



Seed to Seat



Life Cycle Assessment Eve Chair by Andrew Dominic

The overall environmental impact of the Eve Chair is low for a bespoke furniture piece. The carbon footprint of 101 kg CO₂ eq. to manufacture 4 chairs is equal to that of driving 674 km in an average car sold in South Africa, or the total carbon footprint of the average South African over a 4-day period.

There are three basic reasons for the low environmental impact: considerable reliance on American cherry wood, which is better than carbon neutral at point of delivery to the studio in Cape Town; avoidance of energy intensive materials and additives in the design; and limited use of energy during manufacturing in South Africa, estimated to be only 24 kWh for the four chairs.

Sustainable cherry wood

The cherry used for the design is a sustainable material. The U.S. forest contains around 400 million cubic meters of cherry wood which is growing at a rate of 11.7 million cubic meters per year of which only 4.3 million, on average, is harvested. This means the volume standing in U.S. forests expands by 7.4 million cubic meters every year. It takes around one second for forest growth to replace



Replacement time of harvested timber

1 second



Carbon footprint (Kg of CO₂ equivalent)

101 Kg

Kms



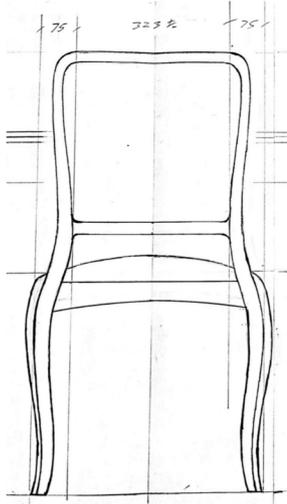
Equivalent distance in a family car (Km)

674 Km



Equivalent carbon footprint for average South African

4 days



the cherry used to manufacture the four chairs. Because inputs of other materials and of energy during manufacturing are so 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. The conversion efficiency of the chairs is lower than some other Seed to Seat designs – a consequence of the fine curved cherry wood elements

incorporated into the Eve Chair. However, this factor is compensated by energy generation from the waste wood, which offsets the use of fossil fuels in South Africa. The curvature of the elements also contributes to the balance between antique and contemporary achieved by the design, helping to ensure longevity.

Carbon storage

A long life means less need for replacement, and therefore less repetition of impacts. The four chairs together will lock away the equivalent of 22.9 kg of CO2 for as long as they are in existence.

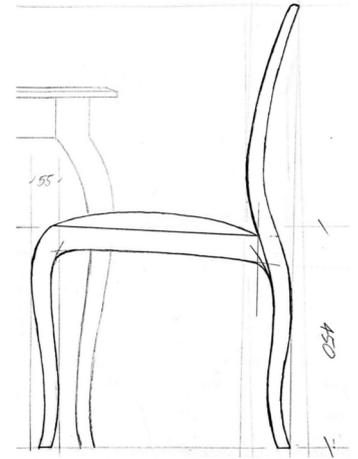
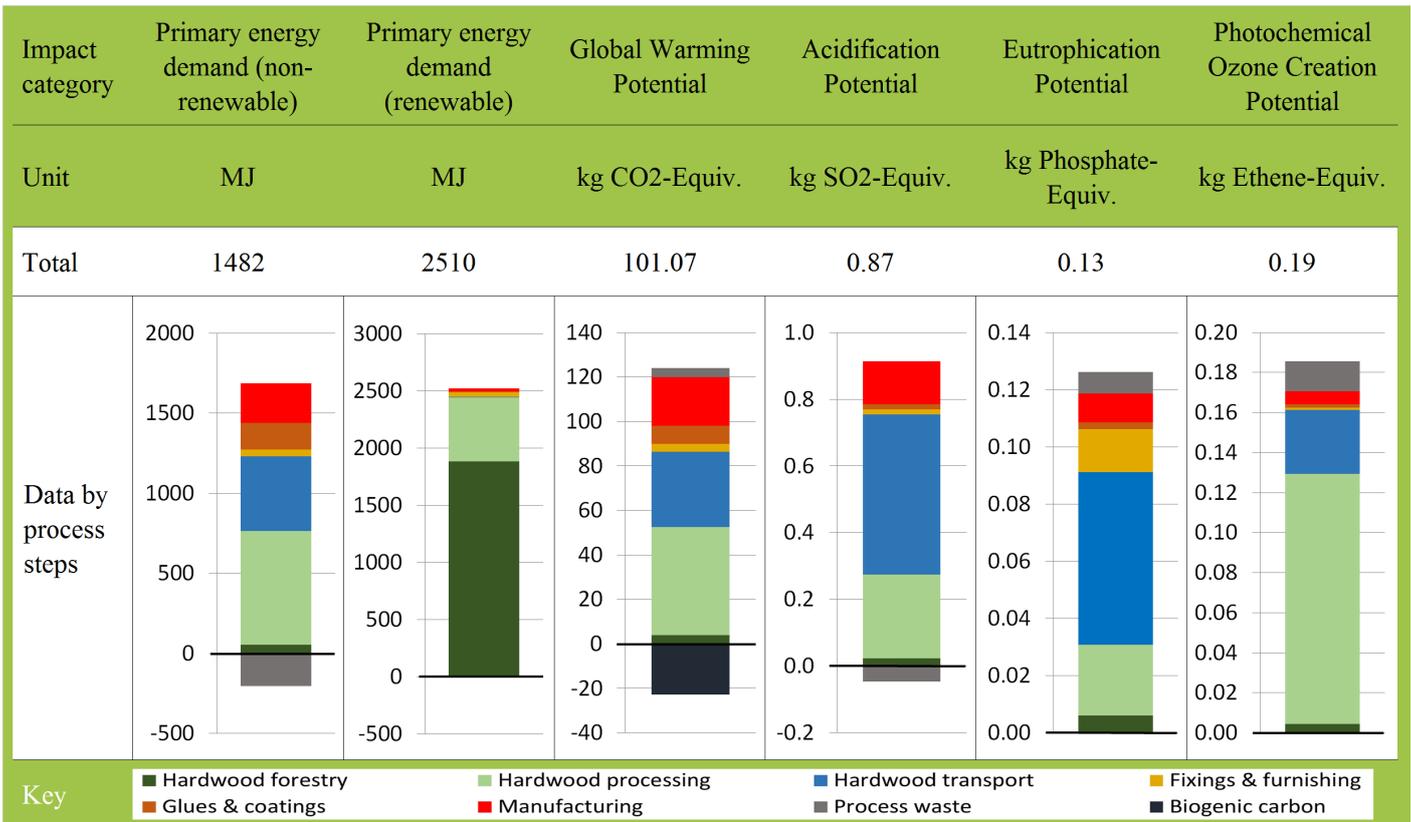


