2014 data for most U.S. states)