FIGURE 1: CRADLE TO FACTORY GATE ENVIRONMENTAL IMPACT OF FOUR EVE CHAIRS



Impact Category	Unit		Hardwood forestry	Hardwood processing	Hardwood transport	Fixings & furnishing	Glues & coatings	Manu-facturing	Process waste	Biogenic carbon	Total
Primary energy demand (non-renewable)	[MJ]	PED (NR)	53.92	710.65	463.81	43.19	165.81	247.89	-203.03	0.00	1482.25
Primary energy demand (renewable)	[MJ]	PED (R)	1881.31	557.76	5.38	43.56	10.04	21.19	-9.42	0.00	2509.83
Global Warming Potential (ex. biogenic carbon)	[kg CO2-Equiv.]	GWP	3.97	48.49	33.85	3.53	8.27	21.81	4.08	-22.93	101.07
Acidification Potential	[kg SO2-Equiv.]	AP	0.0240	0.2509	0.4802	0.0147	0.0151	0.1292	-0.0470	0.0000	0.8670
Eutrophication Potential	[kg Phosphate-Equiv.]	EP	0.0060	0.0248	0.0602	0.0151	0.0023	0.0102	0.0075	0.0000	0.1263
Photochemical Ozone Creation Potential	[kg Ethene-Equiv.]	POCP	0.0043	0.1249	0.0322	0.0009	0.0019	0.0064	0.0149	0.0000	0.1856

Table 1: LCA Key Facts

Seat to Seat Designer: Andrew Dominic			
Functional Unit: Four chairs			
American hardwood delivered to factory gate			
Hardwood species: cherry			
Quantity	m3		0.138
	kg		69.05
Replacement time ⁽¹⁾	seconds		0.74
Carbon footprint	Emissions		86.30
	Wood carbon store	kg CO ₂	-109.58
	Total	eq	-23.28
Wood balance			
Wood delivered to factory			69.4
Wood in product	kg		14.5
Waste wood			55.0
Wood material efficiency	%		21
Completed Seed to Seat prototype for display at 100% Design 2017			
Quantity in product	Hardwood		14.5
	Other material	kg	1.3
	Total		15.7
Sawdust ⁽²⁾	kg		5.5
Waste to incinerator ⁽²⁾	Quantity	kg	16.5
	Energy generated	MJ	128.7
Waste to land fill ⁽²⁾	Quantity	kg	33.0
	Energy generated	MJ	16.0
Carbon footprint	Emissions		145.7
	Biogenic carbon	kg CO ₂	-22.9
	Waste offset ⁽³⁾	eq	-21.7
	Total footprint		101.1
	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 for 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 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)

